THE PERCEIVED VERSUS ACTUAL RISK OF DEVELOPING TYPE 2 DIABETES MELLITUS IN A NEW ZEALAND POPULATION

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Abstract

Background: Type 2 diabetes mellitus (T2DM) has been termed one of the fastest growing non–communicable diseases of all time. Recent research estimates the current prevalence rate of T2DM in New Zealand to be 6.4%, representing 210,000 New Zealand adults. However, the prevalence rate for prediabetes; the precursor to T2DM, is estimated to be much higher, at 25.5%.

An individual's awareness of their risk for developing T2DM is essential to mediate change, which is the first step in managing the disease. However, studies have shown a difference between an individual's actual disease risk and their perceived risk.

Aim: To investigate an individual's perception of risk and compare it to their actual risk of developing T2DM in a New Zealand population. A secondary aim is to investigate determinants of perceived risk in developing T2DM.

Methods: 257 New Zealanders over the age of 18 years, nonpregnant and not diagnosed with diabetes (type 1 or 2) were recruited for this study. Eligible participants took part in an anonymous 10–minute online questionnaire, to assess perceived risk using a validated Risk Perception Survey for Diabetes Development (RPS–DD) and actual risk of developing T2DM using the Diabetes New Zealand 'Are you at risk?' calculator. Statistical analysis via SPSS version 26 was performed to test for differences between low and high perceived risk groups. Regression analysis was conducted to investigate determinants that predict the probability of perceived risk in developing T2DM.

Results: Fifty–three percent (135/257) of participants had an increased actual risk (New Zealand Diabetes 'Are you at risk?' score >5) of developing T2DM, however 86% (220/257) of participants perceived their risk of developing diabetes to be low.

Significant differences between participants with low perceived versus high perceived risk were observed for; GP–recommended testing for CVD/T2DM (56% v 78%, P=0.02), GP communication about CVD/T2DM risk (24% v 51%, P<0.001), prediabetes diagnosis (4% v 24%, P<0.001) and BMI (kg/m^2) (24 (22.1, 26.4) v 27.4 (25.3, 30.8) P<0.001).

Significant predictor variables of the logistic regression model included; prediabetes (OR 8.97 (95% CI 1.61–50.10), P<0.01), eating a diet high in fat and sugar (OR 6.29 (95% CI 1.83–21.63), P<0.01), family history of T2DM (OR 10.17 (95% CI 3.0 – 34.47), P<0.001), low comparative disease risk (OR 0.05 (95% CI 0.01 – 0.18), P<0.001) and planned lifestyle modifications to reduce risk of T2DM (OR 7.13 (95% CI 2.05 – 24.85), P=0.002).

Conclusion: This study demonstrates that a participant's perceived risk of developing T2DM significantly underestimates their actual risk in 257 participants from a New Zealand population. While prediabetes and BMI have been well established in the literature for their association with increased risk perception of developing T2DM, the role of GP–based communication has not. Further research is needed to explore GP–based communication, and the potential impact this has on an individual's understanding of risk in developing T2DM.

Keywords: prediabetes , risk perception, type 2 diabetes mellitus, Risk Perception Survey of Diabetes Development (RPS–DD), actual risk, risk communication, GP communication

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List of Abbreviations

ADA	American Diabetes Association
ApoB	Apolipoprotein B
AUSRISK	Australian Diabetes Risk Calculator
BMI	Body Mass Index
CKD	Chronic kidney disease
CRP	C–reactive protein
CVD	Cardiovascular disease
DN	Diabetic nephropathy
DPS	The Finnish Diabetes Prevention Study
DHAH	Diabetes Heart & Health Survey
DiRECT trial	The Diabetes Remission Clinical Trial
GDM	Gestational diabetes mellitus
GI	Glycaemic index
GWAS	Genome–Wide Association Study
HbA1c	Haemoglobin A1c test
HDL	High Density Lipoprotein
IFG	Impaired Fasting Glucose
IGT	Impaired Glucose Tolerance
IL–1β	Interleukin–1 beta
IL–6	Interleukin–6
IL–18	Interleukin–18
LDL	Low density lipoprotein
LOADD study	Lifestyle Over and Above Drugs in Diabetes
mg/dL	milligrams per decilitre
mmol/L	millimoles per litre
mmol/mol	millimoles per mole

MOH	Ministry of Health
NZSSD	New Zealand Society of the Study of Diabetes
OGTT	Oral glucose tolerance test
PRAMS	Pregnancy Risk Assessment Monitoring System
PREVIEW trial	Prevention of Diabetes through Lifestyle Intervention and Population Studies in Europe and around the World
PROMISE cohort	Prospective Metabolism & Islet Cell Evaluation cohort
RHR	Resting heart rate
RR	Relative risk
RPS–DD	Risk Perception Survey of Developing Diabetes
T2DM	Type 2 diabetes mellitus
TNF–α	Tumour neurosis factor – alpha
TWAS	Transcriptome–wide association scan
UKPDS	UK Prospective Diabetes Study
VADT	Veterans Affairs Diabetes Trial
VLCD’s	Very low carbohydrate diets
VLDL	Very low–density lipoprotein
WHR	Waist to hip ratio

Chapter One – Introduction

Type 2 diabetes mellitus (T2DM) is characterised by elevated blood glucose concentrations. In New Zealand T2DM is diagnosed by a glycated haemoglobin (HbA1c) value equal to, or above 50mmol/mol ((NZSSD), 2011). Its precursor – prediabetes is determined by HbA1c values between 41mmol/mol – 49mmol/mol ((NZSSD), 2011). Measurement of glycated haemoglobin provides information on blood glucose levels over time and the effectiveness of glycaemic control.

Over the past 20 years, diabetes (both prediabetes and T2DM) incidence has been on the rise in New Zealand (Jowitt, 2014). The latest available research estimates T2DM in New Zealand to be 6.4%, meaning an estimated 210,000 New Zealand adults have T2DM (Ministry of Health, 2018/2019). Coppell and colleagues (2013) investigated data from the 2008/09 New Zealand Adult Nutrition survey, which comprised 4,721 adults over the age of 15 years and found a prevalence rate of 25.25% for prediabetes. However, this trend is not specific to New Zealand. In fact prevalence rates of T2DM around the world has been termed one of the fastest growing non–communicable diseases of all time (Fogelholm et al., 2017).

Perceived risk or risk perception plays a pivotal role in a person's health status as it directly impacts on health behaviour intentions (Paek & Hove, 2017). Risk perception is thought to be bi–dimensional, consisting of both an emotional dimension (how an individual feels about the risk) and a cognitive dimension (the knowledge an individual has about the risk) (Paek & Hove, 2017). Yet risk perception is complex, and is influenced by many factors, including risk knowledge (Guess, Caengprasath, Dornhorst, & Frost, 2015), Optimistic Bias (a measure of how optimistic an individual is about the likelihood of the disease risk) ((Walker, Mertz, Kalten, & Flynn, 2003), and degree of personal control around disease development (Shaak et al., 2018) to name a few.

In contrast an individual's actual risk is the biomedical and fundamental underlying risk. Measures of actual risk for prediabetes and T2DM range from more exact measures via blood analysis tests (such as HbA1c or the Oral Glucose Tolerance Test (OGTT)) through to less exact measures such as online risk calculator tools (section 2.3.3.1 & 2.3.3.2), which calculate a risk score based on an algorithm of risk–based questions (Fajardo, Balthazaar, Zalums, Trevena, & Bonner, 2019).

A number of studies have shown significant variances between an individual's perceived risk and their actual disease risk (Heidemann et al., 2019; Hivert, Warner, Shrader, Grant, & Meigs, 2009; Joiner et al., 2016; Kim et al., 2007; Kowall et al., 2017; Pinelli, Berlie, Slaughter, & Jaber, 2009; Yang, Baniak, Imes, Choi, & Chasens, 2018) with some studies showing a significant underestimation of actual risk (Guo, Tang, Zhang, Lommel, & Chen, 2019; Heidemann et al., 2019; Joiner et al., 2016; Kim et al., 2007; Kowall et al., 2017).

A German–based study of 2,327 participants without known T2DM found that of those with an increased actual T2DM risk (n=639), 79% perceived their risk to be absent or slight (Heidemann et al., 2019). A similar trend was observed in another population-based study in Germany (KORA FF4 study), where 1,953 participants without known T2DM found 72% (95% CI 69 – 75) who had prediabetes did not perceive they were at risk of developing the disease (Kowall et al., 2017).

An individual's awareness of their risk for developing T2DM is essential in mediating lifestyle and behaviour change to reduce progression of prediabetes to T2DM. This is the first step in managing the disease. Early detection and awareness of T2DM risk offers a window of opportunity to reverse the disease process for at-risk individuals, and subsequently avoid adverse outcomes, including macrovascular and microvascular complications, neuropathy as well as impairments in memory and cognition. Lean and colleagues (2018) have shown that reversal of T2DM is possible in people who have had the condition for up to ten years.

The investigation of an individuals' risk perception and how this compares with the model of their actual risk can offer insights into the factors that influence risk perception and creates an opportunity to develop strategies to bring risk perception more in alignment with actual risk.

There has been no study to date examining people's perception of risk ,compared with their actual risk of developing T2DM in the New Zealand population. This Masters project will address this.

1.1 Aims of the study

Primary Aim: To investigate an individual's perceived risk of developing T2DM and compare it to their actual risk of developing T2DM in a New Zealand population.

Secondary Aim: To identify factors that influence an individual's perception of risk.

1.2 Hypothesis

Null hypothesis (H0): An individual's perceived risk is the same as their actual risk of developing T2DM in a New Zealand population.

Alternative hypothesis (H1): An individual's perceived risk is not the same as their actual risk of developing T2DM in a New Zealand population.

1.3 Overview

The presentation of this thesis is in five chapters which discuss the relationship of perceived risk and actual risk of developing T2DM in a New Zealand population. Chapter two is a literature review of current studies which investigate the perception of risk as well as actual risk of developing prediabetes and T2DM. Chapter three describes the methodological procedures carried out for this study. Chapter four is a compilation of the findings and results. Chapter five discusses the findings and how they relate to the literature. A conclusion of the study as well as opportunities for further research in this topic are discussed in chapter five.

Chapter Two – Review of the literature

The purpose of this chapter is to offer a review of the literature on the perception of risk as well as actual risk of developing prediabetes and T2DM. This chapter includes an overview and history of prediabetes and T2DM (section 2.1). Definitions associated with T2DM are discussed in section 2.2. Modifiable and non-modifiable risk factors as well as tools for assessing diabetes risk are reviewed in section 2.3. Long term complications of T2DM, including macrovascular and microvascular complications as well as implications for cognition and memory are considered in section 2.4. Risk perception and barriers are discussed in section 2.5. Prevention strategies and reducing T2DM progression is examined in 2.6.

2.1 An overview of prediabetes and T2DM

The term 'diabetes' was first described in humans as early as the 2nd century AD, with Aretaeus of Cappadocia, a Greek physician, communicating the first accurate description of the disease (Karamanou, Protogerou, Tsoucalas, Androutsos, & Poulakou-Rebelakou, 2016). It was not until the 17th century, Thomas Willis, an English doctor formally added the name 'mellitus' to the description of diabetes in an effort to characterise the very sweet taste of urine (Karamanou et al., 2016).

In the 19th century the discovery of the hepatic glycogenic processes was made, through experiments carried out by Oskar Minkowski and Joseph von Mering involving the removal of the pancreas of dogs, succumbing them to diabetes (Karamanou et al., 2016). Further research involving the isolation of pancreatic islet cells led to the discovery of insulin, which revolutionised and propelled the understanding of the disease into an optimistic era of diabetes management (Karamanou et al., 2016).

While the first signs of diabetes in humans has been recorded since antiquity, it has only been in the modern era that the incidence of both prediabetes and T2DM has reached epidemic proportions. The latest Global Report on Diabetes issued by the World Health Organisation states diabetes (both type 1 and type 2 diabetes mellitus) now affects more than 422 million adults worldwide (World Health Organisation, 2016). Currently, individual prevalence rates for type 1 diabetes (an autoimmune condition, which requires exogenous insulin for survival) and type 2 diabetes mellitus are not available, however of the 422 million adults affected by diabetes, a significant proportion are affected by T2DM (World Health Organisation, 2016).

In the late 1990s the Expert Committee on Diagnosis and Classification of T2DM defined the term 'prediabetes', formally acknowledging those individuals who had increased blood glucose levels, but whose levels were not yet high enough to be classified as having type 2 diabetes mellitus (American Diabetes, 2014). This resulted in diagnostic criteria for prediabetes as either (or both): impaired fasting glucose (IFG) (110mg/dL (6.1mmol/L) – 125mg/dL (6.9mmol/L)) and impaired glucose tolerance (IGT) (glucose is at 2 h after OGTT) (140mg/dL (7.8mmol/L) – 199mg/dL (11.0mmol/L)) (American Diabetes, 2014).

In 2003, the criteria for impaired fasting glucose was revised and lowered to 100mg/dL (5.6mmol/L) by the committee. This change was an attempt to align the prevalence rates seen in IGT, however this change was not adopted uniformly. As a result the World Health Organisation, and other diabetes organisations have kept the original IFG criteria (American Diabetes, 2014).

Since 2011, current recommended guidelines to determine both prediabetes and T2DM have been measured by HbA1c (a glycated haemoglobin) in New Zealand, and around the world (Table 2.1). An HbA1c test measures blood glucose levels over a 3-month period. In New Zealand, an HbA1c measurement between 41–49 mmol/mol is classified as prediabetes (a fasting plasma glucose (FPG) concentration of 6.1–6.9 mmol/L). And an HbA1c greater than 50mmol/mol is classified as T2DM ((NZSSD), 2011).

The scope of this thesis focuses on prediabetes and T2DM, however it is worth noting there are other forms of the disease, some of which include; Type 1 diabetes mellitus, Latent Autoimmune Diabetes of Adulthood (LADA), and Maturity Onset Diabetes of the Young (MODY) or monogenetic diabetes.

LADA is an autoimmune disease, much like type 1 diabetes, however it typically presents in adulthood, usually between the age of 30 – 50 years of age. It can often be mistaken for T2DM, due to its slow progression rate, however it is diagnosed by the presence of pancreatic islet autoantibodies (Appel, Wadas, Rosenthal, & Ovalle, 2009). It is thought to be misdiagnosed in up to 10% of T2DM cases in New Zealand, according to a Waitemata District Health Board endocrinologist (Diabetes NZ, 2019).

MODY, or monogenetic diabetes often occurs in early adulthood (usually before 25 years of age). It is an autosomal dominant condition (Ben Khelifa, Barboura, Dandana, Ferchichi, & Miled, 2011) with its cause due to mutations on a single gene (Best Practice Advocacy Centre New Zealand (Bpac NZ), 2018).

Gestational diabetes, another type of diabetes, is discussed in section 2.3 *Risk factors for prediabetes and T2DM*.

2.2 Definitions of prediabetes and T2DM

2.2.1 Prediabetes

The term 'prediabetes' is a condition on a continuum of blood glucose concentrations and risk of T2DM development (McMurray et al., 2010). It can be described as the metabolic midpoint between normoglycaemia and T2DM (Huang, Cai, Mai, Li, & Hu, 2016).

Biomedical measures of prediabetes can be defined as either an impaired fasting glucose (IFG) or an impaired glucose tolerance (IGT) or a combination of both. IFG and IGT have different metabolic processes with differing degrees of long-term metabolic risk and disease outcome (Lorenzo et al., 2013). Fasting plasma glucose measurements are recommended when HbA1c is not available or when there are concerns about its validity when testing for both prediabetes and T2DM ((NZSSD), 2011).

IFG is less prevalent than IGT across the population (Abdul-Ghani, Tripathy, & DeFronzo, 2006). Prevalence of both IFG and IGT increases with age, however IGT is more common in women under the age of 55 years, while IFG is twice as likely in men (Abdul-Ghani et al., 2006). Reasons for this are thought to be due to the reduced hepatic sensitivity to insulin, resulting in higher plasma glucose levels in men, while women have higher circulating levels of oestrogen and progesterone – hormones which can reduce whole body insulin sensitivity (Hilawe, Yatsuya, Kawaguchi, & Aoyama, 2013). Prediabetes can also be defined by a fasting plasma glucose (FPG) and HbA1c (Table 2.1).

Table 2.1 Global classifications of prediabetes & T2DM

	New Zealand[1]	United Kingdom[2]	Australia[3]	United States[4]	World Health Organisation[5]
Normoglycaemia					
- **FPG** (mmol/l)	≤ 6	≤5.4	≤ 6	< 100mg/dL*	≤ 6
- **HbA1c** (mmol/mol)	≤ 40	≤41	≤ 40	≤ 5.6 % *	–
Prediabetes					
- **FPG** (mmol/l)	6.1 – 6.9	5.5 – 6.9	6.1 – 6.9	100 – 125mg/dL*	6.1 – 6.9
- **HbA1c** (mmol/mol)	41 – 49	42 – 47	41 – 47	5.7 – 6.4 %*	–
T2DM					
- **FPG** (mmol/l)	≥7	≥7	≥7	≥ 126mg/dL*	≥7
- **HbA1c** (mmol/mol)	≥50	≥48	≥48	≥ 6.5%*	≥ 48

[1]((NZSSD), 2011) [2](Diabetes.co.uk, 2019; Diabetes.org.uk, n.d), [3](Australian Diabetes Society, n.d), [4] (American Diabetes, 2014) [5](World Health Organization, 2019)

*The United States use % as an HbA1c unit, and mg/dL as an FPG unit, whereas the rest of the world use mmol/mol as a measure for HbA1c and mmol/l for FPG.

FPG = Fasting plasma glucose
HbA1c = glycated haemoglobin

2.2.1.1 Impaired fasting glucose (IFG)

Impaired fasting glucose (IFG) is thought to be a result of impaired hepatic glucose production, which is controlled mainly by concentrations of glucagon as well as plasma insulin (Abdul-Ghani et al., 2006). Individuals with IFG have higher than normal glucose levels upon waking due to impaired basal insulin secretion and reduced hepatic insulin sensitivity (Unwin, Shaw, Zimmet, & Alberti, 2002). In essence, individuals with IFG tend to have hepatic insulin resistance and normal skeletal muscle insulin sensitivity (Nathan et al., 2007).

2.2.1.2 Impaired glucose tolerance (IGT)

In contrast, impaired glucose tolerance (IGT) is associated with impaired insulin sensitivity in peripheral tissues, in particular, in skeletal muscle (Unwin et al., 2002). Skeletal muscle is the primary site of glucose utilisation postprandially (Unwin et al., 2002). Individuals with IGT typically exhibit normal hepatic insulin sensitivity (Nathan et al., 2007).

2.2.1.3 Combined IFG and IGT

Individuals who present with both IFG and IGT are considered to be at the greatest risk of development and progression to T2DM as well as associated cardiovascular disease and in some cases, raised inflammatory responses (Unwin et al., 2002). This is because they have dual impairments of hepatic glucose regulation and reduced insulin sensitivity in periphery tissue, as well as significantly impaired lipoprotein profiles (Lorenzo et al., 2013). One of the largest meta–analysis review of global cohorts which included over 55,000 participants from the Netherlands, Asia, USA, Middle East and Mexico, investigated the annual incidence and relative risk of T2DM. Results from the study reported the highest progression rates (of prediabetes to

T2DM) in individuals with combined IGT and IFG, with a conversion rate of 15–19%, compared with isolated IGT (4–6%) and IFG (6–9%) (Gerstein et al., 2007).

The Diabetes Heart and Health Survey (DHAH) which was carried out in Auckland, New Zealand between 2002 – 2003 showed the prevalence rates of IGT and IFG to be 21.9% and 9.3% respectively (Sundborn et al., 2007). In a more recent study, also carried out by New Zealand-based researchers, a cumulative T2DM incidence rate of 5% was found in 14,043 prediabetic adults after three years from being newly diagnosed with prediabetes (Teng et al., 2019). International progression rates of prediabetes to T2DM range from 2 – 18% per year (Teng et al., 2019).

2.2.2 Type 2 Diabetes Mellitus (T2DM)

Around the world there are differences in HbA1c measures for defining when a person is termed to have T2DM (Table 2.1). In New Zealand T2DM is defined by an HbA1c greater than 50mmol/mol or a FPG greater than or equal to 7 mmol/l (Table 2.1) ((NZSSD), 2011). The HbA1c measure offers relatively low biological variability as well as reliable associations with macrovascular outcomes. The measure is also more convenient for patients, who do not need to fast or provide repeated blood glucose measures unlike the FPG and oral glucose tolerance test (OGTT) ((NZSSD), 2011).

The disadvantages of FPG include the relatively large biological variability, it is also less able to predict long term complications that arise from T2DM such as neuropathy and macrovascular outcomes compared with HbA1c (Elley, Kenealy, Robinson, & Drury, 2008; Selvin et al., 2004).

The Oral Glucose Tolerance Test (OGTT) has been the gold standard measure for determining if a person has T2DM in New Zealand up to 2011, when the HbA1c was introduced. An advantage of the OGTT is its accuracy, often diagnosing a larger number of asymptomatic T2DM cases compared with the HbA1c (Hussain, 2016). However the OGTT is more labour-intensive for patients, as well as being more costly from a laboratory perspective (Hussain, 2016).

2.3 Risk factors for prediabetes and T2DM

There are many factors which increase a person's risk for developing prediabetes and T2DM. Some key risk factors include: being overweight or obese, suboptimal diet and exercise, smoking, inadequate sleep, genetics, ethnicity, family history, gestational diabetes and age (Bellou, Belbasis, Tzoulaki, & Evangelou, 2018; Jowitt, 2014; Khaodhiar, Cummings, & Apovian, 2009; Yaggi, Araujo, & McKinlay, 2006; Yang et al., 2018; Zhang et al., 2019) (Kirkman et al., 2012; Plows, Stanley, Baker, Reynolds, & Vickers, 2018).

Risk factors for T2DM can be classified as either modifiable (section 2.3.1) or non-modifiable (section 2.3.2). Modifiable risk factors can be controlled or changed by the individual to help reduce their risk. These include controlling weight gain, eating a healthy balanced diet, not smoking, as well as getting adequate sleep at night. Non-modifiable risk factors include factors that cannot be manipulated or controlled by an individual to reduce their risk, such as genetics, ethnicity, and age.

2.3.1 Modifiable risk factors

2.3.1.1 Obesity

"*New Zealand is the fourth most obese country in the OECD region*", according to Boyd Swinburn, Professor of Population Nutrition and Global Health at the University of Auckland (Sydney Ideas, 2019). With 32.2% of New Zealand adults over the age of 15 years classified as obese (OECD, 2017). The United States, Chile and Mexico taking podium positions of 1st, 2nd and 3rd, respectively (OECD, 2017). While the exact cause of T2DM is not completely understood, obesity is strongly associated with insulin resistance, and as a result, prediabetes and T2DM (Barazzoni, Gortan Cappellari, Ragni, & Nisoli, 2018).

Adipose tissue, once thought of as a simple storage solution for unused energy, is actually an endocrine factory in its own right – producing hormones, adipocytokines and other substances which impact the production of insulin as well as insulin's ability to work effectively in the body (Khaodhiar et al., 2009).

Obesity reduces the ability of the liver and muscles to utilise glucose, resulting in both an increased production of insulin from the pancreatic beta cells as well as a resistance to insulin at hepatic and muscular sites (Khaodhiar et al., 2009). The increased production of inflammatory markers, namely Interleukin–6 (IL–6) and tumour–necrosis factor–α (TNF–α) as a result of an obesogenic state are also implicated in the development of T2DM (Khaodhiar et al., 2009). A systematic review and meta–analysis of 19 prospective studies involving 39,136 participants found strong associations between increased levels of inflammatory cytokines (Interleukin–1β (IL–1β), IL–6, Interleukin–18 (IL–18), C–reactive protein (CRP)),TNF–α and T2DM risk (Liu et al., 2016).

In a recent review of 86 studies, obesity, as measured by body mass index (BMI) had a statistically significant and strong positive association with T2DM development (Bellou et al., 2018). Furthermore, Bellou and colleagues (2018) found the metabolic health of an obese individual had an impact on the degree of risk of developing T2DM. Obese individuals who were metabolically unhealthy (ie were hypertensive, had dyslipidaemia and/or had hyperglycaemia) had a 10-fold increase in risk of T2DM development compared to metabolically healthy obese individuals, who only had a four-fold increased risk.

Another systematic review of 89 studies which investigated co-morbidities associated with T2DM, showed a significant association between obesity (as defined by BMI) and 18 co-morbidities including many types of cancers and cardiovascular disease (Guh et al., 2009). However, the strongest association was observed for T2DM in females who were overweight (RR = 3.92 (95% CI: 3.10–4.97)) and obese (12.41 (9.03–17.06)) (Guh et al., 2009).

There is consistent support for obesity management to reduce the progression from prediabetes to T2DM (American Diabetes, 2018). Furthermore, the reduction in weight (ideally 7% of total bodyweight) earlier rather than later in the hyperglycaemic state can result in reversal of beta-cell dysfunction, before insulin secretion capacity is impacted (American Diabetes, 2018).

The Clinical Guidelines for Weight Management in New Zealand Adults (2017) outlines the increase in risk for developing T2DM (as well as hypertension and cardiovascular disease) with elevated waist circumference (WC) measurements (WC>102 cm for men; WC>88cm for women) and increasing BMI levels above 24.9 kg/m2. The guidelines also advocate for at least 5% loss in body weight to achieve positive metabolic health outcomes (such as improved insulin sensitivity , with additional weight loss above 5% body weight conferring additional disease risk reduction benefits (Ministry of Health, 2017).

2.3.1.1.1 Gestational diabetes mellitus (GDM)

Gestational diabetes mellitus (GDM) can be defined as abnormal glucose metabolism during pregnancy. It is a common complication, affecting approximately 14% of pregnancies, globally (Plows et al., 2018). Both GDM and T2DM share common risk factors including overweight and obesity (Kim et al., 2010).

The cause of GDM is thought to be due to both reduced insulin sensitivity and an inability for the pancreatic beta cells to produce the required amount of insulin to meet demands for pregnancy (Lacroix, Kina, & Hivert, 2013). While gene-variant and Genome-Wide Association Studies (GWAS) have indicated a genetic component to insulin dysregulation observed in GDM (Kwak et al., 2012; Mao, Li, & Gao, 2012), maternal overweight and obesity is thought to be the main contributor to the prevalence rates seen in GDM (Kim et al., 2010). A two-year analysis of 23,904 women from the Pregnancy Risk Assessment Monitoring Systems (PRAMS) which spanned across seven US states concluded nearly half of all GDM cases could be prevented if overweight and obese women (BMI≥25kg/m^2) had a GDM risk equal to women of a normal BMI (18.5 – 24.9kg/m^2) (Kim et al., 2010).

The prevalence of GDM in New Zealand is not completely known. A retrospective study which analysed a cohort of nearly 7000 pregnant women from the Growing Up in New Zealand study found a prevalence rate of 6.2% (Lawrence, Wall, & Bloomfield, 2019).

GDM can have adverse health outcomes for both the baby (macrosomia, increased risk of CVD and T2DM later in life as well as hypoglycaemia immediately after birth) and the mother (increased risk of developing T2DM, pre–eclampsia and increased risk of future pregnancies with GDM)(Lawrence et al., 2019).

2.3.1.2 Diet & Exercise

The relationship between diet and T2DM was first observed around 3,000 years ago when T2DM was seen as a disease of the rich, whose diet consumed mostly of oil, flour and sugar (Sami, Ansari, Butt, & Hamid, 2017). Mortality rates of T2DM were also tracked during both World Wars, where rates declined in war-torn countries as a result of famine but flourished in countries untouched by war, where food was abundant (Sami et al., 2017). Since then, research has delved into the details of the human to diet to understand the exact constituent's that underpin T2DM risk development. Results from a recent umbrella review of meta-analysis showed a positive relationship for excess sugar (specifically in the form of sugar sweetened beverages) and risk of T2DM development (Neuenschwander et al., 2019). Similarly, a positive relationship was also seen for red and processed meats and risk of T2DM development in the review. Conversely a diet rich in wholegrains and cereal fibre have shown an inverse relationship with T2DM risk (Neuenschwander et al., 2019). These findings have been supported by an expert review of both observational studies and randomised controlled trials which found a positive association for cereal fibres, unsaturated fatty acids and an inverse association for foods with added sugar, a high glycemic load as well as sugar sweetened beverages (Palacios, Kramer, & Maki, 2019).

Today there is little doubt that a suboptimal diet (one high in sugar and low in fibre), and lack of exercise play a crucial role in the development of both prediabetes and T2DM. So much so, that healthy lifestyle strategies such as the 'Global strategy on diet, physical activity and health', have been developed by the World Health Organisation, with similar initiatives employed in most government health departments around the globe (WHO, 2004). Supporting government initiatives, is a significant amount of literature, such as the PREVIEW trial and the Finnish Diabetes Prevention Study (DPS) which provide strong evidence for a focus on lifestyle modification in the form of healthy diet and exercise (Fogelholm et al., 2017; Tuomilehto et al., 2001).

The Finnish (DPS) was the first randomised controlled trial to demonstrate lifestyle-change intervention can prevent T2DM in high-risk individuals (Lindstrom et al., 2003; Lindstrom et al., 2013). The study recruited 522 men and women with impaired glucose tolerance (mean age 55yrs, mean BMI: 31kg/m^2) who were randomised to either receive an intervention (individualised lifestyle-change counselling aimed at reducing weight through healthier eating and increased physical activity) or standard care (control) consisting of oral and written (2-page booklet) information on healthy eating and physical activity at baseline and at annual follow–ups. Results during the trial showed a 58% reduction in T2DM risk in the intervention group ($P<0.001$). Furthermore, the cumulative incidence of T2DM after four years was significantly lower in the intervention group (11% (CI 95% 6 – 15%) compared to the control group (23% (CI 95% 17–29%) (Tuomilehto et al., 2001). These results are reflective of the significant net weight loss seen in the intervention group at the one (4.2kg ±5.1kg) and two (3.5kg ±5.5kg) year follow–ups compared with the control group, who had a net weight loss of 0.8kg ±3.7kg and 0.8kg ±4.4kg respectively (Tuomilehto et al., 2001).

A similar trend was also reported in a recent review of 14 studies with nearly 1 million participants. Participants who had the healthiest lifestyle (as defined by maintaining a healthy weight, eating a balanced diet, having at least 30 minutes of exercise/day and avoiding smoking and excessive alcohol consumption) had a 75% lower risk of developing diabetes (HR 0.25 [95% CI 0.18, 0.35]) (Zhang et al., 2019).

Bellou and colleagues (2020) found convincing evidence for the role of poor diet and increased risk of T2DM development in a review of 86 studies. In particular: increased consumption of processed meats and sugar-sweetened beverages showed strong evidence for an increased risk for T2DM development. Conversely, increased consumption of wholegrain foods showed strong evidence for a protective effect against T2DM development. This was due to the fibre-rich nature of the foods which reduced the rate of gastric emptying, enabling a slow release of glucose into the blood stream (Bellou et al., 2018).

Exercise plays a key role in mediating T2DM risk development, via increased glucose utilisation and insulin sensitivity at skeletal muscle sites, thereby regulating blood glucose levels (Asif, 2014). Exercise also results in energy expenditure, which reduces adipose tissue stores, assisting with weight maintenance (Asif, 2014).

The Diabetes Prevention Program Research Group (2002) demonstrated a reduction in T2DM incidence of 58% (95% CI 48–68%) by using a lifestyle intervention, which included 150minutes/week of exercise, in 3,234 participants without T2DM. When comparing this with the metformin (850mg twice a day) intervention only a 31% (95% CI 17–43%) reduction in T2DM incidence was achieved (The Diabetes Prevention Program (DPP) Research Group, 2002).

2.3.2.3 Smoking

Smoking is thought to impact T2DM risk via both direct and indirect mechanisms involving insulin regulation (Artese, Stamford, & Moffatt, 2019). Smokers tend to have greater central adiposity compared with non-smokers resulting in increased insulin resistance (Reaven & Tsao, 2003) despite the appetite-reducing mechanisms of nicotine (Kawamoto et al., 2010). Direct mechanisms on insulin regulation is thought to be via increased secretions of hormones such cortisol and catecholamines that counter the effects of insulin, resulting in insulin resistance (Artese et al., 2019). Furthermore, evidence for decreased levels of adiponectin, a protein produced by adipocytes which increase insulin sensitivity has been found in smokers compared with non-smokers (Kawamoto et al., 2010). A cross sectional study of 724 Japanese men without a prior history of T2DM demonstrated via multilinear regression analysis, an inverse relationship with serum high molecular weight (HMW) adiponectin and BMI as well as smoking frequency (Kawamoto et al., 2010).

A 2017 systematic review and meta–analysis of 22 articles involving 343,573 participants examined the relationship between smoking status, intensity, cessation and risk of developing T2DM in Japan (Akter, Goto, & Mizoue, 2017). Results from the meta-analysis found a linear dose-response relationship between T2DM risk and the number of cigarettes consumed. For each increase of 10 cigarettes smoked per day there was a 16% increase in risk of T2DM. Additionally there was a negative relationship between T2DM risk and smoking cessation post 5-years, with a steady decrease in risk for each year of smoking cessation. This risk was comparable to a non–smoker at 10 years of smoking cessation.

2.3.2.4 Sleep

Sleep deprivation has been linked to insulin resistance and glucose dysregulation (Yaggi et al., 2006). The mechanisms of action in which sleep deprivation disrupts these metabolic functions are thought to be due to changes in hormonal and endocrine functions which influence carbohydrate metabolism as well as cortisol production (Yaggi et al., 2006).

A study which involved a cohort of male participants from the Massachusetts Male Aging Study found a U–shaped pattern to the number of hours of sleep attainted per night and risk of developing T2DM (Yaggi et al., 2006). Males who had less than 6 hours of sleep per night were twice as likely to develop T2DM compared to males who had 7 hours sleep per night. Conversely, males who reported having more than 8 hours of sleep per night were three times as likely to develop T2DM compared to males who had 7 hours sleep per night (Yaggi et al., 2006).

A recent meta-analysis of ten studies which included over 18,000 cases of T2DM also confirmed a U-shaped relationship between hours of sleep per night and risk of developing T2DM over a two to 16 year follow up period (Shan et al., 2015). The relative risk for T2DM was 1.09 (95% CI 1.04–1.15) per one hour less than seven hours sleep per night, and the relative risk was 1.14 (95% CI 1.03–1.26) per one hour of additional sleep beyond 7 hours (Shan et al., 2015).

2.3.2 Non–modifiable risk factors

2.3.2.1 Genetic factors

With the modern advances in gene-technology and the sequencing of the human-genome, the identification of genes associated with the development and progression of T2DM has grown. As a result there are 120 distinct genetic loci now documented, explaining approximately 20% of all T2DM cases (Szabo, Mate, Csep, & Benedek, 2018).

A recent study by Guo and colleagues (2019) investigated the genetic correlation between resting heart rates (RHR) and metabolic disorders including T2DM from UK Biobank data (n = 428,250). Summary-level data was available for 74,124 cases of T2DM. Findings from the study found statistically significant genetic correlations between RHR and T2DM (r_g = 0.22; 95% CI 0.18 to 0.26; p = 1.99 × 10^{-22}) and six metabolic characteristics including; body mass index (BMI), waist to hip ratio (WHR), fasting insulin, fasting glucose, triglycerides and high–density lipoprotein (HDL); r_g range −0.12 to 0.24; p < 0.05) (Guo, Chung, et al., 2019).

Analysis from transcriptome-wide association scans (TWAS) discovered seven genes (SMARCAD1, RP11–53O19.3, CTC–498M16.4, PDE8B, AKTIP, KDM4B, and TSHZ3) that were statistically separate and shared between RHR and T2DM in the cardiovascular and nervous system tissue (Guo, Chung, et al., 2019). This study offers evidence for a genetic correlation between high RHR and metabolic orders such as T2DM (Guo, Chung, et al., 2019).

In a twin study of 40 pairs of monozygotic and 46 pairs of dizygotic twin females Cohen and colleagues (2006) found approximately one third of the variation in HbA1c levels could be explained by the glycation gap (GG), a measure of the difference between HbA1c concentrations and estimated concentrations of the enzyme fructosamine (Cohen et al., 2006). GG was more strongly associated with monozygotic twins than dizygotic, r=0.65 and r=0.48 respectively (Cohen et al., 2006). Twin studies offer the opportunity to identify genetic contributions to the progression of T2DM in isolation of the environment (Willemsen et al., 2015).

2.3.2.2 Ethnicity

The incidence rates of prediabetes and T2DM are over represented in ethnic groups including Asian, Māori and Pacific people, among others (Jowitt, 2014; Metcalf, Kyle, Kenealy, Sundborn, & Jackson, 2018). Why certain ethnic groups have higher prevalence rates of abnormal glycaemia is complex and multifactorial. Genetic risk factors such as the 'thrifty genotype' has been suggested as a possible contribution to the diabetes development in people of Pacific background (Jowitt, 2014). Differences in metabolic markers (including; impairment of beta-cell function, dysregulation of glucose and impaired insulin sensitivity) in different ethnic groups have also been reported, irrespective of age or BMI (Jowitt, 2014). Additional reasons for ethnic disparity include access to and utilisation of high quality healthcare (Ellison-Loschmann & Pearce, 2006; Jatrana, Crampton, & Norris, 2011).

Data from a cross-sectional study (The Auckland Diabetes, Heart and Health Survey) of 3,559 participants, found ethnic differences in mean HbA1c levels of both normal and abnormal glycaemic participants (Metcalf et al., 2018). Results showed, that after controlling for age and gender, HbA1c levels were higher for Pacific by 5.5 (SE=0.25)mmol/mol, Māori by 2.5 (SE=0.24)mmol/mol and Asian by 2.3 (SE=0.40)mmol/mol compared with New Zealand Europeans. It is worth noting the higher prevalence rates of smoking and increased BMI in both Māori and Pacific participants in this study, both of which are risk factors for T2DM as well. Why HbA1c levels are higher in ethnic minorities is a likely result of a complex–multifactorial equation including disparities in erythrocyte lifespan, differences in glycation, reduced access to healthcare as well as factors associated with socioeconomic status (Metcalf et al., 2018).

Access and utilisation of healthcare for ethnic minorities has also been examined as a possible explanation for higher rates of prediabetes and T2DM. Between 1988 to 1990, the New Zealand Workforce survey was conducted, involving 5,677 multicultural staff from worksites in Tokoroa and Auckland (Scragg, Baker, Metcalf, & Dryson, 1991). The cross-sectional survey found prevalence rates of newly diagnosed T2DM to be 9.7% for Màori, 7.7% for Pacific people and just 1.7% for Europeans. A decade on, between 2002 and 2003, the Diabetes Heart and Health (DHAH) study demonstrated prevalence rates for newly diagnosed T2DM had decreased for both Màori (3.8%) and Pacific people (4%) (Sundborn et al., 2007). One reason for this decrease in prevalence rates of newly diagnosed T2DM in Màori was thought to be attributed to the 1991 health reforms which initiated growth of new Màori healthcare providers (Ellison-Loschmann & Pearce, 2006; Sundborn et al., 2007). During this time Màori healthcare providers grew from just 13 in 1994 to over 240 in 2004 resulting in earlier and increased access to healthcare for Màori (Ellison-Loschmann & Pearce, 2006; Sundborn et al., 2007).

Data from a third wave (2004-2005) of the longitudinal Survey of Family, Income and Employment (SoFIE) investigated ethnic differences in financial barriers to prescription medication access in 18,320 New Zealand adults (Jatrana et al., 2011). Of the 18,320 adults surveyed, 14,315 (78.1%) were New Zealand European, 1,975 (10.8%) were Màori and 800 (4.4%) were Pacific. Results from the analysis showed the odds of deferring prescription medicine purchases at least once in the preceding

12-month period were higher for Màori (OR 2.98 (95% CI 2.56 – 3.47) and Pacific people (OR 3.52 (95% CI 2.85 – 4.35) compared with New Zealand European (Jatrana et al., 2011).

2.3.2.4 Age

T2DM risk increases as a direct result of the aging process, and is associated with reduced capacity of pancreatic beta-cell function and reduced insulin sensitivity resulting in glycaemic dysregulation (Kirkman et al., 2012).

Coupled with age-related risk, older-aged population groups also tend to have reduced physical activity levels. This was highlighted in results from the latest New Zealand Ministry of Health 2018/2019 Survey where 16% of 65–74 year olds and 31% of ≥75–year olds were reported doing less than 30 minutes of physical activity per week (Ministry of Health, 2018/2019). This is well under current New Zealand physical activity guidelines for older people of 30 minutes of moderate physical activity on at least five days per week (Ministry of Health, 2013).

According to the National Diabetes Statistics Report, published in 2017, by the Centres for Disease Control and Prevention (CDC), approximately 30 million US adults have T2DM (Centers for Disease Control and Prevention, 2017). This statistic is over-represented in the ≥65 year demographic, with 25.2% reported as having T2DM (Centers for Disease Control and Prevention, 2017). A similar trend exists in New Zealand. An estimated 210,000 of the total population have T2DM, with 27%

and 45.2% represented by the 55–64 year and ≥ 65–year demographic, respectively (Ministry of Health, 2018/2019).

Researchers from the Centre for Disease Control and Prevention (CDC) forecast prevalence rates of diabetes will double over the next two decades due to the aging population, even if incidence rates flatten (Boyle, Thompson, Gregg, Barker, & Williamson, 2010).

2.3.3 Who should be assessed for T2DM risk in New Zealand?

The New Zealand Society for the Study in Diabetes (NZSSD) is the nation's leading body on scientific and clinical standards in diabetes. Their position statement on the diagnosis and screening for T2DM recommends screening to commence in low-risk, asymptomatic men and women at 45 years and 55 years respectively ((NZSSD), 2011). This is alongside CVD screening recommendations.

Individuals with risk factors for T2DM, such as; ischaemic heart disease, vascular disease, obesity (BMI>30kg/m^2), family history of diabetes, taking long-term antipsychotic or steroid medication, or a history of gestational diabetes in pregnancy should be screened from 25 years of age ((NZSSD), 2011).

Children and young adults who are obese (BMI>30kg/m^2) should be routinely screened if; they are of Pacific, Māori or Asian/Indian ethnicity or if there has been a family history of the disease ((NZSSD), 2011).

Risk factors can be used as a means for determining a person's risk of developing T2DM and this is discussed in section 2.3.3.1 below.

2.3.3.1 Assessment of actual risk using risk calculator tools

Measuring actual risk of T2DM development can be done via invasive and non-invasive methods. Invasive methods include blood analysis of biochemical markers such as HbA1c or fasting plasma glucose (FPG) as discussed in section 2.2 of this chapter. Less invasive techniques include risk calculator tools, which are based on a series of questions around modifiable (ie physical activity levels, diet and BMI) and non-modifiable risk factors (ie family history, age and ethnicity) for developing T2DM. Each question in the risk calculator tool has a numeric value. The numeric value of all questions adds together to produce a risk score specific to that risk calculator.

2.3.3.2 Risk calculator tools

The development of online risk calculator tools in recent years has led to the ability for individuals to assess their own disease risk in greater numbers than ever before (Skolbekken, 2019). This has provided an opportunity for people to feel empowered and in charge of their health. However it also has the potential to negatively impact individuals who receive a higher calculated risk score compared with their actual risk as determined by gold-standard methods (Skolbekken, 2019).

The Diabetes New Zealand 'Are you at risk?' calculator comprises of eight questions which ask about; weight, physical activity levels, diet, family history of diabetes, ethnicity, gestational diabetes, and age. Responses to these questions categorise individuals either into a low risk category (score between 3–5) and an increased risk category (score greater than 6).

Despite contacting Diabetes New Zealand and conducting a search of the literature, it was not possible to gain insight into how or when the risk assessment tool was developed. Email correspondence from Diabetes New Zealand –

> *"The Risk Assessment tool came from our Diabetes NZ Auckland branch which produced it (the risk assessment tool) following a consensus discussion with their consultant medical advisor at the time……no report from the consensus discussion is available from the Diabetes NZ Auckland branch……..the risk calculator will be reviewed at appropriate intervals''*

Comparing similar risk assessment tools from around the world. The Australian T2DM Risk Assessment tool (AUSDRISK) comprises of 11 questions including: age, gender, ethnicity, country of birth, family history, history of high blood sugar, medication use for blood pressure, smoking status, fruit and vegetable intake, physical activity level and waist measurement. Results from these questions rank individuals on a 6-point risk continuum from low risk (0–5 points) up to very high risk (20+ points). AUSDRISK assesses the risk of developing T2DM in the next five years, rather than an immediate diabetes risk, which is dissimilar to other risk tools discussed in this section. AUSDRISK was developed by the Baker IDI Heart and Diabetes Institute and has been validated in the Australian Diabetes, Obesity and Lifestyle Study (AusDiab study) (Chen et al., 2010).

The Diabetes UK Risk Calculator was developed in conjunction with Diabetes UK, the University of Leicester and the University Hospital of Leicester NHS trust, and comprises of eight questions, similar to the Diabetes New Zealand risk calculator. Questions differ slightly in that the UK Risk Calculator asks about gender, waist circumference measurement and blood pressure, however it omits lifestyle questions around diet and physical activity levels. Responses from the Risk Calculator are categorised into one of four risk groups: low risk (score 0–6), increased risk (7–15), moderate risk (16–24) and high risk (25–47).

The American Diabetes Association (ADA) first launched their diabetes risk calculator in the early 1990s. The risk calculator was modelled on data from the 1999–2004 NHANES study, which was subsequently validated through a number of large-scale studies including; the Atherosclerosis Risk in Communities (ARIC) study, 2005–6 NHANES study and the Cardiovascular Health Study (CHS) (Stiglic & Pajnkihar, 2015).

The ADA risk calculator is based on nine questions which include: age, gender, history of gestational diabetes and family history of diabetes, blood pressure, physical activity levels, ethnicity as well as height and weight. Responses are then calculated into either a low risk (less than 5) or high risk (greater than 5). From the studies in the literature review (Table 2.2) the ADA risk calculator is the most frequently reported risk calculator used to assess T2DM actual risk.

A recent study by Fajardo and colleagues (2019) evaluated thirty–five risk calculator tools available online including: AUSDRISK, Diabetes UK Risk calculator and the ADA. The Diabetes New Zealand 'Are you at risk?' calculator was not included in the evaluation. Findings from the study indicated nearly half of the risk calculators do not state the underlying model in which the calculators are based on, making it difficult for individuals as well as health professionals to correlate differences in risk results between multiple risk calculator used (Fajardo et al., 2019). This limitation was also observed when researching the Diabetes New Zealand 'Are you at risk?' calculator for this research project.

Only 32% of the risk calculator tools evaluated by Fajardo and colleagues (2019) used visual aids in communicating numeric risk information, a gold standard measure in ensuring results of risk information is understood by the general population (Fajardo et al., 2019). While visual aids were used in the questions of the Diabetes New Zealand 'Are you at risk' calculator, there were no visual aids to assist with communicating risk information based on the calculated risk score. This is an important point to consider, given the low levels of health literacy in New Zealand (discussed further in 5.2.9).

A review by Buijsse and colleagues (2011) found risk scores based on forty-six risk assessment tools provided relatively good predictability of T2DM development when used in the population that were designed for; but show wide variability between populations (Buijsse, Simmons, Griffin, & Schulze, 2011).

The Diabetes New Zealand 'Are you at risk' calculator was chosen for the current project as it was the risk calculator that most aligned with the target population being investigated, despite some limitations of the calculator (as discussed already in this section and further in section 5.3.1).

2.4 Type 2 diabetes mellitus and long–term complications

T2DM is a progressive and chronic condition characterised by both insulin resistance and an insulin insufficiency (Asif, 2014). Both insulin resistance and insufficiency result in significantly elevated blood glucose concentrations increasing the risk for adverse outcomes (Asif, 2014). Unlike some diseases, T2DM offers a window of opportunity to reverse the disease process and subsequent adverse outcomes including macrovascular complications (section 2.4.1) impairments in memory and cognition (section 2.4.2) and microvascular complications (section 2.4.3).

Studies have shown an association between prediabetes and T2DM and increased risk of macrovascular complications (Ford, Zhao, & Li, 2010; Huang et al., 2016; Sarwar et al., 2010) increased risk of decline in cognition (Geijselaers et al., 2017; Zheng, Yan, Yang, Zhong, & Xie, 2018) chronic kidney disease and diabetic retinopathy and nephropathy (Adler et al., 2003; Lee et al., 2015; Tabak, Herder, Rathmann, Brunner, & Kivimaki, 2012; Wasserman, Wang, & Brown, 2018),

Recent research such as the PREVIEW and DiRECT trials have had significant results in both reducing the risk of participants developing T2DM as well as reversing T2DM through lifestyle modifications in diet and exercise (Fogelholm et al., 2017; Lean et al., 2018). Lean and colleagues (2018) have shown that reversal of T2DM is possible in people who have had the condition for up to ten years. The window of opportunity to reverse T2DM highlights the importance of early intervention around individual diabetes risk knowledge and communication strategies. The UK Prospective Diabetes Study (UKPDS), a landmark trial, investigated different therapy treatments of 4,209 participants who had been newly diagnosed with T2DM in 4, over a 6–year period found reduced beta-cell functionality at the time of diagnosis (Turner et al., 1995). Furthermore, this reduction in beta-cell function continued to decline over time. Results from the UKPDS trial showed that a reduction in just 1% of HbA1c levels in patients recently diagnosed with T2DM have a significant risk reduction for long-term complications, such as vascular disease, cataract extraction, myocardial events and stroke (Turner et al., 1995). This finding was supported by another landmark trial – the Diabetes Control and Complications Trial (DCCT), which involved 1,441 insulin-dependent participants with type 1 diabetes mellitus who underwent intensive diabetes therapy for glycaemic control (Shamoon et al., 1993). Of the 1,441 participants, 726 presented with no retinopathy at initiation of the study and were classified as the primary-prevention cohort. The remaining 715 presented with mild retinopathy and were classified as the secondary-prevention cohort. Each cohort was randomly assigned to received either intensive insulin therapy guided by an insulin-pump and glucose monitoring or usual care (one to two daily injections). Results after 6.5 years demonstrated a risk reduction for developing retinopathy of 76% (95% CI 62–85%) compared with usual care in the primary-prevention cohort. Similarly in the secondary-prevention cohort, intensive therapy reduced the development of retinopathy by 54% (95% CI 39–66%) compared to usual care (Shamoon et al., 1993).

2.4.1 Macrovascular complications

Macrovascular disease involves the large blood vessels of the body, mainly affecting coronary arteries as well as the aorta with typical pathogenic progression being cardiovascular disease and stroke (Fowler, 2008).

Prediabetes and T2DM is associated with an increased risk of cardiovascular disease and vascular-related events (Wasserman et al., 2018). A meta-analysis of 53 prospective cohort studies spanning over 1.6 million normoglycaemic and prediabetic participants, showed prediabetic participants were associated with an increased risk of cardiovascular disease (RR 1.13 (IFG–ADA) 1.26 (IFG–WHO) and 1.30 (IGT)) and coronary heart disease (RR (1.10 (IFG–ADA), 1.18 (IFG–WHO) and 1.20 (IGT) (Huang et al., 2016).

Similar trends were also observed from the Emerging Risk Factors Collaboration study, which investigated 102 cohorts of nearly 700,000 participants across 25 countries. Results from analysing participant blood glucose levels, found those with T2DM resulted in an approximate two-fold increase in risk of vascular diseases such that: the adjusted hazard ratio for coronary heart disease was 2.00 (95% CI 1.83–2.19) and 2.27 (95% CI 1.95–2.65) for ischaemic stroke (Sarwar et al., 2010).

Although strong associations were seen for vascular risk in individuals with T2DM, such associations were not seen as strongly in those with impaired fasting glucose, which is logical, as blood glucose concentrations are not as high. Compared with fasting blood glucose concentrations between 3.90–5.59mmol/L, the hazard ratio for coronary heart disease was 1.11 (95% CI 1.04–1.18) and 1.17 (95% CI 1.08–1.26) for fasting blood glucose concentrations between 5.60–6.09mmol/L and 6.10–6.99mmol/L respectively (Sarwar et al., 2010).

A similar result was observed in a systematic review of 18 observational studies investigating the relative risk of cardiovascular disease for both impaired fasting glucose and impaired glucose tolerance. Both impaired fasting glucose and impaired glucose tolerance were associated with a moderate increased risk for cardiovascular disease, with an overall relative risk ratio of 1.20 (95% CI 1.12–1.28) for impaired fasting glucose between 6.–6.9mmol/L (110–125mg/dL) and 1.18 (95% CI 1.18 (1.09–1.28) for impaired fasting glucose of 5.6–6.9mmol/L (100–125mg/dL) (Ford et al., 2010).

2.4.2 Cognition and Memory

One of the largest and most recent prospective studies; The English Longitudinal Study of Ageing (ELSA) demonstrated significant ($p<0.001$) cognitive decline (as assessed by immediate and delayed recall of ten dissimilar words) in participants with T2DM (n=446) and prediabetes (n=1190) compared with their normoglycaemic participants. Findings showed a 1 mmol/mol increase in HbA1c resulted in global cognitive decline in memory (–0.0005SD/year (95% CI –0.0009, –

0.0001)), cognition (−0.0009 SD/year, (95% CI −0.0014, −0.0003)) and executive function (−0.0008SD/year, (95% CI −0.0013, −0.0004)) (Zheng et al., 2018). This 10-year study with over 5000 participants highlights the potential effects T2DM has on cognitive function, but also the potential effects of being in the 'vicinity' of T2DM.

In contrast, such associations on decline in cognitive function and prediabetes were not seen in the Maastricht study, which investigated the role of insulin resistance, hyperglycaemia and blood pressure in approximately 2,500 individuals with either normoglycaemia, T2DM or prediabetes (Geijselaers et al., 2017). Results indicated those participants with normoglycaemia as well as prediabetes performed similarly in tests of cognition, processing speed and executive function and attention, compared to those individuals with T2DM, who performed worse (Geijselaers et al., 2017).

2.4.3 Microvascular complications

Microvascular complications in T2DM are common and typically present as; retinopathy, nephropathy or CAN (cardiac automatic neuropathy) (Dal Canto et al., 2019). Diabetic retinopathy, which causes impaired vision and blindness, is the most common microvascular complication in T2DM, affecting approximately 100 million people globally (Leasher et al., 2016). Diabetic nephropathy (DN) can be characterised on a continuum of increased urinary albumin output through to chronic kidney disease (CKD). DN results from poor glycaemic control as well as other risk factors; such as smoking, chronic hypertension, genetic disposition and dyslipidaemia, which contribute to the development and progression of microvascular complications (Dal Canto et al., 2019). CAN is a significant complication of diabetes mellitus (DM) defined by a deficiency in cardiovascular autonomic control resulting in an increased risk of cardiovascular mortality (Serhiyenko & Serhiyenko, 2018). Established risk factors for CAN in people with T2DM include suboptimal glycaemic control, dyslipidaemia, hypertension and obesity (Serhiyenko & Serhiyenko, 2018).

As the disease state of T2DM progresses, so does the prevalence rates for DN (Dal Canto et al., 2019). Findings from the UK Prospective Diabetes Study (UKPDS) showed an increased risk for death from a cardiovascular–related event with increasing degrees of diabetic nephropathy (Adler et al., 2003). T2DM can also induce a group of neuropathic disorders which affect both the autonomic and somatic nervous systems (Dal Canto et al., 2019). Diabetic neuropathy, known as diabetic peripheral neuropathy (DPN) can be broadly described as damage to multiple structures of the peripheral nerve and can involve autonomic, sensory as well as motor fibres depending on the cause of the clinical manifestation (Stino & Smith, 2017).

In a recent longitudinal study, over 450 individuals were investigated for peripheral neuropathy via the use of a vibratory sensation instrument (MNSI – Michigan Neuropathy Screening Instrument) (Lee et al., 2015). Results illustrated the prevalence of neuropathy was highest (50%) in those individuals with recently diagnosed T2DM at the 3–year follow up period, followed closely by those individuals with prediabetes (49%) (Lee et al., 2015).

2.5 Perceptions of risk in developing T2DM

An individual's perception of a disease risk can be more significant than the diagnosis itself, for in the perception, lies an individual's ability to initiate disease risk-reduction behaviours (Troughton et al., 2008). Many important psychological constructs already exist in an applied setting that have stressed this very idea – the seriousness with which an individual perceives their condition will directly impact their likelihood to engage in beneficial health-related behaviours (Troughton et al., 2008).

It has been well cited in the literature that the combination of diet therapy and physical activity resulting in modest weight loss can significantly reduce the risk of T2DM development in those who have knowledge of their prediabetes and even reverse prediabetes (Geiss et al., 2010). Optimal management strategies for those at risk of T2DM include adherence to a healthy diet, stress reduction, physical activity and glucose monitoring/management, however it is thought that only a minority of patients actually achieve optimal management of their metabolic condition (Clinical Guidelines Taskforce (IDF), 2012).

A cross-sectional analysis from the 2007/2008 and 2009/2010 National Health and Nutrition Survey (NHANES) identified a total of 2,964 participants who had prediabetes out of 10,539 eligible participants (Gopalan, Lorincz, Wirtalla, Marcus, & Long, 2015). Of those 2,964 participants, only 11.8% were aware they had the condition. Participants who were prediabetes–aware, had increased odds of engagement in both physical activity levels as well as weight management strategies (AOR = 1.5 (95% CI 1.1 – 2.0)). Achievements in the Diabetes Prevention Programme (DPP) targets in prediabetes-aware participants was significantly higher than participants who were unaware (9.1% v 4.6%, P=0.02) (Gopalan et al., 2015). These results indicate having an awareness of prediabetes as well as receiving advice around risk, can modulate risk-reducing behaviours (Gopalan et al., 2015). However it is important to note that while prediabetes-aware subjects were more likely to engage in risk-reducing behaviours, overall, very few subjects actually reported reaching the DPP targets for physical activity (>150 minutes/week of moderate activity) and weight management (loss of 7% of body weight within the last year) (Gopalan et al., 2015). Exact reasons for this are not completely understood, although it is thought GP advice alone was insufficient to initiate and sustain risk-reduction behaviours in order to meet DPP targets for physical activity and weight management in the majority of participants (Gopalan et al., 2015).

2.5.1 Risk perception and actual risk

A number of studies (Table 2.2) have shown differences between an individual's perception of risk and their actual disease risk of T2DM (Heidemann et al., 2019; Hivert et al., 2009; Joiner et al., 2016; Kowall et al., 2017; Pinelli et al., 2009; Yang et al., 2018).

Measurement tools used to assess actual and perceived risk of T2DM vary across studies, which make direct comparisons between studies (Table 2.2) difficult. While a number of studies (Table 2.2) used the validated RPS–DD to assess perceived risk of developing T2DM (Guess et al., 2015; Guo, Tang, et al., 2019; Hivert et al., 2009; Joiner et al., 2016; Pinelli et al., 2009; Shaak et al., 2018; Walker et al., 2003), other studies used self-designed questions to assess perceived risk (Claassen et al., 2011; Graham et al., 2006; Heidemann et al., 2019; Kowall et al., 2017; Maty & Tippens, 2011; Yang et al., 2018).

Similarly, measures of actual risk of T2DM development from studies (Table 2.2) have either been biomedical measures (such as OGTT or HbA1c) or differing variations of risk calculator tools (section 2.3.3.2), the most commonly used from the literature (Table 2.2) was the American Diabetes Association (ADA). However, what has emerged as a common theme within the studies (Table 2.2) is an underestimation of actual risk based on an individual's perceived risk.

In the KORA FF4 study of 1,953 German individuals who completed a comprehensive health survey revealed individuals with undiagnosed T2DM and prediabetes significantly underestimated their risk of T2DM development in the future (Kowall et al., 2017). Furthermore 72% (CI 95% 69–75) of individuals with prediabetes believed they had no risk of developing T2DM (Kowall et al., 2017).

Similar findings were found in a cohort of 176 young mothers (mean age 31 years) with preschool aged children. Nearly 90% perceived their risk for developing T2DM to be slight or non-existent despite presenting with a family history of diabetes and as well as low levels of physical activity and fruit and vegetable intakes – risk factors which contribute to actual diabetes risk (Guo, Tang, et al., 2019). Results from this study highlight education and risk knowledge as potential focus points for reducing the disparity between perceived and actual risk.

Similar findings were observed in a cohort of 120 prediabetic Hispanic adults who undertook a bi-lingual version of the RPS–DD survey (Shaak et al., 2018). Nearly 77% of participants who undertook the survey reported knowledge of their diagnosis of prediabetes, yet diabetes risk knowledge was relatively low, with just over half of the diabetes risk knowledge questions answered correctly (5.59; SD = 1.65, range 0–11) (Shaak et al., 2018).

Table 2.2 Studies investigating perceived and actual risk of developing T2DM

Author	*Type of study*	*N*	*Subject characteristics*	*Measurement tools for actual and perceived risk*	*Outcome*
(Claassen et al., 2011)	Postal survey of diabetes & CVD risk participants (sourced from population–based screening programme in 2007)	255	Adults at increased risk for Diabetes & CVD (57–79yrs)	**Actual risk measure:** 4 physiological risk factors (blood pressure, cholesterol, height & weight) and 3 behavioural risk factors (eating habits, physical activity level and smoking status) **Perceived risk measure:** two 4–point scale questions: 1. "How likely do you think it is that you will get diabetes within the next 10 years?" 2. "Based on your feelings, what is the chance that you will develop diabetes within the next 10 years?"	- Weak associations between risk factors and perceived risk of T2DM were found with self–reported risk factors contributing to 11% of the variance in perceived risk of T2DM
(Graham et al., 2006)	Cross–sectional multi–centre study using adapted screening tool (based on ADA 1997 & American Heart Association 2003b risk assessment questionnaire)	255	Volunteers who attended health/screening events sponsored by national African American organisations	**Actual risk measure**: scoring a 'yes' or 'no' response to the ADA risk questionnaire **Perception of risk measure**: 34–question survey with 6 sections on; demographics, diabetes status, attitudes, risk assessment, access and glucose reading	- 44% were at high risk for T2DM, 19% at low risk, 8% no risk and 29% did not respond to the ADA questionnaire. - 36% of participants who thought they were not at risk of developing T2DM had a high risk
(Guess et al., 2015)	Cross–sectional study	59	Patients from local GP practices (mean age=56.5yrs +/– 11.7yrs)	**Actual risk measure:** Diabetes UK risk assessment (scores: 0–6pts = low risk; 7–15pts = increased risk; 16–24pts = moderate risk; 25+pts = high risk) + OGTT **Perceived risk measure:** RPS– DD (adapted slightly for a UK population)	- 44% (26/59) had a high risk of developing T2DM, of this group, 34.6% perceived their risk to be slight

(Guo, Tang, et al., 2019)	Cross–sectional survey using adapted RPS–DD & CHINARISK	179	Mothers (mean age 31.19 years) of preschool children (aged 3–7years)	**Actual risk measure:** CHINARISK (Chinese version of the Canadian Diabetes Risk Assessment Questionnaire) **Perceive risk measure:** Question from the RPS–DD 'how do you perceive your risk of developing diabetes' on a 4–point Likert scale from almost no risk to high risk	- Approximately 90% of mothers had a low or slight perceived risk of developing T2DM, despite nearly 50% having risk factors for T2DM
(Heidemann et al., 2019)	Nation–wide German population survey	2327	Adults (18–97yrs) without diagnosed diabetes	**Actual risk measure:** German Diabetes Risk Score (GDRS) – calculates a 5yr probability of developing T2D **Perceived risk measure:** 4–point scale question: "What do you think is your risk for getting diabetes over the next 5 years?"	- Across the four categories of actual risk: low (<2%), still low (2– <5%), elevated (5 – 10%) and high (>10%), participant reported a perceived risk of 89%,84.5%,79.3% and 78.9% respectively
(Hivert et al., 2009)	Risk Perception Survey for Diabetes Development (RPS –DD) + clinical markers of risk	150	Non–diabetic primary care patients	**Actual risk measure:** validated health record (unpublished) based on the following risk measures; anthropometry, resting blood pressure and fasting blood glucose **Perceived risk measure:** validated Risk Perception Survey for the Development of Diabetes (RPS–DD)	- Patients with high perceived risk (34%) were more likely to have an actual increased risk of developing T2DM, however they were not more likely to adopt healthier lifestyle behaviours to decrease their risk (high 26% v low 29.2% P=0.69)
(Joiner et al., 2016)	Descriptive cross–sectional study using RPS–DD + A1C marker	146	Foreign–born, Spanish–speaking US Latinos attending local food–pantry distributions and health events/clinics in San Francisco Bay area (mean age = 39.2yrs +/–9.9yrs)	**Actual risk measure**: ADA risk test (score ≥ 5 indicates high risk) + A1C (3 categories: <5.7%; 5.7% – 6.5%; ≥6.5%) **Perceived risk measure:** Spanish language translation of the RPS–DD (42 items with 6 measures; Personal Disease Risk scale, Environmental Health Risk scale, Personal Control subscale, Optimistic Bias subscale, Worry subscale, and Diabetes Risk Knowledge test)	- 69% had a low perceived risk of developing T2DM, of this group 20% had an ADA risk score ≥5 and 11% had an A1c result consistent with prediabetes
(Kim et al., 2007)	Cross–sectional design	217	Women with a history of Gestational diabetes mellitus (GDM)	**Actual risk measure:** history of GDM **Perceived risk measure**: 4–point Likert scale question: "What do you think your risk or change is for getting diabetes over the next 10 years?'' Answers included ''almost no chance'', ''slight chance'', ''moderate chance'' and ''high chance''	- 90% reported GDM as a risk factor for future T2DM development, but only 16% believed they had a high chance of developing T2DM - Women who perceived their risk to be moderate or high reported they were more likely to modify future lifestyle behaviour (OR 9.1 (95% CI 1.5 – 57))

(Kowall et al., 2017)	Population–based KORA FF4 Study	1953	Adults (mean 59.1yrs) without known diabetes	**Actual risk measure:** Oral Glucose Tolerance Test (OGTT) **Perceived risk measure:** three questions asked about risk perception 1. How do you estimate your risk currently? 2. Do you believe you are at risk in the future? 3. How serious do you think T2D is in your view?	- 72% (95% CI 69–75) of participants with prediabetes believed they were not at risk of developing T2DM. - 74% (95% CI 65–82) of participants with UDM believed they had low or very low risk of developing T2DM
(Maty & Tippens, 2011)	Cross–sectional survey	324	Chinese & Hispanic/Latino Adults (mean age = 45.2yrs)	**Actual risk measure:** based on self–reported risk factors as determined by the American Diabetes Association (ADA) guidelines **Perceived risk measure:** Perceived diabetes risk was determined from the question: '*If you do not have diabetes, do you think you are at risk for developing diabetes?*' Response options were: *'yes'*, '*no'* and *'I don't know'*.	- 43% of participants had a high risk of developing TDM (based on having two or more ADA risk factors) - 24.6% reported no perceived risk and 52.7% were unaware of their risk
(Pinelli et al., 2009)	Cross–sectional study: RPS–DD Survey + American Diabetes Association (ADA) Risk Test	218	Pharmacists (46.2yrs +/–12.2yrs)	**Actual risk measure:** ADA risk test (score of 3–9 = low risk and a score of 10+ = high risk) **Perceived risk measure:** RPS–DD	- According to the ADA results, 36% of pharmacists had a higher risk of developing T2DM - Significant differences between ADA risk (low v high) status and Comparative Disease risk such that: low 1.93±0.42 v high 2.08±0.42, P=0.02). Overall, there was slight to moderate perceived risk of developing T2DM (2.25±0.90)
(Shaak et al., 2018)	Cross–sectional (bilingual) mailed survey	120	Registry of electronic records from a multi–hospital network in Pennsylvania (aged between 18–65yrs, Hispanic with prediabetes)	**Actual risk measure:** ICD–10 diagnosis code (impaired fasting glucose/HbA1c reflecting prediabetes) **Perceived risk measure**: RPS–DD	- Low knowledge of T2DM risk (mean score from Diabetes Risk Knowledge test = 5.59 (out of a possible 11) SD (1.65) despite 77% of participants reported being told they had prediabetes -
(Walker et al., 2003)	Cross–sectional study using the RPS–DD	535	Non–diabetic Physicians attending continuing education workshops in the USA (mean age = 48.9yrs +/– 9.8yrs	**Actual risk measure:** ADA risk test **Perceived risk measure:** RPS–DD	- 196 physicians had a high risk of developing T2DM based on self–reported ADA risk test - 50% of them reported an optimistic bias that they were less likely to get T2DM compared to their peers -

(Yang et al., 2018)	Sample from the 2011–2014 National Health & Nutrition Examination Survey (NHANES)	9496	Adults (<20yrs)	**Actual risk measure:** American Diabetes Association Guidelines **Perceived risk measure:** closed–ended question: ''Do you feel you could be at risk for diabetes or prediabetes?"	- 28.4%(n=2696) indicated a high perceived risk for T2DM development. - Of the 2696, 38.3% (n=1032) had an actual risk of T2DM development

2.5.2 Barriers and risk perception

Certain factors can act as barriers, reducing an individual's ability to initiate behaviour change strategies to reduce T2DM risk. Barriers can be environmental such as the ease to which individuals can access parks or gyms to exercise. The design of roadings, and the opportunity for cycle-lanes and walkways can also act as barriers if not designed well. Barriers can also be financial such as the affordability of healthy food, doctor's visits, and gym memberships. Lack of time due to family and work responsibilities can also be a barrier (Winett et al., 2015) as well as mistrust of health professional advice (Lawrence, Nathan Reynolds, & Joseph Venn, 2017) An individual's lack of awareness of their disease risk can also be a barrier (Gopalan et al., 2015).

The 'Resist–Diabetes study' performed by Winett and colleagues (2014) investigated the effectiveness of a theory-based maintenance approach by differing doses of resistance training (RT) in an aim to analyse if a higher-dose social cognitive theory (SCT) approach would produce greater RT adherence than a lower-dose standard treatment in 170 men and women with prediabetes. The study spanned over 15 months and showed very little difference between high or low-dose treatment approaches with both treatment groups reporting barriers for not completing RT sessions.

For the SCT group, barriers included travel for work or vacation (22.3 %), busy schedule and typical family responsibilities (21.71 %), and minor health-related issues (26.9 %). Barriers pertaining to the health club environment, motivation, or financial costs were minimal (12.4 %). The standard group reported similar results; travel (18.9 %), busy schedule and family responsibilities (20.0 %), minor health issues (30.5 %), and only minimal reporting for health club issues. (8.7 %) (Winett et al., 2015).

Whilst this study did provide some insights into potential barriers faced by people with prediabetes who implemented lifestyle changes, it failed to report on other potential significant findings such as weight change, reduction in diagnostic parameters (such as those defining IGT or IFG) which would have given a deeper insight into the effectiveness of each of the treatment arms. Furthermore the perceived barriers reported in this study were confined to resistance training only, which is just one facet of lifestyle change that could be perceived as a barrier to change in people with prediabetes, thus further studies are needed to explore all facets of lifestyle change that could be perceived as potential barriers to change.

In a more extensive study, researchers conducted semi-structured qualitative interviews with 35 prediabetic participants to explore patient knowledge around the risk of developing diabetes now and in the future, as well as perspectives on treatment options available (O'Brien et al., 2016). Results from the interviews suggested there are gaps in knowledge around the risk of T2DM and treatment options available, however when participants were presented with the evidence and options, they felt motivated that prediabetes had optimistic outcomes and felt that a diagnosis of prediabetes was not a ‘given’ for diabetes progression to T2DM (O'Brien et al., 2016). For example, many participants had overestimated the risk of development of T2DM from prediabetes and felt surprised and reassured when they were told the risk of development to T2DM was lower than they actually thought (O'Brien et al., 2016). Additionally when participants were told about the reduction in risk of T2DM development with the use of metformin as well as intensive lifestyle interventions, they felt motivated to take control of their prediabetes, with the knowledge of solutions and management options available to them (O'Brien et al., 2016).

A recent pilot study investigating healthy food perceptions in people with both T2DM and prediabetes via focus group discussions illustrated participants were distrusting of professional nutrition advice due to the inconsistencies in information given. This acted as a barrier for participants to trust in the advice given to initiate change (Lawrence et al., 2017). Furthermore, the study also highlighted participant's nutritional knowledge varied between participants and was at times contradictory to national nutritional guidelines (Lawrence et al., 2017). Lack of nutritional knowledge as a barrier to diabetes management was also seen in a study conducted in rural Kentucky with 71 participants with self–reported T2DM in an aim to investigate challenges rural residents of Kentucky face in diabetes self-management (Ashrafzadeh, Tohidi, & Nasseh, 2017). The study highlighted those participants who perceived diet to play an important role in diabetes management (blood sugar control) showed more interest in attending cooking classes. This perception was a stronger determinant of cooking class interest above other important factors of blood sugar control including exercise, medication compliance and glucose monitoring. This result suggests understanding participants perceptions and beliefs on a personal level could help inform and develop a more personalised treatment programme in disease management. A limitation of this study was the small participant numbers (n=12), with only two participants diagnosed with prediabetes. (Lawrence et al., 2017).

Whilst Lawrence et al (2017) offered some interesting insights into what participant's perceived as 'healthy', this research was limited in its focus, concentrating only on healthy food perceptions with respect to; perceptions of dietary information, food components and factors that are perceived to influence the healthfulness of foods (Lawrence, et al. 2017). The study did mention there was a gap in the literature to investigate beliefs and perceptions of subjects at an earlier stage of the disease (ie at the prediabetic stage, or early diagnosis of T2DM).

2.6 Prevention strategies

Prevention is amongst one of the most powerful public health approaches that can achieve a reduction in T2DM (Shawley-Brzoska & Misra, 2018). Preventative prescriptions for a reduction in T2DM incidence are centred around lifestyle modification (changes in diet and exercise) with or without the use of pharmacological agents, (Coppell et al., 2010; Fogelholm et al., 2017; Knowler et al., 2002; Lean et al., 2018; Shawley-Brzoska & Misra, 2018; Tuomilehto et al., 2001). Multiple dietary approaches have been investigated in the management of T2DM, including reduced calorie diets, low carbohydrate diets, the Mediterranean Diet (MD) as well as low GI diets (Fogelholm et al., 2017; Georgoulis, Kontogianni, & Yiannakouris, 2014; Krebs et al., 2013; Zafar et al., 2019).

A recent systematic review and meta-analysis of studies including more than 300,000 participants found evidence for an inverse dose-response relationship between those participants who consumed a plant-based diet compared with those who did not, and risk for developing T2DM (RR, 0.77; 95% CI, 0.71–0.84) (Qian, Liu, Hu, Bhupathiraju, & Sun, 2019). However, despite individual's being armed with nutrition and exercise knowledge to initiate behaviour change and lifestyle modification, these lifestyle strategies fail to accommodate an individual's perceptions and beliefs, not just about their condition, but them as individuals as well, coupled with the fact that behaviours learnt over a lifetime are not easily unlearnt or changed. For example many individuals know what healthy food is, and that exercise is important for healthy outcomes to reduce the risk of T2DM, but such compartmental knowledge of nutrition and lifestyle strategies can often be blurred by levels of self-efficacy, motivation and personal beliefs, especially during busy daily routines that generate stress, anxiety and every-day challenges.

In one of the largest international randomised control trials (PREVIEW) to date, 2,326 (including 321 from New Zealand) overweight prediabetic participants were recruited to investigate the most effective lifestyle pattern for reducing the risk of T2DM development (Fogelholm et al., 2017). What made this study unique was that it recruited participants first, into an intensive 8-week weight loss programme (Cambridge weight loss programme) (phase I) via the use of daily meal replacements totalling 800 calories/day. The goal was for participants to achieve a reduction of at least 8% of their baseline body weight first, before becoming eligible for the randomisation phase (phase II). There were 1,854 participants who achieved this, with 35% returning to normoglycaemic levels at the end of the 8-week period (Christensen et al., 2018).

These participants were then recruited into a 3-year randomised weight maintenance phase which included eight treatment arms of; diet (high protein/low GI diet versus traditional best practice moderate protein/higher carbohydrate moderate GI diet), exercise (75 minutes high intensity v 150 minutes/moderate intensity) and behaviour change support.

Results from the 3-year study found an incident rate for T2DM to be just 4%. This is an impressive result. Even the researchers were expecting a higher (13%) incidence rate (Sydney Ideas, 2019). However, it is worth noting the trial had a relatively large dropout rate, with just under 950 participants completing the study. There were also similarities in treatment groups with regards to urinary nitrate outputs suggesting non-adherence to differing protein intakes between the treatment groups. The challenge now remains in how to translate these study-based successes into real-life clinical practice.

A similar, but smaller randomised study called the Diabetes Remission Clinical Trial (DiRECT) was carried out in the UK, involving 49 different primary care practices with 306 participants who were overweight and had had T2DM for at least 6 years (Lean et al., 2018). Participants were randomised to either receive routine care or weight management programme ((involving a total diet replacement of approx. 850 calories/day for 3-5 months), a food-reintroduction phase and then a weight-maintenance programme). Results from the study showed statistically significant differences for weight loss of 15kg+ (26% in the treatment group v 0% of participants in the control arm, $P<0.0001$) as well as T2DM remission (defined by HbA1c<48mmol/mol) (46% of participants in the treatment arm v 4% of participants in the control arm, P<0.0001). What was different between the DiRECT trial compared with the PREVIEW trial was that this study was done in the context of a primary care setting, proving study findings can be translated into a real-life clinical setting.

In contrast to the PREVIEW and DiRECT trials, The Diabetes Prevention Programme (DPP) study investigated a lifestyle intervention (7% BW loss + 150mins/week of exercise) and compared it against the pharmacological 'go-to' drug for managing glucose control in T2DM patients – Metformin (Diabetes Prevention Program Research Group, 2002). Lifestyle coaches and behavioural strategies were made available to participants in the lifestyle intervention group. Results from the 3,234 overweight participants with prediabetes found the lifestyle intervention reduced the incidence of diabetes by 58% and by 31% in the Metformin group compared with control in an approximate 3-year follow–up period, suggesting lifestyle intervention is more effective at managing glucose control that Metformin.

Another largescale study which has explored lifestyle modification in an attempt to reduce T2DM risk is The Finnish Diabetes Prevention Study (DPS) (Lindstrom et al., 2003). In this randomised control trial 522 overweight adults with impaired glucose tolerance (IGT) were divided into a control group (standard care) and a treatment group (lifestyle intervention of resistance exercises and dietary advice). Results from one and three year follow-ups showed significantly greater weight-loss in the intervention group compared to the control, with 3.5kg and 2.6kg differences between groups, respectively (Lindstrom et al., 2003).

A review by Hall and colleagues (2016) investigated different macronutrient compositions in the diet and the effect this had on T2DM management outcomes. The authors examined the evidence for weight loss and glycaemic control in; very low carbohydrate diets (VLCDs), lower carbohydrate, higher protein (LC/HP) diets and low carbohydrate paleolithic–type diets. The role of macronutrient manipulation in the form of VLCD's (typically <50g CHO/day) showed initial success in weight loss and glycaemic control, although they reported a lack of consistency in results with limited evidence for long-term benefits in either HbA1c levels or sustained weight loss (Hall, Strong, & Krebs, 2016).

Hall and colleagues (2016) also reported a systematic review of 13 randomised controlled trials investigating low carbohydrate/high protein diets compared with low fat/high carbohydrate diets (Hession, Rolland, Kulkarni, Wise, & Broom, 2009). Results from the 13 RCTs, which ranged in duration from 6 – 36 months found low carbohydrate diets were more effective in reducing weight at 6 months and up to one year, compared with low fat/high carbohydrate diets. Although they note, there were only a small number of studies which included participants with diabetes. A year after Hall and colleagues (2016) published their review, a meta-analysis of nine randomised controlled trials with 734 T2DM patients reported a significant decrease in HbA1c levels in the low carbohydrate diet (LCD) group compared with the control ((weighted mean difference (WMD): –0.44, 95% CI: –0.61,–0.26), P=0.00)) (Meng et al., 2017). No significant WMD were observed for weight loss between LCD and control groups (Meng et al., 2017).

While Hall and colleagues (2016) state dietary composition should underpin the tri–dimensional foundation for optimal T2DM management via improved glycaemic control, optimal weight management (through weight loss or maintenance) and reducing the risk of microvascular and macrovascular complications, what appears to be most important in optimal T2DM management, irrespective of carbohydrate type or amount, is that it can be maintained long–term (Hall et al., 2016). Furthermore, Hall and colleagues (2016) note the complex nature of gene–environment interactions and the need for further investigation into the role they play in individualisation of diet prescriptions (Hall et al., 2016).

The Mediterranean diet was first coined by Ancel Keys, who established the link between saturated fat and CVD. In more recent years research has established support for the link between a Mediterranean-style diet and its' protective mechanisms against T2DM (Georgoulis et al., 2014). A recent systematic review which included 8 meta-analyses and 5 RCTs showed the Mediterranean diet was more effective at improving glycaemic control and risk factors for CVD (including a reduction in body weight, reduced total cholesterol and high-density lipoprotein cholesterol) compared with control diets and diets lower in fat (Esposito et al., 2015).

While most research in the field of T2DM prevention have focused on lifestyle change (diet and exercise), a recent New Zealand based study of 14,043 primary care patients with prediabetes from the Upper North Island region demonstrated the use of native language was a protective factor in reducing progression of prediabetes to T2DM (Teng et al., 2019). Results from the study found nearly two thirds lower progression rates to T2DM in those participants who spoke Te Reo Māori (RR 0.31 CI: 0.12 –0.81). This finding is important, given the greater progression rates and incidence of T2DM in Māori and Pacific Peoples, compared to their NZ European peers (Teng et al., 2019).

The amount of research examining prevention strategies and their impact in improving glycaemic control and reducing progression of prediabetes to T2DM can only be strengthened with understanding an individuals' perception of their risk and comparing it to their actual risk of developing T2DM. This will offer insights into barriers of understanding risk. The current study will address an individual's perceived risk and compare it to their actual risk of developing T2DM in a sample of New Zealanders.

Chapter Three – Method

The purpose of this chapter is to provide details of the methods used to carry out the research project. Section 3.1 describes the ethical approval process of the study and section 3.2 discusses the participants, including screening (inclusion/exclusion criteria) and sample size. Section 3.3 describes the survey design, the questionnaire platform used as well as details of the three sections of the online questionnaire which include; general health and demographics section; perceived risk of T2DM section (as measured by the RPS–DD) and actual risk of T2DM section (as measured by the Diabetes New Zealand 'Are you at risk?' calculator. Section 3.4 describes the statistical analysis carried out based on both participant's perceived risk and actual risk status.

3.1 Ethical approval process

The research project was approved by the Massey University Human Ethics Committee: Human Ethics Northern Committee (Application NOR 19/13). All participants were informed of the study benefits and risks as well as what was required of them in taking part in the questionnaire via the participant information sheet (Appendix 1). The questionnaire was anonymous. All data collected from the questionnaire was stored electronically via the password protected Massey account of Qualtrics. This data was then analysed via the password protected Massey account of SPSS.

3.2 Participants

Participants were men and non-pregnant women, over the age of 18 years without a diagnosis of diabetes and who were New Zealand residents or citizens.

3.2.1 Recruitment process

The main avenue for recruiting participants was via the School of Sport, Exercise & Nutrition research participant database at Massey University, Albany. The database collects contact information from previous research participants (who provide their permission and declared interest in being contacted about future research projects). The study was also advertised to employees at the New Zealand Heart Foundation (n=95) via their internal communication channel Yammer. The study was also advertised in the Massey University e–newsletter.

An email (Appendix 2) advertising the study, along with the participant information sheet (Appendix 1) and a link to the questionnaire (Appendix 3) was sent to the School of Sport, Exercise & Nutrition research participant database (n=960). Participants who clicked on the link to the questionnaire were first screened for eligibility by answering four eligibility questions based on the inclusion/exclusion criteria (section 3.2.2). Eligible participants, who satisfied all four screening questions were then directed to the questionnaire.

Data collection was from July 2019 to October 2019.

3.2.2 Screening

Before participants were directed to the online questionnaire they were asked four eligibility questions (Appendix 3) based on the below inclusion and exclusion criteria such that participants; had to be a New Zealand citizen or resident, over the age of 18 years, non–pregnant and not have a diagnosis of diabetes (type 1 or type 2 diabetes mellitus).

3.2.2.1 Inclusion criteria

The terms ''New Zealand citizen or resident'' were chosen as the method of determining a New Zealand population, given this was the primary population under investigation in this study.

Adults over the age of 18 years were chosen as the risk of developing T2DM increases with age, with prevalence rates of both prediabetes and T2DM more significantly represented in an adult population (although it is noted incidence rates are increasing in childhood).

The questionnaire was only available in electronic format, therefore participants had to have access to a computer.

3.2.2.2 Exclusion criteria

Women who were pregnant were excluded due to the potential for bias towards perceived risk around developing T2DM. Additionally, fluctuations in weight could potentially impact on the actual risk score of developing T2DM, which would not be a true reflection of actual risk.

People who had a diagnosis of type 1 diabetes mellitus or type 2 diabetes mellitus were excluded due to the bias this would cause to their perceived risk of developing T2DM.

3.2.3 Sample size

Based on previous studies (Table 2.2) which have investigated perceived risk versus actual risk of developing T2DM, participant numbers have ranged from 59 (Guess et al 2015) to 9,496 (Yang et al., 2018). For these studies there has been no specific justification for sample size or power of these studies given to be able to determine a sample size. Nine of the 14 studies (64%) shown in Table 2.2 had a sample size ranging from 120–350 participants. This sample size range was the basis for recruitment numbers in the present study which also examined perceived vs actual risk of T2DM development (Claassen et al., 2011; Graham et al., 2006; Guo, Tang, et al., 2019; Hivert et al., 2009; Joiner et al., 2016; Kim et al., 2007; Maty & Tippens, 2011; Pinelli et al., 2009; Shaak et al., 2018).

3.3 Study Design

This study is an observational cross-sectional design due to the observational nature of the data (characteristics and frequencies) collected with no assigned exposures to participants in investigating perceptions and actual risk of developing T2DM using an online questionnaire.

3.3.1 Questionnaire

The questionnaire (Appendix 3) was designed in the platform Qualtrics, via the secure Massey University Qualtrics account. The questionnaire was only available in electronic format for participants to complete. Eligible participants were directed to answer all three sections of the online questionnaire, which took approximately 10 minutes to complete.

Section one of the questionnaire consisted of twelve general health and demographic questions (section 3.3.1.1). Section two consisted of questions from the validated Risk Perception Survey of Diabetes Development (RPS–DD) (Walker et al., 2003) (Revised 2009 ©E.A Walker 2009) as well as three questions on risk perception and lifestyle modification (RPLM–DD) from Kim et al (2007) (section 3.3.1.2). Section three consisted of questions from the Diabetes New Zealand 'Are you at risk?' calculator (section 3.3.1.3). At the end of section three, participants were provided with their actual risk score of developing T2DM and information about their score.

3.3.1.1 Section one: General health and demographic questions

Section one of the questionnaire consisted of 12 questions on: age, weight, height, ethnicity, education level, suburb and city of residence, employment, previous medical history as well as questions regarding visits and experiences of risk communication and CVD/T2DM tests recommended by their healthcare provider. BMI was calculated in SPSS based on weight and height information obtained from section one of the questionnaire.

3.3.1.2 Section two: Perceived risk of T2DM development

Section two of the questionnaire included the validated Risk Perception Survey for Developing Diabetes (RPS–DD) (Walker et al., 2003) (Revised 2009 ©E.A Walker 2009) , which has been reported in previous literature (Guess et al., 2015; Hivert et al., 2009; Joiner et al., 2016; Shaak et al., 2018; Walker et al., 2003) and assesses various dimensions of perceived risk for developing T2DM. Section two of the questionnaire also included three questions on risk perception and lifestyle modification in developing diabetes (RPLM–DD) based on previous literature by Kim et al (2007).

Section two consisted of eight questions with four main subscales assessing; general attitudes towards risk including Personal Control, Optimistic Bias, Comparative Disease risk and Comparative Environmental risk as well as questions around diabetes knowledge of risk factors that could increase the risk of developing T2DM as well as risk perception and lifestyle modification questions.

The Optimistic Bias subscale assessed a participant's belief in their risk on a scale from 1 (less bias) to 4 (more bias) of developing diabetes compared with others of similar age and gender.

The Personal Control subscale assessed a participant's belief in their self-control over developing diabetes. A 4-point scale from 1 (strongly agree) to 4 (strongly disagree) was used with a higher score indicating greater perception of control.
The Comparative Disease risk subscale assessed a participant's belief in their perceived risk of developing 14 common diseases or disorders, compared with diabetes. A 4-point scale from 1 (almost no risk) to 4 (high risk) was used, with a higher reported score indicating a greater perceived risk.

The Comparative Environmental subscale assessed a participant's belief in their perceived risk of being exposed to nine environmental hazards such as exposure to household chemicals, medical x–rays and air pollution. A 4-point scale from 1 (almost no risk) to 4 (high risk) was used, with a higher reported score indicating a greater perceived risk.

Questions on Diabetes Risk Knowledge were also included which asked participants to rate risk on a 4-point scale, such that; 1 (increases the risk), 2 (has no effect), 3 (decreases the risk) and 4 (don't know) on the impact diabetes risk factors such as age, ethnicity, diet, exercise and family history of diabetes, have on the development of diabetes.

The last three questions of section two asked participants about their risk perception and lifestyle modification (diet and exercise) with respect to developing T2DM. The first of these questions asked participant's opinions on lifestyle modification (diet and exercise)and if it could prevent T2DM. Responses were on a 5-point Likert scale from strongly agree to strongly disagree. The next question asked participants what their 10-year risk of developing T2DM was on a 4-point Likert scale from almost no change to high chance. Participants were also asked if they had any plans to modify lifestyle factors (diet and exercise) to lower their risk of developing T2DM. This required a 'yes' or 'no' response.

Participants were stratified into 'low perceived diabetes risk' and 'high perceived diabetes risk'' based on the Comparative Disease risk question of developing diabetes compared to other diseases. Participants who answered 'almost no risk' or 'slight risk' were classified as having a low perceived diabetes risk and participants who answered 'moderate risk' or 'high risk' were classified as having a high perceived diabetes risk. This method of obtaining a low and high perceived risk measure has been done in previous literature (Guo, Tang, et al., 2019; Hivert et al., 2009; Joiner et al., 2016)

3.3.1.3 Section three: Actual risk of T2DM development

This section of the questionnaire was based on eight questions relating to the participant's actual risk of developing diabetes. Questions in this section were based on the Diabetes New Zealand website risk calculator 'Are you at risk?' (Appendix 4). Each question has a 'yes' or 'no' answer. Each answer to the question had a participant–blinded numeric score attached, which contributed to the overall actual risk score that the participant viewed at the end of section three in the questionnaire.

Three questions from the Diabetes 'Are you at risk?' calculator was slightly modified to reduce the 'perception factor' in the question. The first question that was slightly modified was: *''I am overweight for my height''* (Appendix 3) which was modified to: *''Is your BMI (body mass index) over 25? To work out your BMI, please click here''* (Appendix 3). The second question that was slightly modified was to add a quantifier to the question *''I do very little physical activity''* (Appendix 3), so that it read; *''I do very little physical activity (ie less than 2.5 hours per week)''* (Appendix 3). The third question that was slightly modified also had a quantifier added to the question, such that ''I often eat foods high in fat and sugar'' (Appendix 3) became *'' I often (ie most days of the week) eat foods that are high in fat and sugar?''* (Appendix 3).

Based on the Diabetes New Zealand 'Are you at risk?' calculator, actual risk of developing diabetes was stratified into two risk groups; low risk (a score of between 3–5) and increased risk (a score greater than 5). The risk stratification was based directly on the Diabetes New Zealand ''Are you at risk?'' risk scoring criteria.

Participants who had a score between 3 – 5 were told they had a low risk of developing T2DM now, but they may have an increased risk in the future. Participants who had a score between 3 – 5 were categorised in the study as having a 'low risk' of developing T2DM.

Participants who had a score greater than 5 were told they had an increased risk of developing T2DM now, however only a doctor could diagnose T2DM. Participants were directed to contact or visit their GP for more information. Participants who had a score greater than 5 were categorised in the study as having an 'increased risk' of developing T2DM.

Additional information about the participant's risk score was included at the end of the questionnaire, which has been sourced directly from the Diabetes New Zealand website (Appendix 3 & 4). The information about a participant's risk score could be viewed at the same time as viewing their risk score.

3.4 Statistical analysis

The IBM Statistical Software Package (SPSS) version 26 was used to analyse the data. A P value of less than 0.05 was considered a statistically significant result. Due to the nature of the data set (outliers, zero scores, and significant categorical data) normalisation was not an option, hence non-parametric tests were used for analysis of the results.

3.4.1 Demographic characteristics

The Mann-Whitney and Chi-squares tests were used to determine significant differences in demographic characteristics of the participants, stratified by low and high perceived risk status. Effect size was reported for significant P–values ($P<0.05$). Descriptive characteristics were represented as total numbers and percentages.

3.4.1.1 Ethnicity

Analysis for differences in ethnicity was not possible in the current study as the majority (88% (225/257)) of participants recruited were of New Zealand European ethnicity. Only 1% of participants identified as Màori and no participants identified as being of Pacific peoples. Given both prediabetes and T2DM in New Zealand is overrepresented in ethnicities such as Màori and Pacific peoples, underrepresentation of these ethnicities is the most significant limitation of this study. This limitation is discussed further under section 5.3.2.

3.4.2 Perceived risk versus actual risk

The Wilcoxon Signed Ranks test was used to determine differences between participant's actual risk (low and increased risk) of developing diabetes and their perceived risk (low and high risk) of developing diabetes. Effect size (r) was reported for significant values of P. Further analysis using the Wilcoxon Signed Ranks test was also carried out for the RPS–DD question regarding what participants perceive their 10–year risk of developing diabetes to be. This variable was recoded to generate a 'low' and 'high' perceived 10–year risk. Effect size (r) was reported for significant values of P.

Participants perceived risk score was presented on a Likert scale such that participants who answered 'almost no risk' or 'slight risk' to the Comparative Disease risk question of developing diabetes compared to other diseases (Appendix 3) were given a 'low risk' classification. Participant's actual risk score, based on the Diabetes New Zealand 'Are you at risk?' calculator (Appendix 4) was represented as median (25^{th}, 75^{th} quartiles).

3.4.3 Analysis of the Risk Perception Survey of Developing Diabetes (RPS–DD)

3.4.3.1 Reliability analysis of the RPS–DD

Cronbach's α were determined for the five scales of the RPS–DD: Personal Control, Optimistic Bias, Risk Knowledge, Comparative Disease Risk and Environmental Disease risk. Two subscales for Personal Control as well as both subscales for Optimistic Bias were reverse scored due to the reserve-phrasing of these subscales. The reverse-phrasing was to reduce response bias to the questions.

A Cronbach's α is a measure of internal consistency, or how closely related two variables are. A Cronbach's α of 0.80 or greater is considered a good measure of reliability and consistency of the questionnaire (Field, 2009).

Reliability analysis of the five scales were stratified by actual and perceived risk status. Values are represented as medians (25^{th}, 75^{th} percentiles).

3.4.3.2 RPS–DD Diabetes Risk Knowledge

The Diabetes Risk Knowledge section of the RPS-DD consisted of ten questions which were recoded into new variables in order to obtain a binary 'correct' (one response per question) or 'incorrect' (for all other responses). All correct responses were summed for each of the ten questions. Pearson's Chi square analysis was carried out to analyse differences in knowledge between low and high perceived risk participants. Fisher's Exact Test was used where assumptions of the Pearson's Chi

Square had been violated. Effect size (Phi) was given for significant P-values. Diabetes knowledge values are represented as number and percentage of correct answers.

3.4.4 Gender analysis

The data was stratified by gender to see if there was a significant difference between gender and the frequency of GP visits, GP communication of diabetes risk and GP-recommended tests of diabetes and CVD, perceived risk, actual risk, prediabetes diagnosis, education level and RPS-DD Diabetes Risk Knowledge scores. The data are non-normally distributed, so the Pearson's chi-square test was used. Data were cleaned for missing values and to meet assumptions of the test. Significant differences are recorded at P-value <0.05. Effect size (Cramer's V) are reported for significant values of P. Values reported are presented as total numbers and percentages.

3.4.5 GP Communication and risk

Pearson Chi-square analysis was carried out to determine if there was a significant difference between actual risk status (low vs increased) and GP communication about diabetes/CVD risk and frequency of GP visits as per the questions asked in section one of the questionnaire (Appendix 3). Significant differences are reported at P<0.05. Values are reported as numbers and percentages. Spearman's correlations (Rho(s)) were also conducted to ascertain any associations between the above-mentioned variables.

3.4.6 Identifying factors that influence perceived risk

3.4.6.1 Spearman's correlation analysis

Spearman's correlation (Rho(s)) analysis was conducted to understand possible variables that correlated with perceived risk status. Statistically significant correlations were determined at $P<0.05$. Variables that were included in the Spearman's correlation analysis included; gender, education level, age, the five subscales from the RPS–DD, frequency of GP visits, GP-recommended tests for T2DM/CVD, GP communication about T2DM/CVD risk, risk factors for T2DM, RPS-DD beliefs on health and diabetes.

3.4.6.2 Binary logistic regression analysis

Binary logistic regression analysis was conducted to determine the variables that could potentially predict perceived risk of developing T2DM. Beta values, standard error, odds ratio (exp(B)) and 95% confidence intervals (CI) are reported. Nagelkerke R^2 is also reported to explain the variation of the dependent variable (perceived risk) based on the predictor variables included in the model. Variables with $P<0.05$ were determined to be a statistically significant predictor of the model.

Chapter Four – Results

The purpose of chapter four is to describe the findings of this research project. Section 4.1 provides information on the participants involved in this study. Section 4.2 describes the findings between participant's perceived risk compared to their actual risk status. Section 4.3 reports on the analysis of the RPS–DD including, reliability of the questionnaire, diabetes knowledge and motivation. Section 4.4 focuses on GP–related variables and the relationship this has with actual risk status. Section 4.5 identifies factors that influence a perceived risk model of T2DM development.

4.1 Participants

4.1.1 Recruitment

A variety of methods were used to recruit participants for this study (section 3.2.1). Data collection took place between July 2019 until October 2019. Two hundred and ninety-three participants answered the initial screening questionnaire. After screening, 266 participants were eligible and completed the questionnaire. Nine participants were excluded due to due to missing data resulting in an inability to compute a risk score, resulting in 257 participant data that were included in the main analysis. Where analysis has been made due to missing data for other specific variables less than 257, n has been reported.

4.1.2 Demographic characteristics

Of the 257 participants, 68% (175/257) were female, 31% (80/257) were male and 0.8% (2/257) participants did not specify male or female. Ninety-one percent (235/257) of participants were from the Auckland region of New Zealand. Three percent (8/257) were from the Northland region. Two percent (4/257) were from the Wellington region. One percent (3/257) were from the Waikato region. Less than one percent were from the Canterbury region (2/257), Taranaki region (1/257), Manawatu region (1/257), Bay of Plenty region (1/257) and West Coast region (1/257) and one participant was currently residing in London but was a New Zealand citizen or resident.

Demographic characteristics (Table 4.1) of participants were stratified by their perceived risk for developing T2DM which was either a low perceived risk or a high perceived risk, based on the RPS-DD question 'What do you think your risk of developing diabetes is?' (Appendix 3).

Participants with a low perception of T2DM risk were 86% (220/257) and 14% (37/257) had a high perception of T2DM risk (Table 4.1). There were no statistically significant differences between participants with low and high perceived risk for developing T2DM for; gender, age, ethnicity, education level, previous history of gestational diabetes or frequency in GP visits (Table 4.1).

Statistically significant differences between low and high perceived risk participants was observed for; a diagnosis of prediabetes, GP-recommended tests for diabetes or cardiovascular disease, GP-led discussions around diabetes and cardiovascular risks as well as actual diabetes risk status (Table 4.1).

Table 4.1 Participant characteristics stratified by low and high perceived risk status

Characteristics	Low perceived risk (n=220)	High perceived risk (n=37)	P value	Effect size
Gender				
- **Male n (%)**	64 (29%)	16 (43%)	0.13	n/a
- **Female n (%)**	155 (70.5%)	20 (54.5%)		
- **Other n (%)**	1 (0.5%)	1 (0.5%)		
Age (years) n (%)				
- **18–24**	6 (3%)	2 (5%)	0.87*	n/a
- **25–34**	24 (11%)	5 (14%)		
- **35–44**	32 (14%)	3 (8%)		
- **45–54**	24 (11%)	3 (8%)		
- **55+**	134 (61%)	24 (65%)		
Ethnicity n (%)^ (n=255)				
- **NZ European**	193 (89%)	32 (87%)	0.82***	n/a
- **Asian (all)**	7 (3%)	2 (5%)		
- **Màori**	2 (1%)	0 (0%)		
- **Other**	16 (7%)	3 (8%)		
BMI (kg/m²) ^^	24 (22.1,26.4)	27.4 (25.3, 30.8)	**<0.001***	−0.29
Education Level n (%)				
- **High School Cert.**	35 (16%)	3 (8%)	0.44*	n/a
- **Certificate**	30 (14%)	7 (19%)		
- **Diploma**	35 (16%)	8 (22%)		
- **Bachelor's degree**	59 (27%)	6 (16%)		
- **Post Graduate Qual.**	55 (25%)	9 (24%)		
- **Other**	6 (2%)	4 (11%)		
Diagnosis of prediabetes n (%) (n=250)				
- **Yes**	9 (4%)	9 (26%)	**<0.001*****	−0.30
- **No**	206 (96%)	26 (74%)		
Previous gestational diabetes n (%) (n=244)				
- **Yes**	4 (2%)	1 (1%)	0.36	n/a
- **No**	142 (68%)	16 (48.5%)		
- **Not applicable**	64 (30%)	16 (48.5%)		
GP visit frequency n (%) (n=244)				
- **Every 3 – 6 months**	118 (57%)	25 (70%)	0.12*	n/a
- **Once a year**	55 (26%)	8 (22%)		
- **Less than once a year**	35 (17%)	3 (8%)		

GP testing for T2DM/ CVD n (%) (n=255) - **Yes** - **No**	123 (56%) 95 (44%)	29 (78%) 8 (12%)	**0.02****	−0.16
GP communication about diabetes & CVD risks (n=250) - **Yes** - **No**	51 (24%) 163 (76%)	19 (51%) 18 (49%)	**<0.001****	−0.2
Actual risk status^^^ - **Low risk** - **Increased risk**	117 (53%) 103 (47%)	5 (14%) 32 (86%)	**<0.001***	−0.28

^No participants identified as Pacific Peoples. Asian includes all Asian ethnicity as well as South Asian

^^BMI (kg/m^2) = median (25^{th}, 75^{th})

^^^Actual risk status defined by Diabetes New Zealand 'know your risk' calculator; Low risk= risk score between 3 – 5. Increased risk= risk score > 5.

*P–values determined by Mann–Whitney test and $r=Z\sqrt{n}$ (effect size) calculated by Mann–Whitney Z score, where variables are ordinal. **P–values determined by Chi–square where variables are nominal; ***P–value reported from Fisher's Exact test where assumptions of Pearson's Chi–square are violated for 2x2 or Likelihood ratio for greater than 2x2 contingency Tables

Significant results of P<0.05 are represented in **bold.**

4.2 Perceived risk versus actual risk

Figure 4.1 illustrates participant's actual risk status (low vs increased) and their perceived risk status (low v high) of developing T2DM. There is a significant difference (P<0.001) between participant's actual risk status as stratified by their risk perception, such that 86% (220/257) had a low perceived risk of developing T2DM, yet 47% (103/220) within this group had an increased actual risk of developing T2DM (Z=–9.43, P<0.001, r= –0.41).

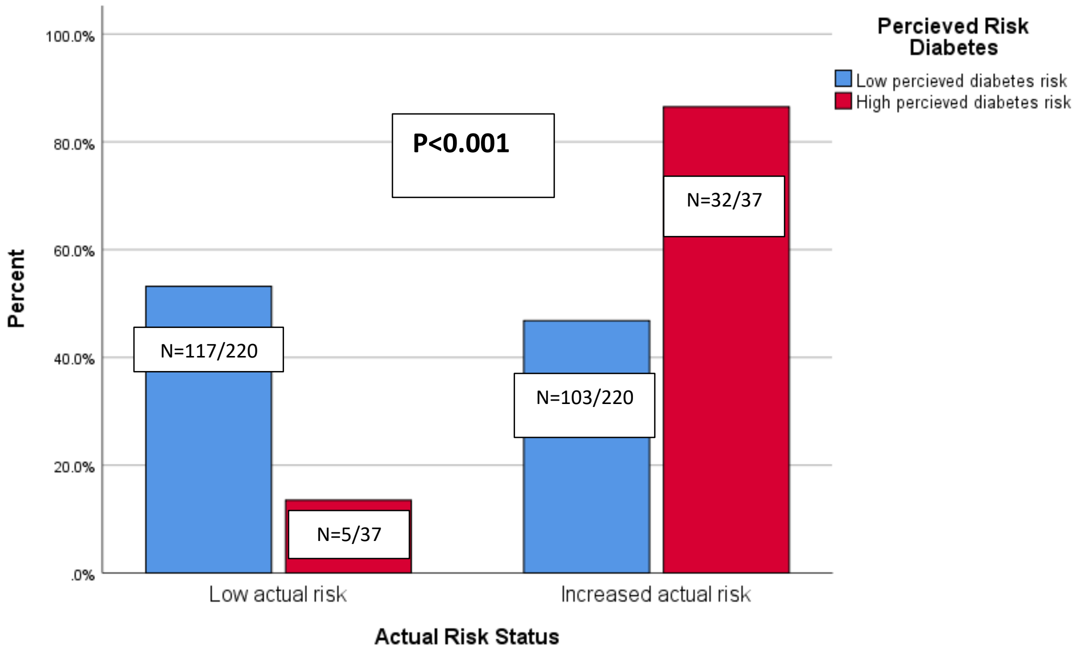

Figure 4.1 Percentage of total participants (n=257) and their perceived and actual risk

4.2.1 Gender

Figure 4.2 depicts risk perception and actual risk by gender; male (n=80) and female (n=175). A greater percentage of males than females had increased actual risk of developing T2DM; 59% (47/80) and 50% (87/175) respectively. Of the 59% of males who had an increased actual risk, 66% (31/47) had a low perceived risk of T2DM development. Similarly, of the 50% of women with an increased actual risk, 82% (71/87) perceived their risk of T2DM development to be low. While a higher percentage of increased risk females perceived their risk to be low compared to males, there were no statistically significant differences between the genders for actual risk status or perceived risk status. While there were no significant differences between gender and perceived risk status in the low actual risk group, there were significant differences between gender and perceived risk status in the increased actual risk group ($\chi 2(1) = 4.11$, $P=0.04$, Phi=-0.175).

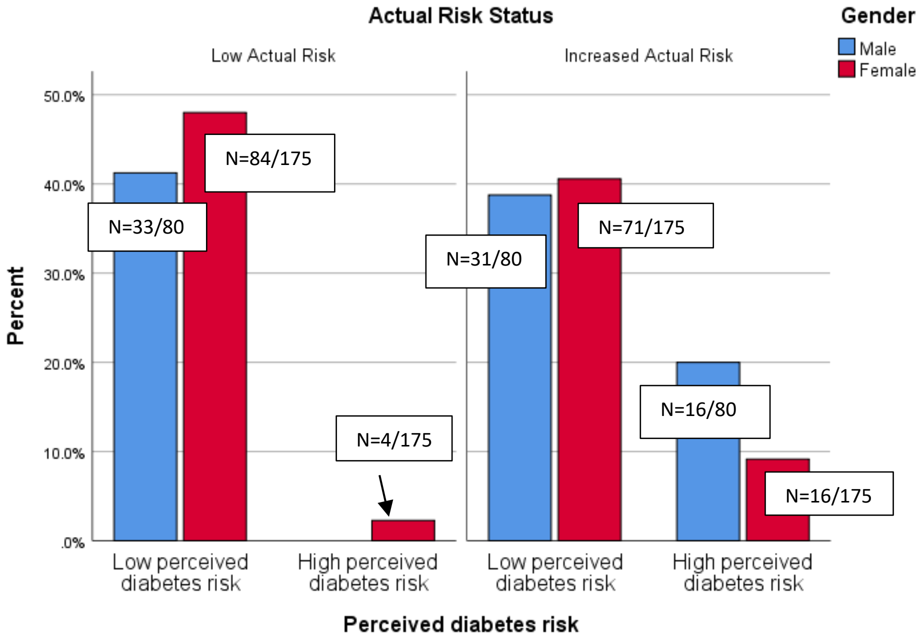

Figure 4.2 Percentage of participants and their perceived and actual risk by gender

Pearson's chi-square analysis for Low Actual Risk (gender*perceived risk) = $\chi^2(1) = 2.59$, P*=0.10
*P value reported from Fisher's Exact test as assumptions of Pearson's Chi–square violated for 2x2

Pearson's chi-square analysis for Increased Actual Risk (gender*perceived risk) = $\chi^2(1) = 4.11$, P=0.04, Phi=-0.175

4.3 Analysis of the RPS–DD

4.3.1 Reliability analysis

Participants were categorised into low actual risk and increased actual risk as defined by the Diabetes New Zealand 'Are you at risk?' calculator as well as low and high perceived risk, as defined by section 2 of questionnaire (Appendix 3) 'How at risk do you believe you are for developing diabetes'. Participants with a low actual risk of T2DM had a significantly higher score for perceived Personal Control compared with the increased actual risk group (3.8 (3.3–4.0) v 3.3 (3.0–3.5), P<0.001) (Table 4.2).

This result suggests participants who had a low actual risk of developing T2DM perceived they had greater control over their health compared to participants with an increased actual risk. This was also observed in the participants who had low perceived risk, with a significantly higher score for Personal Control, compared to participants with a high perceived risk (3.5 (3.0–3.8) v 3.3 (3.0–3.5), P=0.01). Cronbach's α, which represents the internal consistency of the variables within the personal control scale was 0.70, representing moderate reliability and internal consistency (Table 4.2).

Participants who had a low actual risk had a significantly higher optimistic bias score, which suggests a higher perceived risk for developing diabetes compared with participants who an increased actual risk score (3.0 (2.5–3.0) v 2.5 (2.0–3.0), P<0.001) (Table 4.2). This trend was also observed when stratifying participants by perceived risk; participants with low perceived risk had a higher Optimistic Bias score compared to participants with a high perceived risk, however this was not statistically significant (3.0 (2.5 –3.0) v 2.0 (2.0 – 3.0), P=0.18). The Cronbach's α for the Optimistic Bias subscale was 0.71 (Table 4.2).

The Comparative Disease risk subscale asked participants to rate how at risk they thought they were of getting each of the fourteen listed health conditions and diseases (such as diabetes heart disease, cancer and AIDS) .

Participants who had a low actual risk had a significantly lower Comparative Disease risk score compared to participants with an increased actual risk (1.7 (1.5 –2.0) v 1.9 (1.7–2.1), P<0.001) (Table 4.2). The low actual risk participants perceived they had a lower risk of developing all diseases listed in the Comparative subscale compared to participants with an actual increased risk. This was also observed for participants with low and high perceived risk (1.8 (1.5–2.0) v 2.4 (2–2.5), P<0.001). The Cronbach's α for the Comparative Disease risk subscale was 0.80, indicating very good reliability and internal consistency of the variables listed in the subscale (Table 4.2).

There were no statistically significant differences between participants with low and increased actual risk, or participants with low and high perceived risk with respect to the Environmental Health risk subscale. The Cronbach's α for this subscale showed high reliability (0.88) (Table 4.2).

Significant differences in the Risk Knowledge subscale was observed for perceived risk but not for actual risk. Participants with low perceived risk had a significantly higher diabetes knowledge score compared to participants with high perceived risk for developing diabetes (8.0 (6.0–9.0) v 7.0 (6.0 –8.0), P<0.001). The Cronbach's α for Risk Knowledge was 0.68, just under the 0.70 threshold for good internal constancy and reliability (Table 4.2).

Table 4.2 Reliability analysis of the Risk Perception Survey for Developing Diabetes (RPS–DD) stratified by actual diabetes risk.

RPS–DD subscales	Cronbach α***	Low actual risk of diabetes* (n= 122)	Increased actual risk of diabetes * (n=135)	Low Perceived risk** (n=220)	High Perceived risk** (n=37)
Personal Control (over health)	0.70	**3.8 (3.3–4.0)**	**3.2 (3.0–3.5)**	**3.5 (3.0–3.8)**	**3.25 (3.0–3.5)**
Optimistic Bias	0.71	**3.0 (2.5–3.0)**	**2.5 (2.0–3.0)**	3.0 (2.5–3.0)	2.0 (2.0–3.0)
Risk Knowledge	0.68	8.0 (6.0 –9.0)	7.0 (6.0–8.0)	**8.0 (6.0–9.0)**	**7.0(6.0–8.0)**
Comparative Disease risk	0.80	**1.7 (1.5–2.0)**	**1.93 (1.7–2.1)**	**1.8 (1.5–2.0)**	**2.4 (2.0–2.5)**
Environmental Disease risk	0.88	1.7 (1.3 –2.1)	1.55 (1.3 – 2.0)	1.6 (1.3–2.0)	1.7 (1.4–2.2)

*Actual risk of diabetes as defined by the Diabetes New Zealand 'are you at risk' calculator; low risk = score of 3–5 and increased risk = score >5
**Perceived risk of diabetes as defined by RPS–DD 'how at risk do you believe you are for developing diabetes'
^ Mann–Whitney t test. Statistically significant results at P<0.05 is represented in **bold**. Values represented as median (25th, 75th quartiles).
***Cronbach α = 0.70 and above is good , 0.80 and above is better and 0.90 and above is optimal reliability and internal consistency

4.3.2 Diabetes Knowledge

The scores from the Diabetes Knowledge section were analysed to see if there was a difference in diabetes knowledge between participants of low perceived risk and high perceived risk of developing diabetes (Table 4.3).

Median score of participants with low perceived risk was 8.0 (6.0–9.0) compared to 7.0 (6.0–8.0) for participants with high perceived risk. This difference in knowledge scores between participants with low and high perceived risk was significant (U=3224, P=0.04 (2–tailed)), with knowledge of diabetes as assessed by the RPS–DD being significantly higher in participants with low perceived risk of developing T2DM.

On further analysis of individual RPS–DD Diabetes Knowledge questions (Table 4.3) only two questions were significantly different between participants who had low and high perceived risk. The two questions were '*Does having diabetes in pregnancy increase your risk of diabetes?*' and *'Does being over 65 years of age increase the risk of diabetes?'*

Table 4.3 Diabetes knowledge from the RPS–DD stratified by perceived risk status

Diabetes knowledge questions#	Low Perceived risk (n=220)	High Perceived risk (n=37)	P value	Effect size (Phi)
Being Asian	43 (20%)	8 (22%)	0.77*	n/a
Being Caucasian	110 (50%)	14 (38%)	0.17*	n/a
Being Māori	169 (77%)	24 (65%)	0.12*	n/a
Eating a healthy diet	215 (98%)	35 (95%)	0.27^	n/a
Being of Pacific People	178 (81%)	27 (73%)	0.27*	n/a
Having had diabetes during pregnancy [1]	146 (66%)	15 (41%)	**<0.01***	0.18
Having a family history of diabetes	203 (92%)	35 (95%)	1.00^	n/a
Being over 65 years of age[2]	121 (55%)	29 (78%)	**<0.01***	0.17
Exercising regularly	214 (97%)	36 (97%)	1.00^	n/a
Controlling weight gain	215 (98%)	37 (100%)	1.00^	n/a

Pearson's Chi square: [1] χ^2 (1) = 9.03, P<0.01; [2] χ^2 (1) = 7.12, P<0.01

#To assess participant's knowledge of T2DM risk they were asked the following question: *Think about people in the general public and NOT about your own personal risk of getting diabetes. Which statement most closely reflects your view of how each item affects their risk for diabetes?*
Participants were asked to select ONE answer (either: increases the risk, has no effect on risk, decreases risk or don't know) for each of the 10 items listed in Table 4.3 giving them a possible score out of 10 for each correct answer.
(answers: Being Asian = increases risk; Being Caucasian = no effect; Being Màori = increases risk; Eating a healthy diet= decreases risk; Being of Pacific People = increases risk; diabetes during pregnancy=increases risk; family history of diabetes=increases risk, 65+yrs=increases risk; exercising regularly=decreases risk; controlling weight gain=decreases risk).

*P–values reported from Pearson's Chi Square
^Fisher's Exact Test P–value reported when assumptions of Pearson's Chi Square not met
P–values <0.05 represented in **bold**

Sixty–six percent (146/220) participants in the low perceived group correctly answered '*increases the risk*' to the question *''Does having diabetes in pregnancy increase the risk of developing diabetes?''* compared with 41% (15/37) of participants in the high perceived group (χ^2 (1) = 9.03, P<0.01). The effect size (Phi) was 0.18, which represented a small effect. However, of note 78% (137/175) of females answered this question correctly, compared with only 22% (18/80) of males, suggesting gender could be influencing the result shown. The test for interaction effects did not report any significant effect between gender and the question on gestational diabetes (P=0.4).

Seventy–eight percent (29/37) of participants in the high perceived risk group answered correctly '*increases the risk*' to the question '*'Does being over 65 years of age increase the risk of developing diabetes''*, compared with 55% (121/220) of participants in the low perceived risk group (χ^2 (1) = 7.12, P<0.01). The effect size (phi) was 0.17, indicating a small effect size.

There was relatively poor knowledge around ethnicity (being Asian) as a risk factor for T2DM, with only 20% of participants with low perceived risk and 22% of participants with high perceived risk correctly answering '*increases the risk*' to this question. A similar trend was also observed for ethnicity (being Caucasian) with only 38% of high perceived risk participants correctly answering '*has no effect*' to this question.

4.3.3 Motivation

Participants were asked if they planned to make diet or exercise changes in the future, that they believed would lower their risk of developing diabetes. This question was designed to assess participant's motivation in lifestyle behaviour change.

Of the 257 participants who answered this question 42% (108/257) said 'yes' they planned to make changes, whilst 58% (149/257) said they were not planning to make any lifestyle changes. When stratified by the participant's perceived risk of developing T2DM, there was a significant difference between the groups, with 78% (29/37) of participants with a high perceived answering 'yes' to making lifestyle changes in the near future to reduce their risk, compared with 36% (80/220) of participants with low perceived risk (χ^2 (1)=22.9, P<0.001). This was a medium effect size, (Phi) was –0.30 (Table 4.3).

4.4 GP Communication, visits, and actual risk status

There is a significant difference between GP communication and actual risk status (P=0.03), and GP-recommended tests and actual risk status (P=0.03), but not for GP visits and actual risk status (P=0.22) (Table 4.4).

Overall, GP communication about T2DM/CVD risk to participants was low, with only 21% (24/116) and 33% (42/128) of participants with low and increased actual risk receiving risk communication from their GP, respectively (χ^2 (1) = 4.53, P=0.03) (Table 4.4).

GP-recommended tests for T2DM/CVD was reported in 52% (60/116) of participants with low actual risk and in 66% (84/128) of participants with increased actual risk (χ^2 (1) = 4.86, P=0.03) (Table 4.4).

Spearman's correlations between actual risk status and GP communication about risk are significant, yet weakly and negatively correlated (Rho(s) = –0.14, P=0.03). The same correlation relationship was seen between GP-recommended tests for CVD/T2DM and participants actual risk (Rho(s) = –0.14, P=0.03).

Table 4.4 GP communication, visits & tests about T2DM/ CVD risk stratified by participant actual risk status

	*Low Actual Risk	*Increased Actual Risk	P value	Rho(s)#
GP Communication about T2DM/CVD risk (n=244)			**0.03^**	–0.14
- **Yes**	24 (21%)	42 (33%)		
- **No**	92 (79%)	86 (67%)		
Frequency of GP visits (n=244)			0.22^^	Not correlated
- **Occasionally (every 3 – 6 months)**	65 (56%)	78 (61%)		
- **Once a year**	28 (24%)	35 (27%)		
- **Less than once a year**	23 (20%)	15 (12%)		
GP-recommended tests for CVD/T2DM (n=244)			**0.03^^^**	–0.14
- **Yes**	60 (52%)	84 (66%)		
- **No**	56 (48%)	44 (34%)		
***Actual risk score (n= 257)**	3 (1,4)	7 (6,9)		

*Actual risk of diabetes as defined by the Diabetes New Zealand 'Are you at risk?' calculator; low actual risk = score of 3–5 and increased actual risk = score >5. Scores presented in medians (25th, 75th quartiles).
^Pearson's Chi-square: χ^2 (1) = 4.53, P=0.03 Phi = –0.14; ^^Pearson's Chi-square: χ^2 (2) = 3.06, P=0.22;
^^^Pearson's Chi-square: χ^2 (1) = 4.86, P=0.03 Phi = –0.14
#Spearman's correlations significant at P<0.05

4.4.1 Gender

Significant differences were observed between males and female for; GP risk communication about T2DM/CVD risk, education level and RPS–DD Diabetes Knowledge scores (Table 4.5).

Thirty-eight percent (29/80) of males reported having a discussion with their GP about the risks of diabetes and cardiovascular disease, however only 23% (40/175) females reported having a T2DM/CVD risk discussion with their GP (χ^2 (1) = 5.51, P=0.02). Of the 29 males who reported having a GP discussion about T2DM/CVD, 76% (22/29) had an increased actual risk of developing T2DM according to the Diabetes New Zealand 'are you at risk' calculator compared with 55% (22/40) of females with an increased actual risk. Furthermore, 34% (10/29) of males had a high perceived risk compared with 20% (8/40) of females who perceived their risk of developing T2DM to be high.

Females had significantly more education than males, with 53% (94/175) of females having either a bachelors or post graduate qualification, compared with 44% (35/80) of males (χ^2 (5)= 11.02, P=0.05).

Females also had significantly higher RPS-DD Diabetes Knowledge scores 8 (7,9) compared to males 7 (6,8) (U=3131.5, P<0.001, r =–0.15), although the effect size was small (Table 4.5).

Table 4.5 GP information and risk status stratified by gender

	Male	Female	P value*	Effect size^
GP visit frequency (n=250)				
- **Every 3– 6 months**	42 (54%)	103 (60%)	0.24	n/a
- **Once a year**	19 (24%)	46 (26%)		
- **Less than once a year**	17 (22%)	40 (23%)		
GP Communication about diabetes risk (n=249)				
- **Yes**	29 (38%)	40 (23%)	**0.02****	0.15
- **No**	48 (62%)	132 (78%)		
GP–recommended testing for diabetes (n=249)				
- **Yes**	49 (64%)	98 (57%)	0.32	n/a
- **No**	28 (36%)	74 (43%)		
Perceived risk (n=255)				
- **Low**	64 (80%)	155 (89%)	0.07	n/a
- **High**	16 (20%)	20 (11%)		
Actual risk (n=255)				
- **Low**	33 (41%)	88 (50%)	0.18	n/a
- **Increased**	47 (59%)	87 (50%)		
Prediabetes diagnosis (n=248)				
- **Yes**	6 (8%)	12 (7%)	0.86	n/a
- **No**	72 (92%)	158 (93%)		
Education level (n=255)				
- **High School Certificate**	8 (10%)	29 (17%)	0.05	0.21
- **Certificate**	19 (24%)	17 (10%)		
- **Diploma**	14 (18%)	29 (17%)		
- **Bachelor's degree**	19 (24%)	46 (26%)		
- **Post Graduate qualification**	16 (20%)	48 (27%)		
- **Other**	4 (5%)	6 (3%)		
RPS–DD Diabetes Knowledge scores# (n=255)	7 (6,8)	8 (7,9)	**P<0.001**	–0.15

*Pearson's Chi Square Test **GP Communication: χ^2 (1) = 5.51, P=0.02 ; Education: χ^2 (5) = 11.02, P=0.05
^Cramer's V effect size ; n/a – no effect size given for P>0.05 as significance not met
Mann–Whitney test: median (25th, 75th) U=3131.5, P<0.001 (2–tailed), r=–0.15
P values < 0.05 represented in bold

4.5 Factors that influence perceived risk

4.5.1 Potential variables that influence perceived risk

Table 4.6 represents potential variables that may play a role in perceived risk of T2DM development. Significant variables that correlated with perceived risk status (low vs high) included; GP communication about T2DM/CVD risk (P=0.001), BMI>25kg/m^2 (P<0.001), family history of diabetes (P<0.001), exercising <2.5hrs/week (P=0.03), eating a diet high in fat and sugar (P<0.001), having a diagnosis of prediabetes (P<0.001), Comparative Disease risk (P<0.001), Personal Control (P=0.01), Optimistic Bias (P=0.001), and planned behaviour change to reduce diabetes risk (P<0.001) (Table 4.6).

Table 4.6 Potential variables of perceived risk in developing T2DM

Perceived Risk (n=244)	R_s	P-value (2-tailed)
Demographic & health variables		
- **Ethnicity**	0.06	0.37
- **Gender**	-0.12	0.05
- **Education Level**	0.06	0.39
- **Age**	0.002	0.98
- **Diagnosis of prediabetes**	-0.30	**<0.001***
Primary care variables		
- **Frequency of GP visits**	-0.10	0.12
- **GP-recommended tests for T2D or CVD**	-0.16	0.01*
- **GP communication about T2D or CVD risk**	-0.21	**<0.001***
Risk factors for T2D (based on risk calculator)		
- **BMI>25kg/m^2**	-0.32	**<0.001***

- **Family history**	−0.30	**<0.001***
- **Exercise <2.5hrs/week**	−0.14	**0.03***
- **Diet high in fat & sugar**	−0.21	**<0.001***
Beliefs on health & T2DM knowledge (from RPS–DD)		
- **Comparative Disease risk**	0.38	**<0.001***
- **Environmental Disease risk**	0.08	0.22
- **Personal Control**	−0.17	**0.01***
- **Optimistic Bias**	−0.20	**0.001***
- **Planned lifestyle modification to lower T2D risk**	−0.31	**<0.001***
- **Diabetes Knowledge (RPS–DD)**	0.13	0.05

Spearman's correlation analysis
*Statistically significant results from P values <0.05 are represented in **bold.**

4.5.2 A model of predictive variables that influence risk perception

Table 4.7 represents the likelihood of significantly correlated variables predicting perceived risk of developing T2DM.

There were five significant predictor variables (Table 4.7) in the logistic regression model of perceived risk including; having a diagnosis of prediabetes (P<0.01), eating a diet high in fat and sugar (P<0.01), having a family history of diabetes (P<0.001), having a low Comparative Disease risk (P<0.001) and planned lifestyle modifications (such as diet and exercise) to reduce risk of developing diabetes (P=0.002).

Table 4.7 A model of predictive variables that influence risk perception

Predictive Variables	B	Wald (X^2)	P-value	OR	95% CI
Diagnosis of prediabetes					
- **Yes**	2.19	6.25	**0.01***	8.97	1.61–50.10
GP Communication about risk					
- **Yes**	0.39	0.39	0.53	1.50	0.44 – 4.88
Risk factors					
- **Exercise <2.5 hrs/week**	0.82	1.34	0.25	2.27	0.57 – 9.08
- **Diet high in fat and sugar**	1.84	8.51	**<0.01***	6.29	1.83 – 21.63
- **Family history**	2.32	13.86	**<0.001***	10.17	3.00 – 34.47
- **BMI>25kg/m^2**	0.84	2.14	0.14	2.31	0.75 – 7.11
Health risk beliefs					
- **Optimistic bias (low)**	−0.75	1.48	0.23	0.47	0.14 – 1.58
- **Personal control (low)**	1.07	2.17	0.14	2.92	0.70 – 12.16
- **Comparative disease risk (low)**	−3.24	23.10	**<0.001***	0.04	0.01 – 0.15
- **Planned lifestyle modification to lower risk (yes)**	1.97	9.52	**0.002***	7.13	2.05 – 24.85

*Statistically significant at P<0.05 level, represented by bold
Binary logistic regression model: $X^2(10) = 109.7$, P<0.001

A test of the model, complete with predictors (Table 4.7) compared to an intercept–only model was statistically significant χ^2 (10, n=244) = 107.4, P<0.001.

The model had an initial success rate of 85.2%, correctly classifying participants with low perceived risk 100% (208/208). The success rate of the model significantly improved after the addition of the above-mentioned predictor variables, increasing the success rate to 91.4%.

While there was a slight reduction in the correct classification of participants with low perceived risk, from 100% to 96% (199/208), there was a significant increase in correct classification of participants who perceived their risk to be high, increasing to 58% (21/36) from the original success rate of 0%. This model explained 64% (Nagelkerke R^2) of the variation in perceived risk.

The odds ratio for having a diagnosis of insulin resistance was 8.97 (95% CI 1.61–50.10), indicating, while holding all other variables constant, having a diagnosis of insulin resistance is 8.97 times more likely to result in an increased perceived risk of developing T2DM compared to not having a diagnosis of insulin resistance.

Participants who reported eating a diet high in fat and sugar as well as a family history of T2DM had an odds ratio of 6.29 (95% CI 1.83–21.63) and 10.17 (95% CI 3.00–34.47) respectively. This result suggests participants were at least 1.83 times and 3.00 times more likely to have an increased perceived risk of developing T2DM if they reported having a diet high in fat and sugar and a family history of T2DM, respectively.

Participants who reported having planned behaviour modification to reduce their risk of T2DM had an odds ratio of 7.13 (95% CI 2.05–24.85). This result indicates when holding all other variables constant, planned behaviour modification (in the form of diet and exercise) is 7.13 times more likely to result in an increased perceived risk of developing T2DM compared to no planned behaviour modification.

Chapter 5 – Discussion

This study investigated the perception versus actual risk of developing T2DM in a New Zealand population. The validated RPS–DD questionnaire (Walker et al, 2009) was used to assess perceived risk and the Diabetes New Zealand 'Are you at risk?' calculator questions determined actual risk.

The main aim of this study was to investigate an individual's perception of risk and compare it to their actual risk of developing T2DM. A secondary aim of this study was to determine what factors influence an individual's perception of risk.

This chapter presents the discussion and interpretation of results obtained from the statistical analysis of the perceived versus actual risk data collected via an online questionnaire from 257 New Zealand participants. Section 5.1 explores the main aim of this research and discusses the findings of perceived versus actual risk of developing T2DM in this group of participants. Section 5.2 discusses the secondary aim which investigated predictors of risk perception including: having a diagnosis of prediabetes, consuming a diet high in fat and sugar, having a family history of diabetes, having a low Comparative Disease risk and planned lifestyle modification. GP communication about T2DM/CVD risk, frequency of GP visits, risk perception and age, health literacy and gender are also reviewed. Limitations of the study and future opportunities for research are considered in section 5.3 and 5.4, respectively. Section 5.5 discusses an overall conclusion of the study.

5.1 Perceived risk compared with actual risk of developing T2DM in a New Zealand population

What was most striking from the results uncovered in this study was the large and significant disparity between participant's perception of risk and their actual risk of developing T2DM. Overall, only 14% (37/257) of participants perceived they were at risk for developing T2DM, despite 53% (135/257) having an increased actual risk (a risk score ≥5) as defined by the Diabetes New Zealand 'Are you at risk?' calculator.

Furthermore, of the 86% (220/257) who had a low perceived risk of developing T2DM, 47% (103/220) within this group had an increased actual risk of developing T2DM ($Z=-9.43$, $P<0.001$, $r=-0.41$). This result shows participants significantly underestimate their risk of developing T2DM, therefore we can reject our null hypothesis, and accept our alternative hypothesis such that: an individual's perceived risk is not the same as their actual risk of developing T2DM in this sample of participants from a New Zealand population.

Although striking, this is not a new finding. In fact, underestimation of actual T2DM risk is a common theme in diabetes risk perception literature (Table 2.2) (Graham et al., 2006; Guess et al., 2015; Guo, Tang, et al., 2019; Heidemann et al., 2019; Joiner et al., 2016; Kim et al., 2007; Kowall et al., 2017). Why this is, is not fully understood. Findings from the present study would suggest a need for greater discussion about T2DM risk in the primary care setting, given 76% (163/214) of participants who perceived their risk of developing diabetes to be low, reported not having received diabetes risk communication from their GP. This was significant ($P<0.001$). Despite participants with a low perceived risk visiting their GP relatively frequently, with 56% (120/214) visiting their GP at least once every three to six months.

A similar finding was found in a UK-based study of 59 subjects where nearly half of the cohort had not had risk communication about their risk status from a GP, despite 26 (44%) having a high risk as classified by the Diabetes UK risk assessment (Guess et al., 2015). Furthermore, of those participants who had been informed of their high risk status (42%) had significantly higher perceived risk scores (P<0.001) (Guess et al., 2015). A similar finding was seen in a nation-wide German-based survey of 2,327 participants where researchers investigated diabetes knowledge and information needs (Heidemann et al., 2019). Results from Heidemann and colleagues (2019) showed determinants of perceived risk of diabetes included whether participants had been informed of their actual diabetes risk from their primary healthcare provider.

In contrast, one study (Table 2.2) of 9,496 adults from the National Health & Nutrition Examination Survey (NHANES) showed an overestimation of perceived risk in a subsample of high perceived-risk participants (Yang et al., 2018). Of the 9,496 participants, 28.4% (n=2,696) reported a high perceived risk for developing T2DM, however only 38.3% of this high perceived risk group had an actual risk of T2DM development, as measured by the American Diabetes Association guidelines. A reason for this overestimation could be because most participants (74.8%) had received risk information from their doctor regarding T2DM.

In another study (Table 2.2) only a weak association was observed between self-reported actual risk factors and perceived risk of T2DM development in 255 older aged adults (57–79 years) with an increased risk for CVD and T2DM (Claassen et al., 2011). One reason for this weak association could be due to the close-ended questions used to assess causal beliefs of disease risk, which is thought to overestimate disease risk knowledge (Claassen et al., 2011).

In another cross-sectional study of 324 Chinese and Hispanic or Latino adults (mean age 45.2 years) 52.7% of participants were simply unaware of their risk, although 43% of participants had a high risk of developing T2DM as measured by the American Diabetes Association (ADA) guidelines.

5.2 What influences an individual's perception of diabetes risk?

A secondary aim of this study was to investigate potential variables that influence an individual's perception of risk to help understand mediators of risk perception. It is clear from examining perceived versus actual risk that an individual's understanding of factors that lead to the development of T2DM is low. Why this is, is not clear. Possible explanations could be attributed to knowledge of risk factors that lead to T2DM development, or it could be attributed to a lack of acknowledgement of personal T2DM risk, especially given the absence of physical symptoms often associated with risk of T2DM development. The latter is difficult to comment on from the current study. Examining Diabetes Risk Knowledge, participant knowledge of T2DM risk factors is relatively good with a median score of 8 (6-9) out of a possible 10 for participants with low perceived risk and 7 (6–8) out of 10 for participants with high perceived risk. Examining what influences an individual's perception of T2DM risk will facilitate better strategies to enable a person to understand and hopefully implement changes in their life to reduce the risk of developing T2DM.

The regression analysis highlighted significant predictors of risk perception including having a diagnosis of prediabetes, consuming a diet high in fat and sugar, having a family history of diabetes, having a low Comparative Disease risk and planned lifestyle modification. These variables and their influence on an individual's perception of risk are discussed below.

Variables also discussed with regards to influencing an individual's risk perception include GP communication around T2DM/CVD risk, frequency of GP visits, age, health literacy and gender.

5.2.1 Previous diagnosis of prediabetes

Results from this study showed having a previous diagnosis of prediabetes was a significant predictor of increased risk perception of developing T2DM (OR 8.97 (95% 1.61–50.10), P<0.001). This result is logical, given prediabetes/T2DM communication would be standard treatment of care for a patient with a clinical diagnosis of prediabetes, therefore it is expected the patient to have some knowledge or understanding from their GP of the risks associated with developing T2DM and hence have a greater perceived risk. This was also reflected in the current results with 78% (14/18) participants with a diagnosis of prediabetes, reporting having received GP-communication about CVD/T2DM risk.

A similar trend was observed in a US-based study where a history of prediabetes in participants significantly predicted T2DM risk perception (unadjusted OR 16.15, P<0.001) (Joiner et al., 2016). Hivert and colleagues (2009) also demonstrated patients with metabolic syndrome (self-reported) were more likely to have a high perceived risk of developing T2DM compared with those patients who did not have metabolic syndrome (53% v 35%, P = 0.04). An explanation for these findings was not discussed in the studies.

5.2.2 Diet

Participants who reported consuming a diet high in sugar and fat were significantly more likely to have a high perceived risk of developing T2DM in the current study (OR 6.29 (95% 1.83 –21.63), P<0.01).

A similar trend was observed in a study by Yang et al (2018) who reported on nine risk factors participants perceived as increasing an individual's risk for developing T2DM. Results showed participants ranked poor diet as the third highest risk factor for developing T2DM out of the nine risk factors. In contrast, a study involving 255 participants from the Netherlands who were at risk for T2DM and CVD reported no significant association between unhealthy eating habits and risk perception of developing T2DM (Claassen et al., 2011). This could be because participants were also asked about risk factors that increase the risk of CVD at the same time, potentially diluting the risk perception of T2DM by direct comparison with CVD.

This was evident by the significantly lower mean risk scores for T2DM compared with CVD (Claassen et al., 2011).

Guess et al (2015) showed a significant correlation between participant's Healthy Eating Index (HEI) score, a measure of diet quality (with higher scores reflecting healthier diet quality), and their risk perception, such that participants with an increased perceived risk of developing T2DM also had significantly higher HEI scores ($r^2 = 0.243$, $P=0.048$). This indicates having an awareness of risk influences healthier eating behaviours (Guess et al., 2015). In another study involving 255 participants who were at risk for T2DM and CVD no significant association between unhealthy eating habits and risk perception of developing T2DM could be made (Claassen et al., 2011).

5.2.3 Family history

Family history was the largest predictor variable of perceived risk in the current study, with participants 10.17 times more likely to have a high perceived risk of developing T2DM if they reported having had a family history of diabetes (OR 10.17 (95% 3.00–34.47), $P<0.001$). This is not a new finding in the risk perception literature (Guo, Tang, et al., 2019; Heidemann et al., 2019; Hivert et al., 2009).

In a German-based study of adults with an increased actual risk of developing T2DM (n=639) family history of diabetes was a significant determinant of perceived risk

(OR 2.10 (95% CI 1.06–4.16)) (Heidemann et al., 2019). A similar observation was seen in a study of 176 mothers of preschool aged children in China, where participants who reported having a family history of diabetes (95% CI 0.40–1.31) had a higher perceived risk of developing T2DM. Family history of diabetes explained 12.5% of the variance of overall perceived risk (Guo, Tang, et al., 2019). While Joiner and colleagues (2016) also demonstrated the probability of a participant having an increased perceived risk of developing T2DM was significantly greater if they reported having a family history of diabetes. This significance did not translate into their logistic regression model of perceived risk (OR 2.07 (95% CI 0.59–7.18), P=0.25).

5.2.4 Comparative Disease risk

Comparative Disease risk, while significant in the logistic model of determinants for perceived risk, the odds ratio was only 0.05 (95% CI 0.01–0.18). In contrast, Joiner and colleagues (2016) showed a significant odds ratio for Comparative Disease risk in their study of foreign born US Latino adults (n=135) (OR 60.56 (95% CI 10.71–342.58) P<0.001) such that for every one-unit increment in Comparative Disease risk, participants were 10.71 times more likely to have a high perceived risk of developing T2DM. The significant and large odds ratio could be attributed to the fact that diabetes was the top-ranked health/disease condition in the Comparative Disease risk scale in this study. In contrast, a US-based study by Walker and colleagues (2003) who investigated risk perceptions in 535 nondiabetic physicians, diabetes was the 5th ranked health/disease condition. This could be due to the higher level of knowledge physicians had as illustrated by their higher mean

Diabetes Risk knowledge scores compared with participants from the Joiner et al (2016) study (mean knowledge score 8.86 versus 4.36). The scores were out of a possible eleven.

5.2.5 Planned behaviour modification

Planned behaviour modification (in the form of diet and exercise) was the third largest predictor variable in the model of perceived risk in the current study (OR 7.13 (95% CI 2.05–24.85), P=0.002). This result is in contrast to a US-based study of 150 nondiabetic primary care patients who reported they were not more likely to make healthier lifestyle changes in the near future, despite having a high perceived risk of developing T2DM. Although it is worth noting this result was not significant (high 26% v low 29.2%, P=0.69) (Hivert et al., 2009). Hivert and colleagues (2009) noted one reason for this finding could be because this group showed significant (P=0.006) belief that doing exercise and following diets were a lot more effort.

5.2.6 GP Communication about T2DM risk

Communication and trust between patient and doctor with regards to an individuals' disease risk is central to mediating behaviour change and therefore risk status (Heidemann et al., 2019).

Overall, GP communication about T2DM/CVD risk to participants in this study was low, with only 21% and 33% of participants with low and increased actual risk receiving risk communication information from their GP respectively (Appendix 3). The lack of GP communication around risk could be due to several factors, one most obvious being the time constraint facing health providers in a clinical setting, where 15-minute appointments are often the norm and discussions beyond immediate symptoms and treatment options are not always possible.

Another possibility is communication around risk is potentially communicated in a way that is not understood or remembered by patients. Since the inception of the information deficit model in the early 1970s, communication about health information from health professional to patient has been of the view –

> ''*if we arm patients and families with a deeper understanding of medical concepts on the cognitive level it will keep them healthy or compel them to treat their disease, leading to a healthier life''* (''The Information Deficit Model''(2018)).

However, this model does not take into consideration the many factors which influences a patient's health decision-making process, including their health literacy level (discussed in section 5.2.9).

For example, factors influencing an individual's health decision-making process are also impacted by financial, cultural, religious, and personal beliefs ('The Information Deficit Model'', 2018).

An inability for the health professional to take pause and see through the ''lens'' of how the patient views their health may be a missed opportunity to engage with the patient on a level beyond citing the latest medical research. By understanding a patient's current knowledge of their health condition, as well as their fears and potential anxieties which may be preventing optimal health outcomes, offers opportunities for greater patient understanding and engagement in their treatment and ultimately, their health outcomes.

A 6-month study of patients (n=32) who had recently been diagnosed with T2DM from GP practices around New Zealand found there was an opportunity to improve the effectiveness of communication during consultations (Dowell et al., 2018). Patients found the biomedical model of diabetes impersonal and difficult to relate to their personal circumstances. Some of the interactions between healthcare provider and patient illustrated this point, where the healthcare provider focused on getting the patient to understand they needed to do more physical activity, whilst not engaging in the potential barriers (looking after sick family/work) the patient faced in being able to do the exercise (Dowell et al., 2018).
Dowell and colleagues (2018) offer insights for healthcare professionals to focus on a patient-centred approach regarding lifestyle advice and information on reducing diabetes risk, rather than conforming to a time–focused checklist aimed at simply informing the patient.

Another possible explanation for the lack of discussion around GP-risk communication in this participant group could be simply, they were not viewed as being at risk of developing T2DM by their GP. This explanation is supported by the correlation data between actual risk and GP communication about risk as well as GP-recommended tests for CVD and diabetes, whereby negative, weak correlations (Rho(s) = –0.14) were observed for these variables with actual risk (Table 4.5). Had the GP viewed these participants as having an increased actual risk, you would have expected to see an increase in GP-recommended tests as well as risk communication discussions. But the opposite was observed in the data.

Obvious risk factors for the development of T2DM from a GP perspective that would typically be communicated in a clinical setting, (assuming the information had been offered/asked of participants during GP visits) would be; age, BMI, previous history of prediabetes and history of having had gestational diabetes in pregnancy.

Most participants in this study were over the age of 55 years, which is a risk factor for the development of T2DM. However, the total median BMI for participants was in the normal healthy range 24.4 (22.1,27.3). Additionally, only 7% (18/257) participants reported having prediabetes and only 3% (5/175) of female participants reported having had gestational diabetes during pregnancy.

However, when analysing participant responses (n=244) to GP communication about risk of CVD/T2DM development as stratified by participant actual risk status, (defined by the Diabetes New Zealand 'Are you at risk?' calculator) there were significant differences between the participants actual risk and GP communication about CVD/T2DM. Sixty–six percent (87/128) of participants with an increased actual risk of developing T2DM (median actual risk score 7 (6,9)) reported not receiving any GP communication about T2DM risk during their GP visits compared with 79% (93/116) of participants with a low actual risk (median actual risk score 3 (1,4)) (χ^2 (1) = 5.15, P=0.02). Although this finding is significant, it is worth noting it was a small effect size (Phi = –0.14).

Effective communication between a doctor and their patient has many benefits, including increased patient understanding and adherence to treatments, reduced morbidity and increased quality of life (Mikesell, 2013). Furthermore, a patient–centred approach to treatment through effective communication, has an ability to transform clinical outcomes for that patient (Mikesell, 2013). Over the last decade in New Zealand, there has been a focus on the importance of the patient-centred approach to clinical care.

The Royal New Zealand College of GPs now endorses a new communication skills courses for GPs, which is founded on the principles of shared-decision making and stems from the ''Choosing Wisely Campaign'', a global initiative aimed to improve patient-doctor communication so that patients are able to make the best decision that optimises their health outcomes (RNZCGP, 2018) .

The importance of successful communication in delivering advice on lifestyle change in the clinical setting is becoming an increasing focus point (Coppell et al., 2017). A recent study indicated a nurse-led communication style, supported by the primary GP can assist weight loss strategies in patients with prediabetes (Connor, Coppell, Gray, & Sullivan, 2019). Furthermore, Heidemann and colleagues (2019) demonstrated an independent determinant of a participant's (moderate/high) perceived risk status was being informed about an increased diabetes risk by a physician (3.27 (1.51–7.07) (Heidemann et al., 2019).

5.2.7 Frequency of GP visits

Another possibility as to why participants reported receiving minimal communication around CVD/T2DM risk from their GP could be attributed to the frequency of GP visits made by the participants. However, over half (59%) of participant's reported visiting their GP every 3–6 months, which is relatively frequent when compared to a German–based study (n=2327), where only 37% reported having had a health check–up in the past two years (Heidemann et al., 2019).

When examining the possible relationship between GP frequency (3–6months, once a year, less than once a year) and GP communication about CVD/T2DM risk in the current study, 27% received communication vs 55% who did not. This finding was not significant, suggesting the frequency of GP visits did not impact on GP communication on CVD/T2DM risk. This finding is similar to Heidemann and colleagues (2019) where participants who had been informed by a physician about their risk were more likely to have an increased perceived risk of developing T2DM (OR 3.27 (95% CI 1.51–7.07) $P<0.05$) despite only 37% of participants visiting their GP in the past two years.

Given GP visits are not fully funded in New Zealand, access to health information regarding T2DM via a primary care setting may be a financial barrier for some New Zealanders. Alternative sources of T2DM health information available to the general public include campaigns, such as the 2015 Diabetes in Action campaign which aimed to raise awareness of risk factors associated with both T2DM and T1DM as well as encourage people to take action. This has been done through a range of initiatives including the launch of the online risk assessment tool (the one used in the current study), national roadshows as well as implementing a national Fitbit 'MoveMeant' day, where people could sign up and commit to doing 10,000 steps a day. At time of publication, there does not appear to be any formal data available to evaluate the effectiveness of this campaign, however it has gained popularity, with the Fitbit MoveMeant challenge returning each year since 2015. While this campaign and its health information on T2DM was made freely available to New Zealander's, the requirement of a Fitbit to take part in the MoveMeant challenge could have been a financial barrier for some people.

In 2015, the Ministry of Health issued a 5-year plan aimed to improve access and quality to people-centred healthcare services for people at high risk or living with T2DM (Ministry of Health, 2015). This plan builds on the already established health promotion initiatives such as the Green Prescription. The 5-year plan acknowledges the increased prevalence of T2DM in Màori and Pacific peoples compared with New Zealand European and because of this, the strategies to reduce such disparities are guided by both the Màori Health Strategy *He Korowai Oranga* and *'Ala Mo'ui: Pathways to Pacific Health and Wellbeing 2014–2018.* One of the six key principles in the 5-year strategic plan are to raise awareness and knowledge of T2DM through education-based programmes such as the implementation of *Healthy Families NZ.* This programme spans 10 New Zealand locations including over 1 million New Zealanders at increased risk for chronic diseases such as T2DM (Ministry of Health, 2020). The programme encourages improvements in health including increased physical activity, healthy nutrition, and a reduction in both rates of smoking and alcohol-related harm (Ministry of Health, 2020). The systems approach of the *Healthy Families NZ* is a collaboration between local iwi, councils and local Pacific-led communities, with each of the 10 New Zealand locations offering a slightly different programme, tailored to that community (Ministry of Health, 2020). It is still too soon in the implementation phase of the progamme to determine the impact on risk factors or outcomes for T2DM (Matheson et al., 2018).

5.2.8 Risk perception and age

No significant association was seen between age and perception of risk in the current study (Table 4.1). This finding differs from other studies, where a lower age has been associated with an increased perception of diabetes risk (Claassen et al., 2011; Heidemann et al., 2019).

A study of 639 German participants without T2DM, who had either a moderate or high perceived risk of diabetes were significantly associated with being younger in age (Heidemann et al., 2019). Similarly, a study from the Netherlands of 255 participants at risk for CVD and diabetes, found that participants who were 65 years or older had reduced risk perceptions, compared with younger participants. This finding was statistically significant in regression analysis model of perceived risk (OR –0.17, $t_{239} = -2.61$, P=0.01) (Claassen et al., 2011).

Why an increased risk perception has been associated with a lower age is not fully understood. One reason is thought to be due to poor knowledge around diabetes risk (Claassen et al., 2011) although the participants in the current study actually had relatively good diabetes risk knowledge, as indicated by their risk scores (Table 4.2). However a reduced perception of diabetes risk has also been established in young persons, as was the case for 176 young Chinese mothers (mean age 31 years) of preschool aged children, where approximately 90% perceived their risk to be slight or non-existent, despite presenting with risk factors for T2DM (Guo, Tang, et al., 2019). One reason for this finding could be due to the limited knowledge participants had around diabetes risk factors, with mean scores for the Diabetes Risk Knowledge subscale being 4.48 out of a possible 11. (Guo, Tang, et al., 2019)

5.2.9 Participant health literacy

Health literacy has been described as the ability for people to access and understand health information that enable them to make informed decisions about their health care (Ministry of Health, 2010). New Zealand as a nation has relatively poor health literacy, with just over half (56%) of both Māori and non-Māori scoring below the minimum health literacy level in the Adult Literacy and Life Skills Survey (ALL) in 2006 (Ministry of Health, 2010). The number of Māori participants in the current study was small, with less than 1% of the participant numbers identifying as Māori.

Participants in the current study displayed relatively good health literacy in the form of diabetes knowledge, with the median Diabetes Risk Knowledge score being 8.0 (6.0 – 8.0) out of a possible 10. This score is probably reflective of the high education level of participants where 51% had either a graduate or post graduate qualification. Furthermore, participants were invited from a Massey University research database which would have most likely generated some participant bias in terms of knowledge and lifestyle factors associated with health. Participants who register for research studies typically have a vested interest in their own health and are subsequently more knowledgeable via exposure to research information and dissemination. Similar results have also been found in a previous study investigating health beliefs among a Hispanic prediabetic population, where an increased education level of participants corresponded to increased knowledge of diabetes risk (Shaak et al., 2018).

Based on both the high education level of the participants in the current study, as well as their high knowledge of diabetes risk, participants' health literacy does not appear to be a contributing factor to their low perceived risk of developing diabetes. Coupled with this, there were no statistically significant differences found in Diabetes Knowledge scores and participants with low or high perceived risk. Furthermore, diabetes risk knowledge was not a significant predictor variable to the model of perceived risk in this study. This is in contrast to a US-based study of 535 nondiabetic physicians where Diabetes Risk Knowledge score was one of five independent predictor variables contributing to 33.7% of the variance seen in their risk perception of T2DM model ($F=49.43$, $P<0.0001$) (Walker et al., 2003).

Following on from the results of the 2006 ALL survey, the Ministry of Health developed the Health Literacy Framework and review, aimed at building a health literate system, workforce and consumers of health services through a provider-focused approach (Ministry of Health, 2015). One of the six key components in the Health Literacy Framework was communication with consumers accessing health services. This is supported by findings from a UK-based study of 59 patients from local GP practices, where those patients (42%) who had been informed of their risk by their healthcare provider had significantly higher knowledge scores (8.0± 3.0 v 5.9 ±0.2, P<0.001) as well as a greater perceived risk (2.6± 0.1 v 2.0±0.1, P<0.001).

5.2.10 Gender and risk perception

There was no statistically significant association between risk perception and gender in this study with 80% of males and 89% of females perceiving their risk to be low (P=0.07). This finding is in contrast to a study of 150 non-diabetes primary care patients in Massachusetts, where 69% of women perceived their risk to be high compared with 44% of males (P=0.005) (Hivert et al., 2009).

Similarly the KORA FF4 study also found women were more likely to perceive a higher risk of diabetes compared to men (Prevalence Rate (PR) = 1.2, 0.9–1.5) (Kowall et al., 2017). Why there were no significant differences between gender and risk perception observed in the current study is not fully understood. One possible explanation was the similar incidence of prediabetes between the gender (8% v 7%, P=0.86), which was the largest predictor variable in the perceived risk model of this study. Another possible explanation could be attributed to the balancing out of the two variables; Diabetes Risk Knowledge scores and GP communication about CVD/T2DM risk, such that significantly more females reported not receiving GP communication about CVD/T2DM risk compared to males (78% v 62%, P=0.02) but females had significantly higher Risk Knowledge scores compared to males (8 (7,9) v 7 (6,8), P<0.001).

Both increased GP communication about risk and higher Risk Knowledge scores have been associated with increased perceived risk of developing T2DM (Guess et al., 2015).

5.3 Limitations of the study

5.3.1 Risk calculator tools

There are many different diabetes risk tools available to assess actual risk including: the ADA risk calculator (Bang et al., 2009), AUSDRISK (Chen et al., 2010), CANRISK (Robinson, Agarwal, & Nerenberg, 2011) and the Diabetes UK risk calculator among some of them.

This study used the Diabetes New Zealand 'Are you at risk?' calculator tool due to the study examining a New Zealand population and their perception of risk. Comparing actual risk results against the gold standard measure of HbA1c and fasting plasma glucose, has shown the risk tool overestimates actual risk (Joiner et al., 2016). Additionally, participant feedback from this study highlighted the potential 'black or white' nature of the risk calculator tool, without taking into consideration the individual, or the way the questions are framed in the risk assessment calculator. For example, one participant in the current study was confused by the wording of the '*yes*', *'no'* question *'I often eat foods high in fat and sugar'.* This is not simply a 'yes' or 'no' answer, as some people eat a low sugar diet but may consume high quantities of good quality fats, as was the case with this participant. The interpretation of the question can result in incorrect answers which can reduce the accuracy of the risk assessment tool.

Another potential limitation of the risk calculator tool is that it does not consider some individuals, such as those who are endurance athletes. Comments from one participant reported –

‘*I'm going to look like someone who down-values their own risk, but my finding has been that as an endurance athlete (I mean running 30–50km a week, doing half a dozen marathons a year, half and full Ironman every year), with a BMI of around 26, I sometimes don't score well in these sorts of things because of the nature of the questions.''* – this participant scored in the increased risk category (risk score = 10) due to unmodifiable risk factors including; age, large baby (4+kg) at birth and a slightly elevated BMI. The participant goes on to say – ''*…my perception of my risk IS different from your calculator…but in this instance, I might not be wrong!''*

Furthermore, there are elements of perception within the actual risk assessment tool. While questions from the Diabetes New Zealand ‘Are you at risk?’ tool have been slightly adapted in this study to reduce these perceptions, such as providing a quantifiable measure in the form of BMI for height and weight (section 3 of Appendix 3) as well as add quantifiers to some of the lifestyle (diet and exercise) questions (section 3 of Appendix 3), it is difficult to eradicate all perception.

5.3.2 Sample

The sample of participants were drawn from a Massey University research database, which consisted of people who had previously volunteered to participate in research projects. This database of participants is more likely to be a more health-aware sample of people, compared to the general population due to their previous experience and interest in volunteering for research. The health-information and the experiences (ie having anthropometric evaluations or blood analysis done) they would have been exposed to would most likely increase their health-awareness and knowledge as a result of volunteering.

The participant sample in the current study was heavily weighted female, of a New Zealand European ethnicity, with 91% of participants from the Auckland region. Therefore extrapolating findings from this study would not be appropriate to the general population of New Zealand because T2DM is more prevalent in males than females (Joshy et al., 2009) and it is also over-represented in Māori and Pacific Island peoples (Jowitt, 2014).

Additionally, there was a large difference between the number of participants in the low and high perceived risk groups. Therefore, caution should be used when interpreting the results. This is because it reduces the power of the statistical tests and therefore the strength of significant associations observed. Although similar differences have been observed in other studies; Guess et al (2015) reported 95% (55/58) participants with a low or moderate perceived risk and 5% (3/58) participants with a high perceived risk. A similar observation was also reported in Joiner et al (2016) where only 31% of participants (n=135) reported a moderate/high perceived risk.

5.3.2.1 Ethnicity

The most significant limitation of this study was the lack of ethnic diversity of participants. Particularly because rates of both doctor diagnosed and undiagnosed T2DM in New Zealand are overrepresented in Pacific Peoples (15.4%) and Màori (9.6%) compared with New Zealand Europeans (6.1%) (Coppell et al., 2013). Furthermore, the burden of disease not only affects these ethnic groups disproportionality, they are also living with the disease earlier in life, with increasing incidence of T2DM now seen in children under 15 years according to a recent prospective Auckland study (Sjardin et al., 2018).

5.4 Future direction and opportunities

This study identified factors that influence an individual's risk perception of developing T2DM. However more research is needed in the form of larger studies of perceived versus actual risk with a more heterogenous cohort of participants that would allow for examination of ethnicity differences in risk perception. Further research with larger cohorts would allow for extrapolation and identification of influences that would enable people to understand risk and make more informed decisions for implementing change.

If the current global pandemic crisis of COVID-19 has taught us anything, it is how fortunate we are to live in an era of modern technology. The sudden increase in demand for telehealth services and remote clinical consults is an example of such fortune. However, it also offers us an opportunity to consider this technology as a tool for prediabetes and T2DM management in the long-term. Consider a government-led initiative that funds telehealth services, patient portals coupled with automated and targeted healthcare information to high risk individuals. Such a concept would reduce barriers to healthcare services as well as allow high risk individuals to receive information relevant to them, in a stepwise and targeted manner. While further research is need in this area, maximising technology to optimise patient health outcomes is a welcomed target priority in the recent 5-year strategic plan for people at high risk or living with T2DM (Ministry of Health, 2015).

5.5 Conclusion

To date, this is the first study that has demonstrated perceived risk of developing T2DM significantly underestimated actual risk in a cohort of 257 participants from a New Zealand population. These findings are supported by the current literature (Guess et al., 2015; Heidemann et al., 2019; Joiner et al., 2016; Kowall et al., 2017). Significant factors that were associated with a higher perceived risk include: increased GP-recommended tests for diabetes/CVD, increased GP-communication about diabetes/CVD risk, diagnosis of prediabetes and an increased BMI. Whilst insulin resistance and BMI have been well established in the literature for their association with increased risk perception (Claassen et al., 2011; Kowall et al., 2017), the role of GP-based communication around risk of developing T2DM has not. While further studies are needed to corroborate these findings, it does offer an opportunity to consider how current T2DM risk communication in New Zealand primary care settings impacts on patient perception of risk in T2DM development.

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Appendices

Appendix 1 – Participant Information Sheet (& consent)

Appendix 2 – Email advertisement

Appendix 3 – Perception v Risk of developing T2DM questionnaire (includes screening questionnaire)

Appendix 4 – Diabetes New Zealand 'Are you at risk?' calculator

Appendix 5 – Scoring for the RPS–DD

Appendix 6 – Risk Perception & Lifestyle Modification – Diabetes Development (RPLM–DD) (Kim et al 2007).

Appendix 1 – Participant Information Sheet (& consent)

Study title:
The PART 2DD Study –Perceived vs Actual Risk of Type 2 Diabetes Development in a New Zealand Population.

Ethics committee ref: NOR 19/13

Locality: **Online questionnaire**

Lead investigator: **Associate Professor Pamela von Hurst**

Contact: **+64 (09) 414 0800 ext. 43657**

My name is Libby Evans and I am a Masters' student at Massey University. As part of my Masters' requirements I am investigating the perceived versus actual risk of developing type 2 diabetes in a New Zealand population.

In order to gather this information I have developed an online questionnaire that I would like to invite you to take part in. Whether or not you take part is your choice.

This Participant Information Sheet will help you decide if you'd like to take part in this online questionnaire. It sets out why this study is being done, what your participation would involve, what the benefits and risks to you might be, and what would happen after the study ends. You do not have to decide today whether or not you will participate in this study. Before you decide you may want to talk about the study with other people, such as family, whānau, friends, or healthcare providers. Feel free to do this.

By clicking 'submit' at the end of the questionnaire you will be consenting to participating in the research project.

WHAT IS THE PURPOSE OF THE STUDY?

Recent research estimates the current rate of type 2 diabetes in New Zealand to be 6.5%. This means approximately 210,000 New Zealand adults have type 2 diabetes (NZ Health Survey 2015/16, MOH 2016). However, rates for pre–diabetes (also known as high blood sugar) are estimated at a much higher rate of approximately 26% (Coppell et al, 2013).

Diabetes can result in long lasting health complications such as kidney disease, blindness and amputations. The importance of being able to prevent the development of type 2 diabetes is important. An individuals' awareness of their risk for the development of diabetes is essential for them to be able to make changes in their lifestyle, which is the first step in treating the disease.

However, a number of studies that have investigated the relationship between an individual's actual risk of diabetes development and their perceived risk have shown an underestimation of actual disease risk.

To date no study has investigated this relationship in a New Zealand population. This study will investigate such a relationship. As well as offer insight into the development of lifestyle and behaviour interventions which could provide a more targeted approach around increasing awareness and knowledge of the disease in an aim to foster behaviour and lifestyle change in a New Zealand population.

It is important to note:

Type 1 and type 2 diabetes are very different conditions. Type 2 diabetes is the most common type of diabetes, and usually occurs in adulthood (but can usually be prevented by following a healthy lifestyle)[1]. Unlike type 1 diabetes, which is an autoimmune disease, usually occurring in children, and it cannot be prevented).[2]

What will my participation in the study involve?

We have chosen to study adults over the age of 18 years, who are residents or citizens of New Zealand and who are **not** currently pregnant.

The online questionnaire is approximately 10 minutes in length. It is completely anonymous.

At the end of the questionnaire you will be able to calculate your risk score of developing type 2 diabetes based on your answers given in the questionnaire. There will also be information provided about your risk score and what it means for you.

To be eligible for the online questionnaire you must be:

- A New Zealand citizen or resident
- Over the age of 18 years.
- Not currently pregnant
- No previous doctor diagnosis of diabetes (type 1 or 2)
- Be able to read and understand English

What are the possible benefits and risks of this study?

Foreseeable risks, adverse–effects and discomforts that you may encounter by taking part in this study are minimal. Based on your answers to the online questionnaire, you will be provided with a risk assessment score of your risk for diabetes development, which could result in negative emotions if your risk score puts you at a higher risk for development of type 2 diabetes or if you find you have a higher weight range classification that you thought. Information on your risk score and what you can do about your risk score will be provided at the end of the questionnaire.

Direct benefits of participating in this study include; an increased awareness and knowledge of the processes involved in research by actively participating in it. Additionally, you will be provided with a risk assessment score for your risk of diabetes development, as well as a relevant recommendation based on your risk assessment score.

What are my rights?

Participating in this study is completely voluntary and you are free to decline to participate, or to withdraw from the research at any practicable time, without experiencing any disadvantage.

WHAT HAPPENS AFTER THE STUDY OR IF I CHANGE MY MIND?

The anonymous data from the questionnaire will be collected through an online survey platform that only Massey University researchers are able access via login and password details. The data will then be stored at a secure location with the research team.

Electronic data and records will be the responsibility of the Principal investigator. All data will be kept for 5 years, at which point it will be destroyed.

All answers in the questionnaire will be saved up to the point of withdrawing, and any data previously entered will be deleted prior to analysis, manually by the research team.

The results of this study will be published as a Masters' thesis and a copy will be held by Massey University, available through the Massey University library. Publication in a peer–reviewed journal will also be considered.

As this survey is anonymous, you are unable to withdraw from the study after you have submitted it.

WHO DO I CONTACT FOR MORE INFORMATION OR IF I HAVE CONCERNS?

If you have any questions, concerns or complaints about the study at any stage, you can contact:

Dr. Pamela von Hurst: Associate Professor, School of Sport, Exercise & Nutrition, Albany

Phone: +64 (09) 414 0800 ext. 43657

Email: P.R.vonHurst@massey.ac.nz

Libby Evans: Masters Student, School of Sport, Exercise & Nutrition, Albany

Email:libby.evans2012@gmail.com

This project has been reviewed and approved by the Massey University Human Ethics Committee: Northern, Application NOR 19/13.

If you have any concerns about the conduct of this research, please contact Associate Professor David Tappin (Committee Chair), Massey University Human Ethics Committee: Northern, email humanethicsnorth@massey.ac.nz

If you want to talk to someone who isn't involved with the study, you can contact an independent health and disability advocate on:

Phone: 0800 555 050
Fax: 0800 2 SUPPORT (0800 2787 7678)
Email: advocacy@hdc.org.nz

References:

1. Diabetes New Zealand. (n.d). *Understanding type 2 diabetes*. Retrieved on 8th May 2019 from https://www.diabetes.org.nz/understand–type–2–diabetes
2. Diabetes New Zealand. (n.d). *Understanding type 1 diabetes.* Retrieved on 8th May 2019 from https://www.diabetes.org.nz/type1diabetes

Appendix 2 – Email advertisement

Hi,

Would you like to know what your risk for developing type 2 diabetes is?

The School of Sport, Exercise and Nutrition at Massey University is conducting a study, via an online questionnaire, to look at the perception versus actual risk of developing type 2 diabetes.

The purpose of this questionnaire is to investigate the perceptions people have about type 2 diabetes as well as calculating their actual risk of developing the disease.

Approximately 210,000 New Zealand adults have type 2 diabetes and rates for pre–diabetes (also known as high blood sugar) are estimated to be much higher. Diabetes can result in long lasting health complications such as kidney disease, blindness and amputations. An individuals' awareness of their diabetes risk is essential to be able to make changes in their lifestyle to help reduce their risk of developing the disease.

The study involves a **short 10–minute online questionnaire**.

The questionnaire is open to anyone who:

- Is a New Zealand citizen or resident
- Does NOT currently have a diagnosis of type 1 or 2 diabetes
- Is over the age of 18 years
- Is NOT currently pregnant

Benefits in participating in the questionnaire include:

- Obtaining your own personal risk score of developing type 2 diabetes, as well as information about your risk score.
- You will be contributing to valuable research, with results of the research available on the below website early next year.

For more information on the study, please see the attached Participant Information Sheet

Appendix 3 – Perceived v Actual risk of developing T2DM questionnaire

Perceived risk versus actual risk of developing type 2 diabetes

Start of Block: Introduction and screening

Thank you for taking the time to complete this anonymous questionnaire. It will take approximately 10 minutes.

The purpose of this questionnaire is to investigate the perceptions people have about type 2 diabetes as well as their actual risk of developing the disease.

Approximately 210,000 New Zealand adults have type 2 diabetes and rates for prediabetes (also known as high blood sugar) are estimated to be much higher. Type 2 diabetes can result in long lasting health complications such as kidney disease, blindness and amputations. An individuals' awareness of their diabetes risk is essential to be able to make changes in their lifestyle.

This questionnaire will calculate your actual risk of developing type 2 diabetes. Information about your risk score will be provided, and what you can do if you have a high risk score.

Please answer either YES or NO to the following screening questions to see if you meet the requirements to participate in this study.

By clicking 'submit' at the end of this questionnaire, you consent to participating in this research, and we thank you for your valuable time and contribution to this research project.

Do you currently have a diagnosis of diabetes (either type 1 or type 2)?

- Yes
- No

Are you currently pregnant?

- Yes
- No

Are you under 18 years of age?

- Yes
- No

Are you a New Zealand citizen or resident?

- Yes
- No

End of Block: Introduction and screening

Start of Block: Section 1 – Health & Demographic Questions

Q1 How old are you?

- ◯ 18 – 24 years
- ◯ 25 – 34 years
- ◯ 35 – 44 years
- ◯ 45 – 54 years
- ◯ Over 55 years

Q2 What is your current weight (kg)?

____

Q3 What is your current height (cm)?

____

Q4 What is your gender?

- ◯ Male
- ◯ Female
- ◯ Other

Q5 What is your ethnicity?

- ◯ New Zealand European
- ◯ Māori
- ◯ Pacific Island
- ◯ Asian
- ◯ Prefer not to answer
- ◯ Other, please specify ____

Q6 What town or city do you live in?

____

Q7 What is the highest education level you have achieved?

- ◯ High school qualification
- ◯ Certificate
- ◯ Diploma
- ◯ Bachelors degree
- ◯ Post graduate qualifications (such as a Masters or PhD)
- ◯ Other, please specify ____

Q8 Have you ever been diagnosed with prediabetes or insulin resistance (high blood sugars)?

- Yes
- I don' know
- No

Q9 Have you been diagnosed with gestational diabetes (diabetes that occurs during pregnancy)?

- Yes
- I don't know
- No
- Not applicable

Q10 How often would you visit your GP or healthcare provider for a medical appointment?

- Often (more than once a month)
- Occasionally (once every 3 – 6 months
- Once a year
- Less than once a year
- Never

Q11 When you visit your GP or healthcare provider, have they suggested doing a check–up for heart disease or diabetes (such as doing blood tests to test your sugar or cholesterol levels, or by measuring your blood pressure or weight)?

- ◯ Yes
- ◯ No
- ◯ I don't know

Q12 Does your doctor ever talk to you about the risks of heart disease and/or diabetes?

- ◯ Yes
- ◯ No
- ◯ I don't know
- ◯ Not applicable

Page Break

End of Block: Section 1 – Health & Demographic Questions

Start of Block: Perception of Risk

Section 2: The next set of questions ask about what you think your risk or chance of getting diabetes is (Qu 13 – 16 based on the RPS–DD survey by Walker et al, 2003 (Revised 2009) ©E.A Walker 2009; (Qu 17 – 19 based on Risk Perception & Lifestyle modification (RPLM–DD) Kim et al, 2007)

Q13 For EACH of the following statements, please select ONE option that best reflects your opinion

	Strongly Agree	Agree	Disagree	Strongly Disagree
I feel that I have little control over risks to my health	○	○	○	○
If I am going to get diabetes, there is not much I can do about it.	○	○	○	○
I think that my personal efforts will help control my risks of getting diabetes.	○	○	○	○
People who make a good effort to control the risks of getting diabetes are much less likely to get diabetes.	○	○	○	○
Compared to other men or women of my same age, I am less likely than they are to get diabetes.	○	○	○	○
Compared to other men or women of my same age, I am less likely than they are to get a serious disease.	○	○	○	○

Q14 Considering EACH of the following diseases, please rank how at risk you believe you are for developing each of these conditions, where 1 = almost no risk and 4 = high risk

	1 (almost no risk)	2 (slight risk)	3 (moderate risk)	4 (high risk)
Heart disease	○	○	○	○
High blood pressure	○	○	○	○
Arthritis	○	○	○	○
Cancer	○	○	○	○
Diabetes	○	○	○	○
Stroke	○	○	○	○
Hearing loss	○	○	○	○
Infections requiring medical treatment	○	○	○	○
Blindness	○	○	○	○
Osteoporosis	○	○	○	○
Asthma	○	○	○	○
Kidney failure	○	○	○	○
Foot amputation	○	○	○	○
AIDS	○	○	○	○

Q15 Considering the following environmental risks, please rank how at risk you believe you are to injury/death as a result of:

	1 (almost no risk)	2 (slight risk)	3 (moderate risk)	4 (high risk)
Driving or riding in a vehicle	○	○	○	○
Being exposed to air pollution	○	○	○	○
Being involved in violent crimes	○	○	○	○
Exposure to pesticides	○	○	○	○
Exposure to extreme weather conditions	○	○	○	○
Exposure to household chemicals	○	○	○	○
Exposure to secondary smoke	○	○	○	○
Being exposed to medical x–rays or radiation	○	○	○	○
Consuming illegal drugs	○	○	○	○

Q16 We would like you to **think about people in the general public** and NOT about your own personal risk of getting diabetes. Which statement most closely reflects your view of how each item affects their risk for diabetes? (ie for EACH of the following statements, please tick ONE option which best reflects your opinion).

	Increases or raises the risk	Has NO effect on risk	Decreases or lowers the risk	Don't Know
Being Asian	○	○	○	○
Being Caucasian (white)	○	○	○	○
Eating a healthy diet	○	○	○	○
Being Māori	○	○	○	○
Being of Pacific Peoples	○	○	○	○
Having had diabetes during pregnancy	○	○	○	○
Having a family history of diabetes	○	○	○	○
Being 65 years of age or older	○	○	○	○
Exercising regularly	○	○	○	○
Controlling weight gain	○	○	○	○

Q17 For each statement below, please tick the option which best reflects your opinion about possible ways to prevent diabetes:

	Strongly Agree	Agree	Neither agree or disagree	Disagree	Strongly disagree
Doing regular exercise and following a diet take a lot of effort	○	○	○	○	○
Regular exercise and diet may prevent diabetes from developing	○	○	○	○	○
Benefits of following a diet and exercise programme outweigh the effort to do it	○	○	○	○	○

Q18 What do you think your risk or chance is for getting diabetes over the next 10 years? Please select one option

○ Almost no chance

○ Slight chance

○ Moderate chance

○ High chance

Q19 Are you planning to make changes in any lifestyle behaviours (such as diet or exercise) in the near future that you believe will lower your chances of getting diabetes?

○ Yes

○ No

Page Break

Start of Block: Actual Risk

Section 3: Please answer each question in this section. This section will determine your Actual Risk Score for developing type 2 diabetes (Based on the Diabetes New Zealand ''Are you at risk?" calculator)

Q20 I do very little physical activity (ie less than 2.5 hours per week)

- ◯ Yes
- ◯ No

Page Break

Q21 I often (ie most days of the week) eat foods that are high in fat and sugar?

○ Yes points

○ No points

Page Break

Q22 There has been type 2 diabetes in my family? (type 2 diabetes is the most common type of diabetes, most often seen in adulthood and it is usually affected by lifestyle choices such as exercise and diet)

- ◯ Yes
- ◯ No

Page Break

Q23 I am of Māori, Pacific Island, South Asian or Middle Eastern decent?

◯ Yes

◯ No

Page Break

Q24 I have given birth to a baby weighing more than 9 pounds (4 kg) or I have had high blood sugars in pregnancy.

- ○ Yes
- ○ No
- ○ Not applicable

Page Break

Q25 I am between 35 yrs and 64 yrs of age.

- ◯ Yes =
- ◯ No =

Page Break

Q26 I am 65 years or older.

- ○ Yes =
- ○ No =

Page Break

Q27 Is your BMI (body mass index) over 25? To work out your BMI, please click here

◯ Yes

◯ No

Page Break

End of Block: Section 3 – Actual risk of type 2 diabetes development (www.diabetes.org.nz)

Start of Block: Block 7

Your Actual Risk Score is : **$(gr://SC_42BrWXg8ovsczEp/Score)**

Please click the 'submit' button to find out what your score means.

A score of between 3 and 5: You are at low risk for having type 2 diabetes now, however you may be at an increased risk in the future.

A score of greater than 5: You are at an increased risk for having or developing type 2 diabetes now. Only your doctor can confirm a diagnosis of type 2 diabetes. It is recommended that you contact your local GP for further information and advice.

If you have an increased risk for developing type 2 diabetes, rest assured there are lifestyle changes you can make to help reduce your risk.

To try and avoid type 2 diabetes developing, make the following changes as recommended by Diabetes New Zealand:

Stay physically active and get regular exercise. Aim for at least 30 minutes of moderate physical activity each day. Brisk walking, swimming, cycling, Marae activities, dancing and mowing the lawns all count. Remember you don't have to do all of your daily exercise at once. For example, three brisk walks for 10 minutes in the day may be more manageable than one of 30 minutes. Eat healthy food. Keep your weight in a healthy range.

(Sourced directly from Diabetes New Zealand; https://www.diabetes.org.nz/are–you–at–risk–1)

For more information on **types of healthy foods** as well as **how to manage a healthy weight range**, you can visit Eating and Activity Guidelines for New Zealand Adults

-

If you are still concerned about your risk of developing type 2 diabetes, it is important to speak with your doctor for more information.

Appendix 4 – Diabetes New Zealand “Are you at risk?” calculator

Diabetes New Zealand – ‘Are you at Risk Calculator

(sourced from https://www.diabetes.org.nz/are–you–at–risk)

Find out if you are at risk

I am overweight for my height No Yes

0

I do very little physical activity No Yes

0

I often eat foods high in fat and sugar No Yes

0

There is, or has been diabetes in my family No Yes

0

I’m of Māori, Pacific Island, South Asian or Middle Eastern descent No Yes

0

I have had a baby weighing more than 9lbs (4kg) or high blood glucose during pregnancy No Yes

0

I am between 35 and 64 years of age No Yes

0

I am over 65 years of age No Yes

0

Score 3–5: You have probably at low risk for having type 2 diabetes now. However, you may be at a higher risk in the future.

Score 6 or more: You are at greater risk of having type 2 diabetes. Only your health care provider can determine if you have diabetes. Visit your doctor to find out more.

Your Total

BACK

Appendix 5 – Risk Perception Survey for Developing Diabetes (RPS–DD) Scoring Revised Walker et al, 2009)

Risk Perception Survey-Developing Diabetes (RPS-DD) -- Scoring

SUBSCALE	ITEMS	CODING	ALPHA COEFFICIENT
Personal Control	Average Q1, Q2, **Q3R*, Q4R*** (4 items)	Higher score = more personal control	.68
Worry	Average **Q5R & Q8R** (2 items)	Higher score = more worry (better as individual items)	.50
Optimistic Bias	Average **Q6R & Q7R** (2 items)	Higher score = more optimistic bias	.71
Personal Disease Risk	Likert score plus 1 for either myself *or/and* family member having disease, then averaged across Q9-Q23 (15 items)	Higher score = higher perceived comparative personal disease risk	.80
Comparative Environmental Risk	Average Q24-Q32 (9 items)	Higher score = higher perceived comparative environmental risk	.81
COMPOSITE RISK SCORE	Average **Q1R, Q2R**, Q3, Q4, **Q5R,** Q6, Q7, **Q8R**, Q9-Q32 (32 items)	Higher score = more perceived risk (Some are reversed differently from individual scale scoring)	.84

Diabetes Risk Knowledge – Risk of developing diabetes	Sum of correct responses to Q33-Q43 Correct: Score = 1, Incorrect or Don't Know: Score = 0 (11 items)	High score = more knowledgeable/ more correct answers Correct Answers: 33-1 37-1 41-3 34-2 38-1 42-1 35-3 39-1 43-3 36-1 40-1	Use as descriptor of level of knowledge

***R and bolding on items means scoring is reversed to conform to conceptual direction of subscales.**

E.A.. Walker Revised 2009 *DRTC at the Albert Einstein College of Medicine*

Appendix 5 continued… Risk Perception Survey – Developing Diabetes (RPS–DD)

Revised Walker et al 2009

ATTITUDES ABOUT HEALTH

This survey will provide important information about how people feel about the risk of getting a chronic disease, like diabetes. There are no right or wrong answers. We are interested in *your* opinions and attitudes. Please answer each question as best as you can.

General Attitudes

For each item, please circle the number below the response that BEST DESCRIBES YOUR OPINION.

	Strongly Agree	Agree	Disagree	Strongly disagree
1. I feel that I have little control over risks to my health.	1	2	3	4
2. If I am going to get diabetes, there is not much I can do about it.	1	2	3	4
3. I think that my personal efforts will help control my risks of getting diabetes.	1	2	3	4
4. People who make a good effort to control the risks of getting diabetes are much less likely to get diabetes.	1	2	3	4
5. I worry about getting diabetes.	1	2	3	4
6. Compared to other people of my same age and sex (gender), I am *less* likely than they are to get diabetes.	1	2	3	4
7. Compared to other people of my same age and sex (gender), I am *less* likely than they are to get a serious disease.	1	2	3	4
8. Worrying about getting diabetes is very upsetting.	1	2	3	4

Your Attitudes about Health Risks

Below is a list of health problems and diseases. For each one, please circle the number below the words to tell us if you think **your own personal health** is at "almost no risk," "slight risk," "moderate risk" or "high risk" from these problems.

> If you, or a family member, already have the disease (or had the disease in the past), please *also* check (√) the appropriate line on the right.
> ⇓

	Almost No Risk	Slight Risk	Moderate Risk	High Risk	Have(or had) this disease: *myself*	*family member*
9. Arthritis	1	2	3	4	____	____
10. Heart Disease	1	2	3	4	____	____
11. Cancer	1	2	3	4	____	____
12. High blood pressure	1	2	3	4	____	____
13. Hearing loss	1	2	3	4	____	____
14. Asthma	1	2	3	4	____	____
15. Diabetes	1	2	3	4	____	____
16. Osteoporosis (bone disease)	1	2	3	4	____	____
17. Stroke	1	2	3	4	____	____
18. Blindness	1	2	3	4	____	____
19. Foot amputation	1	2	3	4	____	____
20. Infections needing treatment by a doctor	1	2	3	4	____	____
21. Impotence (only in men)	1	2	3	4	____	____
22. Kidney failure	1	2	3	4	____	____
23. AIDS	1	2	3	4	____	____

Environmental Health Risks

Below is a list of possible hazards or dangerous conditions in the environment around most of us.

For each one, please circle the number below the words to tell us if your **own personal health** is at "almost no risk," "slight risk," "moderate risk" or "high risk" from each of the following hazards or conditions.

	Almost No Risk	**Slight Risk**	**Moderate Risk**	**High Risk**
24. Medical X-rays (radiation)	1	2	3	4
25. Violent crime	1	2	3	4
26. Extreme weather (hot or cold)	1	2	3	4
27. Driving/riding in an automobile	1	2	3	4
28. "Street" drugs (illegal drugs)	1	2	3	4
29. Air pollution	1	2	3	4
30. Pesticides	1	2	3	4
31. Household chemicals	1	2	3	4
32. Cigarette smoke from people smoking around you	1	2	3	4

Risks of Getting Diabetes for People in the General Public

We would like you to **think about people in the general public** and NOT about your own personal risk of getting diabetes.

Circle the number below the words that best describe your opinion about whether each item listed below *increases (or raises) the risk* of someone getting diabetes, *has no effect on the risk*, or *decreases (or lowers) the risk* of someone getting diabetes.

	Increases the risk	**Has NO effect on risk**	**Decreases the risk**	**Don't Know**
33. Being Asian American	1	2	3	0
34. Being Caucasian (White)	1	2	3	0
35. Eating a healthy diet	1	2	3	0
36. Being Black or African-American	1	2	3	0
37. Being Hispanic	1	2	3	0
38. Having had diabetes during pregnancy	1	2	3	0
39. Having a blood relative with diabetes	1	2	3	0
40. Being 65 years of age or older	1	2	3	0
41. Exercising regularly	1	2	3	0
42. Being American Indian	1	2	3	0
43. Controlling weight gain	1	2	3	0

Thanks!

Appendix 6 – Risk Perception & Lifestyle Modification – Diabetes Development (RPLM–DD) (Kim et al 2007)

25. For each item below, let us know the response that BEST DESCRIBES YOUR OPINION about possible ways to prevent diabetes.	Strongly	Agree	Neither Agree or Disagree	Disagree	Strongly Disagree
A. Doing regular exercise and following a diet take a lot of effort.	1☐	2☐	3☐	4☐	6☐
B. Regular exercise and diet may prevent diabetes from developing.	1☐	2☐	3☐	4☐	6☐
C. Benefits of following a diet and exercise program outweigh the effort to do it.	1☐	2☐	3☐	4☐	6☐

26. What do you think your risk or chance is for getting diabetes over the next 10 years?

1☐ Almost no chance
2☐ Slight chance
3☐ Moderate chance
4☐ High chance

27. If you don't change your lifestyle behaviors, such as diet or exercise, what is your risk or chance of getting diabetes over the next 10 years?

1☐ Almost no chance
2☐ Slight chance
3☐ Moderate chance
4☐ High chance