





# BMJ Open Trends in diabetes monitoring and control among Aboriginal and Torres Strait Islander Peoples attending general practice in urban and rural locations in Australia: a repeated cross-sectional study using data from a national general practice database (MedicineInsight)

Antoinette Liddell <sup>1</sup>, Natalie Pink,<sup>1,2</sup> Fernanda Baldim Jardim Nobre,<sup>1,2</sup> Carla Bernardo <sup>2</sup>, Susan Williams,<sup>1</sup> Nigel Stocks <sup>2</sup>, David Gonzalez-Chica <sup>1,2</sup>

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For numbered affiliations see end of article.

## Correspondence to

Antoinette Liddell;  
antoinette.liddell@adelaide.edu.au

## ABSTRACT

**Objective** To determine the proportion of Aboriginal and/or Torres Strait Islander Peoples with diabetes who were monitored according to recommended national guidelines and had their clinical parameters within recommended targets. We also examined trends over time (2013–2022) and compared urban and rural areas.

**Design** A repeated cross-sectional study using data from a national general practice database (MedicineInsight, 2013–2022).

**Setting** De-identified electronic health records (EHR) of people attending 427 mainstream general practices across Australia.

**Participants** This study included all Aboriginal and/or Torres Strait Islander adults (18+ years) diagnosed with diabetes mellitus who were regular patients (attended at least once a year in three consecutive years) within the MedicineInsight database.

**Outcome measures** Outcomes measured were (i) monitoring of blood glucose, lipids, blood pressure (BP), renal function and Body Mass Index (BMI)/waist circumference (WC) and (ii) achieving recommended targets: glycosylated haemoglobin (HbA1c)  $\leq 7.0\%$ , fasting glucose 4–7 mmol/L, random glucose 5–10 mmol/L, total cholesterol  $\leq 4.0$  mmol/L, low-density lipoprotein  $< 2.0$  mmol/L, BP  $\leq 130/80$  mmHg, estimated glomerular filtration rate  $> 60$  mL/min/1.73 m<sup>2</sup>, urine albumin-creatinine ratio (uACR)  $< 2.5$  mg/mmol (men);  $< 3.5$  (women), BMI  $< 25$  kg/m<sup>2</sup>, WC  $< 80$  cm (men);  $< 94$  (women). Adjusted analyses explored trends and differences in outcomes according to practice remoteness using Australian Statistical Geography Standard (ASGS) classifications: major cities (ASGS-1), inner regional (ASGS-2) or rural/remote (ASGS3-5).

## STRENGTHS AND LIMITATIONS OF THIS STUDY

- ⇒ A large national sample, the diversity of locations across all Australian states and the comprehensive clinical information available in MedicineInsight.
- ⇒ The proportion of Aboriginal and/or Torres Strait Islander Peoples in the database was similar to national figures, thus providing a national perspective.
- ⇒ The use of electronic health records avoids self-report bias by providing general practitioner-reported diagnoses, in addition to objective laboratory results.
- ⇒ Only those who identified as Aboriginal and/or Torres Strait Islander persons were included and the MedicineInsight database is not indicative of the Aboriginal Community Controlled Health Services (ACCHOs).
- ⇒ Measurements reported in progress notes were not available.

**Results** Between 70% and 90% of individuals were monitored for the clinical parameters above, except for BMI/WC (55%–75%). Trends in monitoring over time were similar across remoteness areas, increasing slightly in 2013–2014 and declining from 2019. Among those monitored, 53%–86% achieved targets for blood glucose, lipids and renal function; 32%–42% for BP; and  $< 10\%$  had normal BMI/WC. In 2022, the proportion achieving targets was lower in rural than urban areas for blood glucose (68.4%, 95% CI: 60.8 to 75.9 vs 86.3%, 95% CI: 81.8 to 90.7) and lipids (61.3%, 95% CI: 54.1 to 68.5 vs 79.5%, 95% CI: 73.8 to 85.3).

**Conclusion** The risk of diabetes complications among Aboriginal and/or Torres Strait Islander Peoples could be

reduced by improving management of blood pressure and overweight/obesity in all areas, and blood glucose and lipids in rural areas.

## INTRODUCTION

Diabetes mellitus is a chronic condition affecting 1 in 10 individuals aged 20–79 years, totalling 537 million adults worldwide and responsible for one death every 5 s in 2021.<sup>1,2</sup> Some ethnic groups are more susceptible to developing diabetes, as higher incidence rates have been reported among Indigenous and African American populations.<sup>1</sup>

In Australia, data from the National Aboriginal and Torres Strait Islander Health Survey 2018–2019 estimated that 10.7% of Aboriginal and/or Torres Strait Islander adults were living with type 2 diabetes, a prevalence almost three times higher than non-Indigenous adults.<sup>3</sup> Furthermore, diabetes is the second leading cause of death among Aboriginal and/or Torres Strait Islander Peoples (8.7% of all deaths in women and 6.2% in men) after coronary heart disease (11.6% of all deaths).<sup>4,5</sup>

Experiences of racism, marginalisation, overcrowded housing, unemployment, food insecurity, low education and poor access to health professionals, especially among those living in remote areas, continue to affect this population in the aftermath of Australia's historical white policies and colonisation.<sup>6</sup> These social determinants contribute to the higher prevalence of diabetes and poor health outcomes among Aboriginal and/or Torres Strait Islander Peoples.<sup>7</sup>

As a lifelong disease, diabetes mellitus is often managed in general practice<sup>8</sup> and requires regular monitoring and control of clinical targets to prevent progression and complications such as hypertension, chronic kidney disease and cardiovascular disease.<sup>3,5</sup> In Australia, the latest guidelines for Aboriginal and/or Torres Strait Islander Peoples with diabetes advise monitoring glycosylated haemoglobin (HbA1c), blood pressure (BP), Body Mass Index (BMI) or waist circumference (WC), and lipids every 3 to 6 months, and albumin to creatinine ratio (ACR) and estimated glomerular filtration rate (eGFR) monitoring every 12 months in the absence of chronic kidney disease.<sup>9</sup> Discrepancies between real-world management of patients in Australian general practice and guideline recommendations were previously reported.<sup>10</sup> However, there is limited evidence among Aboriginal and/or Torres Strait Islander Peoples.

A systematic review published in 2020 identified 13 studies focused on Aboriginal and/or Torres Strait Islander adults with diabetes, with the most recent study using 2016 data. According to that review, 41%–74% of patients had their HbA1c, 52%–88% their BP and 16%–91% their lipid levels checked within 12 months.<sup>11</sup> Only eight studies investigated diabetes control and found that 18%–34% of patients met targets for HbA1c ( $\leq 7.0\%$ ), 36%–69% for BP ( $\leq 130/80$  mm Hg) and 7%–65% for low-density lipoprotein (LDL) cholesterol ( $\leq 2.5$  mmol/L). The considerable variability in these findings could result from the diverse

settings (many studies reporting local data from a few health services), different study periods (1998 to 2016) and data sources. More recent evidence based on data reported by Aboriginal Health Services across Australia (2018) showed that 52% and 66% of the individuals with diabetes had their HbA1c and BP recorded in the past 6 months, respectively.<sup>12</sup>

Most of the above-mentioned studies were sourced from specialised Aboriginal Community Controlled Health Services (ACCHOs) rather than general practice settings. Aboriginal and/or Torres Strait Islander Peoples can choose to attend those services for their healthcare. Still, half of them attend mainstream general practice as it remains the most accessible option.<sup>13,14</sup> Information on potential determinants like socioeconomic status or co-occurring health conditions was also not widely explored.<sup>11,13</sup> Similarly, there is limited evidence about how monitoring and control of diabetes vary according to geographical location, although the burden of diabetes in this population is higher in rural/remote areas.<sup>15</sup>

This study aimed to determine if Aboriginal and/or Torres Strait Islander Peoples with diabetes, who attend general practices across Australia, were monitored appropriately and if glycaemic levels and other clinical parameters met recommended targets. It also explores trends over the past 10 years and differences in clinical monitoring or control between those living in urban or rural/remote locations.

## METHODS

### Data source

This repeated cross-sectional study used data from MedicineInsight, a national general practice database collecting de-identified electronic health records (EHR) of people attending 427 mainstream general practices across all Australian states and territories. MedicineInsight patients are broadly representative of the Australian population; however, the data may not be representative of all practices in Australia based on geography and size.<sup>16</sup> Although the database does not intend to represent the Aboriginal and/or Torres Strait Islander population, the proportion of people identified as Aboriginal and/or Torres Strait Islander in the database (2.4%) closely resembles census data (3.2%),<sup>16</sup> with 54% of them usually attending a general practice for health problems (75% in urban areas and 27% in remote settings).<sup>14</sup>

The MedicineInsight database contains information on patient sociodemographics, medical diagnoses, laboratory requests and results, prescribed medications, immunisations and health measurements.<sup>16</sup> Further information on the MedicineInsight database has been previously published.<sup>17,18</sup>

### Study sample

We extracted information from all Aboriginal and/or Torres Strait Islander adults (18+ years) diagnosed with any type of diabetes mellitus, excluding prediabetes

and gestational diabetes, who attended a general practice within MedicineInsight between July 2011 and June 2022. To ensure patients would have an accurate medical history recorded and avoid underestimating results (ie, by inflating the denominator with people not regular to the practice), we only included 'regular' patients, defined as those who had consulted at the same practice at least once a year in three consecutive years. This definition follows suggested measures for enhancing diagnosis accuracy when using EHR and the specificities of diabetes diagnosis and monitoring.<sup>19–22</sup> Different fields in MedicineInsight (ie, 'diagnosis', 'reason for encounter', 'reason for prescription') were searched to identify patients with a recorded diagnosis of diabetes. Algorithms were based on standard clinical terminology listed in the Clinical Coded Phenotype 157 from the UK Phenotype Library.<sup>23</sup> Abbreviations and misspellings of those terms were also included. Patients were identified as having diabetes if between July 2011 and June 2021: (1) 'diabetes' was recorded at least once as a 'diagnosis', 'reason for encounter' or 'reason for prescription'; or (2) antidiabetic medications were prescribed (except newer classes of medication used for weight loss such as glucagon-like peptide 1 agonists; metformin was considered only in the absence of polycystic ovary syndrome diagnosis); or (3) a history of diabetes diagnosis was flagged ('observation' field).

### Outcomes

This study focused on five clinical parameters relevant to diabetes management according to the Central Australian Rural Practitioners Association (CARPA) Standard Treatment Manual:<sup>9</sup> blood glucose levels, lipid levels, BP, renal function and body measurements.

First, we explored the proportion of patients with diabetes diagnosis in each financial year (July to June) who had their clinical parameters monitored (based on pathology requests or results, or recorded measurements during a consultation) in the subsequent 12 months (eg, monitoring between July 2021 and June 2022 for individuals with diabetes who consulted between July 2020 and June 2021). Monitoring included laboratory requests or results of (i) blood glucose (HbA1c, fasting and/or random glucose), (ii) lipid profile (total cholesterol (TC), LDL cholesterol, high-density lipoprotein (HDL) cholesterol, very low-density lipoprotein (VLDL) cholesterol, non-HDL cholesterol and/or triglycerides) and (iii) renal function (eg, eGFR and/or ACR). Information on BP, BMI and WC monitoring was extracted from the 'observations' field, which includes measurements performed during a consultation.

Second, we determined the proportion of patients monitored who achieved the recommended clinical goals for blood glucose (HbA1c  $\leq 7.0\%$  or, in the absence of that test, fasting glucose between 4 and 7 mmol/L or random glucose between 5 and 10 mmol/L), BP ( $\leq 130/80$  mm Hg), lipids (TC  $\leq 4$  mmol/L or LDL  $< 2$  mmol/L), renal function (ACR  $< 2.5$  men, ACR  $< 3.5$  women or eGFR  $\geq 60$

in the absence of ACR) and body measurement (BMI  $< 25$  kg/m<sup>2</sup> or WC in the absence of BMI ( $< 94$  cm in men;  $< 80$  cm in women)).<sup>9</sup> If several measurements were taken for the same parameter in the same financial year, the median of these values was used for analysis.

### Remoteness of residence

Remoteness is generated by MedicineInsight using the postcode of the practice and based on the Australian Statistical Geography Standard (ASGS) classification (major cities (ASGS-1), inner regional (ASGS-2), outer regional (ASGS-3), remote (ASGS-4) or very remote areas (ASGS-5)) generated by the Australian Bureau of Statistics (ABS). The ASGS classification considers the town size (2016 census data) and distance/access to main services.<sup>24</sup> This variable was extracted from the database and reclassified for analysis as (1) urban (major cities), (2) inner regional or (3) rural (outer regional, remote or very remote areas).

### Covariates

Covariates used to describe the sample and included as potential confounders included a macroeconomic indicator (Index of Relative Socioeconomic Advantage and Disadvantage (IRSAD) in quintiles) of the practice, patient's sociodemographic characteristics (gender (male, female), age group (18–34, 35–49, 50–64, 65–74, 75+ years), IRSAD quintile), smoking status (non-smoker, ex-smoker, current smoker) and comorbidities (chronic kidney disease (CKD), ischaemic heart disease, heart failure, aortic disease, peripheral arterial disease, stroke). Comorbidities were identified using algorithms similar to those used for diabetes diagnosis, and details have been published elsewhere.<sup>10 16 18 25</sup>

### Statistical analysis

All statistical analyses were conducted using Stata 18 (StataCorp, Texas, USA), with practices treated as clusters and employing weights based on the number of visits to the practice. The distribution of sociodemographic and clinical characteristics of the final sample was presented as proportions with their corresponding 95% CIs.

The adjusted prevalence of diabetes monitoring and control of each clinical parameter between 2013 and 2022 was presented graphically to facilitate reader's interpretability. Further details with the corresponding 95% CI were included as supplementary tables. All results were stratified according to the remoteness of residence and adjusted for any differences in the distribution of sociodemographic or clinical characteristics over time (practice IRSAD, age, gender, patient IRSAD, smoking status, history of cardiovascular disease (CVD) or CKD using logistic regression models. Adjusted ORs (aOR) derived from these models were transformed into marginal adjusted proportions (ie, adjusted prevalence) using the Stata command 'margins', which computes adjusted outcome probabilities for each independent variable category, averaging or integrating the results over the other

covariates included in the model.<sup>26 27</sup> Poisson regression models were used to assess trends in diabetes monitoring and control between 2013 and 2022. Average annual per cent changes over the investigated period along with their 95% CI were calculated based on incidence rate ratios (IRR) and presented in tables.

### Patient and public involvement

Community engagement with local Kurna elders, members of the GPEx Aboriginal Health Team and Indigenous medical doctors from across Australia occurred before the design and commencement of the study by the author, Dr Natalie Pink, a Nyikina Aboriginal person based in Tarndanya (Adelaide), Kurna land. Details of the discussion with the informal Indigenous advisory group and their contribution were previously described.<sup>17</sup> Moreover, the provision of information for the study underwent a formal approval process guided by the MedicineInsight independent external Data Governance Committee that includes general practitioners (GPs), consumer advocates, privacy experts and researchers. Furthermore, two of the authors are active clinicians regularly attending patients affected by diabetes, which also supported the design of the study.

### RESULTS

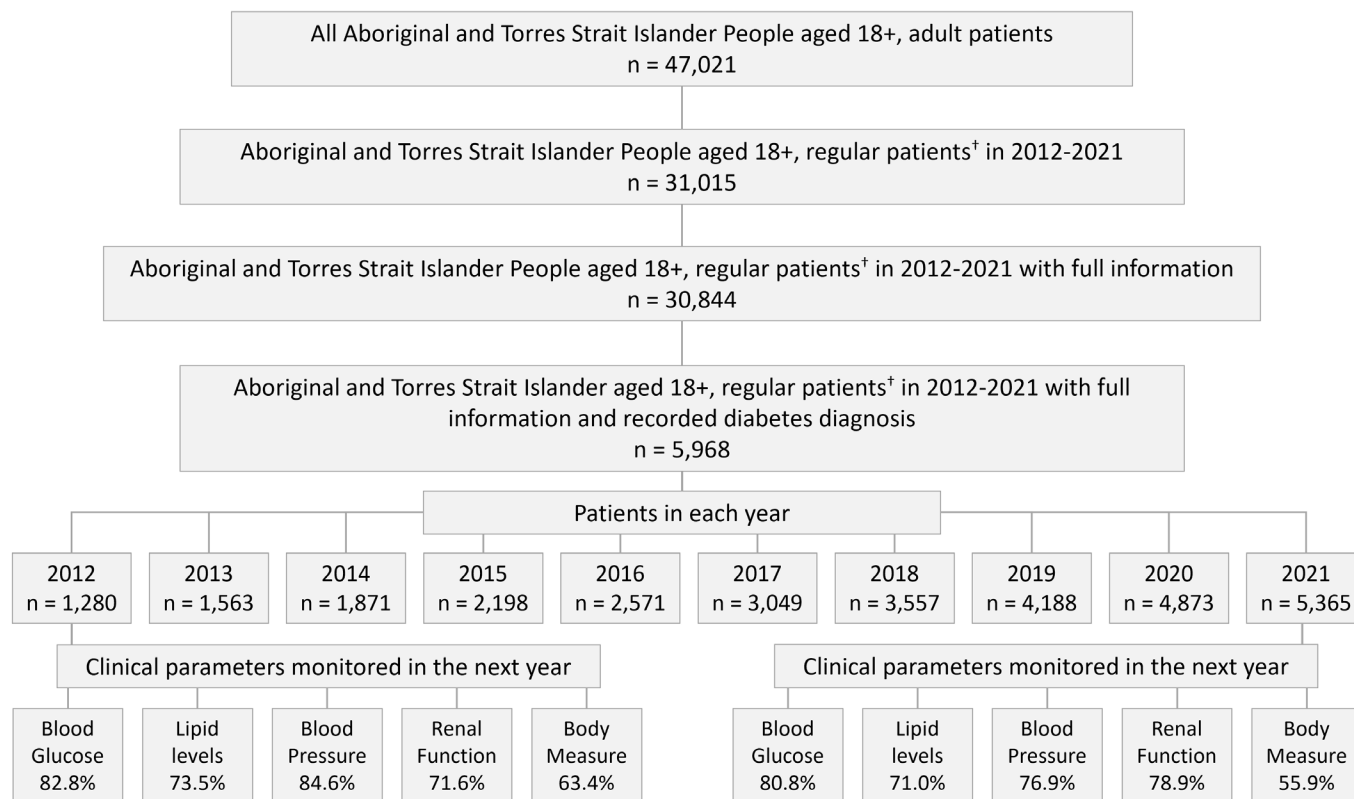
From 25874 Aboriginal and/or Torres Strait Islander adult regular patients in MedicineInsight who attended

their practices in 2021, 5365 had a diagnosis of diabetes (17.3%, 95% CI 16.4 to 18.1; [figure 1](#)), with a mean age of 55.7 years (SD=16) and 58.1% females.

[Table 1](#) shows that Aboriginal and/or Torres Strait Islanders with diabetes living in inner regional or rural Australia were more likely to attend practices located in more disadvantaged areas compared with those living in urban areas. The distribution according to gender or age did not differ across all regions. However, the proportion of smokers and people with CVD or CKD was slightly higher in rural compared with urban areas.

### Clinical parameters monitoring

[Figure 2](#) shows that blood glucose, lipid profile and renal function monitoring between 2013 and 2022 were similar among urban, inner regional or rural regions (see also online supplemental tables S1-S5). However, a higher prevalence of BP and body measurement monitoring was observed among individuals living in rural areas during the initial years of the study, but the differences dissipated in subsequent years. In 2013, 90.0% (95% CI 87.2 to 92.7) of individuals with diabetes in rural areas had their BP checked compared with 82.1% (95% CI 77.1 to 87.1) in urban areas (online supplemental table S4). By 2022, it had fallen to 79.3% (95% CI 75.7 to 82.9) in rural and 75.6% (95% CI 72.4 to 78.9) in urban areas (annual average change  $-0.58$  (95% CI  $-0.96$  to  $-0.20$ ) and  $-0.31$  (95% CI  $-0.83$  to  $+0.21$ ), respectively; [table 2](#)). The more



**Figure 1** Sample selection for Aboriginal and Torres Strait Islander patients with recorded diabetes diagnosis. †Regular patients:  $\geq 3$  consultations in 2020–2022, with at least one in each of these 3 years.

**Table 1** Sociodemographic and clinical profile of regular† patients in 2021 (n=5365) aged 18+ with diabetes diagnosis and assessed for monitoring and control in 2022

Variables	Total (n=5365)		Urban (n=1680)		Inner regional (n=1462)		Rural (n=2223)	
	%	(95% CI)	%	(95% CI)	%	(95% CI)	%	(95% CI)
Practice IRSAD quintiles								
Most advantaged	6.4	(4.0 to 10.2)	16.6	(11.0 to 24.1)	1.6	(0.7 to 3.4)	1.8	(0.3 to 10.3)
High	9.4	(5.6 to 15.3)	16.5	(11.8 to 22.8)	3	(1.1 to 8.2)	7.9	(2.2 to 25.0)
Middle	33.7	(19.4 to 51.8)	23.9	(16.0 to 34.1)	31.1	(18.1 to 48.0)	42.8	(16.3 to 74.3)
Low	25.9	(18.1 to 35.5)	26.6	(18.7 to 36.4)	31.4	(20.9 to 44.2)	21.8	(9.9 to 41.6)
Most disadvantaged	24.6	(16.5 to 35.1)	16.4	(10.1 to 25.5)	32.9	(21.2 to 47.1)	25.6	(12.1 to 46.4)
Gender								
Male	41.9	(40.3 to 43.6)	41.5	(38.9 to 44.1)	41.7	(38.7 to 44.8)	42.4	(40.0 to 44.9)
Female	58.1	(56.4 to 59.7)	58.5	(55.9 to 61.1)	58.3	(55.2 to 61.3)	57.6	(55.1 to 60.0)
Age group								
18–34	11.3	(10.0 to 12.8)	14.2	(12.1 to 16.7)	11.6	(9.5 to 14.0)	9	(7.6 to 10.5)
35–49	21.7	(20.2 to 23.2)	21.2	(19.1 to 23.4)	21.6	(19.1 to 24.4)	22.1	(19.8 to 24.6)
50–64	36.8	(34.0 to 39.7)	34.8	(31.9 to 37.8)	34.3	(31.6 to 37.0)	40	(35.6 to 44.5)
65–74	19.2	(17.5 to 21.0)	18.7	(16.5 to 21.1)	20.1	(17.9 to 22.5)	19.1	(16.0 to 22.6)
75+	11	(9.6 to 12.5)	11.1	(9.3 to 13.3)	12.4	(10.5 to 14.6)	9.9	(7.9 to 12.4)
IRSAD quintile								
Most advantaged	6.2	(4.2 to 9.3)	15	(10.8 to 20.5)	1.3	(0.6 to 3.0)	2.7	(0.8 to 8.6)
High	10.2	(8.1 to 12.8)	18.3	(14.8 to 22.5)	5.1	(3.4 to 7.5)	7.3	(3.7 to 13.8)
Middle	25.7	(19.5 to 33.0)	25.5	(20.4 to 31.3)	27.8	(18.2 to 39.9)	24.6	(13.1 to 41.4)
Low	30.3	(24.9 to 36.4)	26.1	(20.7 to 32.3)	29.2	(20.7 to 39.5)	34.2	(22.8 to 47.7)
Most disadvantaged	27.5	(23.0 to 32.6)	15.1	(10.6 to 21.0)	36.6	(27.7 to 46.6)	31.2	(22.9 to 41.0)
Smoking status								
Non-smoker	34.7	(32.8 to 36.6)	36.8	(33.9 to 39.8)	33.9	(30.0 to 38.1)	33.5	(31.0 to 36.0)
Ex-smoker	31.9	(30.1 to 33.8)	30.3	(27.7 to 33.1)	34.2	(30.7 to 37.9)	31.7	(28.9 to 34.8)
Smoker	30.2	(27.6 to 32.9)	28.1	(25.2 to 31.2)	29	(25.6 to 32.6)	32.5	(28.4 to 36.9)
Not stated/not recorded	3.2	(2.2 to 4.6)	4.8	(2.9 to 7.6)	2.9	(1.8 to 4.7)	2.2	(1.2 to 4.1)
Cardiovascular disease*								

Continued



Table 1 Continued

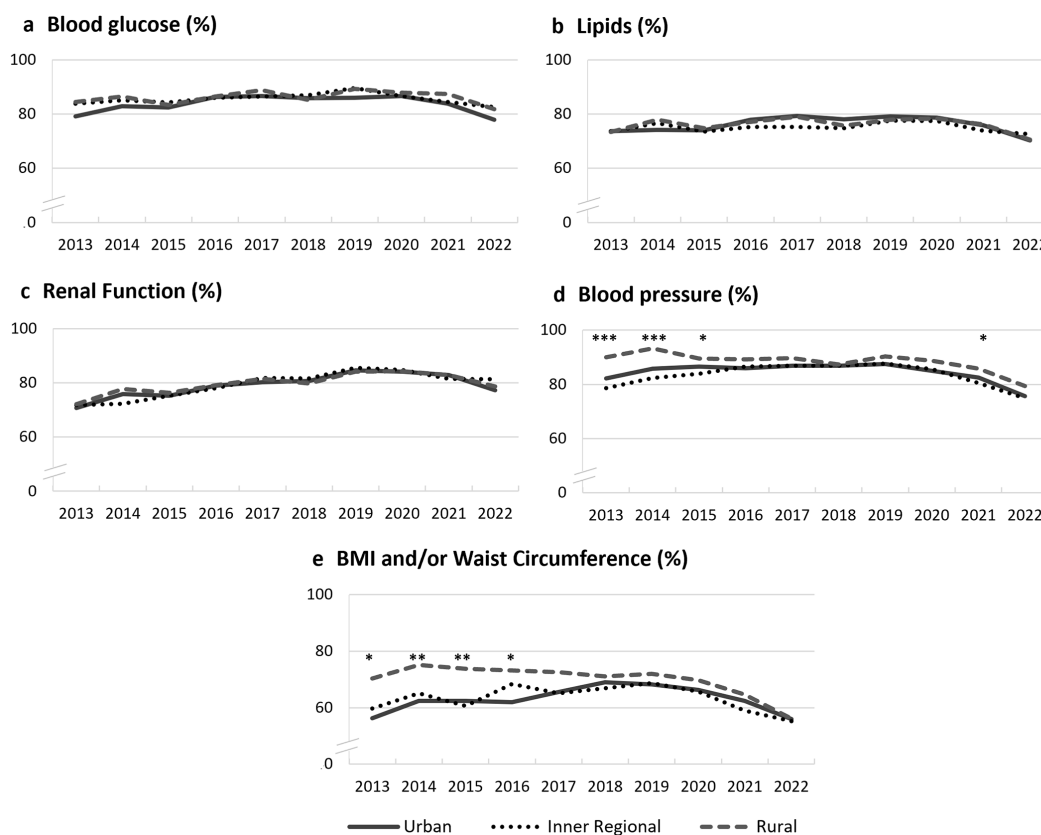
Variables	Total (n=5365)		Urban (n=1680)		Inner regional (n=1462)		Rural (n=2223)	
	%	(95% CI)	%	(95% CI)	%	(95% CI)	%	(95% CI)
Yes	25.4	(22.6 to 28.5)	23.9	(21.4 to 26.5)	23.8	(21.0 to 26.8)	27.7	(22.8 to 33.2)
Chronic kidney disease								
Yes	15.3	(13.3 to 17.4)	12.5	(10.8 to 14.4)	15.3	(13.3 to 17.6)	17.4	(14.2 to 21.0)

\*Includes ischaemic heart disease, stroke, heart failure, peripheral arterial disease and aortic disease.  
†Regular patients: ≥3 consultations in 2020–2022, with at least one in each of these 3 years.  
BMI, Body Mass Index; IRSAD, Index of Relative Socio-economic Advantage and Disadvantage.

frequent monitoring of BMI/waist circumference in rural areas observed between 2013 and 2018 (~75%) also decreased in recent years (annual average change  $-0.93$  (95% CI  $-1.60$  to  $-0.25$ ) in rural areas,  $+0.61$  (95% CI  $-0.65$  to  $+1.90$ ) in urban areas), leading to a similar prevalence of body measurement across regions in recent years (~60%).

The control of most clinical parameters was different among geographical locations. Blood glucose and lipid

control were higher in urban (~80%) than rural areas (~60%) during the whole period (figure 3; see also online supplemental tables S6–S12 for proportions of patients meeting clinical targets across all individual parameters, including HbA1c). The most recent data (2022) showed that 86.3% (95% CI 81.8 to 90.7) of patients in urban areas had their blood glucose controlled compared with only 68.4% (95% CI 60.8 to 75.9) in rural areas, while 79.5% (95% CI 73.8 to 85.3) had their lipids controlled



**Figure 2** Adjusted prevalence of monitoring of clinical parameters from 2013 to 2022, stratified according to the remoteness of residence. Results based on logistic regression models adjusted for practice IRSAD, age, gender, patient IRSAD, smoking status and history of CVD or CKD. Sample size per year N2013=1280; N2014=1563; N2015=1871; N2016=2198; N2017=2571; N2018=3049; N2019=3557; N2020=4188; N2021=4873; N2022=5365. BMI, body mass index; CKD, chronic kidney disease; CVD, cardiovascular disease; IRSAD, Index of Relative Socioeconomic Advantage and Disadvantage. \*\*\* $p < 0.001$ ; \*\* $p < 0.01$ ; \* $p < 0.05$ .

**Table 2** Annual average change of monitoring and control of clinical parameters from 2013 to 2022

	Urban		Inner regional		Rural	
	(%)	95% CI	(%)	95% CI	(%)	95% CI
<b>Monitoring</b>						
Blood glucose	0.52	(0.01 to 1.03)	0.82	(0.06 to 1.6)	0.41	(-0.73 to 1.56)
Lipid level	0.89	(0.22 to 1.56)	0.94	(0.18 to 1.71)	0.49	(-1.13 to 2.14)
Renal function	2.06	(1.17 to 2.96)	2.64	(1.55 to 3.73)	1.45	(-0.41 to 3.36)
Blood pressure	-0.31	(-0.83 to 0.21)	0.31	(-0.72 to 1.37)	-0.58	(-0.96 to -0.2)
Body measure	0.61	(-0.65 to 1.9)	0.51	(-0.99 to 2.03)	-0.93	(-1.6 to -0.25)
<b>Control</b>						
Blood glucose	0.74	(0 to 1.48)	0.8	(-0.09 to 1.71)	1.79	(0.91 to 2.68)
Lipid level	0.15	(-0.79 to 1.12)	1.46	(-0.24 to 3.2)	1.02	(-1.31 to 3.42)
Renal function	-0.65	(-1.75 to 0.45)	-0.84	(-1.92 to 0.24)	-0.26	(-1.28 to 0.76)
Blood pressure	-1.82	(-3.01 to -0.62)	-1.4	(-3.21 to 0.44)	-1.01	(-2.3 to 0.29)
Body measure	1.53	(-2.8 to 6.06)	3.59	(-1.56 to 9.02)	3.01	(-0.15 to 6.29)

in urban and 61.3% (95% CI 54.1 to 68.5) in rural areas. Over the study period, approximately two-thirds of patients presented healthy renal function levels, with a slightly lower proportion in rural areas from 2015. Overall, BP and body measurements did not differ among regions for most of the period. Only around 40% and 10% of patients had their BP and BMI/waist circumference under recommended targets, respectively.

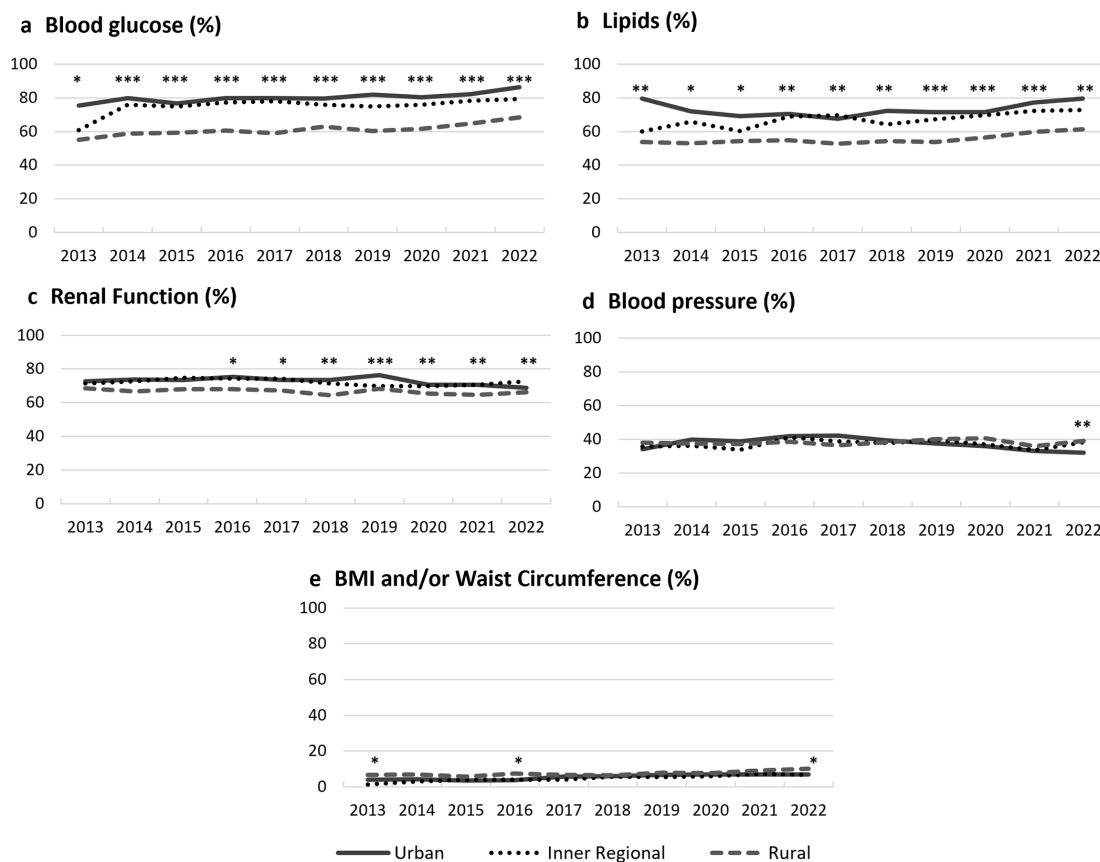
### Recommended clinical targets (control)

The control of most clinical parameters was different among geographical locations. Blood glucose and lipid control were higher in urban (~80%) than rural areas (~60%) during the whole period (figure 3; see also online supplemental tables S6–S12 for proportions of patients meeting clinical targets across all individual parameters, including HbA1c). The most recent data (2022) showed that 86.3% (95% CI 81.8 to 90.7) of patients in urban areas had their blood glucose controlled compared with only 68.4% (95% CI 60.8 to 75.9) in rural areas, while 79.5% (95% CI 73.8 to 85.3) had their lipids controlled in urban and 61.3% (95% CI 54.1 to 68.5) in rural areas. Over the study period, approximately two-thirds of patients presented healthy renal function levels, with a slightly lower proportion in rural areas from 2015. Overall, BP and body measurements did not differ among regions for most of the period. Only around 40% and 10% of patients had their BP and BMI/waist circumference under recommended targets, respectively.

Trends in controlling clinical parameters did not change over time, except for better blood glucose control in rural Australia (+1.79% (95% CI +0.91 to +2.68)) and lower BP control in urban areas (-1.82% (95% CI -3.01 to -0.62)).

### DISCUSSION

This is one of the first studies to investigate nationwide monitoring and control of diabetes among Aboriginal and/or Torres Strait Islander Peoples attending mainstream general practice, and comparing urban, regional and rural Australia. Four main findings can be highlighted based on our results. First, around four in five individuals with diabetes had their glucose levels, lipid levels, BP or renal function checked, with no substantial changes over time or discrepancies between urban or rural scenarios. Second, BMI and/or waist circumference monitoring declined over time in rural areas, and less than three in five individuals with diabetes had their BMI or waist circumference monitored by 2022, irrespective of the region. A similar decline was observed for BP monitoring in rural areas, especially from 2019, possibly related to challenges posed by the COVID-19 pandemic. Third, the prevalence of blood glucose and lipid control and healthy renal function was lower in rural than urban areas over the 10-year period. Finally, control of blood pressure and body measurement was not influenced by



**Figure 3** Adjusted prevalence of clinical parameters controlled from 2013 to 2022 among those monitored, stratified according to the remoteness of residence. Results based on logistic regression models adjusted for practice IRSAD, age, gender, patient IRSAD, smoking status and history of CVD or CKD. Numbers per year vary according to the specific parameter. BMI, body mass index; CKD, chronic kidney disease; CVD, cardiovascular disease; IRSAD, Index of Relative Socioeconomic Advantage and Disadvantage. \*\*\* $p < 0.001$ ; \*\* $p < 0.01$ ; \* $p < 0.05$ .

the geographical location. Only two in five patients with diabetes reached recommended BP targets, and only one in 10 had a normal weight.

Our findings showed that most patients had their clinical parameters monitored. A comprehensive review of 123 Australian studies of the diagnosis and the management of diabetes was published in 2020 and included 35 studies with Aboriginal and/or Torres Strait Islander Peoples.<sup>11</sup> This review reported varied estimates for glucose (HbA1c) monitoring over 12 months (ranging from 41% to 74%). Our estimates may be higher because we also considered fasting and random blood glucose tests in the main analysis. However, when HbA1c was explored individually, results were around 70%–80% in any investigated year (Supplementary material). Similarly, we found a slightly higher proportion of BP (75%–93%) and renal function (71%–86%) monitoring compared with the studies included in the review (53%–88% and 47%–81%, respectively).<sup>11</sup> For lipids and body measures, our results were comparable to previous findings.<sup>11</sup> Possible reasons for differences among these estimates include that many of these studies were limited to specific geographical areas and certain age groups. Furthermore, these studies included estimates for Aboriginal and/or Torres Strait Islander populations attending various practice settings

which included Indigenous health services/centres, primary healthcare centres, (ACCHOs) and Indigenous community health centres.<sup>11</sup>

In our study, the monitoring of the clinical parameters was consistent across urban, inner regional and rural areas. It was higher than the reported prevalence of diabetes monitoring among non-Aboriginal people attending Australian general practice, which was 45% for HbA1c, 42% for lipid levels and 27% for renal function.<sup>18</sup> This suggests GPs are committed to providing comprehensive diabetes care for Aboriginal and Torres Strait Islander Peoples irrespective of the geographical location. It is also consistent with results of a previous study using MedicineInsight data that showed no disparities in the pharmacological management of diabetes in rural or urban Australia.<sup>17</sup>

Monitoring of BMI/waist circumference was lower (55%–75%) than other clinical parameters (70%–90%), despite overweight and obesity representing an important risk factor for further diabetes complications.<sup>9</sup> Previous studies have explored the different barriers that GPs experience when measuring body weight and managing obesity, including the sociocultural context, communication, availability of resources, knowledge, beliefs and stigma,<sup>28–30</sup> which together may influence

GPs' motivations to monitor weight. It is possible that GPs monitor BMI/waist circumference but do not report in the medical records (eg, measured but not recorded, or recorded in the progress notes). However, a report from the Australian Institute of Health and Welfare (AIHW) based on data provided by Aboriginal Health Services showed a similar level (61%) of Aboriginal and/or Torres Strait Islander patients with diabetes had their BMI recorded in 2023.<sup>31</sup> Notably, we found a higher frequency of BMI/WC and BP monitoring in rural locations up to 2017/2018, compared with urban. This finding is consistent with a previous population-based study showing the assessment of different lifestyle risk factors was higher in rural than urban settings in 2017.<sup>32</sup>

Our results for diabetes control showed lower levels than monitoring for all parameters, most noticeably for BP and BMI/waist circumference. Except for those two parameters, results were still better than previously reported findings.<sup>11</sup> Our results showed that approximately 60%–80% of Aboriginal and/or Torres Strait Islander patients achieved recommended targets of blood glucose and lipids, with consistently lower proportions in rural compared with urban areas. Previous studies have reported varying estimates for controlled HbA1c and lipids, ranging from 18–34% and 7%–66% of patients, respectively.<sup>11</sup> Despite the differences observed in blood glucose control across urban and rural areas, the prescription of antidiabetic medications was found to be similar in those areas.<sup>17</sup> Therefore, other factors would explain the lower levels of glucose control in rural Australia, such as restricted access to diabetic friendly or fresh food, sociodemographic or other lifestyle factors.

Around 90% of patients in this study had overweight/obesity. In previous studies, the proportion of patients reported to be overweight/obese varied between 40% and 90%.<sup>11</sup> Furthermore, a study conducted in regional Victoria found that 71% of Aboriginal and/or Torres Strait Islander Peoples with diabetes attending an ACCHO had overweight/obesity.<sup>33</sup> The AIHW also reported an overweight/obesity prevalence of 71% for those attending an ACCHO and 65.4% for those attending a non-ACCHO services.<sup>31</sup> The proportion of patients with uncontrolled blood pressure (around 60%) is also of concern and highlights the need for improved management to avoid the development of renal complications.<sup>34</sup> The increased risk of renal disease among Aboriginal and/or Torres Strait Islander Peoples with diabetes and high blood pressure is well established,<sup>9</sup> and our results showed that 40% of patients already have impaired renal function.

For most parameters, our findings indicate a steady prevalence of diabetes monitoring over the study period, and across locations, notwithstanding a slight decline since 2019. Future exploration will be important to establish whether this decline occurred due to the COVID-19 pandemic and has now returned to prepandemic levels, or if it represents a new pattern.<sup>35</sup> While our study did not directly explore reasons for changes, it is important to explore how external factors might affect healthcare

delivery. In contrast to other parameters, there was a slight increase over time in renal function monitoring in all geographical areas. This may be related to the fact that most patients presented with uncontrolled blood pressure, and this may have prompted increased attention from GPs to monitor renal function.

The study is not free of limitations. MedicineInsight mostly collects data from mainstream GP clinics and is not indicative of the ACCHOs. However, it provides a national perspective of those attending GP clinics, as 54% of Aboriginal and/or Torres Strait Islander Peoples visit a general practice for health problems.<sup>14</sup> Moreover, the proportion of Aboriginal and/or Torres Strait Islander Peoples in the database was similar to national figures (3%). The diabetes prevalence in our sample (17.3%) is slightly higher than the national estimate for the Aboriginal and Torres Strait Islander population in 2022–2024 (15.5%).<sup>36</sup> This may be explained by the different time period examined in our study (2011–2022) or reflect a difference between the overall Aboriginal and Torres Strait Islander population and those attending general practice. The use of EHR relies on the completeness and accuracy of data recorded by GPs as part of their daily clinical activities. Also, we did not have access to measurements reported in progress notes due to the presence of potentially identifiable information. Despite that, studies conducted worldwide, including in Australia, have shown that EHR can provide accurate information on diabetes prevalence, management and control.<sup>10 11 18 25 37 38</sup> Also, the use of EHR avoids self-report bias by providing GP-reported diagnoses, in addition to objective laboratory results.<sup>16 37 38</sup> Moreover, the large sample size, the diversity of locations across all Australian states and the comprehensive clinical information available strengthen this study.

## CONCLUSION

Aboriginal and Torres Strait Islander Peoples with diabetes who live in rural areas are less likely to have well-controlled glucose and lipids compared with their metropolitan counterparts. This is not due to disparities in monitoring for these parameters but may be related to sociodemographic, environmental and/or lifestyle factors. Improved management of blood pressure and overweight/obesity in all areas could reduce the risk of diabetes complications and the burden of renal disease among Aboriginal and/or Torres Strait Islander Peoples.

### Author affiliations

<sup>1</sup>The University of Adelaide Rural Clinical School, Adelaide, South Australia, Australia

<sup>2</sup>The University of Adelaide Discipline of General Practice, Adelaide, South Australia, Australia

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#### ORCID iDs

Antoinette Liddell <http://orcid.org/0009-0001-5778-3398>

Carla Bernardo <http://orcid.org/0000-0001-6998-6419>

Nigel Stocks <http://orcid.org/0000-0002-9018-0361>

David Gonzalez-Chica <http://orcid.org/0000-0002-7153-2878>

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