Assessing patterns of chronic kidney disease care in Australian primary care: a retrospective cohort study of a national general practice dataset

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Summary

Background Chronic kidney disease (CKD) monitoring and cardiovascular risk management are essential in reducing disease progression and cardiovascular events. This study aimed to understand CKD monitoring and management practices in Australian primary care.

Methods We conducted a retrospective, population-based cohort study of adults who attended general practices participating in MedicineInsight between 1 January 2011 and 30 June 2020 and met diagnostic criteria for CKD. Care quality was assessed in the 18-months following identification of CKD. Core monitoring was defined as at least one assessment of all the following measurements: blood pressure, estimated glomerular filtration rate (eGFR), urine albumin creatinine ratio (UACR), lipid profile, and HbA1c in patients with diabetes. Cardiovascular risk management comprised medication prescription (ACEi/ARB and statin), blood pressure target achievement and LDL cholesterol <2 mmol/L. Modified Poisson regression models adjusted for socio-demographic and clinical characteristics were used to identify patient factors associated with completion of monitoring and medication prescription.

Findings CKD was identified in 140,780 patients, of which 34.2% received core monitoring within 18 months of CKD identification. Measurement of the individual components of the core monitoring outcome varied: blood pressure (88.7%), eGFR (86.0%), UACR (41.1%), lipids (70.9%) and HbA1c (85.5%). ACEi/ARB were prescribed in 65.2% of the cohort and 54.4% were prescribed a statin. Blood pressure targets of <140/90 mmHg and <130/80 mmHg were achieved in 57.9% and 29.3% of patients, respectively. LDL target of <2 mmol/L was achieved in 38.8% of patients. Older age, comorbid diabetes and hypertension were associated with a greater likelihood of monitoring and medication prescription.

Interpretation In this large, population-based study, we observed substantial variation in CKD risk monitoring and the management of cardiovascular risk in patients with CKD. We identified several priority areas for CKD management in primary care including need for improvement in albuminuria monitoring.

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Keywords: Chronic kidney disease; Monitoring; Quality of care; Primary care

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Research in context

Evidence before this study

Chronic kidney disease (CKD) is a non-communicable disease of global public concern with an increasing prevalence. CKD progression and cardiovascular complications can be attenuated with disease monitoring and guideline-directed care. We performed a literature review (across EMBASE Ovid and PubMed) of observational studies relating to patterns of CKD care. Internationally, variability in the concordance of CKD care with clinical practice guidelines has been reported, with gaps in monitoring and use of guideline recommended therapies. In Australia, however, such assessments have been limited.

Added value of this study

Using a large nationally representative Australian primary care data source, we outline the CKD monitoring and cardiovascular risk management patterns, from 2011 to 2022. Our study found low rates of completion of monitoring (34%) largely driven by low albuminuria monitoring. We have identified several priority areas for improving CKD care including increasing albuminuria monitoring and improving cardiovascular risk management. Our findings highlight the need for implementation strategies to improve CKD care.

Implications of all the available evidence

CKD is a global public health concern. There are significant gaps in the identification, monitoring and management of CKD internationally and in Australia. Future work is required to further understand facilitators and barriers of CKD care in primary care, with a subsequent focus on implementation strategies to improve CKD care.

Introduction

Chronic kidney disease (CKD) is a global public health concern, estimated to affect greater than 10% of the world's population,[1] and this burden of CKD continues to increase.[2] Without fundamental improvements in prevention and management, CKD is estimated to become the fifth leading cause of years of life loss by 2040.[3]

In Australia the prevalence of CKD is estimated to be up to 11%,[4,5] representing up to 2.8 million people. Much of the morbidity and mortality of CKD is attributed to cardiovascular disease or progression to advanced kidney disease. Routine monitoring in CKD is essential for risk assessment, detection of deterioration and implementation of guideline directed therapies to improve kidney and cardiovascular outcomes.[6]

CKD is primarily diagnosed and managed in primary care. National primary care guidelines recommend routine surveillance of renal function, albuminuria and blood pressure, in addition to use of angiotensin converting enzyme inhibitors (ACE inhibitor) or angiotensin receptor blockers (ARBs), sodium-glucose co-transporter 2 inhibitor (SGLT2 inhibitor) and statin therapy in those at high cardiovascular risk.[7] Emerging international studies on the patterns of CKD management in general practice indicate variable concordance of CKD care with clinical practice guidelines, including substantial gaps in monitoring and use of guideline-recommended therapies.[8–10] In Australia, such assessments have been limited. Recent studies[11,12] are limited by their relatively small sample size and geographical coverage,[12] and lack of assessment regarding guideline-concordant CKD care in relation to cardiovascular risk management.[11]

Thus, using a large, nationally representative, primary care data source in Australia, we conducted a community-based cohort study to assess CKD monitoring practices (measurement of cardio-renal-metabolic parameters) and cardiovascular risk management (blood pressure and lipid control), and their alignment with clinical guideline recommendations for CKD care.

Methods

Study design and source population

MedicineInsight is a national Australian primary care data source that includes de-identified longitudinal electronic health records on patients visiting primary care participating practices across all states and territories.[13,14] Recorded data includes information on socio-demographic and clinical characteristics (including comorbidities), laboratory results, and prescription medications.

Identification of study cohort

We derived a study cohort that was comprised of all adults (≥18 years) who had at least 1 clinical encounter at a MedicineInsight participating primary care centre (n = 392 general practices) with ≥1 eGFR measurement (with or without a urine albumin-creatinine ratio; UACR) between 1 January 2011 and 30 June 2020 (Supplementary Figure S1). The index date was defined as when criteria for presence of CKD were met. CKD was defined using the Kidney Disease Improving Global Outcomes (KDIGO) definition,[15] with local sex-specific albuminuria criteria as per Australian guidelines[16]: two consecutive eGFR measures <60 mL/min/1.73 m^2 at least 90 days part and/or two consecutive UACR measures ≥2.5 mg/mmol for males and ≥3.5 mg/mmol for females at least 90 days apart. In order to minimise potential misclassification of CKD status, due to the use of different eGFR equations during the study period, we re-calculated eGFR directly

using the 2009 Chronic Kidney Disease Epidemiology Collaboration equation.[17] CKD stages were defined as per KDIGO defintions.[6]

Outcomes

Outcomes were assessed across two domains: (1) CKD monitoring and (2) cardiovascular risk management. Kidney disease guidelines recommend comprehensive CKD monitoring of kidney function, albuminuria, other laboratory parameters (urea and electrolytes, lipids and glycated haemoglobin [HbA1c] in patients with diabetes) and blood pressure monitoring at least yearly in all patients with CKD.[15,16] For domain one we defined "core monitoring" as having a record of at least one of all of the following measurements: blood pressure, eGFR, UACR, lipids and HbA1c (in patients with diabetes) within 18 months following the index date (to allow an additional 6 months of potential delays in patient attendance). Individual components of the core monitoring outcome were also assessed separately.

For domain two, cardiovascular risk management was defined as, (1) receiving at least one prescription of an angiotensin converting enzyme (ACE) inhibitor or angiotensin receptor blocker (ARB), and statin prescription in patients over 50 years old or under 50 with additional cardiovascular risk factors (i.e., established cardiovascular disease, diabetes and/or stroke), (2) achieving blood pressure targets of <140/90 mmHg and <130/80 mmHg, (3) achieving a low density lipoprotein cholesterol (LDL) < 2 mmol/L, within 18 months following the index date.

Patient characteristics

We assessed baseline patient information including sex, age categories, remoteness (major cities, regional, remote), socioeconomic disadvantage (Index of Relative Socioeconomic Advantage and Disadvantage; defined based on Australian Census data),[18] smoking status, eGFR categories, albuminuria categories, and comorbid conditions (atrial fibrillation, cardiovascular disease, heart failure, diabetes mellitus, and hypertension) from the relevant data files in MedicineInsight within one year prior to index date.

Statistical analysis

We calculated the percentage of patients who met the criteria for completion of core monitoring (overall and by subgroups of patients stratified by hypertension status, diabetes status, year of cohort entry, sex and age category) and percentage of patients prescribed ACE inhibitors or ARBs and statins. Percentages were also computed for each individual component of the core monitoring outcome. Chi-square tests were used to determine statistically significant differences in monitoring between subgroups.

Modified Poisson models, adjusting for patient characteristics, were constructed to determine variables associated with completion of core monitoring and medication use. Patient characteristics included age, sex, remoteness, socio-economic disadvantage, smoking status, eGFR categories, albuminuria categories and comorbidities (atrial fibrillation, cardiovascular disease, heart failure, diabetes mellitus, and hypertension), and were chosen based on review of prior literature. All candidate variables were forced to be included in the model without any prior selection process. To test for robustness of findings, a sensitivity analysis assessed the completion of core monitoring over a shorter follow-up period (12 months). Additionally, a sensitivity analysis with multiple imputation by fully condition specification[19] for missing values was conducted, and Modified Poisson models were repeated to assess patient characteristics associated with core monitoring and cardiovascular risk management. A two-sided p-value <0.05 was considered statistically significant. All statistical analyses were performed with Stata version 17.0 (Stata, TX).

Patient and public involvement

This study was conducted using previously collected, de-identified, longitudinal healthcare data. No patients were involved in setting the research question or the outcome measures, nor were they involved in developing plans to design or implement the study.

Ethical approval

This study was approved by the MedicineInsight Data Governance Committee (2020-004) and Research Ethics Review Committee of the Sydney Local Health District, NSW, Australia (X21-0428, 2020/ETH00963). A waiver of consent was granted for use of non-re-identifiable routinely collected patient data. The study adheres to the RECORD extension of the STROBE reporting guidelines.[20]

Role of funding source

This study was conducted as part of a research program supported by the University of New South Wales Scientia Program and a sponsorship provided by Boehringer Ingelheim and Eli Lilly Alliance. The design, analysis, interpretation, writing of this manuscript and decision to submit for publication was performed independent of all funding bodies.

Results

Cohort characteristics

Of the 2,466,293 patients with at least 1 serum creatinine measurement recorded in MedicineInsight during the study period, 140,780 patients (5.7%) were identified as having CKD. Patients with CKD had a mean age of 74.3 years (standard deviation [SD] 12.5), 51.4% were female and 32.4% had a record of diabetes mellitus (Table 1). The mean eGFR was 52.4 mL/min/1.73 m^2

	Total	eGFR category			
		≥60	45–59	30–44	<30
	n = 140,780 (%)	18,275 (13.9)	75,405 (57.6)	27,929 (21.3)	9172 (7.0)
Sociodemographic information					
Female	72,474 (51.4)	6378 (34.9)	41,775 (55.4)	15,952 (57.1)	4977 (54.2)
Age, yr, mean, (SD)	74.3 (12.5)	63.7 (13.6)	76.2 (10.0)	79.0 (10.4)	76.9 (13.8)
Age category (years)					
18–29	668 (0.4)	312 (1.7)	81 (0.1)	42 (0.1)	60 (0.6)
30–39	1794 (1.2)	796 (4.3)	228 (0.3)	114 (0.4)	147 (1.6)
40–49	4191 (2.9)	1782 (9.7)	809 (1.0)	284 (1.0)	292 (3.1)
50–59	10,268 (7.2)	3560 (19.4)	3416 (4.5)	874 (3.1)	583 (6.3)
60–69	26,274 (18.6)	5349 (29.2)	13,705 (18.1)	3410 (12.2)	1178 (12.8)
70–79	46,530 (33.0)	4604 (25.1)	28,487 (37.7)	8602 (30.8)	2340 (25.5)
≥80	51,055 (36.2)	1872 (10.2)	28,679 (38.0)	14,603 (52.2)	4572 (49.8)
Remoteness[a]					
Major cities	77,496 (55.3)	10,208 (56.1)	40,965 (54.5)	15,403 (55.4)	5128 (56.1)
Regional	61,366 (43.8)	7765 (42.7)	33,601 (44.7)	12,211 (43.9)	3930 (43.0)
Remote	1234 (0.8)	194 (1.0)	492 (0.6)	169 (0.6)	68 (0.7)
IRSAD Quintile[b]					
1–2 (most disadvantaged)	31,118 (22.2)	4327 (23.8)	16,599 (22.1)	6216 (22.3)	2027 (22.2)
3–4	32,328 (23.0)	4055 (22.3)	17,518 (23.3)	6543 (23.5)	2024 (22.1)
5–6	29,547 (21.0)	3908 (21.5)	15,517 (20.6)	5656 (20.3)	1973 (21.6)
7–8	22,064 (15.7)	3052 (16.8)	11,752 (15.6)	4189 (15.0)	1382 (15.1)
9–10	25,065 (17.8)	2825 (15.5)	13,690 (18.2)	5185 (18.6)	1722 (18.8)
Smoking status					
Smoker	8866 (6.7)	2416 (13.6)	3478 (4.9)	1239 (4.9)	482 (6.0)
Previous smoker	52,124 (39.7)	7261 (41.1)	27,828 (39.3)	10,056 (39.8)	3136 (39.3)
Non-smoker	70,165 (53.5)	7986 (45.2)	39,379 (55.7)	13,920 (55.2)	4359 (54.6)
Laboratory measurements					
eGFR (mL/min/1.73 m^2), mean (SD)	52.4 (17.5)	85.3 (15.2)	53.3 (4.1)	38.8 (4.1)	21.5 (7.2)
Albuminuria					
Normal	15,490 (11.0)	–	11,452 (15.1)	3410 (12.2)	628 (6.8)
Moderately increased	30,563 (21.7)	15,338 (83.9)	4030 (5.3)	2136 (7.6)	800 (8.7)
Severely increased	7717 (5.4)	2937 (16.0)	1151 (1.5)	985 (3.5)	904 (9.8)
Not measured	87,010 (61.8)	–	58,772 (77.9)	21,398 (76.6)	6840 (74.5)
Comorbid conditions					
Atrial fibrillation	18,844 (13.4)	1589 (8.6)	10,574 (14.0)	4604 (16.4)	1363 (14.8)
Cardiovascular disease	37,204 (26.4)	3839 (21.0)	19,534 (25.9)	8769 (31.4)	2967 (32.3)
Congestive heart failure	13,779 (9.7)	850 (4.5)	6716 (8.9)	4183 (14.9)	1558 (16.9)
Diabetes	45,714 (32.4)	12,107 (66.2)	17,341 (23.0)	7019 (25.1)	2605 (28.4)
Hypertension	91,181 (64.7)	12,012 (65.7)	48,309 (64.0)	18,554 (66.4)	5883 (64.1)
Blood pressure (mmHg) mean (SD)					
Systolic	135.9 (18.5)	137.3 (17.7)	135.2 (18.1)	135.7 (19.5)	136.1 (21.1)
Diastolic	74.9 (11.6)	78.5 (11.5)	74.5 (11.1)	72.9 (11.7)	72.7 (12.8)

eGFR = estimated glomerular filtration rate, SD = Standard deviation. Missing data at baseline: Remoteness (684), IRSAD Quintile (658), eGFR (9999), smoking (9625), baseline blood pressure (17,053). [a]2016 Australian Statistical Geography Standard (ASGS) Remoteness Area (remoteness defined as major cities, regional [inner and outer] and remote [remote and very remote]). [b]2016 Index of Relative Socio-Economic Advantage and Disadvantage (IRSAD).

Table 1: **Baseline characteristics of the study cohort, overall and by eGFR category.**

(SD 17.5), such that 13.9% of the cohort had stage 1 or 2 CKD, 57.6% had stage 3a CKD, 21.3% had stage 3b CKD and 7.0% had stage 4 or 5 CKD. Almost two-thirds (61.8%) of the cohort did not have a record of UACR measurement at baseline. In patients with both an eGFR and UACR measure (31% of total cohort), enabling risk stratification according to local and international CKD guidelines, 61.2% were at moderate risk, 23.7% high risk and 15.0% very high risk of CKD progression (Supplementary Figure S2).

Domain 1: CKD monitoring

Overall, complete measurement of the core monitoring elements was achieved in 34.2% of the cohort (Fig. 1a). Measurement of the individual components was variable: 88.7% of patients had their blood pressure

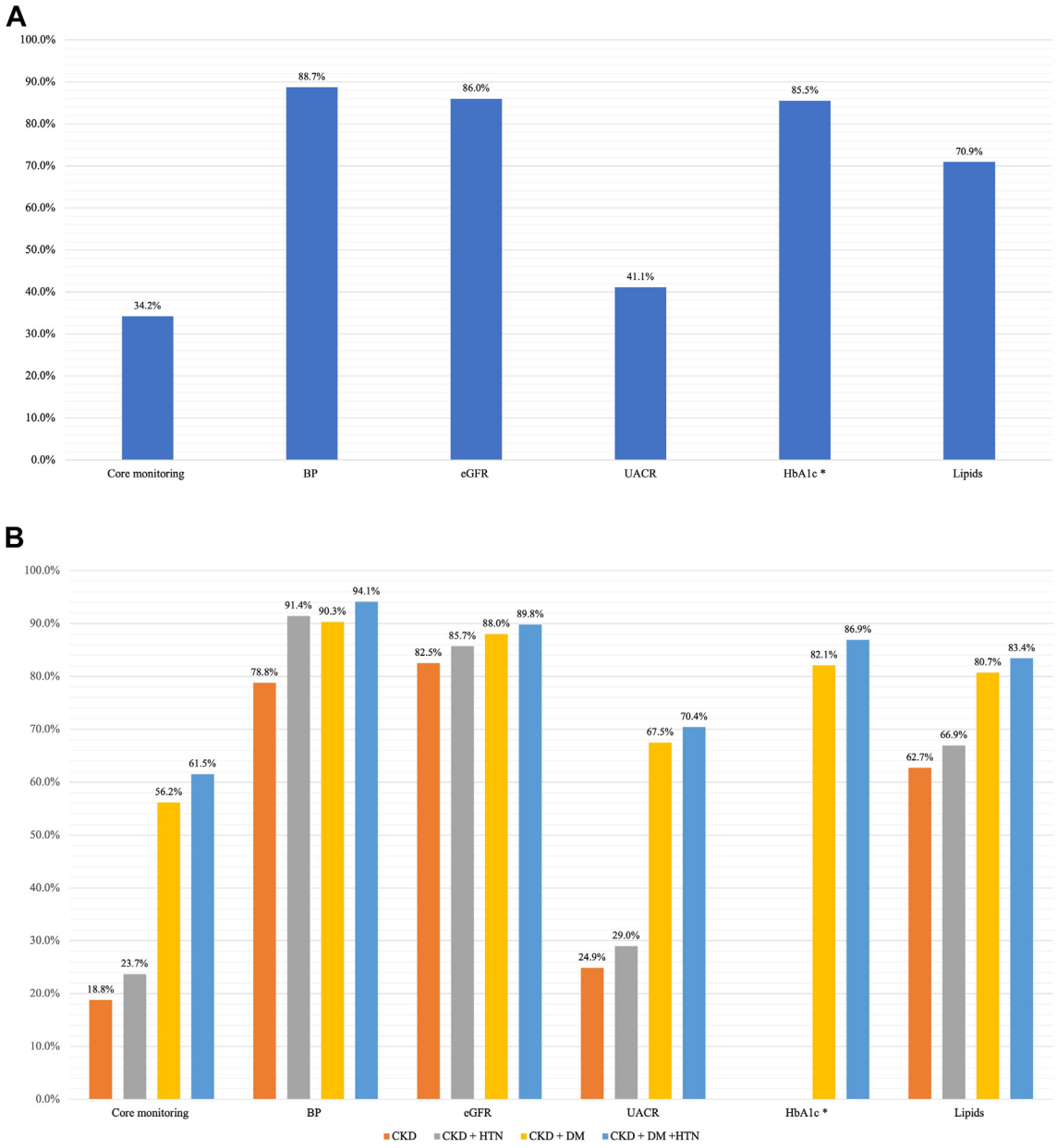

Fig. 1: **Percentage of patients achieving core monitoring (overall [A] and by comorbid hypertension and diabetes status [B]).** CKD = chronic kidney disease, HTN = hypertension, DM = diabetes mellitus, *only reported in patients with diabetes mellitus; differences in percentage of patients achieving completion of core monitoring observed in Fig. 1b across all comorbidity subgroups were statistically significant ($p < 0.0001$).

measured, 86.0% received an eGFR test, 41.1% received a UACR test, 70.9% had their lipid levels measured and 85.5% received an HbA1c test. Complete core monitoring was more frequent among patients with comorbidities, with highest completion rates in those with hypertension and diabetes (61.5%; Fig. 1b). Similarly, patients with diabetes more commonly had monitoring completed across the individual outcome measures of blood pressure, eGFR, UACR and lipids. This was most pronounced for albuminuria monitoring, with 69.6% of patients with diabetes having a recorded measure of UACR. Monitoring was higher in males compared to females (38.8% compared to 29.9%, $p < 0.001$, Supplementary Figure S3a).

Domain 2: cardiovascular risk management

ACE inhibitor or ARBs were prescribed at least once in 65.2% of patients during follow up and statin prescription in 54.4% of patients 50 years old and over or under 50 with additional cardiovascular risk factors (Fig. 2). Prescription of ACEi/ARB and statin was higher in those with comorbid diabetes and/or hypertension compared to those with CKD alone (highest in those with both hypertension and diabetes: 82.4% and 70.3%, respectively; Fig. 2). Prescription of ACEi/ARBs and statins were higher in males compared to females (Supplementary Figure S4a).

Amongst those who received a blood pressure measurement, 57.9% achieved a last recorded blood pressure of <140/90 mmHg, and 29.3% achieved a target of <130/80 mmHg (Fig. 3a). In patients with diabetes and/or moderately or severely increased albuminuria, 27.8% achieved a blood pressure <130/80 mmHg. In contrast to other aspects of monitoring, the achievement of blood pressure target <130/80 mmHg was highest in the group without diabetes or hypertension (36.5%), compared with hypertension (26.0%), diabetes (33.7%), and diabetes and hypertension (26.5%). Among patients with an LDL measurement, 38.8% achieved an LDL of <2 mmol/L (Fig. 3b). LDL <2 mmol/L target achievement was highest in patients with diabetes and hypertension (52.8%) and diabetes (48.1%), compared with patients with hypertension (31.1%) or CKD alone (27.9%).

Temporal trends in CKD care

Analysis by year of cohort entry showed an overall increasing trend in the proportion of patients satisfying the core monitoring criteria over the follow-up period (p for trend <0.0001; Fig. 4a). Improvements in monitoring were largely driven by a small increase in albuminuria monitoring over time (Fig. 4a). In contrast, ACE inhibitor or ARB use decreased over time from 71.7% in 2011 to 61.9% in 2020 (p for trend <0.0001, Fig. 4b). There were fluctuations in achievement of blood pressure target <140/90 mmHg and BP < 130/80 mmHg and LDL <2 mmol/L over time (Fig. 4b).

Factors associated with completion of core monitoring and medication prescription

Fig. 5 shows the relationships between patient characteristics and completion of core monitoring. Increasing age was associated with an increased relative risk of core monitoring completion (reference 18–29 years, RR [95% CI, p values]: 30–39 years 1.65 [1.35–2.02, <0.0001], 40–49 years 2.01 [1.65–2.43, <0.0001], 50–59 years 2.24 [1.85–2.70, <0.0001], 60–69 years 2.38 [1.97–2.87, <0.0001], 70–79 years 2.35 [1.95–2.84, <0.0001] and ≥80 years 1.72 [1.42–2.07, <0.0001]). Female sex was

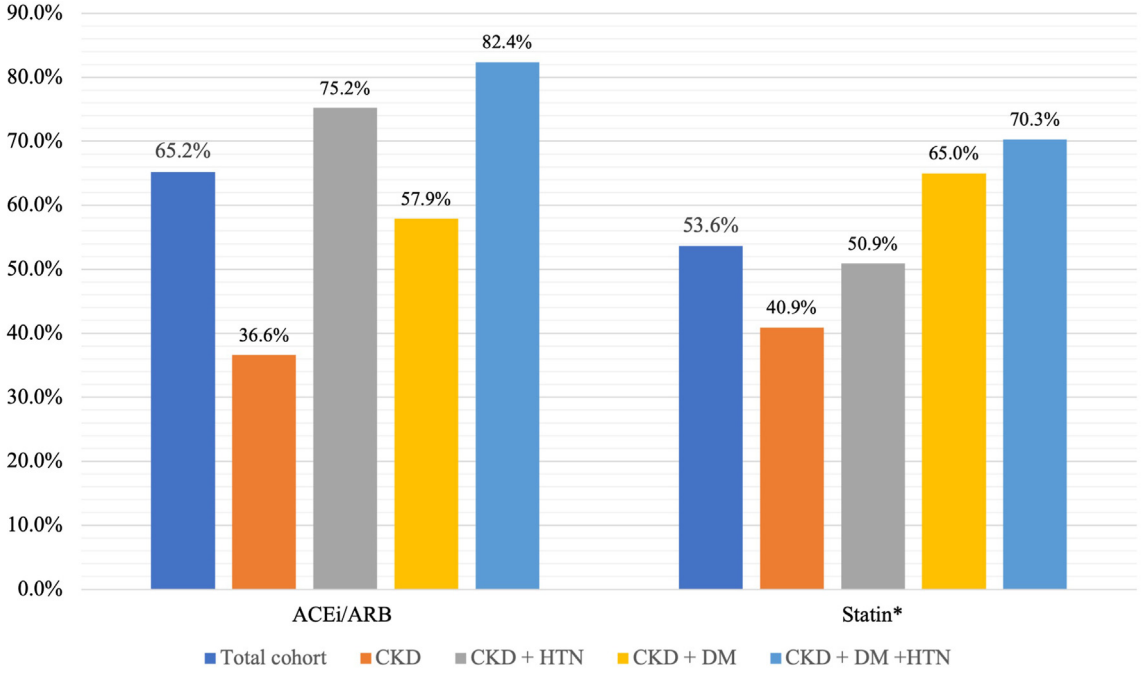

Fig. 2: **Percentage of patients prescribed ACE inhibitor or ARB and a statin (overall and by comorbid hypertension and diabetes status).** CKD = chronic kidney disease, HTN = hypertension, DM = diabetes mellitus, *statin in patients aged 50 and over or under 50 with additional cardiovascular risk factors; differences in medication prescription observed in across comorbidity subgroups were statistically significant (p < 0.0001).

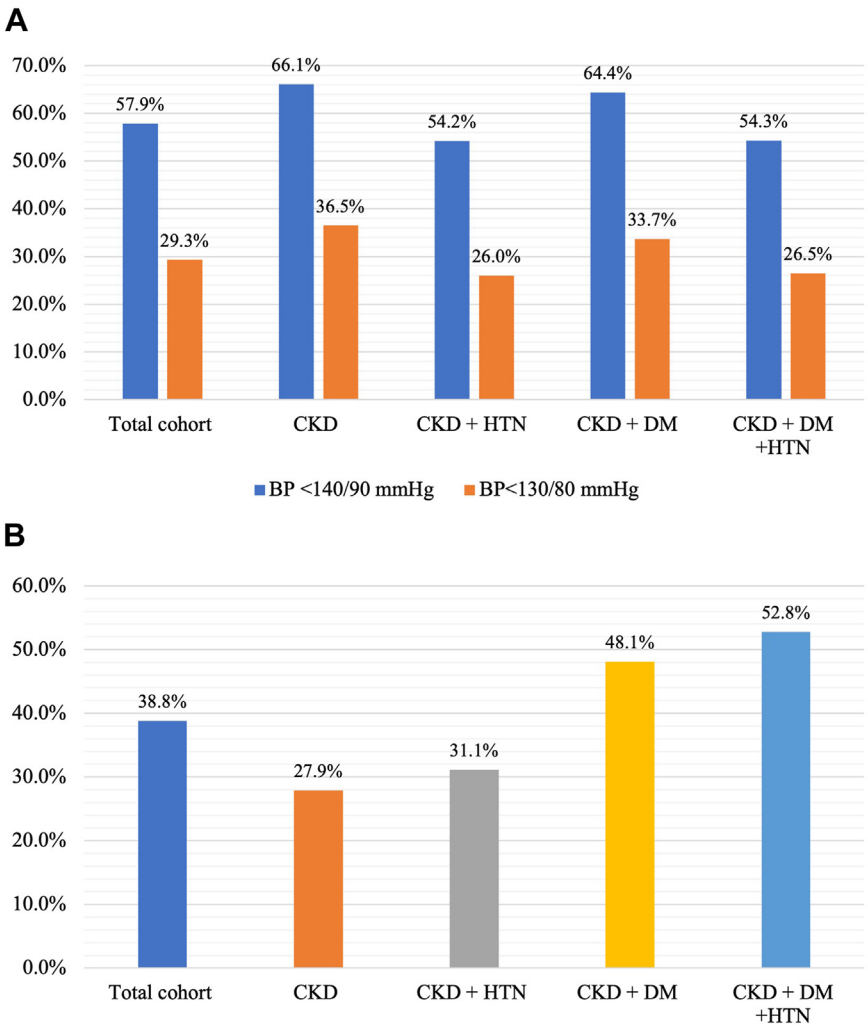

***Fig. 3*: Percentage of patients achieving blood pressure target (A) of <140/90 mmHg and <130/80 mmHg, and LDL target of <2 mmol/L (B) (overall by comorbid hypertension and diabetes status)**. CKD = chronic kidney disease, HTN = hypertension, DM = diabetes mellitus; differences in percentage of patients achieving blood pressure target (2A) across all comorbidity subgroups were statistically significant (CKD + DM < 140/90, p = 0.0014; all other categories p < 0.0001); difference in percentage of patients achieving lipid target (2B) across all comorbidity subgroups were statistically significant (p < 0.0001).

associated with a lower relative risk of core monitoring completion (RR 0.96 [95% CI: 0.95–0.98, p < 0.0001]). Compared with CKD stage 1–2, worsening eGFR stage was associated with a lower risk of core monitoring completion with CKD 3a and CKD 4–5 (RRs [95% CI, p value] for CKD stage 3A, 3B and 4–5: 0.91 [0.89–0.94, <0.0001], 1.01 [0.98–1.04, 0.2898], 0.84 [0.81–0.88, <0.0001], respectively). The presence of diabetes (RR 1.77 [95% CI 1.74–1.81, p < 0.0001]) and hypertension (RR 1.11 [95% CI 1.09–1.12, p < 0.0001]) was associated with increased relative risk of complete core monitoring. Overall, associations were similar across unadjusted and adjusted models (Supplementary Figure S5), and when individual components of the core monitoring outcome were assessed separately (Supplementary Table S1).

Similar trends were seen in adjusted analysis of ACE inhibitor or ARB use and statin use, with baseline medication use having the strongest association with prescription during follow-up (Supplementary Table S2). Compared with normal UACR, the absence of albuminuria measurement was associated with a reduced relative risk of having ACE inhibitor or ARB prescription (RR 0.98 [95% CI 0.97–0.98, p < 0.0001]) and achieving blood pressure targets (BP < 140/90 mmHg RR 0.96 [95% CI 0.95–0.98, p < 0.0001] and BP < 130/80 mmHg RR 0.95 [95% CI 0.92–0.98, p = 0.0010]). Compared with normal UACR, severely increased UACR was associated with increased relative risk of having ACE inhibitor or ARB prescription (RR 1.03 [95% CI 1.01–1.05, p < 0.0001]). Achievement of blood pressure targets were negatively

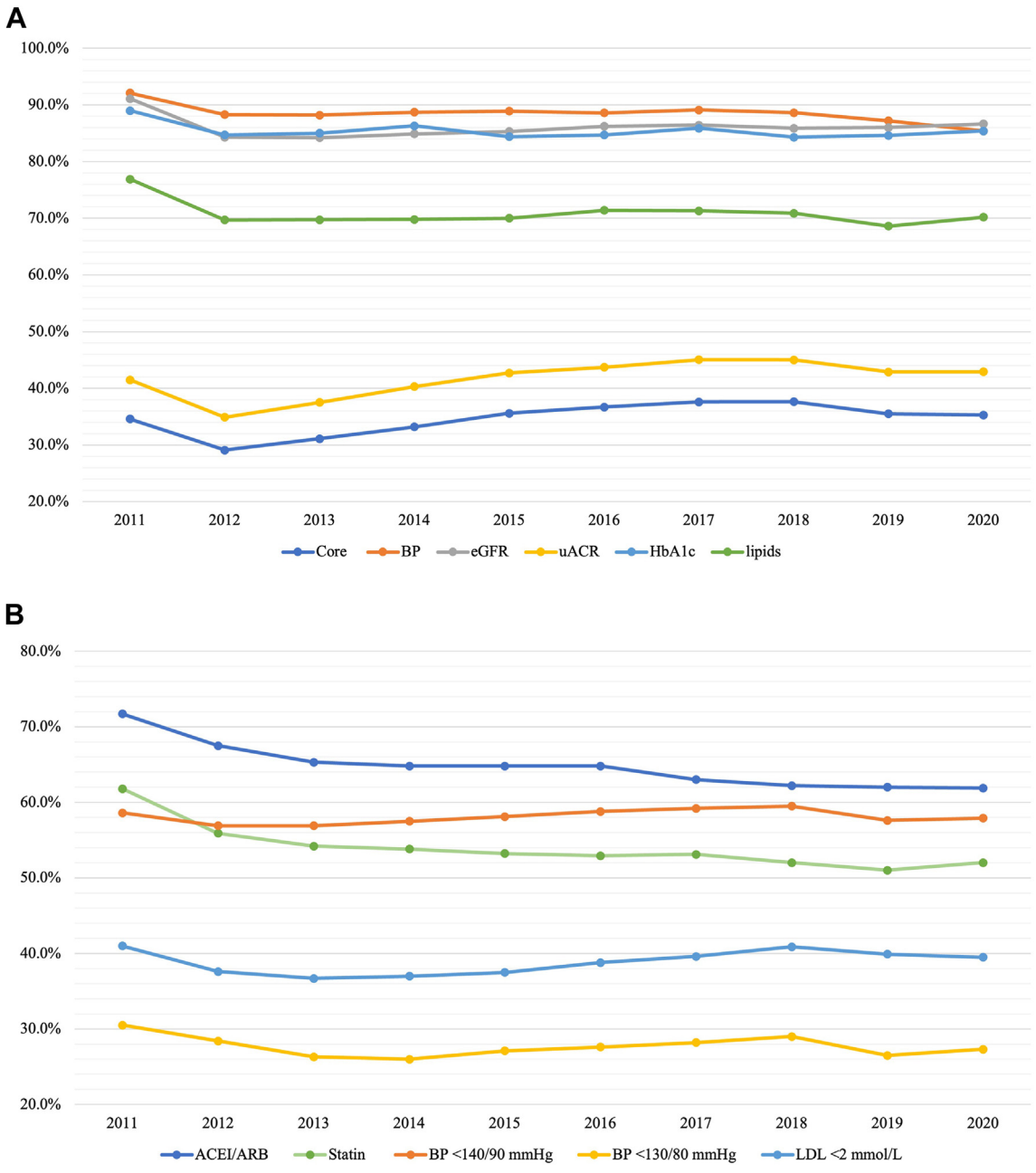

Fig. 4: **Temporal trends in CKD monitoring (A) and cardiovascular risk management (B).**

associated with increasing age, as was female sex and a history of hypertension (Supplementary Table S2).

Sensitivity analysis

In the 12 months following the index date, the completion of core monitoring was 24.5% (Supplementary Figure S6a and b). Overall results on the relationship between patient factors and completion of core monitoring remained largely unchanged (Supplementary Figure S7). Modified Poisson models with multiple imputation of missing values across core monitoring and cardiovascular risk monitoring also remained largely unchanged from the complete case analyses (Supplementary Table S3).

Discussion

In a large, nationally representative cohort of over 140,000 patients with CKD, we observed variation in CKD monitoring and cardiovascular risk management.

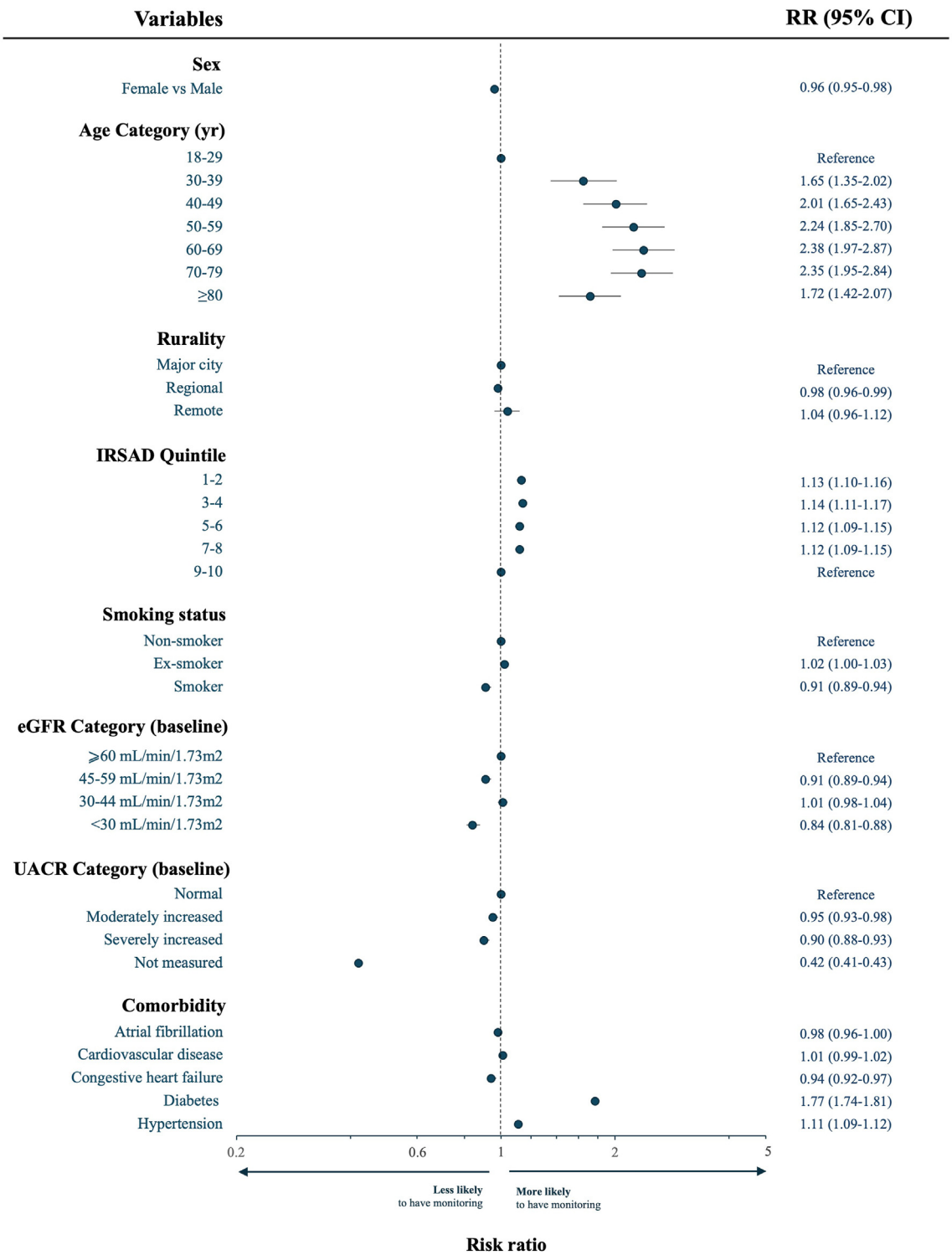

Fig. 5: **Adjusted risk ratios (RR) for core monitoring among people with CKD**. Modified Poisson regression adjusted for all characteristics assessing the relationship between sociodemographic and clinical characteristics and the risk ratios of core monitoring. eGFR = estimated glomerular filtration rate, UACR = urine albumin creatinine ratio, IRSAD = The Index of Relative Socio-economic Advantage and Disadvantage, RR = risk ratio, CI = confidence interval. p values: female sex (<0.0001), age (all categories, <0.0001), rurality (regional, 0.0326; remote, 0.3140), IRSAD (all categories, <0.0001), smoking status (ex-smoker, 0.0070; smoker, <0.0001), eGFR category (45–59, <0.0001; 30–44, 0.2898; <30 mL/min/1.73 m^2, <0.0001), UACR category (moderately increased, 0.0005; severely increased, <0.0001; not measured, <0.0001), atrial fibrillation (0.2088), cardiovascular disease (0.1515), congestive heart failure (0.0001), diabetes (<0.0001), hypertension (<0.0001).

Completion of blood pressure and renal function monitoring was high, while albuminuria monitoring and ACEi/ARB and statin prescription was relatively lower. Complete core monitoring was achieved in 34.2% of patients over a period of 18 months, which was largely attributable to low UACR testing with high completion of the other components. ACE inhibitors or ARBs were prescribed in 65.2% of patients, and statins in 54.4% of patients aged ≥50 years or <50 years with additional risk factors. Approximately two thirds of patients achieved a blood pressure target of <140/90 mmHg, while a target of <130/80 mmHg was achieved in under one third of patients. These findings, in combination with the increasing burden of CKD in Australia,[5,21] highlight the need to implement effective strategies that improve the care and outcomes of patients with CKD.

The extent of guideline-concordant CKD care observed in the current study varied across the care domains. We identified low rates of albuminuria monitoring (41.1%), consistent with accumulating reports indicating suboptimal albuminuria measurement.[8,11,22,23] UACR testing is essential in enabling risk stratification and prognostication, and in guiding medication management.[24] Indeed, when measured, UACR results were associated with increased use of appropriate disease modifying medications, with severely increased UACR being associated with higher rates of ACE inhibitor or ARB use compared to normal or moderately increased albuminuria.

In considering strategies to improve UACR testing it is important to address previous barriers to testing in patients with CKD including lack of perceived management benefits and guideline recommendations,[25] despite recommendations to the contrary.[6,7] We defined CKD based on a biochemical diagnosis based on prior work on MedicineInsight finding significant under-coding in the medical record,[26] in comparison to good sensitivity and specificity for diabetes coding.[27] Improving clinician recognition and coding is a potential strategy to improve care with prior research finding a coded diagnosis of CKD in the medical record was associated with high rates of UACR testing[28] and guideline directed care.[28,29] Additionally, the use of clinical decision support software has been shown in some cases to improve UACR testing.[30,31] Encouragingly, the rate of albuminuria monitoring and subsequently core monitoring was higher in those with a history of diabetes (69.6%), and there was a trend to increased core monitoring over time which was largely driven by a small increase in albuminuria monitoring. These findings suggest increasing uptake of local and international initiatives to improve diabetes care[32–34] in clinical practice. Primary care practices were also eligible for an incentive primary care payment based on achieving the diabetes cycle of care (i.e., yearly albuminuria, eGFR, lipids and blood pressure checks).[35] Effective strategies for achieving improvements across the broader population of patients with CKD are needed.

On the other hand, we observed that blood pressure and eGFR monitoring was completed in a high portion of patients with CKD in primary care, 88.7% and 86.0% respectively. This is consistent with international cohorts with estimates ranging from 70 to 98% for blood pressure monitoring[8,10,11,36,37] and 70–93% for renal function monitoring.[8,10,11,36,38–40] However, high rates of blood pressure monitoring did not appear to translate to blood pressure target achievement, with 57.9% of the cohort achieving the target BP < 140/90 and 29.3% BP < 130/80 mmHg. We do note however, that office blood pressure is not the gold standard, and it is unknown what proportion of patients with hypertension underwent 24-h ambulatory blood pressure monitoring.

Furthermore, whilst the use of ACE inhibitors and ARBs at 65.2% is greater than[8,36,41,42] or similar to[9,43,44] other international cohorts, temporal trends showed a small but steady decline in ACE inhibitor or ARB prescription over time. This has been previously described internationally.[45,46] The reasons for this trend are not entirely clear, however barriers to ACE inhibitor or ARB initiation and ongoing prescription include previous acute kidney injury, hyperkalaemia, advancing CKD and multimorbidity.[47]

There has been a significant expansion in the armamentaria of medications available to delay CKD progression,[48–50] which are recommended in stepwise addition to ACE inhibitors and ARBs. Implementation of these medications with significant benefit in reducing morbidity and mortality associated with CKD is essential. A whole-systems approach is required to address the barriers and ensure implementation of CKD therapies, from public policy and health system reform through to provider and patient education.[51,52]

Notably, we found a lower relative risk of receiving CKD monitoring and cardiovascular risk management in females. Previously, it was thought that sex differences in care may be attributable to co-morbidity burden and slower CKD progression.[53] Our findings persisted despite adjusting for age, comorbidities and CKD stage. This has previously been reported with prior studies finding similar differences in CKD care that persist after adjusting for clinical and socio-demographic characteristics.[8,54] The reasons for this are still to be established and this finding warrants further research to explore potential reasons for this.

This study has several strengths including a contemporary cohort, the large community based nationally representative data source allowing for greater generalisability of results and longitudinal analysis. However, there are several limitations. The data reflect primary care data, and thus is likely to be incomplete particularly in relation to those with more severe

disease. Patients who are attending specialist care, recommended in those with CKD stage 4 or 5 or severely increased albuminuria, are likely to be receiving monitoring at specialist services that may not be captured in primary care medical records and likely explains the association with decreased monitoring in more advanced CKD in this study. This is only a small subset of the patients however with only 7.0% having stage 4–5 CKD in this cohort. The MedicineInsight data came from an opt in program, and thus used a non-random recruitment strategy. Broadly, the data are consistent with the larger Australian population,[13] however, sampling differences across Australian states and territories cannot be excluded. There is the potential for unmeasured confounding based both on uncaptured data and other confounders not analysed. Co-morbidity and observational data are extracted from coded or charted data within the medical record, and thus if entered as free text this would not be captured. There is also potential for data duplication if patients are attending multiple participating practices, although, given the general practice setting, significant movement across sites is not expected. It is possible that for some patients, CKD definition was first met prior to the study period. Our study may thus include patterns of CKD management at the time of both incident and prevalent CKD. Furthermore, the final years of follow-up occurred during the COVID-19 pandemic with reduced access to non-emergency health services, which likely explains the slight decrease in monitoring following CKD identification in 2019 and 2020.

Conclusion

This study highlights the priority areas for CKD care in a large nationally representative cohort. Whilst there were high rates of monitoring of blood pressure, eGFR and HbA1c, there is need to improve albuminuria monitoring which is essential for risk stratification and required for current CKD medication eligibility. Additionally, increasing uptake of ACE inhibitors and ARBs is a priority as they have been the standard for CKD care and the base medication to which newer guideline directed care is added. Further work is required to understand translation of CKD recognition and monitoring, into comprehensive management, and more broadly implementation strategies to improve all facets of CKD care.

Contributors

HW, JW, SK, PR and MJ contributed to the concept and rationale for the study and interpretation of the results. HW, JW, PR, SK, and MJ developed the study protocol and oversaw the implementation of the study analytical plan. HW drafted the initial manuscript, and MJ revised the initial draft. HW and MJ had access to all of the raw study data, verified the data and take responsibility for the integrity of the data. All authors contributed to the design of the study, interpretation of the data and, critical revision of the manuscript and approved the final manuscript for submission.

Data sharing statement

The current study is based on data from MedicineInsight, a national general practice data source developed by NPS MedicineWise and managed by the Australian Commission on Safety and Quality in Health Care.[14] All relevant data are within the manuscript and its supplemental material.

Declaration of interests

The Renal Division of The George Institute for Global Health has received sponsorship funding provided by Boehringer Ingelheim and Eli Lilly Alliance and is supported by the University of New South Wales Scientia Program. The design, analysis, interpretation or writing of this manuscript was performed independent of all funding bodies. All study authors assumed final responsibility for all aspects of the study, including the decision to submit the manuscript for publication. MJ is responsible for research projects that have received research funding from Boehringer Ingelheim and Eli Lilly Alliance. MJ received research advisory group fees from NPS MedicineWise for a project outside the current study paid to his institution. SK has received consulting fees from Amgen, Chinook/Novartis and Boehringer and Ingelheim. BLN has received fees for travel support, advisory boards, publication support, scientific presentations and steering committee roles from AstraZeneca, Alexion, Bayer, Boehringer and Ingelheim, CSL-Behring, CSL-Seqirus, HCP Live, Medscape, Menarini, Novo Nordisk, Travere Therapeutics and Cornerstone Medical Education. SVB has received research grants from the National Health and Medical Research Council of Australia, advisory board fees from Bayer, AstraZeneca, and Vifor Pharma; speaker's honoraria from Bayer, AstraZeneca, Vifor Pharma, and Pfizer; and nonfinancial research support from Bayer, all fees paid to The George Institute for Global Health. CN has received project grants from Safer Care Victoria. DP has received research grants from the National Health and Medical Research Council of Australia.

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Appendix A. Supplementary data

Supplementary data related to this article can be found at https://doi.org/10.1016/j.lanwpc.2025.101541.

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