Projected increases in the prevalence of diabetes mellitus in Aotearoa New Zealand, 2020–2044

Andrea Teng, James Stanley, Jeremy Krebs, Christopher GCA Jackson, Jonathan Koea, Nina Scott, Dianne Sika-Paotonu, Jeannine Stairmand, Chunhuan Lao, Ross Lawrenson, Jason Gurney

ABSTRACT

BACKGROUND: The prevalence of diabetes has been increasing in Aotearoa New Zealand by approximately 7% per year, and is three times higher among Māori and Pacific peoples than in Europeans. The depth of the diabetes epidemic, and the expansive breadth of services required for its management, elevate the need for high-quality evidence on the projected future burden of this complex disease.

METHODS: In this manuscript we have projected the prevalence of diabetes (type 1 and type 2 combined) out to 2040–2044 using age-period-cohort modelling. National-level data from central government on diabetes prevalence (Virtual Diabetes Register) were used to describe recent diabetes prevalence trends (2006–2019) by age group, calendar period and birth cohort, with these trends used to project diabetes prevalence out from 2020 to 2044.

RESULTS: Aotearoa New Zealand will experience a significant increase in the absolute volume of prevalent diabetes, rising by nearly 90% to more than 500,000 by 2044. The age-standardised prevalence of diabetes will increase from around 3.9% of the population (268,248) to 5.0% overall (502,358). The prevalence and volume of diabetes diagnoses will increase most drastically for Pacific peoples, most notably Pacific females for whom diabetes prevalence is projected to increase to 17% of the population by 2044.

CONCLUSIONS: The increases in the future burden of diabetes mellitus projected here will heighten pressure on health services. Immediate action is required to reduce new cases of diabetes and other obesity-related illnesses. Fiscal policies to prevent these diseases, coupled with population-level interventions to more effectively manage and control diabetes, are effective tools for reducing disease burden.

More than half a billion people (529 million) globally are currently estimated to be living with diabetes mellitus, with this prevalence projected to rise to 1.3 billion by 2050.[1] By far the most important driver of this global trend is obesity, with a recent large-scale review finding that up to 83% of all cases of diabetes are now attributable to obesity.[2] While it has been identified that biological factors (including genetics) have a role to play in risk of obesity, the simultaneous increases that have been observed in the prevalence of obesity across the world appear to be driven by the social determinants of obesity, including food environments.[3] The prevalence of diabetes has been increasing in Aotearoa New Zealand by approximately 7% per year, and is three times higher among Māori and Pacific peoples than in Europeans.[4] As such, the social determinants of the obesity epidemic are squarely implicated in both the overall volume of new diabetes diagnoses, as well as the significant disparities that exist in the burden of this disease within populations.[5]

The magnitude of this health issue, and the high likelihood that it will worsen over time, is difficult to fathom. In terms of healthcare delivery, diabetes is a multifaceted, multisystem disease that requires clinical input spanning all levels of our healthcare system.[6] Caring for a person with diabetes over time often involves a multidisciplinary team, which might include a general practitioner, endocrinologist, nurses, dietitians, pharmacists and other allied healthcare professionals.[7] The annual direct and indirect costs attributed to type 2 diabetes alone in Aotearoa New Zealand is estimated to be more than NZ$2 billion, projected to increase to approximately $3.5 billion in the next 20 years.[8]

The depth of the diabetes epidemic, and the expansive breadth of services required for its management, elevate the need for high-quality evidence on the projected future burden of this complex disease. Such evidence can be utilised to project future health service needs and can

provide a base for considering the cost effectiveness of public health interventions to reduce the future burden of diabetes.[9]

Numerous methods have been used to predict future prevalence rates of diabetes, including simple linear models,[8,10] dynamic Markov modelling[9] and Bayesian meta-regression modelling.[1] A 2020 report in Aotearoa New Zealand utilised a generalised linear model to estimate the prevalence of type 2 diabetes out to 2040 based on data from 2014 to 2018.[8] For the current study, we have projected the future prevalence of diabetes using age-period-cohort (APC) modelling.[11,12] This model allows for changes that occur over time in the age structure of a population (e.g., an ageing population), as well as cohort effects (such as increases over time in the obesogenic environment). In this way, APC modelling can be utilised as a proxy for underlying changes in risk factors (like obesity) among the population.[11]

In this manuscript we have projected the combined prevalence of type 1 and type 2 diabetes out to 2040–2044 using APC modelling. To do this we have used national-level data on diabetes prevalence to describe recent diabetes prevalence trends (2006–2019) by age group, calendar period and birth cohort, and then utilised these trends to project diabetes prevalence out from 2020 to 2044.

Methods

Numerator data

Diabetes prevalence for 2006–2019 was derived from the Virtual Diabetes Register (VDR). The VDR defines diabetes status based on routine healthcare data[13] and has been validated against primary care registers.[13,14] The VDR sets the diabetes status of each individual in Aotearoa New Zealand based on multiple data sources:[15]

- publicly funded hospital discharges with diabetes discharge code within the previous 10-year period;
- attendance at a diabetes education or diabetes screening appointment in an outpatient setting collection within the previous 3 years;
- publicly funded diabetes pharmaceuticals dispensed in community on two or more occasions within the previous 2 years, with some exclusions (e.g., insulin used by women between 5 months before and 2 weeks after giving birth);
- access to laboratory services, including four HbA_{1c} measurements and two albumin to creatinine ratio (ACR) measurements within the last 2 years, but excluding HbA_{1c} measurements within 9 months of birth.

A de-identified VDR dataset was extracted from National Collections data, provided by the data custodians Health New Zealand – Te Whatu Ora. Diabetes prevalence data were aggregated by 5-year age groups (0–85+ years old) over three historical time periods (2006–2009, 2010–2014, 2015–2019) for males and females. Because of concerns regarding poorer data coverage in the underlying VDR source datasets within the first time period (2006–2009), diabetes prevalence for this period was estimated by linear extrapolation from the 2010–2014 and 2015–2019 prevalences. Projections made using both this extrapolation method and the existing 2006–2009 data are shown in Appendix Table 2; the selected method made little (if any) difference to the projections. Ethnicity data were classified using the "total ethnicity" approach, wherein individuals can belong to more than one ethnic grouping (Māori, Pacific, Asian [South Asian and Other Asian] and European/Other). Sex was categorised as either female or male.

Denominator data

Denominator data were sourced from two places. Historical residential population data were requested from Stats NZ (custom extract) for 30 June 2001, 2006, 2013 and 2018, by 5-year age groups, sex and total ethnicity. Interpolation was used to estimate population numbers between data points, and linear extrapolation was used to give population numbers in 2019 to ensure that we had denominator data for the same period as the diabetes data. Person-time was then summed up for each of the five historical time periods.

Projected population estimates were extracted from a publicly available Stats NZ dataset, which covered the period 2020–2043.[16] We linearly extrapolated the 2042–2043 trend to calculate 2044 population numbers. Person-years (denominator) were summed for males and females by 5-year age groups in each of five projected 5-year time periods (2020–2024, 2025–2029, 2030–2034, 2035–2039, 2040–2044) in the total population and by total ethnicity.

Statistical analysis

Projected numbers of diabetes cases and

age-standardised prevalence rates (ASR; average per year per 100 population) were reported in the overall population and separately for males and females in the five projected time periods (2020–2044). The World Health Organization world population standard was used as the standard population. Sex-specific findings were also reported by ethnicity.

APC modelling was run using the Nordpred software package[17] in R (R Institute, Vienna, Austria). Default Nordpred settings were used for the modelled age groups, recent slope, the cut trend (which reduced the drift in subsequent projection periods) and the link function (link is g(x)=x^0.2, called power5).[18,19] The youngest age group that was modelled and projected was required to have at least 20 diabetes cases in every time period.

In addition to calculating projected diabetes cases and ASR, average annual percentage changes (AAPC) in diabetes cases and age-standardised prevalence were also calculated by comparing results in 2040–2044 with 2015–2019, assuming a constant change and adjusting for the years in between ((1+%change over 25 years)^(1/25)).

Results

Our total projected diabetes prevalence numbers and rates are presented in Table 1 and Figure 1. We project that the total number of people living with diabetes in Aotearoa New Zealand will rise from 268,248 in 2015–2019 (average annual prevalence in observed VDR data) to 502,358 by 2040–2044, a total increase of 87% and an average annual increase of 2.5%. The number of females with diabetes is projected to increase from 128,488 in 2015–2019 to 247,055 (92% increase), while the number of males with diabetes increases from 139,750 to 257,893 (85% increase). The number of total Māori living with diabetes will increase from 42,930 to 98,146 (129% increase), total Pacific from 38,215 to 106,485 (175% increase), total Asian from 42,933 to 136,084 (218% increase) and total European from 153,016 to 234,717 (53% increase).

In terms of ASR (Table 1/Figure 1), standardised to the World Health Organization World Population Standard, the prevalence rate of diabetes will continue to increase over time for both males and females, with females experiencing the most rapid increases (female ASR 3.6% in 2015–2019 to 5.0% in 2040–2044; male ASR 4.2% in 2015–2019 to 5.1% in 2040–2044). The largest absolute increases are projected to occur among Pacific females (13.1–17.3%) and males (ASR 12.4–14.2%), with smaller increases in prevalence rates among other ethnic groups (Table 1/Figure 2).

Discussion

Key findings

In this study, we have used APC models to project the prevalence of diabetes mellitus out from 2020–2044. Our projections suggest that over this time period:

- Aotearoa New Zealand will experience a significant increase in the absolute volume of prevalent diabetes, rising by nearly 90% to more than 500,000 by 2044;
- the age-standardised prevalence of diabetes mellitus will increase from approximately 3.9% of the population to 5.0% overall, an increase of around 30%;
- both the prevalence rate and volume of new prevalent diabetes diagnoses will increase most drastically for Pacific peoples, most notably Pacific females for whom diabetes prevalence is projected to increase to 17% of the population by 2044;
- by 2044, the combined number of Māori, Pacific and Asian peoples with diabetes (339,799) will exceed the number of Europeans with diabetes (234,717);
- the age-standardised prevalence rate of diabetes mellitus in females will increase faster than for males, with rates for these two groups conflating by 2044.

How do these projections compare to other regions?

The closest comparison data are from two recent reports: first, the Global Burden of Disease (GBD) study, which found that the number of people living with diabetes globally would increase from 529 million in 2021 to 1.31 billion by 2050, an increase of more than 148% globally, and approximately 48% in high-income countries.[1] Second, the International Diabetes Federation (IDF) Diabetes Atlas projects that the number of people living with diabetes globally will increase from 536 million in 2021 to 783 million by 2045, an increase of around 46% globally and approximately 13% in high-income countries.[20] While our own projections are not necessarily comparable due to methodological differences between studies, our observation of a near 90%

Table 1: Projected number of people with diabetes and age-standardised diabetes prevalence in 2040–2044 compared to 2015–2019, Aotearoa New Zealand.

		Historic				Projected				AAPC	
		2015–2019				2040–2044					
		Cases (n)	Pop. (n)	Crude (%)	ASR (%)	Cases (n)	Pop. (n)	Crude (%)	ASR (%)	People (%)	ASR (%)
Total	All	268,248	4,808,896	5.6	3.9	502,358	5,890,600	8.5	5.0	2.5	1.0
Males	All males	139,750	2,378,558	5.9	4.2	254,624	2,926,840	8.7	5.1	2.4	0.7
Total ethnicity	Māori	20,930	392,350	5.3	6.5	45,068	610,320	7.4	6.9	3.1	0.3
	Pacific	17,876	198,630	9.0	12.4	46,891	329,880	14.2	14.2	3.9	0.5
	Asian	22,236	356,764	6.2	7.2	67,332	705,120	9.5	6.8	4.5	−0.3
	European	81,349	1,681,504	4.8	3.0	121,778	1,907,560	6.4	3.4	1.6	0.5
Females	All females	128,488	2,430,338	5.3	3.6	247,055	2,963,760	8.3	5.0	2.6	1.2
Total ethnicity	Māori	22,000	399,296	5.5	6.1	53,078	611,960	8.7	7.6	3.6	0.9
	Pacific	20,339	196,384	10.4	13.1	58,381	324,600	18	17.3	4.3	1.1
	Asian	20,697	367,960	5.6	5.8	69,049	712,860	9.7	6.4	4.9	0.4
	European	71,667	1,734,308	4.1	2.5	112,939	1,954,980	5.8	3.2	1.8	1.0

AAPC = average annual percentage change; ASR = the age-standardised prevalence rate per 100 population (or percent).
Cases (n) are the average number of people with diabetes in each year of the time period.

Figure 1: Projected diabetes prevalent cases (left) and rates (right) in Aotearoa New Zealand, 2020–2044.

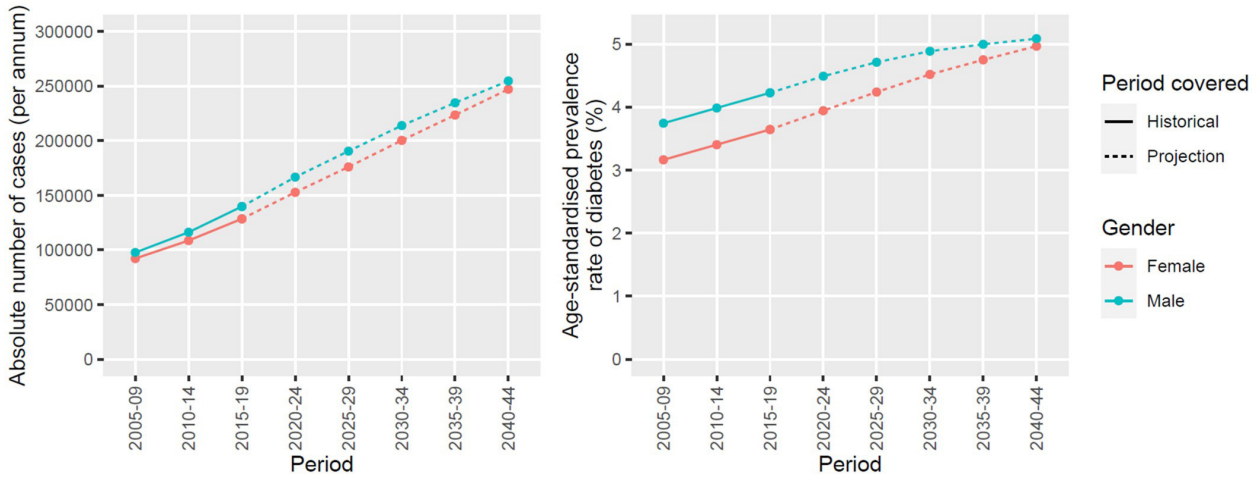
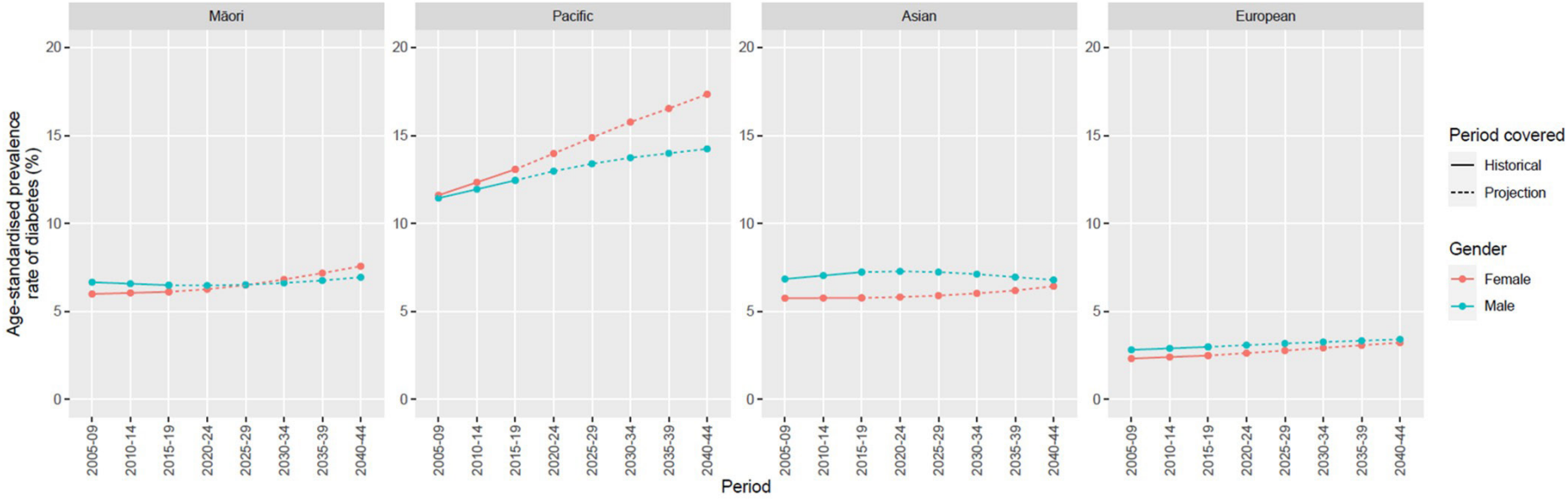


Figure 2: Projected diabetes prevalence rates by ethnicity in Aotearoa New Zealand, 2020–2044.



increase in diabetes prevalence is substantially higher than that projected for other high-income countries.

What is driving these increases?

The steep climb in the absolute number of New Zealanders with diabetes is driven by three factors: 1) population growth (more people living in Aotearoa New Zealand), 2) an ageing population (with a greater proportion of the population in age groups at higher risk of developing type 2 diabetes), and, perhaps most importantly, 3) actual increases in the risk of developing diabetes (increases in the proportion of the population diagnosed with diabetes within age groups, thus independent of age). The last factor is particularly important for Pacific peoples, for whom the projected increase in diabetes prevalence was most pronounced. This increasing prevalence will be almost entirely due to type 2 diabetes,[1] and it is likely that changing obesity profiles underpin the increase in prevalence. While biological factors such as genetics may contribute to changes in prevalence, these changes in obesity profiles are driven by disparities within our population in terms of access to the social and structural determinants of good health.[3,21] Socio-economic position (SEP) and the food environment, leading to excess weight, are likely to be major factors in the pronounced disparities in projected prevalence of diabetes for Pacific peoples. For example, progression of pre-diabetes to diabetes in Aotearoa New Zealand is associated with SEP and obesity.[22] High diabetes prevalence is concerning for Pacific peoples, who have been seen to have poorer diabetes control relative to other ethnic groups,[23] and who experience barriers to accessing healthcare.[24]

What do we need to do?

While population growth and an ageing population are difficult to change, it is within our control as a society to take meaningful action against the obesity epidemic—with a view to "plugging the dam" and reducing the number of people in Aotearoa New Zealand who will go on to develop type 2 diabetes. The recent report from Aotearoa New Zealand's Public Health Advisory Committee provides a number of recommendations regarding actions to improve our food environments, including fiscal policies such as sugary drinks taxation, restriction of unhealthy food marketing to children and community-based initiatives that improve access to nutritious, locally produced food.[25] Such actions will serve to reduce the rate of new cases of diabetes, while improvements in diabetes management (glycaemic control) will decrease the number of those who progress on to complications (vascular and neurological), as well as the severity of those complications. We also note that there is evidence of the effectiveness of population-level interventions to more effectively manage and control diabetes, and these interventions show promise.[26,27] As such, our diabetes crisis (both current and impending) provides an excellent opportunity for multiple agencies to work together to meaningfully reduce the population-level impact of a long-term condition.

Given the striking and inequitable patterning of our projections by ethnicity—where by 2044 we project that nearly one in seven Pacific males and one in six Pacific females will be living with diabetes, compared to one in 16 European males and one in 18 females (crude data)—actions taken to prevent diabetes and improve its clinical management must be designed and tailored to work best for Māori, Pacific and Asian populations. There is excellent work being undertaken and completed around the country to drive this vision forward; for example, the Government is developing a diabetes action plan; the independent Public Health Advisory Committee has completed a project on food environments; and multiple organisations are working within communities to address the drivers of our obesogenic environment and increase availability and accessibility of healthy food.[29] There is also a need for action in the management of pre-diabetes/early diabetes to reverse metabolic deficit, and we note that the DiRECT study in the United Kingdom has shown that weight management programmes can be delivered at scale nationally and achieve near 50% remission of diabetes symptoms.[28] The Green Prescription initiative, an exercise prescription programme, has shown some promise in improving activity levels,[30,31] and may benefit from further evaluation regarding what has worked and what has not. These and similar initiatives must continue to be resourced and supported as a matter of high priority if we are to avoid the unsustainable and potentially system-crippling future burden of diabetes that we have projected here.

Strengths and limitations

Like all projection models, APC models rely on the validity of available data for projecting trends into the future. For example, both population

count and diabetes prevalence projections are based on existing trends up to 2019, and do not account for any step-wise changes from major policy or health system setting changes after this date. If population changes into the future do not meet these assumptions, then the projections will be inaccurate. We considered presenting variation around our projected prevalence rates and volumes related to these analytical steps, but ultimately decided that the assumptions underpinning these variations could be misleading or inaccurate. As such, while we have done the best that we can to present robust projections, these are underpinned by methodological assumptions and should therefore be interpreted as indicative rather than precise.[11]

We have presented projections in diabetes prevalence for the total population, rather than focussing only on adults. We note that had we focussed solely on adults, the overall projected prevalence rate would have been higher than that reported here. However, because of the growing prevalence of both type 1 and type 2 diabetes among children and young adults,[32] we wanted to ensure that these groups were captured within our APC models, and thus included people of all ages within our analysis.

It is unclear whether changes in clinical practice and data collection have affected diabetes estimates over time. Indeed, the algorithm has been validated and is designed to avoid this, e.g., having strict criteria for the number of HbA_{1c} screening tests and excluding indicators of diabetes around the time of childbirth in women.[15] Some people in the VDR may have pre-diabetes rather than diabetes. The VDR accounts for 5.7% higher estimates of diabetes at the aggregate level when compared to laboratory records.[12] It is likely that we have under-counted the prevalence diabetes in Māori and possibly for Pacific peoples, given the under-count of Māori ethnicity in National Health Index data, which is used in the VDR algorithm.[33] Finally, we note that due to constraints with available data, this study projects diabetes prevalence (i.e., the total number of previously diagnosed cases within the population) rather than diabetes incidence (i.e., the number of new cases within the population diagnosed per year). Further methodological work is required to determine whether it is feasible to collect data on diabetes incidence at a national level.

Conclusions

Using APC modelling to project the prevalence of diabetes mellitus out to 2044, we found that Aotearoa New Zealand will experience a significant increase in the absolute volume of prevalent diabetes, rising by nearly 90% to more than 500,000 by 2044. We found that the age-standardised prevalence of diabetes will increase from around 3.9% of the population to 5.0% overall. We found that both the rate and volume of new prevalent diabetes diagnoses will increase most drastically for Pacific peoples—most notably Pacific females, for whom diabetes prevalence is projected to increase to 17% of the population by 2044. The projected increases in the future burden of diabetes mellitus in Aotearoa New Zealand are likely to stretch our health system to breaking point, if not beyond: and as such, immediate and bold action is required to stem the tide of diabetes and other obesity-related illnesses.

COMPETING INTERESTS
Nil.

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AUTHOR INFORMATION
Dr Andrea Teng: Department of Public Health, University of Otago, Wellington, Aotearoa New Zealand.
Prof James Stanley: Department of Public Health, University of Otago, Wellington, Aotearoa New Zealand.
Prof Jeremy Krebs: Department of Medicine, University of Otago, Wellington, Aotearoa New Zealand.
Prof Christopher GCA Jackson: Department of Medicine, University of Otago, Dunedin, Aotearoa New Zealand.
Prof Jonathan Koea: General Surgery, Te Whatu Ora – Waitematā, Auckland, Aotearoa New Zealand; Medical Surgery, The University of Auckland, Auckland, Aotearoa New Zealand.
Dr Nina Scott: Te Whatu Ora – Waikato, Hamilton, Aotearoa New Zealand.
A/Prof Dianne Sika-Paotonu: Dean's Department, University of Otago, Wellington, Aotearoa New Zealand.
Jeannine Stairmand: Department of Public Health, University of Otago, Wellington, Aotearoa New Zealand.
Dr Chunhuan Lao: Medical Research Centre, The University of Waikato, Hamilton, Aotearoa New Zealand.
Prof Ross Lawrenson: Medical Research Centre, The University of Waikato, Hamilton, Aotearoa New Zealand; Commissioning, Health New Zealand – Te Whatu Ora, Waikato, Hamilton, Aotearoa New Zealand.
A/Prof Jason Gurney: Department of Public Health, University of Otago, Wellington, Aotearoa New Zealand.

CORRESPONDING AUTHOR
A/Prof Jason Gurney: Department of Public Health, University of Otago, PO Box 7343, Wellington, Aotearoa New Zealand. E: jason.gurney@otago.ac.nz

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Appendix

Appendix Table 1: Virtual Diabetes Register inclusion criteria.

To be categorised as diabetes in any given year a person would have to meet one of these VDR criteria (2006–2019):	Coverage:
Publicly funded diabetes pharmaceuticals dispensed in the community on two or more occasions in the last 2 years. Excludes metformin in women 12–45 years, and insulin used between 5 months before and 2 weeks after giving birth.	Dataset quality has improved over time, e.g., in 2005 87% of dispensing had a unique identifier and this was 98% by 2010.
Laboratory records of four or more HbA_{1c} measurements and two ACR measurements within the last 2 years (excluding HbA_{1c} measurements within 9 months of giving birth).	Quality has improved over time, e.g., 88% of claims had an NHI in 2004 and this was 98% coverage by 2010.
Outpatient record of diabetes, education, management or screening in the last 3 years.	Records began in July 2006 (affecting 2006–2008 VDR).
Publicly funded hospital discharge with a diabetes discharge code in the last 10 years.	Records since 1988.

See source for further information.[15]
We used Output 2 VDR data—diabetes prevalence estimates on people who were alive and enrolled in a primary health organisation at some point during the calendar year of the VDR.[15]
VDR = Virtual Diabetes Register; ACR = albumin to creatinine ratio; NHI = National Health Index.

Appendix Table 2: The projected diabetes prevalence (2040–2044) found when using a linear extrapolation ("back-estimation") of 2010–2014 and 2015–2019 Virtual Diabetes Register (VDR) data to determine historical diabetes prevalence for the 2006–2009 period (top), compared to projections made using actual 2006–2009 VDR data. The projected number of cases is practically identical between the two methods; for example, using the existing 2006–2009 VDR data marginally increased the number of projected diabetes cases compared to the back-estimation method by 0.8% or 4,079 cases in total (out of 502,358 projected cases using the back-estimation method).

		Back-estimation of 2006–2009 data					
		Projected				**AAPC**	
		2040–2044					
		Cases (n)	**Pop. (n)**	**Crude (%)**	**ASR (%)**	**People (%)**	**ASR (%)**
Total	All	502,358	5,890,600	8.5	5.0	2.5	1.0
Males	All males	254,624	2,926,840	8.7	5.1	2.4	0.7
Total ethnicity	Māori	45,068	610,320	7.4	6.9	3.1	0.3
	Pacific	46,891	329,880	14.2	14.2	3.9	0.5
	Asian	67,332	705,120	9.5	6.8	4.5	−0.3
	European	121,778	1,907,560	6.4	3.4	1.6	0.5
Females	All females	247,055	2,963,760	8.3	5.0	2.6	1.2
Total ethnicity	Māori	53,078	611,960	8.7	7.6	3.6	0.9
	Pacific	58,381	324,600	18	17.3	4.3	1.1
	Asian	69,049	712,860	9.7	6.4	4.9	0.4
	European	112,939	1,954,980	5.8	3.2	1.8	1.0
		Using existing 2006–2009 data					
		Projected				**AAPC**	
		2040–2044					
		Cases (n)	**Pop. (n)**	**Crude (%)**	**ASR (%)**	**People (%)**	**ASR (%)**
Total	All	506,437	5,890,600	8.6	4.9	2.6	0.9
Males	All males	257,893	2,926,840	8.8	5.0	2.5	0.7
Total ethnicity	Māori	42,776	610,320	7	6.5	2.9	0.0
	Pacific	48,654	329,880	14.7	14.8	4.1	0.7
	Asian	72,798	705,120	10.3	7.3	4.9	0.0
	European	122,750	1,907,560	6.4	3.2	1.7	0.3

Appendix Table 2 (continued): The projected diabetes prevalence (2040–2044) found when using a linear extrapolation ("back-estimation") of 2010–2014 and 2015–2019 Virtual Diabetes Register (VDR) data to determine historical diabetes prevalence for the 2006–2009 period (top), compared to projections made using actual 2006–2009 VDR data. The projected number of cases is practically identical between the two methods; for example, using the existing 2006–2009 VDR data marginally increased the number of projected diabetes cases compared to the back-estimation method by 0.8% or 4,079 cases in total (out of 502,358 projected cases using the back-estimation method).

Females	All females	247,422	2,963,760	8.3	4.9	2.7	1.2
Total ethnicity	Māori	51,838	611,960	8.5	7.4	3.5	0.7
	Pacific	57,831	324,600	17.8	17.1	4.3	1.1
	Asian	69,286	712,860	9.7	6.3	5	0.4
	European	111,554	1,954,980	5.7	3.0	1.8	0.8

AAPC = average annual percentage changes; ASR = age-standardised prevalence rate.