ORIGINAL RESEARCH PAPER

ORIGINAL RESEARCH: HEALTH SERVICES

The Royal New Zealand College of General Practitioners
Te Whare Tohu Rata o Aotearoa

The epidemiology of diabetes in the Waikato region: an analysis of primary care data

Lynne Chepulis BSc, MSc, MPhil, PhD;[1,3] Brittany Morison BAppSc, MSc;[1] Rawiri Keenan MBChB, FRNZCGP;[1] Ryan Paul BHB, MBChB, FRACP, PhD;[1,2] Chunhuan Lao PhD;[1] Ross Lawrenson MBBS, MD, FAFPHM, FFPH, FRCGP[1,2]

[1] Medical Research Centre, University of Waikato, Hamilton, New Zealand
[2] Waikato District Health Board, Hamilton, New Zealand
[3] Corresponding author. Email: lynnec@waikato.ac.znz

J PRIM HEALTH CARE
2021;13(1):44–54.
doi:10.1071/HC20067
Received 7 July 2020
Accepted 1 March 2021
Published 31 March 2021

ABSTRACT

INTRODUCTION: Diabetes mellitus is common in primary care, yet little has been reported of its primary care prevalence or the clinical characteristics of patients with Type 2 diabetes mellitus (T2DM).

AIM: To determine the prevalence of diabetes mellitus and clinical characteristics of diabetes patients in primary care in the Waikato region.

METHODS: Primary care data were extracted from the electronic records of 15 general practices for patients aged >20 years with current diabetes mellitus at 20 June 2017. Diabetes mellitus was defined as having a glycated haemoglobin (HbA1c) of ≥50 mmol/mol (6.7%) or having being dispensed two or more anti-diabetic medications in the previous 12 months. Additional data collected included patients' ethnicity, age, sex and years since diagnosis.

RESULTS: The overall prevalence of diabetes mellitus was 5.7% and was higher for Māori (8.6%), Asian (7.0%) and Pacific peoples (9.1%) than Europeans (5.0%; all $P < 0.001$). For patients with T2DM for whom current diabetes annual review data were available ($n = 2227$) the mean body mass index (BMI) was 32.8 ± 0.2 kg/m^2, but BMI was higher in Māori, younger patients, females and patients diagnosed <2 years previously (all $P < 0.001$). Similarly, HbA1c levels were highest in Māori and younger patients (both $P < 0.001$), with 40% of patients overall having a HbA1c of ≤53 mmol/mol (7.0%). Approximately 70% of all patients had at least one measure of hypertension (systolic ≥130 or diastolic ≥80 mmHg), or dyslipidaemia. More than 85% of patients had completed a recent retinal screen and foot check.

DISCUSSION: We found that management of T2DM was suboptimal, with measures for many patients not meeting clinical targets. Support should be provided to improve weight and glycaemic management, particularly for Māori, females and younger patients.

KEYWORDS: type 2 diabetes mellitus; diabetes management; clinical characteristics; prevalence; hypertension; BMI

Introduction

In New Zealand, at least one-quarter of a million people are estimated to be diagnosed with diabetes. Most of these (~90%) have Type 2 diabetes mellitus (T2DM), which is often associated with metabolic syndrome, with most of the remainder being diagnosed with Type 1 diabetes mellitus (T1DM), an autoimmune disorder.[1] Patterns of diagnosis differ for T1DM and T2DM. T1DM is often diagnosed early in childhood and adolescence, and patients are nearly always symptomatic at the time of diagnosis.[2] In contrast, T2DM tends to be diagnosed later in life

and is often associated with obesity.[3] In New Zealand, T2DM is often detected as a result of cardiovascular risk screening rather than presentation of symptoms,[4] and the disease affects proportionately more Māori, Pasifika and Asian people.[3,5]

T2DM is mainly managed in primary care, and general practice health professionals are expected to assess patients at least annually using the Diabetes Annual Review.[6] This includes measurement of glycaemic control (eg glycated haemoglobin; HbA1c) and other clinical measures such as blood pressure, lipids, urinary albumin:creatinine ratio, neurovascular examination of the feet and body mass index (BMI). However, uptake of the Diabetes Annual Review by patients appears to be limited (often due to them not visiting their GP), with unpublished data indicating that up to 50% of patients with diabetes do not commence or complete a Diabetes Annual Review in any given year. Therefore, many patients may not have their T2DM appropriately managed, resulting in poor glycaemic control and poorer health outcomes.

In New Zealand, there is no comprehensive reporting on diabetes prevalence and management. Estimated diabetes prevalence is reported annually from the Virtual Diabetes Register,[7] although these reports are derived from aggregated health data and do not include people who do not engage with the health-care system. In addition, internal reports are routinely provided to primary health-care organisations and general practices, but these data are generally not published more widely.

A small number of studies have reported on the prevalence of diabetes mellitus in New Zealand; though these are more than 10 years old and only one was specific to the Waikato region.[3,8–10] More recently, a large national study reported on the prevalence of diabetes mellitus among patients who had completed a cardiovascular risk assessment, though these data were pooled for the time period 2004–16.[5] Further, while the characteristics of Waikato patients with T1DM have been recently described,[11,12] less is known about the clinical characteristics of patients with T2DM in this region. One study from 2008 found that three-quarters of diabetes patients had a HbA1c of ≤8% (64 mmol/mol), and reduced glycaemic control was more likely in males, Māori, Asian and people diagnosed >five years previously.[10] Diabetic foot disease has also been reported to be prevalent in the Waikato region,[13] but there are no recent data on the number of patients attending retinal screening or who meet clinical targets set by the guidelines for risk of diabetes complications in the New Zealand primary care handbook.[14] Therefore, this study aimed to provide a recent snapshot of diabetes in primary care in the Waikato region, including prevalence and clinical characteristics of patients.

WHAT GAP THIS FILLS

What is already known: The prevalence of diabetes mellitus in New Zealand is increasing, resulting in increasing disparity between people of Māori and non-Māori ethnicity. Management of T2DM in primary care is complex, depending on patient and health system factors.

What this study adds: The overall prevalence of diabetes mellitus in primary care in the Waikato region was 5.7%, higher than the 4.7% reported in 2008. Most patients with T2DM were not meeting multiple clinical target measures, suggesting improved management may be required.

Methods

Data collection

We conducted a cross-sectional study using data from 15 general practices across the Waikato region. Demographic and clinical data were collected directly from the electronic health records (patient management systems (Medtech32®)) for all enrolled patients aged >20 years who had a recorded diagnosis of diabetes mellitus at 30 June 2017. Patients were then included for analysis if they had 'current' diabetes between 1 July 2016 and 30 June 2017. This included if their most recent HbA1c (with the previous 12 months) was ≥50 mmol/mol (6.7%) or if they had received antidiabetic medication (two or more dispensed prescriptions of oral hypoglycaemic agents or insulin) during this time. To determine the latter, individual patient (National Health Index (NHI))-linked medication data were obtained from the National Pharmaceutical Collection. The Pharmaceutical dataset contains all publicly funded pharmaceutical dispensing information including date of dispensing, quantity dispensed and chemical or

brand name. The rural or urban status of each practice was also recorded.[15]

Full data collected for this cohort of patients with diabetes included patient age, gender, ethnicity, year of diagnosis, type of diabetes (T1DM or T2DM) and whether they had an active online Health Portal account (yes or no). Ethnicity was coded directly from the primary care records, and this was grouped as European (including New Zealand European; NZE), Māori, Asian, Pacific (including Cook Island Māori) and Others. Where year of diagnosis or type of diabetes was missing in the primary care records, this information was retrieved from the Waikato District Health Board (DHB) records using patients' NHI codes. Patients for whom the exact year of diabetes diagnosis could not be ascertained, although clinical records indicated that diagnosis was >two years previously, were coded as 'unknown' for year of diagnosis but retained in the dataset. In addition, the full count of enrolled patients at each general practice was recorded, and collectively, these data were used to calculate diabetes prevalence (see analysis section below).

The most recent clinical measurements (weight, height, most recent HbA1c, blood pressure, urinary albumin:creatinine ratio, serum lipid studies, smoking status, foot check risk assessment (low, medium, high, or urgent) and retinal screening in the past two years (yes or no) were then collected for patients with T2DM who had completed the 2017 Diabetes Annual Review. For this subset of patients, the clinical data were collected from 1 July 2017 to 30 June 2018 (the 2017 Diabetes Annual Review year), whereas retinal screening data were collected from 1 July 2016 to 30 June 2018 to allow for the fact that this is required only once every two years. Patients with T1DM were excluded as their care is often managed in secondary care and there were large gaps in the primary care data available for these patients.

Ethical approval for this study was granted by the New Zealand Health and Disability Ethics Committee (Reference 19/CEN/8).

Analysis

Diabetes prevalence data were described for all patients with current diabetes (including both T1DM and T2DM) by ethnicity and age (in 10-year increments) using the number of patients with diabetes as the numerator and the total primary care enrolled population (diabetes and non-diabetes) as the denominator ($n = 67{,}971$).

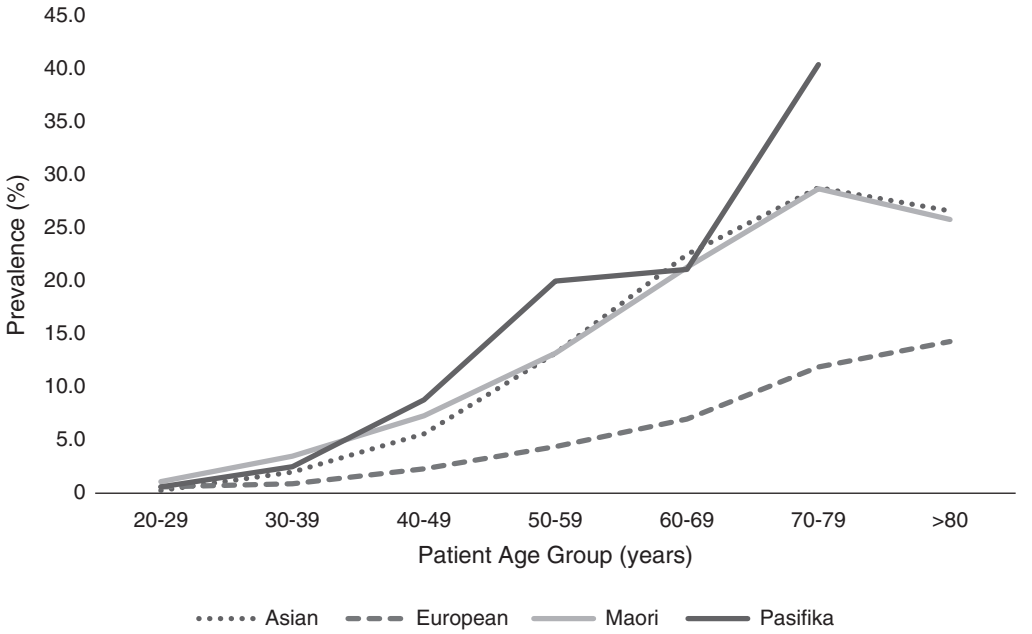
Patients' BMI and the proportion of patients meeting clinical targets for low risk of diabetes complications (HbA1c, lipids, albumin:creatinine ratio, blood pressure, retinal screening, smoking status and foot checks) were then reported for patients with T2DM who had participated in the 2017 Diabetes Annual Review. The clinical targets used were defined by the 2012 New Zealand primary care handbook.[14] BMI was reported as mean ± standard error (SE), and the proportion of patients who were normal weight, overweight or obese were calculated based on the World Health Organization classifications.[16] HbA1c levels were reviewed using two clinical cut-off points: 53 mmol/mol (7%), which is the currently recognised threshold for good glycaemic control,[17,18] and 64 mmol/mol (8%), which was the previous target used by the Ministry of Health[19] and the target reported in the previous Waikato diabetes study.[10]

Clinical outcomes were analysed in this subgroup of patients by ethnicity, age group (20–39, 40–59 and ≥60 years), gender and years since diabetes diagnosis (<2, 2–5, 6–10 and >10 years), as described by Lawrenson *et al.*,[10] but with inclusion of additional groups for duration of diabetes. For this subanalysis, Pacific patients were incorporated into the 'Others' category of ethnicity because there were too few patients in the sample to justify a separate group. Chi-square and analysis of variance (ANOVA) tests (with Bonferroni post-hoc analysis) were used to compare these outcomes, and logistic regression was used to determine the factors contributing to poor glycaemic control and high blood pressure, total cholesterol or urinary albumin:creatinine ratio. Significance was accepted at a level of $P < 0.05$. All data analyses were performed with SPSS version 25 (SPSS Inc.).

Results

A total of 3886 patients with diabetes (T1DM and T2DM) were identified from a combined enrolled population of 68,509, giving an overall diabetes prevalence in patients aged >20 years of 5.7%. This

Figure 1. Age-specific prevalence of diabetes (T1D and T2D combined) for European (n = 51,608), Māori (n = 10,236), Asian (n = 4295) and Pasifika (n = 1159). Numbers in brackets are the number of all enrolled patients in the 15 Waikato practices (diabetes and non-diabetes).



included 303 patients with T1DM (0.4%) and 3583 with T2DM (5.2%). Diabetes prevalence differed by age and ethnicity, and was lower in European people than in other ethnic groups ($P < 0.001$). By ethnicity (with total number of enrolled patients with and without diabetes) the prevalence of diabetes was 5.0% of European ($n = 51,608$), 8.6% of Māori ($n = 10,236$), 7.0% of Asian ($n = 4295$), 9.1% of Pacific ($n = 1159$); and 4.8% of 'Others' ($n = 673$). The age-specific prevalence of diabetes for European, Māori, Asian and Pacific patients is shown in Figure 1.

A total of 2227 patients with T2DM were included for review of their diabetes characteristics. Of these, 1693 of 2156 (78.5%) were enrolled users of the practice's online portal (with a further 71 cases unknown). Portal use was not significantly different by ethnicity, gender, or years since diagnosis, but was higher in patients aged ≥60 years (82.9% vs. 60.0% and 69.8% for patients aged 20–39 and 41–59 years, respectively).

BMI and HbA1c characteristics are presented in Table 1. The overall mean BMI was 32.8 ± 0.2 kg/m^2 and was higher in Māori, younger patients, females and patients diagnosed <2 years ago (all $P < 0.001$). More than three-quarters of Māori with T2DM were obese compared with lower proportions of European and Asians. One-quarter of Asian patients had a healthy BMI, compared to <10% of Māori and European patients (all $P < 0.001$; Table 1). The mean BMI and the proportion of obese patients decreased with increasing patient age and with increasing duration of disease (Table 1). The mean HbA1c of all patients was 60.5 ± 0.5 mmol/mol (7.7%). Mean HbA1c levels were highest in Māori, rural and younger patients, but did not differ by gender ($P = 0.469$) or years since diagnosis ($P = 0.165$). One-third of Māori and other patients aged <60 years had a HbA1c of ≤ 53 mmol/mol (the current recommended target),[17] although in European and older patients, less than half met the recommended clinical target. Overall, 68.0% of patients were at or below the previous clinical target of 64 mmol/mol (8.0%) (Table 1).[19]

The proportion of patients meeting other clinical targets (blood pressure, lipids and albumin creatinine ratio) was relatively low (Table 2). Approximately 70% of patients had at least one measure of hypertension (systolic ≥130 or diastolic

Table 1. BMI and HbA1c levels of Waikato patients with T2D for whom 2017 Diabetes Annual Review data were collected (n = 2227)

	BMI (kg/m^2)					HbA1c			
	N (%)	Mean ± s.e.	% of patients within each range*			N (%)	Mean ± s.e.	% of patients	
			18.5–24.9 (normal weight)	25.0 – 29.9 (overweight)	≥ 30.0 (Obese)			≤53† mmol/mol	≤64† mmol/mol
All	2098 (94.2)	32.8 ± 0.2				2191 (98.4)	60.5 ± 0.5	40.8	68.0
Ethnicity									
European	1428 (96.4)	32.6 ± 0.2	9.2	25.8	59.1	1482 (100.0)	58.4 ± 0.4	43.2	71.7
Māori	428 (90.9)	36.4 ± 0.4	2.2	13.8	77.9	447 (94.9)	66.1 ± 1.0	33.1	57.0
Asian	167 (91.3)	28.4 ± 0.5	25.5	34.8	29.9	181 (98.9)	61.4 ± 1.3	44.8	65.2
Others	75 (82.4)	34.9 ± 0.8	6.5	19.5	71.4	81 (89.0)	64.5 ± 2.0	30.3	64.5
P value		*< 0.001*		*< 0.001*			*< 0001*	*< 0.001*	*< 0.001*
Age (years)									
20–39	50 (80.6)	37.7 ± 1.1	3.1	6.3	68.8	61 (98.3)	71.1 ± 3.2	34.4	42.6
41–59	543 (93.0)	35.7 ± 0.4	4.8	18.5	69.6	569 (97.4)	66.7 ± 0.8	28.8	54.5
≥60	1505 (95.2)	32.1 ± 0.2	11.1	26.6	57.5	1561 (98.7)	57.8 ± 0.4	45.5	73.8
P value		*< 0.001*		*< 0.001*			*< 0.001*	*< 0001*	*< 0.001*
Gender									
Male	1092 (95.7)	32.5 ± 0.2	8.8	26.8	58.1	1141 (100.0)	60.7 ± 0.5	40.4	67.6
Female	1006 (92.6)	33.8 ± 0.2	9.6	20.7	64.1	1050 (96.7)	60.2 ± 0.5	41.7	68.3
P value		*< 0.001*		0.005			*0.469*	*0.418*	*0.718*
Rurality									
Rural	885 (95.4%)	33.3 ± 1.2	10.1	25.2	64.3	916 (98.7)	61.0 ± 0.4	39.2	65.1
Urban	1213 (93.4%)	32.9 ± 0.3	9.5	25.4	64.9	1275 (98.2)	57.1 ± 0.4	45.1	67.5
P value		*0.168*		*0.194*			*0.045*	*0.007*	*0.250*
Years since diagnosis									
≤2	128 (94.8)	34.9 ± 0.7	5.4	23.8	69.2	130 (96.3)	60.0 ± 1.4	44.6	73.1
2 – 5	446 (95.1)	34.2 ± 0.4	7.7	21.2	68.5	454 (96.8)	60.4 ± 0.8	44.3	71.8
6 – 10	679 (94.7)	33.1 ± 0.3	9.7	22.5	65.0	689 (96.1)	61.2 ± 0.7	42.7	68.7
≥10	845 (93.3)	32.3 ± 0.2	11.1	28.9	58.5	849 (93.7)	60.4 ± 0.4	36.7	65.1
P value		*< 0.001*		0.011			*0.165*	*0.02*	*0.048*

*BMI as classified according to the World Health Organization.[16]
†53 mmol/mol (7%) is the current HbA1c threshold,[17] whereas 64 mmol/mol (8%) is the previous Ministry of Health target,[19] as reported against by Lawrenson *et al.*[10]

Table 2. Proportion of Waikato patients with 2017 Diabetes Annual Review data who met clinical targets for reducing diabetes-related complications*

	Percent of patients (with measurements) at or below the recommended clinical target[14]								
	Blood pressure (systolic <130 and diastolic <80 mmHg) N %		Lipids				ACR (<2.5 men and <3.5 women)‡	Retinal screen within last 2 years*	Foot check
			N (%)	Total cholesterol (<4 mmol/L)	Triglycerides (<1.8 mmol/L)	LDL (≤2.5 mmol/L)†			
Ethnicity									
European	1451 (97.9)	29.5	1481 (99.9)	35.7	42.1	34.4	66.5	92.4	90.3
Māori	433 (91.9)	25.6	447 (94.9)	30.9	35.7	31.2	45.4	85.1	85.3
Asian	170 (92.9)	35.9	181 (98.9	32.6	47.0	36.8	61.5	86.4	89.1
Others	76 (83.5)	22.4	76 (83.5)	31.6	48.7	32.1	53.3	93.5	89.6
P value		*0.190*		*0.271*	*0.016*	0.690	*<0.001*	*<0.001*	*0.031*
Age (years)									
20–39	53 (85.5)	34.0	61 (98.4)	19.7	23.0	24.3	57.6	71.9	84.4
41–59	556 (95.2)	26.1	569 (97.4)	26.1	34.8	23.4	64.2	88.3	87.1
≥60	1521 (96.2)	29.8	1560 (97.8)	37.8	44.6	38.0	60.4	92.0	90.1
P value		*0.004*		*<0.001*	*< 0.001*	*<0.001*	*0.248*	*<0.001*	*0.07*
Gender									
Male	1114 (97.6)	29.5	1141 (100.0)	43.8	43.2	41.0	54.9	91.0	89.2
Female	1016 (93.6)	28.3	1049 (96.6)	23.9	39.5	26.0	68.4	89.8	89.1
P value		*0.277*		*<0.001*	*0.079*	*<0.001*	*<0.001*	*0.347*	*0.923*
Rurality									
Rural	889 (95.8)	29.1	915 (98.6)	33.4	39.8	32.4	61.0	86.1	86.7
Urban	1212 (95.4)	32.7	1269 (97.7)	30.3	42.5	34.5	65.3	92.0	89.2
P value		*0.077*		*0.124*	*0.206*	*0.440*	*0.041*	*<0.001*	*0.075*
Years since diagnosis									
≤2	128 (94.8)	28.9	130 (96.3)	26.2	38.5	27.8	72.7	98.5	93.1
2 – 5	449 (95.7)	29.8	454 (96.8)	25.8	38.8	24.8	67.3	90.2	89.5
6–10	688 (96.0)	29.4	689 (96.1)	37.1	40.6	35.4	62.1	94.0	87.7
≥10	851 (93.9)	28.7	849 (93.7)	38.5	44.9	38.2	55.7	95.6	90.2
P value		*0.892*		*<0.001*	*0.104*	0.001	*<0.001*	*<0.001*	*0.204*

*The Diabetes Annual Review year covers the period of 1 July 2017–30 June 2018. With the exception of retinal screening, which should be completed once every 2 years, all clinical measures should be completed once during this time period.

†Includes only 1354 LDL measurements (907 NZE, 269 Māori, 125 Asian, 53 Others; 37 aged 20–39, 354 aged 41–59 and 963 aged > 60 years; 707 males and 647 females; 79 < 2, 294 2–5, 426 6–10 and 498 ≥10 years since diagnosis).

‡Includes 2151 ACR measurements (1459 European, 438 Māori, 179 Asian, 75 Others; 59 aged 20–39, 561 aged 41–59, 531 aged >60 years; 1124 males and 1027 females; 899 rural and 1252 urban, 128 <2, 447 2–5, 678 6–10 and 845 ≥10 years since diagnosis.

≥80 mmHg), a total cholesterol of > 4 mmol/L or a low-density lipoprotein (LDL) of >2.5 mmol/L, although there was no difference by ethnicity for the proportion of patients meeting these clinical targets. Younger patients, females and patients with diabetes of shorter duration were less likely to have cholesterol measures within target, and older patients were more likely to have hypertension (Table 2).

More than half of all patients met the gender-specific clinical targets for albumin:creatinine ratio, but this was less likely in Māori, males and patients with diabetes for ≥10 years (Table 2). Further, although most patients (> 85%) had completed a retinal screen within the last two years, the rate of screening was lower in Māori and Asian (compared with European) as well as in younger patients (Table 2).

Māori were also less likely to have completed a foot check within the last year, though this was completed by 89% of patients overall (Table 2). Of patients having a foot check, only five patients required an urgent referral (all European) and a further 45 patients had a moderate foot risk (34 European, 9 Māori, 2 Asian and 4 others).

With logistic regression, obese patients and patients with increasing age were significantly more likely to have a HbA1c of >53 mmol/mol (7.0%), but there was no difference between ethnicities (Table 3). After adjusting for age, gender, BMI, ethnicity and rurality, obese patients and those enrolled in a rural practice were significantly more likely to have hypertension, and women and younger patients were more likely to have hyperlipidemia (Table 3).

After adjustment for other factors, Māori were three-fold more likely to have an elevated albumin: creatinine ratio (OR 3.1; 95% CI 2.49–4.03), and the rate was also higher in rural patients, Asians and older patients. Females were half as likely as males to have an elevated albumin creatinine ratio (OR 0.50; 95% CI 0.42 – 0.61) (Table 3).

Discussion

This study is the first in more than 10 years to report on diabetes prevalence from primary care data specifically in the Waikato region, while also comprehensively describing the clinical characteristics of these patients. Overall, the prevalence of diabetes in our study was 5.7%, which is comparable to the 5.4% reported for the Waikato region using the Virtual Diabetes Register for 2018.[7] This suggests that reporting on diabetes prevalence using primary care data is accurate, despite the lack of the algorithms used by the Virtual Diabetes Register. Diabetes prevalence in our study is higher than the 4.7% reported using similar Waikato primary care data in 2008,[10] although this increase aligns with observations from the Virtual Diabetes Register data for the same time period.[7] The reasons for this increase in prevalence are diverse, but likely associated with the increase in obesity seen in New Zealand adults during this time,[20] an increase in screening for diabetes and an aging population. Importantly, our study continues to show that there is marked disparity in diabetes prevalence and outcomes between Europeans and patients of other ethnic groups, particularly Māori. Further, the prevalence is likely to be higher still as we excluded from our study well-controlled patients who had a most recent HbA1c of <50 mmol/mol (6.7%). We also cannot account for patients who do not engage with the health-care system.

When compared to the general population described in the 2014–17 New Zealand Health survey,[15] patients with T2DM in our study were more likely to be obese (61.7% vs. 37.0%) and less likely to be of healthy weight (9.2% vs. 20.3%). This concurs with previous reports that obesity strongly correlates with T2DM risk.[21] However, we note that the data presented in our study uses the generic World Health Organization classifications for BMI,[16] despite suggestions that these classifications for healthy, overweight and obese should be adjusted for Asian,[22] Māori and Pacific[23] populations. However, these adjustments are not routinely undertaken in primary care, despite the fact that Asian people, for example, may have significant cardiovascular risk at a significantly lower BMI.[24] It has been suggested that percentage body fat may be a better indicator of cardiovascular risk than BMI.[25]

Primary care guidelines suggest that obesity should be managed through lifestyle change (diet, exercise and behavioural change),[26] although they do not address the significant barriers that many patients experience when attempting weight loss (eg food

Table 3. Adjusted odds ratios of having poor glycaemic control, high blood pressure, elevated cholesterol ratio and elevated ACR

Factors	OR of HbA1c >53 mmol/mol	OR of high blood pressure (≥130/80 mmmHg)	OR of elevated cholesterol (≥4.0 mmol/L)	OR of elevated ACR (≥2.5 mg/mmol for men and ≥ 3.5 mg/mmol for women)
Age (continuous)	0.96 (0.95–0.97)***	1.00 (0.99–1.01)	0.98 (0.97–0.99)***	1.02 (1.01–1.03)***
Gender				
Men	ref	ref	ref	ref
Women	0.83 (0.69–0.99)*	1.03 (0.85–1.25)	2.61 (2.16–3.16)***	0.48 (0.40–0.58)***
Ethnicity				
European	ref	ref	ref	ref
Māori	1.19 (0.94–1.50)	1.16 (0.90–1.51)	0.93 (0.72–1.19)	3.20 (2.51–4.08)***
Asian	0.97 (0.68–1.36)	0.94 (0.65–1.35)	0.92 (0.64–1.33)	1.72 (1.21–2.46)**
Other	1.41 (0.86–2.32)	1.54 (0.88–2.70)	0.91 (0.54–1.53)	2.54 (1.56–4.16)***
BMI				
Healthy	ref	ref	ref	ref
Overweight	1.23 (0.87–1.73)	1.09 (0.77–1.54)	1.00 (0.70–1.41)	0.82 (0.58–1.16)
Obese	1.49 (1.08–2.06)*	1.55 (1.11–2.16)**	1.03 (0.74–1.43)	1.01 (0.73–1.40)
Underweight	2.23 (0.34–14.78)	0.14 (0.01–1.25)	1.82 (0.19–17.59)	0.50 (0.05–4.74)
Unknown	1.43 (0.60–3.41)	n/a†	5.04 (1.10–23.11)*	0.65 (0.18–2.37)
Urban rural				
Urban	ref	ref	ref	ref
Rural	1.46 (1.21–1.75)***	1.31 (1.07–1.60)**	1.10 (0.91–1.34)	1.34 (1.10–1.61)**
Years since diagnosis				
≤2	ref	ref	ref	ref
2 – 5	1.24 (0.83–1.87)	0.93 (0.60–1.45)	1.10 (0.69–1.75)	1.16 (0.74–1.83)
6–10	1.64 (1.10–2.43)*	0.97 (0.64–1.49)	0.70 (0.45–1.09)	1.41 (0.91–2.18)
≥10	2.74 (1.84–4.09)***	1.02 (0.67–1.57)	0.67 (0.43–1.04)	2.01 (1.30–3.11)**
Unknown	1.59 (0.58–4.39)	n/a†	0.24 (0.05–1.23)	2.36 (0.56–9.95)

ACR (Albumin creatinine ratio); OR (odds ratio).
* $P < 0.05$; ** $P < 0.01$; *** $P < 0.001$ versus the reference within each sub-category.
† The number of patients is too low in this subgroup for analysis.

environment, depression and lack of time).[27,28] Hormonal imbalances can also make weight loss more difficult, and insulin use by patients with diabetes may even exacerbate the problem as it has been shown to be associated with weight gain.[29] Clearly, appropriate interventions to reduce obesity are required, and studies do indicate that interventions can be effective when used in primary care.[30] One option might be to use the online portal to provide information and online support to patients around weight loss and diabetes management. More than three-quarters of patients in our study have an active health portal account, and interventions using text reminders and web portals have previously been shown to assist weight loss.[31,32] However, such interventions must be culturally relevant as both obesity and T2DM continue to burden a disproportionate number of Māori patients.

Our study also shows that the management of glycaemic control is less than ideal, with more than half of all patients exceeding the recommended clinical target of 53 mmol/mol (7.0%) and one-third having an HbA1c of >64 mmol/mol (8.0%). Further, glycaemic control in Waikato patients appears

to have worsened since 2008, despite a comparable methodology, with a reduction from 75%[10] to 68% of patients having a HbA1c of ≤64 mmol/mol (8%). The reasons for this are unknown but may relate to our inclusion of a larger number of GP practices (15 vs. 3) and more than twice as many patients (2227 vs. 1111), thereby providing a more representative estimate. However, we expected to see an improvement in glycaemic control in our study as GPs tend to now be more familiar with diabetes management and the availability and efficacy of new medications has improved in recent years.[33] It is possible that this worsening of glycaemic control could be because the diabetes 'get checked' programme ended in July 2012,[34] although the impact of this is unknown given that it has been superseded by the Diabetes Annual Reviews.

Regardless of the change in the proportion of patients meeting HbA1c clinical targets between 2008[10] and 2019, the demographic trends appear to be similar in both studies, with Māori and younger patients continuing to have the highest HbA1c levels. It has been postulated that younger patients with T2DM do not manage their disease effectively because of factors such as high rates of depression, work and family demands, denial and poor dietary patterns,[35,36] the latter of which correlates to the higher rate of obesity seen in younger patients in our study. Further, younger adults may have a relatively new diagnosis compared to many older patients, and several studies have reported that newly diagnosed patients can experience significant barriers to glycaemic control because of a relative lack of appropriate patient education and disease awareness.[37] T2DM has also been shown to be a more progressive disease in younger patients.[38] In addition, for Māori patients, diabetes management can pose additional challenges, including a lack of culturally appropriate resources around diet, exercise, and disease self-management.[39] These must be addressed if we are to reduce the equity gap for T2DM in New Zealand.

The number of patients who do not meet clinical targets for blood pressure and lipids is also concerning, as the greatest risk of death from diabetes is death from cardiovascular disease.[40] Other studies have reported that the prevalence of hypertension in diabetes exceeds 60%, but observe that managing multimorbidity is complex and that GPs must balance the clinical efficacy of medication with the individual preferences and tolerability of each patient.[41] It has also been reported that dyslipidaemia is often not well managed in patients with diabetes unless there is a concomitant diagnosis of coronary artery disease.[42] However, primary care-based interventions have been shown to significantly improve blood pressure and lipid levels in patients with T2DM,[43,44] suggesting that they could be used more to improve the health outcomes of patients with diabetes. Weight loss strategies, in particular, could be useful, as our study shows that obesity correlates directly with HbA1c and hypertension. This may be pertinent for Māori patients with diabetes given that they have consistently higher rates of hospital admissions and cardiovascular mortality,[45] although weight loss is also beneficial for diabetes patients without comorbid cardiovascular disease.[46]

Our study is the first in more than 10 years to comprehensively report on the prevalence and clinical characteristics of diabetes in primary care in the Waikato region. Further, by including 15 different general practices from across the Waikato region with a total enrolled population of nearly 70,000, we were able to equitably represent Māori and Asian patients across our region.

However, we do note several study limitations. First, this study included only patients who were deemed to have diabetes based on their most recent HbA1c and their medication use. In reality, T2DM affects a larger number of patients than reported here, including patients who effectively manage their disease through diet and exercise so that their HbA1c is below the clinical threshold of 50 mmol/mol. Thus, the prevalence is likely to be higher than that reported here; further research should also review patients with well-controlled diabetes for their adherence to clinical targets. Second, our study reports on the clinical characteristics of patients based on their 2017 Diabetes Annual Review data. However, there were an additional 1356 patients who met our criteria for 'current T2DM' for whom we had no available clinical data. These patients were not included in our study, although they may include many with poorly managed disease who need further follow up as lacking regular contact with health-care providers is an indicator of reduced health outcomes. Third, we were unable to

report on social deprivation and this is important to consider when reporting on primary care engagement and health outcomes. We recommend that this is included in any future work.

In conclusion, diabetes prevalence appears to be continuing to rise in the Waikato region of New Zealand, with Māori and Pacific patients being particularly affected. Further work is needed in our region to ensure that these patients are appropriately managed with regard to their diabetes and cardiovascular risk factors.

Competing interests

The authors declare no competing interests.

Acknowledgement

We thank the University of Waikato for providing funding for this study.

References

1. Health Quality and Safety Commission New Zealand. Diabetes. HQSC; 2017. [cited 2020 March]. Available from: https://www.hqsc.govt.nz/our-programmes/health-quality-evaluation/projects/atlas-of-healthcare-variation/diabetes/
2. Derraik JG, Reed PW, Jefferies C, et al. Increasing incidence and age at diagnosis among children with type 1 diabetes mellitus over a 20-year period in Auckland (New Zealand). PLoS One. 2012;7(2):e32640. doi:10.1371/journal.pone.0032640
3. Coppell KJ, Mann JI, Williams SM, et al. Prevalence of diagnosed and undiagnosed diabetes and prediabetes in New Zealand: findings from the 2008/09 Adult Nutrition Survey. N Z Med J. 2013;126(1370):23–42.
4. Teng A, Blakely T, Scott N, et al. What protects against prediabetes progressing to diabetes? Observational study of integrated health and social data. Diabetes Res Clin Pract. 2019;148:119–29. doi:10.1016/j.diabres.2018.12.003
5. Selak V, Poppe K, Grey C, et al. Ethnic differences in cardiovascular risk profiles among 475,241 adults in primary care in Aotearoa, New Zealand. N Z Med J. 2020;133(1521):14–27.
6. Best Practice Advocacy Centre New Zealand. Annual diabetes review. Report 2015; 2015. [cited 2020 January]. Available from: https://bpac.org.nz/Report/2015/August/Diabetes-SamplePractice.pdf
7. Ministry of Health. Virtual Diabetes Register. 2019. [cited 202 April]. Available from: https://www.health.govt.nz/our-work/diseases-and-conditions/diabetes/about-diabetes/virtual-diabetes-register-vdr
8. Sundborn G, Metcalf P, Scragg R, et al. Ethnic differences in the prevalence of new and known diabetes mellitus, impaired glucose tolerance and impaired fasting glucose. Diabetes heart and health survey (DHAH) 2002–2003, Auckland New Zealand. N Z Med J. 2007;120(1257):U2607.
9. Joshy G, Simmons D. Epidemiology of diabetes in New Zealand: revisit to a changing landscape. N Z Med J. 2006;119(1235):U1999.
10. Lawrenson R, Gibbons V, Joshy G, Choi P. Are there disparities in care in people with diabetes? A review of care provided in general practice. J Prim Health Care. 2009;1(3):177–83. doi:10.1071/HC09177
11. Sandhu SK, Corbett VM, Chepulis L, et al. The prevalence of microvascular complications in Waikato children and youth with type 1 diabetes has reduced since 2003. N Z Med J. 2020;133(1510):35–44.
12. Tamatea JAU, Chepulis LM, Wang C, et al. Glycaemic control across the lifespan in a cohort of New Zealand patients with type 1 diabetes mellitus. Intern Med J. 2020. doi:10.1111/imj.14816
13. O'Shea C, McClintock J, Lawrenson R. The prevalence of diabetic foot disease in the Waikato region. Diabetes Res Clin Pract. 2017;129:79–85. doi:10.1016/j.diabres.2017.04.020
14. New Zealand Guidelines Group. New Zealand Primary Care handbook, 3rd edn. 2012. [cited 2020 January]. Available from: www.health.govt. nz/publication/new-zealand-primary-care-handbook-2012
15. Statistics New Zealand. Urban/Rural Profile Categories: North Island. Wellington, Statistics New Zealand; 2001. [cited 2018 May 16]. Available from: www.stats.govt.nz
16. World Health Organization. Body Mass Index (BMI). WHO; 2020. [cited 2020 June]. Available from: https://www.who.int/data/gho/data/themes/theme-details/GHO/body-mass-index-(bmi)?introPage=intro_3.html
17. Paul R. Brief guide to the management of type 2 diabetes in primary care. 2020. [cited 2020 October]. Available from: https://www.pinnaclepractices.co.nz/assets/Resource-files/brief-guide-to-management-of-type-2-diabetes-in-primary-care-updated-march-2020.pdf
18. American Diabetes Association. Glycemic targets: standards of medical care in diabetes—2019. Diabetes Care. 2019;42:S61–70. doi:10.2337/dc19-S006
19. New Zealand Guidelines Group. Guidance on the management of type 2 diabetes. Wellington: Ministry of Health; 2011. [cited 2019 January]. Available from: https://www.moh.govt.nz/notebook/nbbooks.nsf/0/60306295DECB0BC6C-C257A4F000FC0CB/$file/NZGG-management-of-type-2-diabetes-web.pdf
20. Ministry of Health. Annual Update of Key Results 2016/17: New Zealand Health Survey. 2017. [cited 2019 February 26]. Available from: https://www.health.govt.nz/publication/annual-update-key-results-2016-17-new-zealand-health-survey
21. Kusminski CM, Bickel PE, Scherer PE. Targeting adipose tissue in the treatment of obesity-associated diabetes. Nat Rev Drug Discov. 2016;15(9):639. doi:10.1038/nrd.2016.75
22. World Health Organization. Appropriate body-mass index for Asian populations and its implications for policy and intervention strategies. Lancet. 2004;363(9403):157. doi:10.1016/S0140-6736(03)15268-3
23. Rush EC, Freitas I, Plank LD. Body size, body composition and fat distribution: comparative analysis of European, Maori, Pacific Island and Asian Indian adults. Br J Nutr. 2009;102(4):632–41. doi:10.1017/S0007114508207221
24. Asia Pacific Cohort Studies Collaboration. Body mass index and cardiovascular disease in the Asia-Pacific Region: an overview of 33 cohorts involving 310 000 participants. Int J Epidemiol. 2004;33(4):751–8. doi:10.1093/ije/dyh163
25. Zeng Q, Dong S-Y, Sun X-N, et al. Percent body fat is a better predictor of cardiovascular risk factors than body mass index. Braz J Med Biol Res. 2012;45(7):591–600. doi:10.1590/S0100-879X2012007500059
26. Best Practice Advocacy Centre New Zealand. Managing patients who are obese: encouraging and maintaining healthy weight-loss. 2014. [cited 2020 June]. Available from: https://bpac.org.nz/BPJ/2014/December/docs/BPJ65-obesity.pdf
27. Sharifi N, Mahdavi R, Ebrahimi-Mameghani M. Perceived barriers to weight loss programs for overweight or obese women. Health Promot Perspect. 2013;3(1):11.

28. Ciao AC, Latner JD, Durso LE. Treatment seeking and barriers to weight loss treatments of different intensity levels among obese and overweight individuals. Eat Weight Disord. 2012;17(1):e9–16. doi:10.1007/BF03325323
29. Russell-Jones D, Khan R. Insulin-associated weight gain in diabetes–causes, effects and coping strategies. Diabetes Obes Metab. 2007;9(6):799–812. doi:10.1111/j.1463-1326.2006.00686.x
30. Carvajal R, Wadden TA, Tsai AG, et al. Managing obesity in primary care practice: a narrative review. Ann N Y Acad Sci. 2013;1281(1):191. doi:10.1111/nyas.12004
31. Shaw R, Bosworth H. Short message service (SMS) text messaging as an intervention medium for weight loss: a literature review. Health Informatics J. 2012;18(4):235–50. doi:10.1177/1460458212442422
32. Neve M, Morgan PJ, Jones P, Collins C. Effectiveness of web-based interventions in achieving weight loss and weight loss maintenance in overweight and obese adults: a systematic review with meta-analysis. Obes Rev. 2010;11(4):306–21. doi:10.1111/j.1467-789X.2009.00646.x
33. Chatterjee S, Khunti K, Davies M. Type 2 diabetes. Lancet. 2017;389(10085):2239–51. doi:10.1016/S0140-6736(17)30058-2
34. Ministry of Health. Diabetes. 2013. [cited 2020 June]. Available from: https://www.health.govt.nz/our-work/diseases-and-conditions/diabetes
35. Benhalima K, Wilmot E, Khunti K, et al. Type 2 diabetes in younger adults: clinical characteristics, diabetes-related complications and management of risk factors. Prim Care Diabetes. 2011;5(1):57–62. doi:10.1016/j.pcd.2010.08.001
36. Wilmot EG, Davies MJ, Yates T, et al. Type 2 diabetes in younger adults: the emerging UK epidemic. Postgrad Med J. 2010;86(1022):711–8. doi:10.1136/pgmj.2010.100917
37. Li R, Shrestha SS, Lipman R, et al. Diabetes self-management education and training among privately insured persons with newly diagnosed diabetes—United States, 2011–2012. MMWR. 2014;63(46):1045.
38. The Lancet. Type 2 diabetes: the urgent need to protect young people. Lancet. 2018;392(10162):2325.
39. Chepulis L, Morison B, Cassim C, et al. Barriers to diabetes self management in Waikato patients with very poor glycaemic control. Researchsquare. doi:10.21203/rs.3.rs-86639/v1
40. Boussageon R, Bejan-Angoulvant T, Saadatian-Elahi M, et al. Effect of intensive glucose lowering treatment on all cause mortality, cardiovascular death, and microvascular events in type 2 diabetes: meta-analysis of randomised controlled trials. BMJ. 2011;343:d4169. doi:10.1136/bmj.d4169
41. Horr S, Nissen S. Managing hypertension in type 2 diabetes mellitus. Best Pract Res Clin Endocrinol Metab. 2016;30(3):445–54. doi:10.1016/j.beem.2016.06.001
42. Fuke D, Hunt J, Siemienczuk J, et al. Cholesterol management of patients with diabetes in a primary care practice–based research network. Am J Manag Care. 2004;10(2 Pt 2):130–6.
43. Pape GA, Hunt JS, Butler KL, et al. Team-based care approach to cholesterol management in diabetes mellitus: two-year cluster randomized controlled trial. Arch Intern Med. 2011;171(16):1480–6. doi:10.1001/archinternmed.2011.417
44. Coppell KJ, Lee JE, Williams SM, Mann JI. Progression of glycaemia and cardiovascular risk factors in patients of different age groups with new type 2 diabetes over 5 years of follow-up in a diabetes quality improvement initiative. Diabetes Res Clin Pract. 2011;93(3):357–62. doi:10.1016/j.diabres.2011.04.021
45. Yu D, Zhao Z, Osuagwu UL, et al. Ethnic differences in mortality and hospital admission rates between Māori, Pacific, and European New Zealanders with type 2 diabetes between 1994 and 2018: a retrospective, population-based, longitudinal cohort study. Lancet Glob Health. 2021;9:e209–17. doi:10.1016/S2214-109X(20)30412-5
46. Lau DC, Teoh H. Benefits of modest weight loss on the management of type 2 diabetes mellitus. Can J Diabetes. 2013;37(2):128–34. doi:10.1016/j.jcjd.2013.03.023