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Original Article

The prevalence and treatment of chronic kidney disease in a cardiology outpatient clinic

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ABSTRACT

INTRODUCTION. Patients with cardiovascular and chronic kidney disease (CKD) are at increased risk of adverse outcomes, calling for early monitoring of kidney function to reduce morbidity and mortality. We aimed to estimate CKD prevalence, albuminuria, kidney monitoring practices and adherence to guideline-recommended treatment in cardiology outpatients.

METHODS. This cross-sectional study included 196 patients from a cardiology outpatient clinic in Svendborg, Denmark. Blood and urine samples were analysed for the estimated glomerular filtration rate (eGFR), urine albumin-to-creatinine ratio and secondary markers of kidney impairment, in accordance with international guidelines. Medical history, risk factors and demographic information were obtained from a questionnaire. Regular CKD monitoring (≥ 1 ×/year) and nephroprotective drug use were evaluated.

RESULTS. The prevalence of CKD was 50.5%, and 20.9% of patients were categorised with a high or very high CKD risk. In patients with CKD, 23.2% had albuminuria despite normal eGFR, 22.2% had secondary markers of kidney impairment, and only 15.2% were aware of having reduced kidney function. Regular kidney monitoring was lacking in 33.7% of patients, and 64.3% of patients with CKD did not receive the recommended treatment.

CONCLUSIONS. The prevalence of CKD was high in cardiology outpatients. Limited awareness of kidney function, in combination with infrequent screening of CKD, led to inadequate prescription of nephroprotective drugs.

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TRIAL REGISTRATION. Not relevant.

Chronic kidney disease (CKD) is a frequent comorbidity in patients with cardiovascular disease (CVD) [1, 2]. The increasing prevalence of CKD contributes to a high risk of hospitalisation [2, 3], reduced quality of life [4] and a substantial socio-economic burden on healthcare systems [3].

The well-established inverse relationship between kidney function and cardiovascular risk [3] is linked by the cardio-renal syndrome, requiring early detection of CKD, careful monitoring and specialised treatment.

However, conflicting guidelines between medical specialities [5, 6] and a lack of albuminuria testing in both primary and secondary care lead to inconsistent monitoring and inadequate cardio-renoproctive treatment [7, 8]. This occurs despite simple diagnostics and easy access to laboratory tests.

Various drugs have shown significant renal and cardiovascular benefits [9-12]. Sodium-glucose co-transport-2 inhibitors (SGLT2i) reduce the risk of death from renal and cardiovascular causes [9, 10] and decrease the risk of decline in estimated glomerular filtration ratio (eGFR) [9]. Finerenone and glucagon-like peptide-1 receptor agonist (GLP1-RA) reduce the risk of cardiovascular and kidney outcomes in patients with type 2 diabetes (T2DM) [11, 12].

To our knowledge, no recent studies have investigated CKD in cardiology outpatients using a combined assessment of eGFR and urine albumin-creatinine ratio (uACR). Therefore, the primary aim of this cross-sectional study was:

1. to examine the prevalence of CKD in a cardiology outpatient clinic.

The secondary objectives were:

2. to determine the prevalence of patients with albuminuria despite normal eGFR and to investigate secondary markers of kidney impairment

3. to evaluate kidney function monitoring practices, including frequency, diagnostic recognition and awareness among patients and clinicians and

4. to examine the proportion of patients with CKD who received guideline-recommended treatment.

Methods

Study design and patients

This observational cross-sectional study was conducted at the Cardiology Outpatient Clinic at Odense University Hospital (OUH) in Svendborg, Denmark. Patients eligible for enrollment were included from February to April 2024.

The inclusion criteria were: 1) age ≥18 years old and 2) a visit to a cardiologist in the outpatient clinic. The exclusion criteria were 1) life expectancy < 2 years, 2) inability to provide informed written consent and 3) missing information on eGFR or uACR (see Appendix A).

The trial protocol was approved by the Regional Ethical Committee of Southern Denmark (ID S-20230087). The study complied with the Declaration of Helsinki. All participants provided informed oral and written consent before sample collection. Information about laboratory test results and follow-up questions about patient characteristics were collected.

Patients with impaired kidney function but no previous history of CKD were informed of their results and advised to seek follow-up in primary care.

Procedures and outcomes

The prevalence of CKD was determined from blood and urine samples. CKD was defined as an eGFR <60 ml/min./1.73 m^2 and/or a uACR > 30 mg/g, with CKD stages and risk levels classified according to the Kidney Disease Improving Global Outcomes (KDIGO) guidelines [5]. The study design did not permit measuring kidney function at three-month intervals, as recommended by standard guidelines [5].

Blood samples were collected to assess secondary effects of CKD, including anaemia, changes in calcium and phosphate metabolism, vitamin D status, potassium and acid-base disorders (Appendix B). All blood and urine samples were analysed in the laboratories of the OUH. Data on previous medical history, regular monitoring of kidney function, risk factors, current medication and demographic variables were collected using a standardised

questionnaire supplemented by chart reviews (Appendix C). Regular monitoring of kidney disease was defined as having both an eGFR and a uACR measured at least once per year. Clinic visits were classified as either first-time consultations or follow-up visits for known heart disease. Awareness of impaired kidney function was defined as a kidney disease diagnosis or prior oral information about impaired function provided to the patient.

Treatment was assessed according to the international KDIGO guidelines [5]. Blood pressure, weight and height were obtained from medical records or self-reported by patients. All patients were interviewed by the same researcher.

Statistical analysis

The study required 196 patients to achieve sufficient statistical power (Appendix D).

Continuous variables are presented as mean and SD for normally distributed data, or as median and IQR for non-normally distributed data. Categorical variables are reported as numbers and percentages. Differences between groups of continuous variables were compared using Student's t-test for normally distributed data or the Kruskal-Wallis test for non-normally distributed data. Categorical variables were tested with Pearson's χ^2 test. Continuous variables were tested for normality using the Skewness-Kurtosis test and the Shapiro-Wilk test, and power transformation was tested using Turkey's Ladder of Transformation.

Multiple logistic regression was performed to examine the independent associations between CKD, demographic variables and risk factors.

All statistical tests were two-sided, with a $p < 0.05$ considered statistically significant. Statistical analyses were performed using Stata 18.5 (StataCorp LLC, College Station, TX, USA).

Trial registration: not relevant.

Results

Patient demographics

A total of 196 patients were included in the study. Patients with CKD tended to be older (77 versus 67 years), more likely to attend a follow-up visit at the clinic and had a higher prevalence of risk factors and CVD, **Table 1**. No significant gender difference was observed between the two groups. Higher levels of glycated haemoglobin (HbA_{1c}) and phosphate were observed in patients with CKD, whereas cholesterol, low-density lipoproteins and haemoglobin levels were lower. However, patients with CKD were more frequently prescribed statins, angiotensin-converting enzyme inhibitors or angiotensin receptor blockers (ACEi/ARB) and SGLT2i than were patients without CKD. No significant differences were found regarding smoking status, family history of kidney disease, BMI, or blood pressure (Table 1 and Appendix E.1).

TABLE 1 Baseline demographic and disease characteristics of cardiology patients categorised according to kidney function. See full list of patients' demographics, biochemistry and medications in Appendix E.

	No CKD (N_n = 97 (49.5%))	CKD (N_c = 99 (50.5%))	p value	
			Kruskal-Wallis test	Pearson's χ^2 test
Age, median (IQR), yrs	67.0 (62.0-74.0)	77.0 (70.0-81.0)	< 0.001	
Gender, n (%)				0.739
Male	62 (63.9)	61 (61.6)		
Female	35 (36.1)	38 (38.4)		
Smoking status, n (%)				0.563
Never smoker	40 (41.7)	34 (34.3)		
Former smoker	44 (45.8)	52 (52.5)		
Active smoker	12 (12.5)	13 (13.1)		
Follow-up visit in the clinic, n (%)	54 (56.2)	80 (80.8)		< 0.001
Diabetes, n (%)	13 (13.4)	29 (29.3)		0.007
Hypertension, n (%)	50 (51.5)	68 (68.7)		0.014
Cardiovascular disorder[a], n (%)	67 (69.1)	92 (92.9)		< 0.001
Ischaemic heart disease, n (%)				0.015
No ischaemia	73 (75.3)	57 (57.6)		
ACS	7 (7.2)	19 (19.2)		
CCS	17 (17.5)	23 (23.2)		
Heart failure, n (%)				0.018
No heart failure	79 (83.2)	63 (64.9)		
HFpEF	1 (1.1)	3 (3.1)		
HFmrEF	3 (3.2)	2 (2.1)		
HFrEF	12 (12.6)	29 (29.9)		
Atrial fibrillation/flutter, n (%)	30 (30.9)	51 (51.5)		0.003
Heart valve disease[b], n (%)	27 (27.8)	45 (45.5)		0.011
BMI, median (IQR), kg/m^2	26.6 (24.2-30.8)	27.2 (24.0-30.7)	0.982	
Blood pressure, systolic, median (IQR), mmHg	127.5 (117.0-138.0)	132.0 (121.0-144.0)	0.053	
eGFR, median (IQR), ml/min./1.73 m^2	84.0 (76.0-90.0)	52.0 (45.0-59.0)	< 0.001	
uACR, median (IQR), mg/g	9.0 (5.0 14.0	31.0 (9.0 83.0)	< 0.001	
Plasma concentration, median (IQR)				
Creatinine, µmol/l	77.0 (66.0-87.0)	103.0 (84.0-132.0)	< 0.001	
Potassium, mmol/l	4.0 (3.8-4.2)	4.1 (3.8-4.3)	0.497	
HbA_{1c}, mmol/mol	38.0 (36.0-42.0)	41.0 (38.0-46.0)	< 0.001	
Cholesterol, mmol/l	4.8 (3.9-5.5)	4.2 (3.7-5.1)	0.020	
LDL, mmol/l	2.6 (1.8-3.3)	2.0 (1.5-3.0)	0.002	
Haemoglobin, mmol/l	8.9 (8.3-9.5)	8.5 (7.6-9.1)	< 0.001	
Calcium, mmol/l	2.4 (2.3-2.4)	2.4 (2.3-2.4)	0.737	
Phosphate, mmol/l	1.0 (0.9-1.1)	1.1 (0.9-1.2)	0.028	
Bicarbonate, mmol/l	23.8 (23.0-24.4)	23.2 (21.7-25.1)	0.083	
ACEi/ARB, n (%)	46 (47.4)	73 (73.7)		< 0.001
SGLT2i, n (%)	10 (10.3)	34 (34.3)		< 0.001
GLP1-RA, n (%)	6 (6.2)	12 (12.1)		0.157
Medication, n (%)				
Finerenone	0	2 (2.0)		0.159
Statins[c]	48 (49.5)	71 (71.7)		0.001

ACEi/ARB = angiotensin-converting enzyme inhibitor/angiotensin receptor blockers; ACS = acute coronary syndrome; CCS = chronic coronary syndrome; CKD = chronic kidney disease; eGFR = estimated glomerular filtration ratio; GLP-1 RRA = glucagon-like peptide-1 receptor agonist; HFmrEF = heart failure with mildly reduced ejection fraction; HFpEF = heart failure with preserved ejection fraction; HFrEF = heart failure with reduced ejection fraction; SGLT2i = sodium-glucose co-transport 2 inhibitor; uACR = urine albumin-creatinine ratio.
a) A diagnosis of heart failure, ischaemic heart disease, arrhythmia, or valve disease.
b) A diagnosis of aortic stenosis, aortic regurgitation, mitral stenosis, mitral regurgitation, tricuspid regurgitation, bicuspid aortic valve, aortic or mitral valve replacement/repair.
c) Statins or other lipid-lowering drugs.

Prevalence and classification of chronic kidney disease

The prevalence of CKD was 50.5% (95% CI: 43.6-57.4%). Patients were divided into CKD stages and associated risk levels were estimated. Moderate CKD risk was observed in 29.6% of patients, whereas 12.2% had a high risk and 8.7% had a very high risk (**Figure 1**). Severely increased albuminuria (> 300 mg/g) was found in 8% of patients with CKD, with the highest values reaching 3,940 mg/g (**Figure 2**). Among patients with a normal eGFR, 23.2% had moderate or severe albuminuria (> 30 mg/g).

FIGURE 1 Chronic kidney disease (CDK) risk levels classified according to the Kidney Disease Improving Global Outcomes guidelines (N = 196).

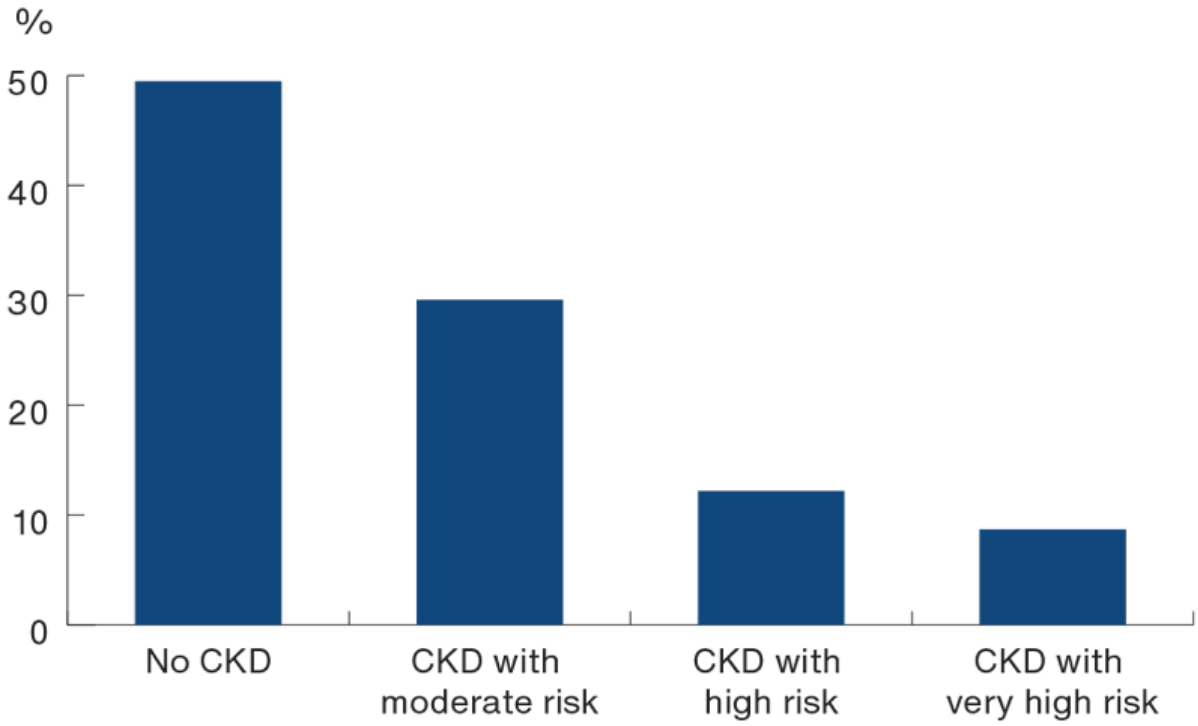

FIGURE 2 Classification of patients included in the study in accordance with the Kidney Disease Improving Global Outcomes guidelines. Counts (%) of 196 patients with information on both estimated glomerular filtration ratio (eGFR) and urine albumin-creatinine ratio.

	Albuminuria category, n (%)			
eGFR category	A1: < 30 mg/g	A2: 30-300 mg/g	A3: > 300 mg/g	total
G1: > 90 ml/min./1.73 m²	28 (14.29)	5 (2.55)	1 (0.51)	34 (17.35)
G2: 60-90 ml/min./1.73 m²	69 (35.20)	16 (8.16)	1 (0.51)	86 (43.88)
G3a: 45-59 ml/min./1.73 m²	36 (18.37)	13 (6.63)	3 (1.53)	52 (26.53)
G3b: 30-44 ml/min./1.73 m²	9 (4.59)	5 (2.55)	2 (1.02)	16 (8.16)
G4: 15-29 ml/min./1.73 m²	2 (1.02)	4 (2.04)	1 (0.51)	7 (3.57)
G5: < 15 ml/min./1.73 m²	0	1 (0.51)	0	1 (0.51)
Total	144 (73.47)	44 (22.45)	8 (4.08)	196 (100)

Low risk Moderate risk High risk Very high risk

Secondary markers of kidney impairment were observed in 22.2% (95% CI: 15.2-31.4%) of patients with CKD

(Figure 2).

Chronic kidney disease monitoring, diagnosis and treatment

Regular monitoring of kidney function was lacking in 33.7% of patients (95% CI: 27.4-40.5%), with no significant difference between patients with and without CKD (p = 0.264) (**Table 2**).

TABLE 2 Characteristics of kidney function, presence of nephrotic disorders, and nephroprotective treatment. The reported values are n (%)

	No CKD (N_n = 97 (49.5%))	CKD (N_c = 99 (50.5%))	Total (N_{tot} = 196 (100.0%)
eGFR > 60 ml/min./1.73 m² and uACR > 30 mg/g	-	23 (23.2)	23 (11.7)
eGFR			
> 60 ml/min./1.73 m²	97 (100.0)	23 (23.2)	120 (61.2)
30-59 ml/min./1.73 m²	-	68 (68.7)	68 (34.7)
< 30 ml/min./1.73 m²	-	8 (8.1)	8 (4.1)
uACR			
30-299 mg/g	-	43 (43.4)	43 (21.9)
> 300-699 mg/g	-	4 (4.0)	4 (2.0)
> 700-1,199 mg/g	-	2 (2.0)	2 (1.0)
> 2,200 mg/g	-	2 (2.0)	2 (1.0)
Secondary markers of impaired kidney function[a]	-	22 (22.2)	22 (11.2)
Monitoring of kidney function[b]			
No regular monitoring	35 (36.1)	31 (31.3)	66 (33.7)
General practice	59 (60.8)	60 (60.6)	119 (60.7)
Department of nephrology	2 (2.1)	6 (6.1)	8 (4.1)
Department of endocrinology	0	2 (2.0)	2 (1.0)
Current/previous nephrological disorder[c]	9 (9.3)	27 (27.3)	36 (18.4)
Diagnosis/awareness of CKD	-	15 (15.2)	15 (7.7)
Adequate nephroprotective treatment[d]			
In T2DM-patients	-	7 (25.0)	7 (5.6)
In patients without T2DM	-	28 (40.6)	28 (16.9)
Subtotal	-	35 (35.7)	35 (17.9)

ACEi/ARB = angiotensin-converting enzyme inhibitor/angiotensin receptor blockers; CKD = chronic kidney disease; eGFR = estimated glomerular filtration ratio; GLP1-RA = glucagon-like peptide-1 receptor agonist; KDIGO = Kidney Disease Improving Global Outcomes; SGLT2i = sodium-glucose co-transport 2 inhibitor; T2DM = type 2 diabetes; uACR = urine albumin-creatinine ratio.
a) Nephrogenic anaemia, acid-base disorder, or changes in the calcium-phosphate metabolism.
b) ≥ 1 × a year including uACR measurement.
c) A current or previous diagnosis of one of the following: CDK, former/current acute kidney disease, kidney stones, kidney cysts, post-renal obstruction, single-functioning kidney, or kidney cancer, this current/previous nephrological disorder does not necessarily imply reduced kidney function.
d) Nephroprotective treatment with ACEi/ARB, SGLT2i, and statins by indication, with addition of GLP-1 RA and finerenone in patients with T2DM, indication and treatment according to the KDIGO guidelines.

Awareness of impaired kidney function or a diagnosis of CKD in the chart system was documented in only 15.2% of patients with CKD.

Recommended treatment was prescribed to 35.7% of patients with CKD, and only 25% of patients with T2DM and CKD received appropriate treatment, despite current class 1A and 1B recommendations [5].

Association between risk factors and chronic kidney disease

A multiple logistic regression analysis found that increasing age was associated with 12% higher odds of CKD per year (95% CI: 1.07-1.18), Appendix F. Patients with heart failure (HF) with reduced ejection fraction (HFrEF) had fivefold higher odds of CKD (95% CI: 1.74-14.36) and those with hypertension (HT) had threefold higher odds (95% CI: 1.25-6.31) than patients without this condition. No other individual risk factors were significantly associated with CKD, and the concurrent presence of multiple risk factors (i.e. smoking, obesity, hypercholesteremia, T2DM and HT) was also not significantly associated with CKD. A likelihood-ratio test indicated an improved model fit when these factors were excluded from the analysis.

Discussion

Summary

In this study, we found that half of the patients in the Cardiology Outpatient Clinic had reduced kidney function. More than 20% were categorised as having a high or very high CKD risk. We demonstrated that among patients with a normal eGFR, over 20% had albuminuria, and secondary markers of kidney impairment were identified in more than 20% of patients with CKD. Furthermore, a third of patients with CKD did not attend regular monitoring of kidney function, and two-thirds did not receive the appropriate nephroprotective treatment in accordance with KDIGO guidelines.

Prevalence of chronic kidney disease

Previous studies have reported a high CKD prevalence in patients with CVD [2, 13-16], supporting the findings of the present study. Amenós et al. [14] found that 37.3% of patients with CVD or at high risk of CVD had an eGFR < 60 ml/min./1.73 m^2. The lower prevalence observed compared with our study may reflect the absence of uACR measurements. In our study, 23.2% of patients with preserved eGFR had moderate or severe albuminuria, suggesting possible underdiagnosis of CKD. These findings are consistent with those of Wagner et al., who reported that 12.9% of patients with preserved eGFR had albuminuria [2]. This highlights the value of uACR testing in assessing kidney function, identifying patients at a high cardiovascular and mortality risk and guiding organ-protective therapy. The current KDIGO classification shows a marked increase in risk within the G1 and G2 categories (eGFR > 60 ml/min/1.73 m^2) depending on uACR [5]. A KDIGO conference recommended that patients with T2DM, HT or CVD undergo regular monitoring of both eGFR and uACR measurement [17].

Treatment of chronic kidney disease

Lindhardt et al. [7] evaluated the use of nephroprotective drugs in Danish primary care. They found that ACEi/ARBs were prescribed to 65%, statins to 56%, SGLT2i to 14% and mineralocorticoid receptor antagonists to 8% of patients with CKD. Similar results have been reported by Mannheimer et al. [8] and Fried et al. [18], with Fried et al. additionally reporting the use of GLP-1 receptor agonists in 3.2% of patients. Our study found comparable results, though with a higher prescription rate of SGLT2i and GLP-1 RA. SGLT2i are more likely to be prescribed to patients with HF, independently of kidney function, contributing to the higher prescription rate.

Subpopulations and risk factors

We found that HRrEF and HT were significantly associated with CKD. This finding is consistent with the high prevalence of CKD reported in the Swedish HF registry [16], in contrast to the lower prevalence observed in patients with IHD [2] (51% versus 29.3%). The stronger association between CKD and HF may be explained by the cardio-renal syndrome, medical treatment, and complex pathophysiological processes in the underlying aetiology of HF.

Age and HT were significantly associated with CKD, which is in accordance with findings from other studies [15]. However, we found no significant association between CKD and T2DM, smoking, IHD or other established risk factors of CKD [1, 2, 15]. These unexpected results may be explained by the relatively small subgroups, resulting in insufficient statistical power.

Clinical implications and perspectives

Treatment with ACEi/ARB and SGLT2i is well-recognised to reduce the risk of death and progression of kidney disease, and in the Flow Trail, GLP1-RA was found to reduce the risk of kidney outcomes and death in patients with T2DM [12]. However, our study found that nephroprotective treatment was not routinely prescribed to patients with both CVD and CKD. According to current guidelines, patients with early-stage CKD should be

identified and managed without delay by primary care physicians or other medical departments that encounter these patients. Referral to a nephrologist is recommended for patients with advanced CKD [5]. In contrast to these recommendations, our study revealed considerable deficiencies in the clinical management of CKD, including failures in detection, proper monitoring and initiation of guideline-based treatment. As a result, many patients receive suboptimal treatment, reflecting a concerning lack of adherence to established clinical guidelines. We hypothesise that morbidity and mortality could be reduced through consensus in clinical guidelines, potentially supported by a specialised cardio-renal clinical for patients with heart and kidney disease. The Steno-2 study clearly documented that intensified interventions slow the progression of CKD in patients with T2DM and uACR > 30 mg/g [19], reducing the risk of hospitalisation for HF by 70% [20].

Limitations

The study was limited by the cross-sectional design, which involved a single measurement of kidney function. Low eGFR and/or high uACR can be temporarily elevated in various conditions. As such, it is recommended to obtain two measurements of eGFR and uACR to accurately diagnose CKD.

Secondly, the study was designed to evaluate the prevalence of CKD and overall treatment trends. The small sample size must be considered when interpreting the findings of the analysis, particularly subgroup analyses of associations with CKD.

Thirdly, the study did not include any data on recommended follow-up in primary care after evaluation of kidney function in the outpatient clinic.

Conclusions

Patients investigated routinely in our cardiology outpatient clinic presented with a 50% prevalence of CKD, and 20% had a high or very high CKD risk. Regular monitoring of kidney function was infrequent, and a substantial number of patients did not receive an accurate diagnosis of CKD or appropriate nephroprotective treatment.

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