Received: 21 March 2023 | Revised: 17 July 2023 | Accepted: 6 August 2023

DOI: 10.1111/ajr.13032

AJRH National Rural Health Alliance WILEY

ORIGINAL RESEARCH

Pharmaceutical management of type 2 diabetes among Indigenous Australians living in urban or rural locations: a comparative study using a national general practice database

Natalie Pink MD[1,2] | **Antoinette Liddell A&TSIHP**[3] | **David Gonzalez-Chica MD MSc PhD**[1,3] | **Nigel Stocks MD DipPH FRACGP FAFPHM**[1]

[1]Discipline of General Practice, Adelaide Medical School, University of Adelaide, Adelaide, South Australia, Australia

[2]GPEx, General Practice Regional Training Organisation, Unley, Adelaide, South Australia, Australia

[3]Adelaide Rural Clinical School, University of Adelaide, Adelaide, South Australia, Australia

Correspondence
David Gonzalez-Chica, 115 Grenfell Street, Level 8, Adelaide Medical School, University of Adelaide, Adelaide, South Australia 5000, Australia.
Email: david.gonzalez@adelaide.edu.au

Funding information
Australian College of Rural and Remote Medicine

Abstract

Introduction: Type 2 diabetes is more prevalent among Aboriginal and Torres Strait Islander Peoples, especially those living in rural than urban areas. However, little is known about how diabetes is managed in different settings.

Objective: To investigate differences in the prevalence of diabetes and the prescription of antidiabetic medications for Aboriginal and/or Torres Strait Islander Peoples living in urban or rural Australia.

Design: Cross-sectional study using de-identified electronic medical records of 29,429 Aboriginal and/or Torres Strait Islander adults (60.4% females; mean age 45.2 ± 17.3 years) regularly attending 528 'mainstream' Australian general practices (MedicineInsight) in 2018.

Findings: The prevalence of diabetes was 16.0%, and it was more frequent among those living in rural areas (22.0; 95% CI 19.3–24.4) than inner regional (17.6%; 95% CI 16.0–19.2) or major cities (15.8%; 95% CI 14.7–17.0; $p < 0.001$). The highest prevalence of diabetes was for males living in rural settings (25.0%). Of those with diabetes, 71.6% (95% CI 69.0–74.0) were prescribed antidiabetics, with a similar frequency in urban and rural areas ($p = 0.291$). After adjustment for sociodemographics, the only difference in diabetes management was a higher prescription of sulfonylureas in rural areas than in major cities (OR 1.39; 1.07–1.80).

Discussion: The prevalence of diabetes was similar to other national data, although we found it was more frequent amongst Aboriginal and/or Torres Strait Islander males, especially those from rural areas.

Conclusion: Despite current recommendations, one-in-four Indigenous Australians with diabetes were not prescribed antidiabetics. The clinical significance of more frequent prescriptions of sulfonylureas in rural locations remains unclear.

KEYWORDS
diabetes mellitus, general practice, indigenous peoples, medication therapy management, rural population

1 | INTRODUCTION

The ongoing effects of colonisation through loss of self-determination, culture and traditional practices of Aboriginal and/or Torres Strait Islander Peoples followed by the introduction of a sedentary Western lifestyle and poor nutritional food options are major contributors to the current high rates of diabetes within Aboriginal and/or Torres Strait Islander Peoples.[1] This was further compounded by social determinants of health – poor economic opportunity, poor access to health care, poor education, racism and loss of cultural connection.[1,2] These and other health disparities and poor health outcomes within Aboriginal and/or Torres Strait Islander Peoples are complex and multifactorial.[1,3]

There is substantial evidence that type 2 diabetes has a high disease burden amongst Aboriginal and/or Torres Strait Islander Peoples in Australia than among non-Indigenous People. Current estimates of diabetes in Aboriginal and/or Torres Strait Islander Peoples range between 7.9% and 10.9%, while the prevalence of diabetes in the Australian total population is only 4.9%.[2,4,5] Moreover, type 2 diabetes (T2DM) is responsible for 7.3% of all deaths among Aboriginal and/or Torres Strait Islander Peoples, and the third leading cause of the gap in death rates between Indigenous and non-Indigenous Australians (17% of the total gap in death rates) after cardiovascular diseases and cancer.[2] Despite the national efforts with the Closing The Gap campaign, there is little improvement in health outcomes or reduction in the burden of diabetes among Aboriginal and/or Torres Strait Islander Peoples.[2] Regarding diabetes pharmacological management, there have been many antidiabetic medications made available to Australians on the Pharmaceutical Benefits Scheme (PBS) and Repatriation Pharmaceutical Benefits Scheme (RPBS). In 2020–21, 5.3% of total PBS and RPBS prescriptions were for antidiabetic medications, and approximately 33% of these were for metformin alone.[5] Metformin was the seventh highest dispensed medication, and the total cost (including out-of-pocket and government-subsidised prescriptions) was over $50 million.[5] Moreover, estimates from 2020 showed that 16 000 Australians commenced insulin for type 2 diabetes across all age groups (children from age 10 years and above).[6] However, the number of Aboriginal and/or Torres Strait Islander Peoples on insulin is difficult to determine and likely underestimated due to difficulty with reporting.[4]

What this paper adds

- Aboriginal and/or Torres Strait Islander adult males living in rural or remote Australia have a higher prevalence of type 2 diabetes than previously described.
- Prescribing patterns are similar across all regions, with approximately 75% prescribed antidiabetic medications.
- Those living in rural and remote locations are more likely to be prescribed a combination of metformin with sulfonylureas.

What is already known on this subject

- The prevalence of type 2 diabetes is disproportionately higher in Aboriginal and Torres Strait Islander Peoples than non-Indigenous Australians.
- The number of Aboriginal and/or Torres Strait Islander Peoples on specific antidiabetic medications has been difficult to determine and likely underestimated due to difficulty with reporting.

As found in the last Bettering the Evaluation and Care of Health (BEACH) report from 2015 to 16, T2DM is commonly managed in general practice settings, with 4 in every 100 encounters diabetes-related and ~70% of medication management decisions for diabetes being made by general practitioners (GPs) alone without specialist input.[7]

The Diabetes Australia guidelines recommend that managing type 2 diabetes should begin with lifestyle changes, followed by pharmaceutical management if no improvement is achieved after 3 months.[8] However, that recommendation is generic, and there are no specific suggestions for Aboriginal and/or Torres Strait Islander Peoples. The Central Australian Rural Practitioners Association (CARPA) manual recommends that lifestyle measures are important across all treatment steps, but suggests that Aboriginal and/or Torres Strait Islander Peoples should be commenced on metformin or other antidiabetic medications on the date of diagnosis of type 2 diabetes.[9] As per both the Diabetes Australia and CARPA clinical guidelines, medication choice usually begins with metformin. If the HbA1c or blood glucose levels are not controlled within 3–6 months, other antidiabetic medications should be added in progressively, starting with a sulfonylurea, followed by a glucagon-like peptide 1 agonist (GLP-1 RA), sodium-glucose co-transporters (SGLT) inhibitors, or Dipeptidyl-peptidase 4 (DPP4) inhibitors, and then escalating to insulin.[8] Insulin is sometimes considered earlier if there is significant hyperglycaemia or ketoacidosis, in which case more urgent management of glycaemia is needed.[8]

The current literature on the prescription of antidiabetic medication examines the entire Australian population and does not focus on Aboriginal and/or Torres Strait Islander Peoples specifically. Given type 2 diabetes is more prevalent in rural and remote areas,[4] there may be differences in prescribed medications due to access to care or availability in these areas. It is well known that earlier diagnosis and prompt diabetes management allow prevention and delay the progression of diabetes-related microvascular and macrovascular complications,[10] which are common within Aboriginal and/or Torres Strait Islander populations.[2] Drawing from their health professional expertise and personal experiences, the two Aboriginal authors and an Indigenous advisory group strongly believe that this study significantly contributes to the existing evidence on diabetes pharmaceutical management in Aboriginal and/or Torres Strait Islander Peoples. The topic resonates deeply with the advisory group's community members, as they themselves utilise mainstream services, and so do their families and extended community. Moreover, they perceived this issue holds particular significance in both rural and remote areas when compared to urban regions, as limited access to healthcare and medications significantly contributes to poor health outcomes.[1–3,10] Therefore, the aim of this study was to evaluate differences in the prevalence of type 2 diabetes among Aboriginal and/or Torres Strait Islander Peoples living in urban or rural Australia, as well as differences in the prescription of specific antidiabetic medications and the most frequent antidiabetic groups prescribed in combinations with metformin or insulin.

2 | METHODS

2.1 | Community engagement and ethics

Dr Natalie Pink, a Nyikina Aboriginal person based in Tarndanya (Adelaide) on Kaurna country, led the study team. Dr Pink also acted as an Aboriginal Engagement Coordinator to ensure the 'spirit and integrity' of the informal advisory group were at the forefront of all community and stakeholder engagement activities relating to this study. Community engagement with local Kaurna elders, members of the GPEx Aboriginal Health Team and Indigenous medical colleagues from across Australia occurred prior to the design and commencement of the study. Members of the community formed an informal Indigenous advisory group who contributed their insights across all stages of the study. At the beginning of the project, the advisory group was consulted on the scope of the project, and the content to be investigated. The group preferred not to compare Indigenous to non-Indigenous people as they felt there was too much literature describing poor health statistics in comparison to the non-Indigenous population. The group specifically preferred a descriptive study of mainstream GP prescription in diabetes management in Aboriginal and/or Torres Strait Islander Peoples' alone. Moreover, they felt the project was a good opportunity for training Aboriginal Health Professionals in quantitative research methods, and were keen to have research at a national level focusing on mainstream GP clinics, rather than Aboriginal Medical Services, as many of the group had family and community members attending these clinics for their medical care. Comparing urban and rural locations was also discussed due to the requirements of the funding of this project to highlight any differences based on remoteness. The advisory group accepted this as part of the project scope. The results were discussed with the group in language that could be clearly understood and there was agreement about the direction of the discussion. We then submitted the proposal to the Aboriginal Health Research Ethics Committee from the Aboriginal Health Council of South Australia, who granted approval (AHREC Protocol #: 04-21-967) to use de-identified data from participating NPS MedicineInsight general practice clinics across Australia. The research was carried out in accordance with the National Health and Medical Research Council (NHMRC) National Statement on Ethical Conduct in Human Research 2007 updated 2018, and is pursuant with the low-risk requirements. The independent MedicineInsight Data Governance Committee approved the study (protocol 2016-007).

2.2 | Data source

This cross-sectional study used data from MedicineInsight, a large general practice database containing de-identified electronic medical records (EMRs) of patients attending approximately 2700 GPs and 622 general practices across Australia (8.2% of all practices in the country) varying in size, billing methods, and type of services. Routinely collected data available in MedicineInsight includes sociodemographic information (e.g. gender, year of birth, 'Indigenous status'), clinical data (i.e. diagnoses, reasons for consultation, reasons for prescriptions, smoking status) and prescribed medications. In 2018, 2.6% of the over two million patients in MedicineInsight were Aboriginal and/or Torres Strait Islander Peoples. Details of the data collection process and characteristics of MedicineInsight have been published elsewhere.[11]

This study was reported according to recommendations from the Reporting of studies Conducted using Observational Routinely-collected health Data (RECORD) Statement.[12] Only practices that provided regular data (no intervals of more than 6 weeks for data provision in the past 2 years) and were established at least 2 years before the end of the analysis period (2018) were selected. Administrative contacts (e.g. phone calls, emails, letters) or duplicated records for the same patient and date were excluded.

2.3 | Study sample

The sample included all Aboriginal and/or Torres Strait Islander adults (18+ years) considered 'regular' patients [at least three consultations in the last 2 years (i.e. frequent or 'active' patients as defined by Royal Australian College of General Practitioners)[13] AND at least one consultation in 2017 and 2018], with a diagnosis of diabetes mellitus and attending a MedicineInsight general practice between January and December 2018. These inclusion criteria aimed to improve diagnosis accuracy, considering the diagnosis of chronic conditions based on EHRs requires data from multiple medical encounters to minimise misclassification.[12,14,15]

Different datasets of the MedicineInsight database (i.e. 'diagnosis', 'reason for encounter', 'reason for prescription') were searched to identify patients with a recorded diagnosis of 'diabetes mellitus' (either type 1 or type 2), using standard clinical terminology, abbreviations, and misspellings of these words. Patients were considered as having diabetes mellitus when that diagnosis was recorded at least twice (either as a 'diagnosis', 'reason for encounter', and/or 'reason for prescription') on different dates between 2011 (the year that MedicineInsight started data extraction) and December 2018. Of the patients included in the study, 55% had data available since 2011 and 88% since 2016. Algorithms used to identify patients with diabetes in MedicineInsight have a sensitivity of 89% and specificity of 100% compared to the recorded diagnosis in the original practice records.[16]

2.4 | Outcome

All prescriptions of antidiabetic medications available in Australia[8,17] and provided to these patients in 2018 were extracted from the script dataset based on the active components and Anatomical Therapeutic Chemical Classification (ATC). These medications included insulin [ATC code A10A] and oral antidiabetic medications [ATC code A10B: metformin, sulfonylureas (glibenclamide, gliclazide, glimepiride, glipizide), Dipeptidyl-peptidase 4 (DPP4) inhibitors (alogliptin, linagliptin, saxagliptin, sitagliptin, vildagliptin), sodium-glucose co-transporters (SGLT) inhibitors (ertugliflozin, empagliflozin, dapagliflozin, canagliflozin), glucagon-like peptide 1 (GLP-1) agonists (exenatide, dulaglutide, liraglutide), thiazolidinediones (pioglitazone, rosiglitazone), acarbose].

The first investigated outcome was the proportion of Aboriginal and/or Torres Strait Islanders Peoples with diabetes diagnosis who were prescribed 'any' of these antidiabetic medications in 2018 (binary outcome). We then explored the specific group of antidiabetic medication that was prescribed. Considering metformin is the first line and most frequent medication prescribed for diabetes management in Australia,[8,17] we also explored the proportion of those managed with metformin who received other antidiabetic medication and the most frequent combinations (i.e. insulin, sulfonylureas, DPP-4 inhibitors, SGLT2 inhibitors, GLP-1 agonists). Combinations with thiazolidinediones, acarbose or with individual medications were not considered due to the small number of participants who were prescribed these combinations. The same approach was used to investigate the most frequent combinations among patients who received insulin prescriptions in 2018.

2.5 | Remoteness of residence

The Australian Statistical Geography Standard (ASGS) remoteness structure (i.e. major cities, inner regional, outer regional, remote, very remote) is a framework of statistical areas used by the Australian Bureau of Statistics (ABS) based on the town size (2016 census data) and distance/access to services (Accessibility and Remoteness Index of Australia).[18] The ASGS remoteness of residence was generated by MedicineInsight based on postcodes and then reclassified for analysis as (1) major cities, (2) inner regional, or (3) rural (i.e. outer regional, remote or very remote Australia).

2.6 | Covariates

Covariates obtained from MedicineInsight included gender (male, female), age (categorised as 18–34, 35–49, 50–64, 65–74, 75+ years), the Index of Relative Socioeconomic Advantage and Disadvantage (IRSAD), smoking status (non-smoker, ex-smoker, current smoker) and relevant diabetes comorbidities (i.e. hypertension, chronic kidney disease, ischaemic heart disease, heart failure, and stroke). IRSAD is an area-level measure of socioeconomic advantage and disadvantage developed by the ABS using census data (e.g. education, employment/income, housing in 2016) and then ranked from most-disadvantaged (lowest rank) to most-advantaged areas (highest rank)[19] Patient and practice IRSAD in quintiles were generated by MedicineInsight based on postcodes, and regrouped for analysis as low (two lowest quintiles), middle or high (two highest quintiles) IRSAD. Data about relevant diabetes comorbidities were extracted from the three diagnosis fields using pre-recorded terms, synonyms, and misspellings related to these diagnoses.[11,20,21]

2.7 | Statistical analysis

All analyses were conducted in Stata MP 16.1 (StataCorp, Texas, USA). Differences in the distribution of socio-demographic or clinical characteristics according to the remoteness of residence were assessed using the Chi-square test. Results for gender differences in the prevalence of diabetes diagnosis or the prevalence of antidiabetic prescriptions according to the remoteness of residence were presented graphically with the corresponding 95% confidence intervals (95% CI).

Logistic regression models were used to test the association between the remoteness of residence and the prescription of antidiabetic medications in 2018. Results were presented as crude odds ratios (OR) and adjusted odds ratios (OR_{adj}), using major cities as the reference category. For adjusted analyses, all results were adjusted for gender, age, and patient and practice IRSAD considering that these variables could be confounders in the relationship between the remoteness of residence and the prescription of antidiabetic medications. Following recommendations of the American Statistical Association, OR_{adj} are reported with their corresponding 95% CI and *p*-values for correct interpretation of the statistical results.[22] All analyses were conducted considering the practice as a cluster, using robust standard errors and conditioned to the number of consultations. Therefore, the *p*-values were obtained using Wald tests for heterogeneity. Individuals with missing data on the outcome, exposure or confounders were excluded from analyses as they represented only 0.1 of the sample and were unlikely to affect the results to consider alternative approaches (e.g. multiple imputation).

3 | RESULTS

In 2018, the MedicineInsight database included 29 429 Aboriginal and/or Torres Strait Islander adults regularly attending 528 general practices [median number of individuals per practice = 29 (interquartile range 10–68); 60.4% females; mean age 45.2 ± 17.3 years). Of these, 4723 individuals (16.0%) had a recorded diagnosis of diabetes mellitus (55.2% females; mean age 57.7 ± 14.4 years). The prevalence of diabetes mellitus was lower among Aboriginal and/or Torres Strait Islander adults living in major cities (15.8%; 95% CI 14.7–17.0) than those from inner regional (17.6%; 95% CI 16.0–19.2) or rural areas (22.0; 95% CI 19.3–24.4; $p < 0.001$). Irrespective of the remoteness of residence, the prevalence of diabetes was higher in males than in females (Figure 1).

Table 1 presents the distribution of sociodemographic and clinical characteristics of Aboriginal and/or Torres Strait Islander adults with diabetes according to the

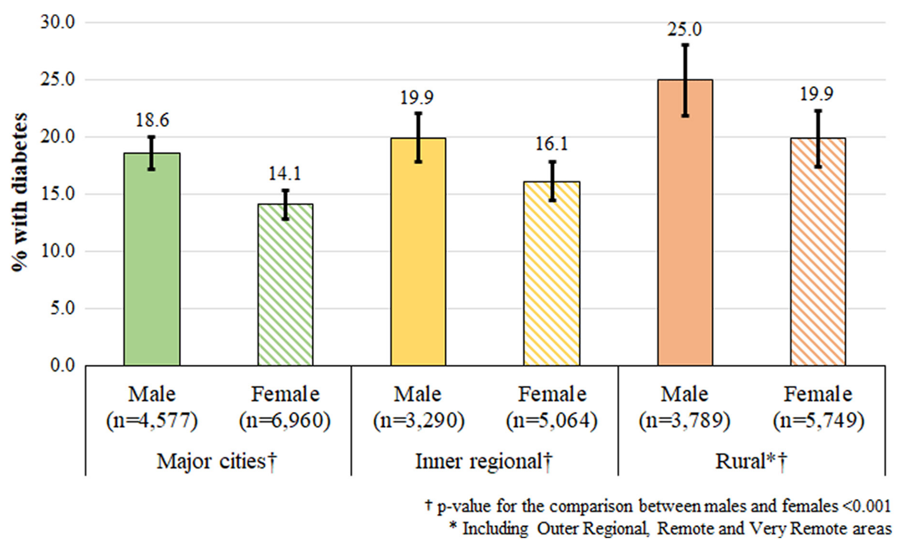

FIGURE 1 Prevalence of diabetes mellitus among Aboriginal and Torres Strait Islander People aged 18+ years according to the remoteness of residence* and sex. Vertical lines represent the 95% CI.

remoteness of residence. Individuals with diabetes living in rural areas were more likely to live or attend practices in more disadvantaged areas than those from major cities or inner regional Australia. Those from rural areas also had a slightly higher frequency of chronic kidney disease (10.2%) than those from major cities (7.1%). No differences were observed according to gender, age or clinical characteristics (smoking, hypertension, ischaemic heart disease, heart failure or stroke; *p*-value >0.1 for all these comparisons). The relationship between these variables and the prescription of any antidiabetic medication is presented in Table S1.

Overall, 71.6% (95% CI 69.0–74.0) of those with diabetes were prescribed antidiabetic medications in 2018. Table 2 shows that there were no differences in that prevalence between major cities, inner regional or rural Australia, even when the results were stratified by gender (Figure 2; *p*-value >0.1 for all comparisons). Table 2 also shows that insulin was less frequently prescribed in rural areas (17.9%) compared to those living in major cities or inner regional (~21%). In contrast, a higher frequency of sulfonylurea prescriptions occurred in rural compared to other settings (20.1% vs. ~15%). After adjustment for sociodemographic characteristics, the only persisting difference was the higher

TABLE 1 Distribution sociodemographic and clinical characteristics among Aboriginal and Torres Strait Islander People with diabetes mellitus according to the remoteness of residence[a]. MedicineInsight, 2018.

	Major cities *n* = 1573%	Inner regional *n* = 1300%	Rural *n* = 1850%	*p*-value[b]
Practice IRSAD				
Low	18.3	37.7	49.4	0.001
Middle	58.0	58.3	37.0	
High	23.7	4.0	13.6	
Gender				
Male	45.4	43.6	44.3	0.654
Female	54.6	56.4	55.7	
Age group (years)				
18–34	7.8	5.3	5.8	0.124
35–49	21.4	22.9	21.1	
50–64	39.4	36.1	40.9	
65–74	19.4	22.6	21.2	
75+	11.9	13.1	11.1	
Participant IRSAD				
Low	21.6	44.1	52.9	<0.001
Middle	52.9	53.2	37.6	
High	25.6	2.8	9.5	
Smoking				
Non-smoker	38.0	36.6	38.3	0.892
Ex-smoker	34.1	34.3	32.9	
Current smoker	27.9	29.1	28.8	
Comorbidities (% yes)				
Hypertension	54.5	55.1	57.0	0.563
Chronic kidney disease	7.1	8.6	10.2	0.037[c]
Ischaemic heart disease	18.9	15.9	19.0	0.134
Heart failure	6.4	7.7	6.8	0.525
Stroke	6.1	6.5	7.1	0.595

[a]Remoteness of residence using the Australian Statistical Geography Standard classification based on the postcode of residence. Outer regional, remote and very remote are classified as rural areas.

[b]Chi-squared test of heterogeneity.

[c]Chi-squared test for trend.

TABLE 2 Prescription of antidiabetic medications among Aboriginal and/or Torres Strait Islander People with diabetes mellitus according to the remoteness of residence[a]. MedicineInsight, 2018.

	Major cities $n = 1573$	Inner regional $n = 1300$	Rural $n = 1850$	p-value[h]
Any antidiabetic prescribed in 2018[b] – % Yes	72.5	73.6	69.4	
OR (95% CI)	1.00	1.06 (0.84–1.33)	0.86 (0.65–1.15)	0.395
OR_{adj} (95% CI)[i]	1.00	1.00 (0.79–1.27)	0.84 (0.63–1.11)	0.386
Type of antidiabetic prescribed				
Metformin – % Yes	60.5	62.5	60.4	
OR (95% CI)	1.00	1.09 (0.89–1.32)	1.00 (0.78–1.27)	0.673
OR_{adj} (95% CI)[i]	1.00	1.04 (0.85–1.27)	0.97 (0.76–1.23)	0.812
Insulin – % Yes	21.4	21.7	17.9	
OR (95% CI)	1.00	1.01 (0.83–1.24)	0.80 (0.65–0.98)	0.036
OR_{adj} (95% CI)[i]	1.00	1.00 (0.81–1.24)	0.82 (0.66–1.02)	0.089
Sulfonylureas[c] – % Yes	15.1	15.3	20.1	
OR (95% CI)	1.00	1.02 (0.77–1.34)	1.41 (1.09–1.83)	0.012
OR_{adj} (95% CI)[i]	1.00	0.99 (0.75–1.32)	1.39 (1.07–1.80)	0.009
DPP-4 inhibitors[d] – % Yes	22.9	23.9	23.2	
OR (95% CI)	1.00	1.05 (0.83–1.33)	1.02 (0.79–1.30)	0.903
OR_{adj} (95% CI)[i]	1.00	1.09 (0.86–1.39)	1.09 (0.85–1.40)	0.719
SGLT2 inhibitors[e] – % Yes	17.7	15.5	15.2	
OR (95% CI)	1.00	0.86 (0.59–1.25)	0.84 (0.58–1.20)	0.599
OR_{adj} (95% CI)[i]	1.00	0.75 (0.52–1.10)	0.75 (0.53–1.05)	0.209
GLP-1 agonists[f] – % Yes	6.3	7.9	5.8	
OR (95% CI)	1.00	1.27 (0.90–1.78)	0.91 (0.65–1.28)	0.157
OR_{adj} (95% CI)[i]	1.00	1.26 (0.89–1.78)	0.92 (0.65–1.30)	0.180
Thiazolidinediones[g] – % Yes	0.3	0.3	0.3	
OR (95% CI)[j]	1.00	1.17 (0.27–5.04)	1.09 (0.30–4.010	0.977
Acarbose – % Yes	0.2	0.2	0.3	
OR (95% CI)[j]	1.00	1.12 (0.19–6.72)	1.39 (0.30–6.37)	0.912

[a]Remoteness of residence using the Australian Statistical Geography Standard classification based on the postcode of residence. Outer regional, remote and very remote are classified as rural areas.

[b]Any prescription provided in 2018, including metformin, sulfonylureas, DPP-4 inhibitor, SGLT2 inhibitors, GLP-1 agonists, acarbose, thiazolidinediones and/or insulin.

[c]Sulfonylureas: glibenclamide, gliclazide, glimepiride, glipizide.

[d]DPP4 inhibitors: alogliptin, linagliptin, saxagliptin, sitagliptin, vildagliptin.

[e]SGLT2 inhibitors: ertugliflozin, empagliflozin, dapagliflozin, canagliflozin.

[f]GLP-1 agonists: exenatide, dulaglutide, liraglutide.

[g]Thiazolidinediones: pioglitazone, rosiglitazone.

[h]Test for heterogeneity.

[i]Adjusted odds ratios (OR_{adj}) based on logistic regression models adjusted for age, gender, patient and practice IRSAD.

[j]The frequency of thiazolidinediones and/or acarbose were too small to allow adjusted regression analysis.

frequency of sulfonylurea prescriptions in rural areas compared to other regions [OR_{adj} 1.39 (1.07–1.80)].

Of those prescribed metformin ($n = 2776$), 65.6% (95% CI 63.8–67.3) received another antidiabetic medication in 2018. That frequency was lower than the co-prescription of insulin with other antidiabetics ($n = 896$; 76.5% (95% CI 73.7–79.1, data not shown in tables). Figure 3a shows that the co-prescription of metformin with other antidiabetics was similar in all regions. Still, the co-prescription of insulin with other antidiabetics was higher in rural (80.6%) than in inner regional (75.0%) or major cities (73.7%; p-value 0.043). The only group of antidiabetic medications more frequently

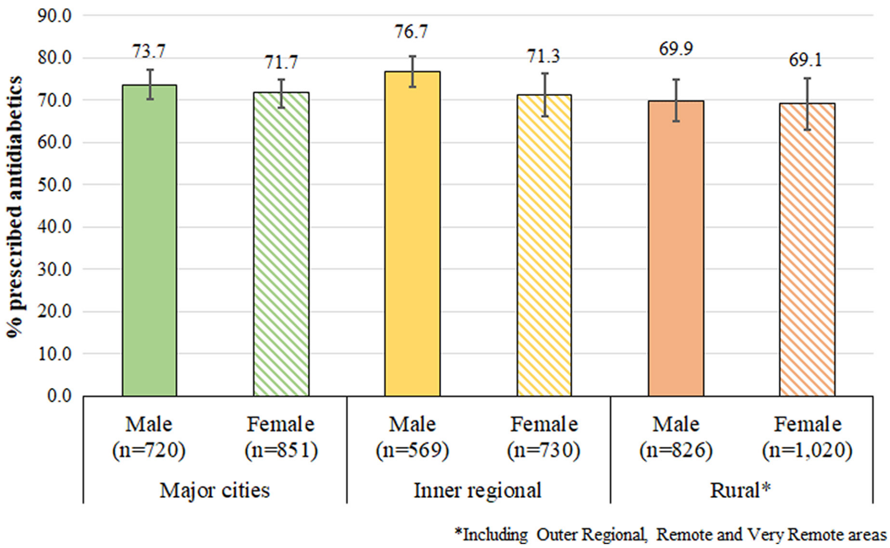

FIGURE 2 Proportion of Aboriginal and Torres Strait Islander People with diabetes mellitus who were prescribed an antidiabetic medication in 2018, stratified according to the remoteness of residence* and sex. Antidiabetics include metformin, insulin sulfonylurea, DPP-4 inhibitor, SGLT2 inhibitors, GLP-1 RA, thiazolidinediones and/or acarbose. Vertical lines represent the 95% CI.

co-prescribed with either metformin or insulin in rural areas than in other settings was sulfonylureas (Figure 3b). The combination of insulin with DPP-4 inhibitors was also more frequent in rural or inner regional areas than in major cities.

4 | DISCUSSION

The MedicineInsight database provided national data to evaluate differences in the prevalence of diabetes and prescribing practices in 'mainstream' general practice clinics for Aboriginal and/or Torres Strait Islander Peoples with diabetes living in urban or rural Australia. First, we found that the prevalence of diabetes was higher amongst Aboriginal and Torres Strait Islander males than Aboriginal and Torres Strait Islander females, irrespective of the remoteness of residence. Second, the prevalence of diabetes was higher in male Aboriginal and/or Torres Strait Islander Peoples from rural and remote areas than in urban areas. Third, three out of four Aboriginal and Torres Strait Islander Peoples with diabetes were prescribed antidiabetic medication, and there were only small differences in prescribing practices across urban, inner regional and rural/remote areas of Australia.

Consistent with our findings, the National Aboriginal and Torres Strait Islander Health Survey 2018–19 found that the prevalence of type 2 diabetes in Aboriginal and/or Torres Strait Islander adults was 17%, and it was higher in rural regions than in urban settings, irrespective of age or gender.[3] Moreover, a systematic review published in 2011 reported that the prevalence of diabetes among Indigenous Australians ranged between 3.5% and 33.1%, with a higher frequency in remote compared to urban settings. The higher prevalence of diabetes in rural areas can be partially explained by socioeconomic differences across regions. According to the Australian Institute of Health and Welfare, individuals living in areas of most disadvantage were more likely to have diabetes (Indigenous and non-Indigenous, 6.3%) than those living in the least disadvantaged areas (4.0%).[4] In our study, Aboriginal and/or Torres Strait Islander Peoples with type 2 diabetes living in rural or remote locations were more likely to reside in a low socioeconomic area than those from major cities or inner regional areas. This finding could be because people in disadvantaged areas are overrepresented in more rural and remote locations, considering that for Indigenous Australians there is a clear gradient of disadvantage by remoteness.[23]

However, different from our study, the National Aboriginal and Torres Strait Islander Health Survey showed female Aboriginal and/or Torres Strait Islander adults reported having type 2 diabetes more frequently than males.[3] A systematic review using data from studies conducted between 1983 and 2005 found that, out of 11 studies (five based on self-reported data), all but two studies reported a higher prevalence of diabetes among Aboriginal and/or Torres Strait Islander women than men.[24] The discrepancy between our findings and those from the survey may reflect methodological differences. Health surveys use population-based samples and self-reported data, which is susceptible to information bias (i.e. male Aboriginal and/or Torres Strait Islander adults may underreport the condition). Previous studies have shown diabetes screening is lower among Aboriginal and/or Torres Strait Islander males,[21,25] and many sociocultural factors make them less likely to use preventive health care services compared to females, which may delay diagnosis.[26] In contrast, we used de-identified medical records of patients attending general practice with information recorded by the GP, and males in our study possibly represent those with a more advanced stage of the disease. Gender disparities in health-seeking behaviour also seem to affect diabetes management, as males with diabetes are 1.3 times more likely to present to emergency services and 1.4 more likely to be hospitalised than women.[4] Therefore, discrepancies across

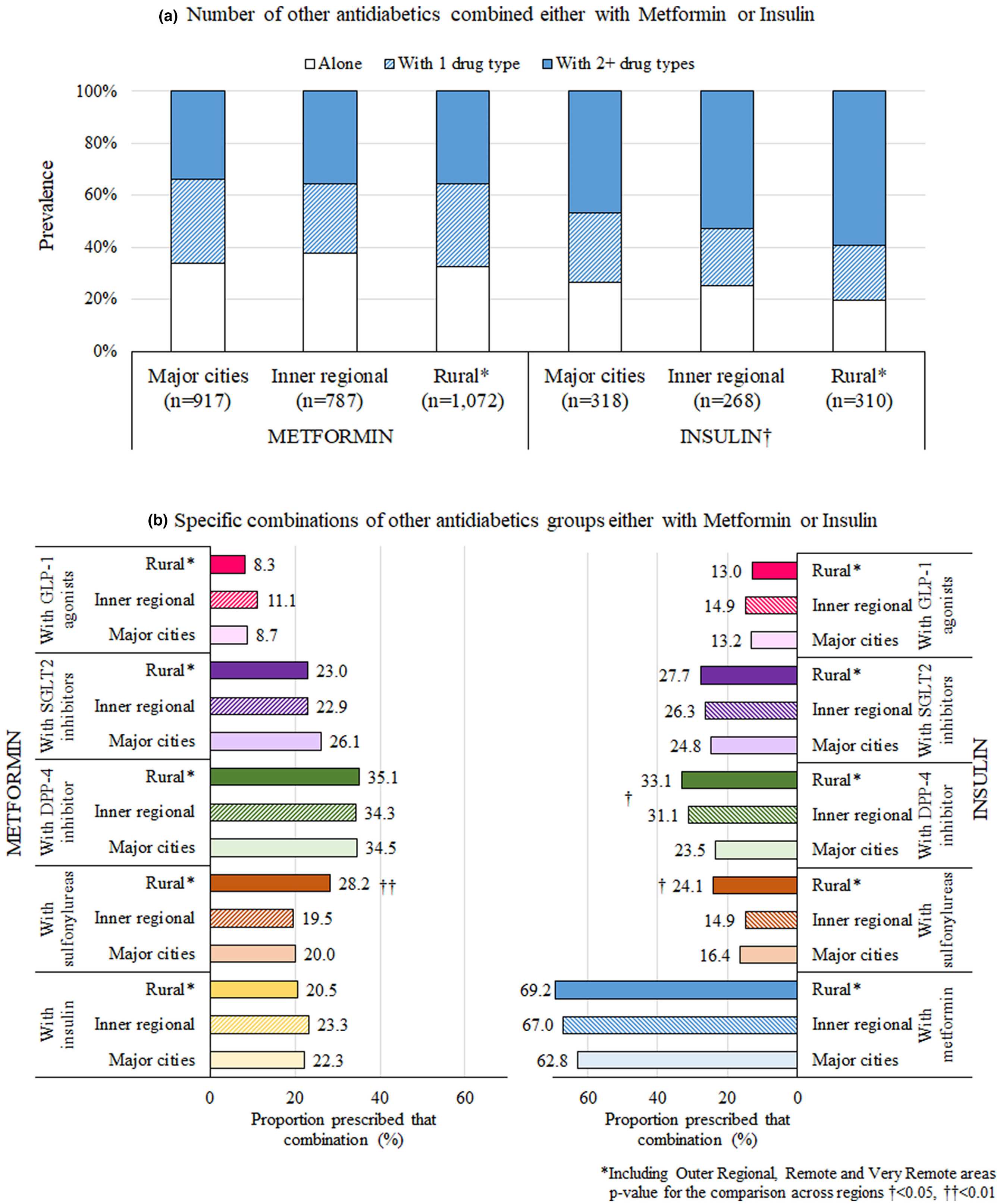

FIGURE 3 Prescription of other antidiabetic groups together with Metformin or Insulin among Aboriginal and Torres Strait Islander People with diabetes mellitus according to the remoteness of residence. MedicineInsight, 2018. Thiazolidinediones and/or acarbose were not included due to their low frequency of prescription (<0.3%).

studies regarding gender differences may result from the study design, data source, methods used to define diabetes, and the stage of the disease.[3,24,27]

Close to 75% of all Aboriginal and/or Torres Strait Islander Peoples with type 2 diabetes were prescribed antidiabetic medications in 2018, and the combination of metformin with sulfonylureas was more frequently prescribed in rural and remote locations compared to urban regions. It is not surprising that metformin was the most commonly prescribed medication because, as detailed previously, clinical guidelines recommend lifestyle measures followed by metformin as first-line management[8] and known PBS and RPBS supply was most often metformin.[5] Unfortunately, no publicly available information compares the combination with sulfonylurea. However, PBS and RPBS medications for 2021 were prescribed more frequently in the following order: metformin, combination with metformin and thirdly sulfonylurea.[5] These results were adjusted for patient characteristics and practice IRSAD. Thus, other determinants not explored in this paper may be responsible for the higher frequency of sulfonylurea prescriptions in rural areas. Nonetheless, the clinical significance of this finding is questionable. Importantly, Aboriginal and/or Torres Strait Islander adults with type 2 diabetes living in rural areas are not disadvantaged by this finding, as irrespective of where they live, three out of four were prescribed some form of antidiabetic medication. However, a further study is needed to explore appropriate management/control because prescribed medications may not translate to dispensed and used. Barriers related to medication costs are likely to be higher in socioeconomically disadvantaged patients.

Lastly, the pharmaceutical management of type 2 diabetes was similar across all regions. Interestingly, insulin prescribing was slightly less in rural and remote locations compared to urban regions. This may be due to access constraints for those living in rural or remote areas. Examples include having access to appropriate storage (a fridge is needed for insulin storage), GP's may not feel comfortable initiating or continuing insulin, or there may be a higher stigma within the rural or remote communities associated with injecting insulin.[28,29] When we assessed the available confounders, the factor that most affected the changes between crude and adjusted results was practice IRSAD. The magnitude of the associations dissipated after the inclusion of that variable in the regression models, but not when age, gender or the patient IRSAD were included. That meant differences in the prescription of insulin are not related to remoteness, but to whether the practice is located in a more advantaged or disadvantaged area. Our findings were consistent with other national data from the AIHW that reported insulin use for people living with type 2 diabetes was higher in urban locations compared to very remote areas, and insulin prescriptions were also more common in higher socioeconomic areas.[5] This finding can impact the choice of medication prescribed to Aboriginal and/or Torres Strait Islander Peoples who are often over-represented in poor socioeconomic circumstances.[10,30]

The strengths of the study include using the MedicineInsight database, a large national general practice database collecting de-identified information about those presenting to mainstream GP clinics throughout Australia. It has been used for analysis in previous studies, and given that it collects data from most geographic regions across Australia, it provides interesting national insights into primary care. This database allows the utilisation of 'real world' health and medical data from approximately 600 Australian general practices, including high-quality prescribing data for antidiabetic medications in Australia during 2018.

However, there are some important limitations to acknowledge. Firstly, our results reflect pharmaceutical management activities performed in general practice rather than in Aboriginal Community Controlled Health Organisations (ACCHOs). Although some ACCHOs are part of the database (i.e. services are not identified for ethical reasons), their involvement is hindered by the data extraction software used by MedicineInsight, as it is not integrated with the main clinical information system used by most ACCHOs (Communicare®).[11] Moreover, different from major cities, where 75% of Indigenous people have general practice as the regular health service and only 15% regularly use ACCHOs, this relationship is inverted in rural settings (6%–41% are regular users of general practice and 50%–75% regular users of ACCHOs).[31] Despite these methodological limitations, the number of Aboriginal and/or Torres Strait Islander people identified in the dataset was 2.6%, which is close to estimations from census data (3.2%).[32] Second, compliance with current clinical guidelines for type 2 diabetes may be higher as GPs contributing data are participating in a voluntary quality improvement program. Thirdly, data entered into the MedicineInsight database relies on the electronic medical record being kept up to date and the extractable fields containing the data needed for extraction.[33] The MedicineInsight dataset consists of unique patient records rather than individuals, and as a result, it is possible that patients attending multiple practices may have been counted more than once. Linkage of this dataset to pharmacy dispensing data or the PBS and RPBS datasets was not possible for this study. This could have provided more accurate prescribing data, particularly for patients prescribed medications from multiple practices or ACCHOs.

5 | CONCLUSION

Type 2 diabetes represents a high burden of morbidity amongst Aboriginal and Torres Strait Islander Peoples which needs to be addressed to help close the gap. The results of this study are consistent with currently available self-reported national data on the prevalence of diabetes among Aboriginal and/or Torres Strait Islander adults and provide further information about prescribing behaviours of GP's treating those with type 2 diabetes. The prevalence of type 2 diabetes in male Aboriginal and Torres Strait Islander adults with type 2 diabetes is higher in rural and remote locations than in urban. Pharmaceutical treatment is being prescribed to ~75% of Aboriginal and Torres Strait Islander adults with type 2 diabetes, irrespective of whether they live in urban or rural settings, although the types of medication regimes vary based on remoteness. Although this study provided insights into general practice antidiabetic prescribing patterns across geographical regions and suggest there are no geographical gaps, it does not inform on relevant aspects of diabetes management such as education adherence, diabetes monitoring and diabetes control. Further studies are warranted to explore these and other aspects related to diabetes management among Aboriginal and Torres Strait Islander populations within rural and remote areas to hopefully address the current gap of diabetes burden.

AUTHOR CONTRIBUTIONS

Natalie Pink: Writing – review and editing; writing – original draft; investigation; funding acquisition; methodology; project administration; conceptualization. **Antoinette Liddell:** Writing – review and editing; investigation; writing – original draft; project administration. **David Gonzalez-Chica:** Formal analysis; writing – review and editing; data curation; supervision; writing – original draft; software; methodology; conceptualization; investigation. **Nigel Stocks:** Supervision; writing – review and editing; writing – original draft; conceptualization; methodology; investigation.

ACKNOWLEDGEMENTS

We would like to acknowledge Assoc Prof Jill Benson for her contribution to the research question design in the early phases of the study development as well as for ongoing education in her role as a medical educator for GP registrar researchers. We are grateful to the Aboriginal and/or Torres Strait Islander peoples involved in the informal consultation group – members of the GPEx Aboriginal Health Team, Kaurna elders, and support from Nunkuwarrin Yunti to undertake the study. We are also grateful to the general practices and general practitioners who participated in the MedicineInsight program and the patients whose de-identified data makes this work possible. Open access publishing facilitated by The University of Adelaide, as part of the Wiley - The University of Adelaide agreement via the Council of Australian University Librarians.

FUNDING INFORMATION

Natalie Pink received financial support from the Australian College of Rural and Remote Medicine for the completion of the study.

CONFLICT OF INTEREST STATEMENT

The authors declare no conflicts of interest.

ETHICAL APPROVAL

The Aboriginal Health Research Ethics Committee (AHREC Protocol #: 04-21-967) provided ethics approval for the research.

ORCID

Antoinette Liddell https://orcid.org/0009-0001-5778-3398
David Gonzalez-Chica https://orcid.org/0000-0002-7153-2878
Nigel Stocks https://orcid.org/0000-0002-9018-0361

REFERENCES

1. Burrow S, Ride K. Review of diabetes among aboriginal and Torres Strait islander people. Mt Lawley, WA: Australian Indigenous HealthInfoNet; 2016. Available from https://healthinfonet.ecu.edu.au/healthinfonet/getContent.php?linkid=590810&title=Review+of+diabetes+among+Aboriginal+and+Torres+Strait+Islander+people. Accessed 01/07/2023
2. Australian Institute of Health and Welfare. Tier 1 - Health Status and Outcomes: 1.09 Diabetes. Canberra: AIHW. 2020. Available from: https://www.indigenoushpf.gov.au/measures/1-09-diabetes. Accessed 07/07/2022
3. Australian Institute of Health and Welfare. *Aboriginal and Torres Strait Islander Health Performance Framework 2020 summary report*. 2020. Available from: https://www.indigenoushpf.gov.au/publications/hpf-summary-2020. Accessed 16/02/2023
4. Australian Institute of Health and Welfare. *Diabetes. Cat. no. CVD 82*. 2020. Available from: https://www.aihw.gov.au/reports/diabetes/diabetes. Accessed 09/09/2021
5. Australian Institute of Health and Welfare. *Diabetes: Australian facts*. 2022. Available from: https://www.aihw.gov.au/reports/diabetes/diabetes. Accessed 18/10/2022
6. Australian Institute of Health and Welfare. *Incidence of insulin-treated diabetes in Australia*. 2020. Available from: https://www.aihw.gov.au/getmedia/5f4dcfa1-4420-4d54-8618-948ce2d6ac4d/AIHW-CDK-11-Factsheet-2020.pdf.aspx. Accessed 16/02/2023
7. Britt H, Miller GC, Henderson J, Bayram C, Harrison C, Valenti L, et al. General practice activity in Australia 2015–16. General practice series no. 40. Sydney: Sydney University Press; 2016.
8. The Royal Australian College of General Practitioners. Management of type 2 diabetes: a handbook for general practice. East Melbourne, Victoria: The Royal Australian College of General Practitioners; 2020. p. 198. https://www.diabetesaustralia.com.au/wp-content/uploads/Available-here.pdf
9. Remote Primary Health Care Manuals. CARPA standard treatment manual (8th edition). Alice Springs. NT: Flinders University; 2022 Available from: https://healthinfonet.ecu.edu.au/healthinfonet/getContent.php?linkid=59268

7&title=CARPA+standard+treatment+manual%3A+a+-clinic+manual+for+primary+health+care+practitioners+in+remote+and+Indigenous+health+services+in+central+and+northern+Australia. Accessed 16/06/2023
10. Nguyen HD, Chitturi S, Maple-Brown LJ. Management of diabetes in indigenous communities: lessons from the Australian aboriginal population. Int Med J. 2016;46:1252–9.
11. Busingye D, Gianacas C, Pollack A, Chidwick K, Merrifield A, Norman S, et al. Data resource profile: MedicineInsight, an Australian national primary health care database. Int J Epidemiol. 2019;48:1741–1741h.
12. Benchimol EI, Smeeth L, Guttmann A, Harron K, Moher D, Petersen I, et al. The reporting of studies conducted using observational routinely-collected health data (RECORD) statement. PLoS Med. 2015;12:e1001885.
13. The Royal Australian College of General Practitioners. The RACGP standards for general practices. 4th ed. Australia: The Royal Australian College of General Practitioners; 2015. https://www.racgp.org.au/running-a-practice/practice-standards/standards-5th-edition/standards-for-general-practices-5th-ed/table-of-contents
14. Tu K, Manuel D, Lam K, Kavanagh D, Mitiku TF, Guo H. Diabetics can be identified in an electronic medical record using laboratory tests and prescriptions. J Clin Epidemiol. 2011;64:431–5.
15. Horsfall L, Walters K, Petersen I. Identifying periods of acceptable computer usage in primary care research databases. Pharmacoepidemiol Drug Saf. 2013;22:64–9.
16. Havard A, Manski-Nankervis JA, Thistlethwaite J, Daniels B, Myton R, Tu K, et al. Validity of algorithms for identifying five chronic conditions in MedicineInsight, an Australian national general practice database. BMC Health Serv Res. 2021;21:551.
17. Drug utilisation sub-committee (DUSC). *Medicines for the treatment of diabetes Australia: Pharmaceutical Benefits Advisory Committee (PBAC)*. 2017. Available from: https://www.pbs.gov.au/industry/listing/participants/public-release-docs/2017-02/diabetes-dusc-prd-2017-02.pdf
18. Australian Bureau of Statistics. *Australian Statistical Geography Standard (ASGS): Volume 5 – Remoteness Structure. Cat. No. 1270.0.55.005*. 2016. Available from: http://www.abs.gov.au/ausstats/abs@.nsf/mf/1270.0.55.005. Accessed 10/03/2019
19. Australian Bureau of Statistics. *Census of Population and Housing: Socio-Economic Indexes for Areas (SEIFA), Australia. Cat. No. 2033.0.55.001*. 2018. Available from: http://www.abs.gov.au/ausstats/abs@.nsf/mf/2033.0.55.001. Accessed 03/08/2021
20. Roseleur J, Gonzalez-Chica DA, Bernardo CO, Geisler BP, Karnon J, Stocks NP. Blood pressure control in Australian general practice: analysis using general practice records of 1.2 million patients from the MedicineInsight database. J Hypertens. 2021;39:1134–42.
21. Zheng M, Bernardo CDO, Stocks N, Gonzalez-Chica D. Diabetes mellitus diagnosis and screening in Australian general practice: a National Study. J Diabetes Res. 2022;2022:1–11.
22. Wasserstein RL, Lazar NA. The ASA statement on p-values: context, process, and purpose. Am Stat. 2016;70:129–33.
23. Australian Institute of Health and Welfare. *Aboriginal and Torres Strait Islander Health Performance Framework 2014 report: detailed analyses. Measure 2.09: Index of disadvantage*. 2015. Available from: https://www.aihw.gov.au/getmedia/44346743-556f-423d-9da9-06325615a833/02_09_index_of_disadvantage.pdf.aspx. Accessed 12/06/2023
24. Minges KE, Zimmet P, Magliano DJ, Dunstan DW, Brown A, Shaw JE. Diabetes prevalence and determinants in indigenous Australian populations: a systematic review. Diabetes Res Clin Pract. 2011;93:139–49.
25. Kiefer MM, Silverman JB, Young BA, Nelson KM. National patterns in diabetes screening: data from the National Health and nutrition examination survey (NHANES) 2005–2012. J Gen Intern Med. 2015;30:612–8.
26. Canuto K, Brown A, Wittert G, Harfield S. Understanding the utilization of primary health care services by indigenous men: a systematic review. BMC Public Health. 2018;18:1198.
27. Matthew JLH, Yuejen Z, Steven G, Paul B, Elizabeth LMB, Elna E, et al. Prevalence and incidence of diabetes among aboriginal people in remote communities of the Northern Territory, Australia: a retrospective, longitudinal data-linkage study. BMJ Open. 2022;12:e059716.
28. Taylor S, Thompson F, McDermott R. Barriers to insulin treatment among Australian Torres Strait islanders with poorly controlled diabetes. Aust J Rural Health. 2016;24:363–70.
29. Thepwongsa IKC, Paul C, Piterman L. Management of type 2 diabetes: Australian rural and remote general practitioners' knowledge, attitudes, and practices. Rural Remote Health. 2014;14:2499.
30. Frier A, Devine S, McBain-Rigg KE, Barnett F, Cassady ZA, Dunning T, et al. Indigenous Australian perspectives on incorporating the social determinants of health into the clinical management of type 2 diabetes. Rural Remote Health. 2021;21:6352.
31. Australian Institute of Health and Welfare. *National Indigenous Australian Agency. Tier 3 – Health system performance: 3.17 Regular general practitioner or health service*. Available from: https://www.indigenoushpf.gov.au/measures/3-17-regular-gp-health-service. Accessed 13/12/2022
32. Australian Bureau of Statistics. *Australia: Aboriginal and Torres Strait Islander population summary*. 2022 Available from: https://www.abs.gov.au/articles/australia-aboriginal-and-torres-strait-islander-population-summary. Accessed 13/12/2022
33. Manski-Nankervis JE, Thuraisingam S, Sluggett JK, Lau P, Blackberry I, Ilomaki J, et al. Prescribing for people with type 2 diabetes and renal impairment in Australian general practice: a national cross sectional study. Prim Care Diabetes. 2019;13:113–21.

SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

How to cite this article: Pink N, Liddell A, Gonzalez-Chica D, Stocks N. Pharmaceutical management of type 2 diabetes among Indigenous Australians living in urban or rural locations: a comparative study using a national general practice database. Aust J Rural Health. 2023;31:979–990. https://doi.org/10.1111/ajr.13032