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Assessing trends and variability in outpatient dual testing for chronic kidney disease with urine albumin and serum creatinine, 2009–2018: a retrospective cohort study in the Veterans Health Administration System

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ABSTRACT

Background Simultaneous urine testing for albumin (UAlb) and serum creatinine (SCr), that is, 'dual testing,' is an accepted quality measure in the management of diabetes. As chronic kidney disease (CKD) is defined by both UAlb and SCr testing, this approach could be more widely adopted in kidney care.

Objective We assessed time trends and facility-level variation in the performance of outpatient dual testing in the integrated Veterans Health Administration (VHA) system.

Design, subjects and main measures This retrospective cohort study included patients with any inpatient or outpatient visit to the VHA system during the period 2009–2018. Dual testing was defined as UAlb and SCr testing in the outpatient setting within a calendar year. We assessed time trends in dual testing by demographics, comorbidities, high-risk (eg, diabetes) specialty care and facilities. A generalised linear mixed-effects model was applied to explore individual and facility-level predictors of receiving dual testing.

Key results We analysed data from approximately 6.9 million veterans per year. Dual testing increased, on average, from 17.4% to 21.2%, but varied substantially among VHA centres (0.3%–43.7% in 2018). Dual testing was strongly associated with diabetes (OR 10.4, 95% CI 10.3 to 10.5, p<0.0001) and not associated with VHA centre complexity level. However, among patients with high-risk conditions including diabetes, <50% received dual testing in any given year. As compared with white veterans, black veterans were less likely to be tested after adjusting for other individual and facility characteristics (OR 0.93, 95% CI 0.92 to 0.93, p<0.0001).

Conclusions Dual testing for CKD in high-risk specialties is increasing but remains low. This appears primarily due to low rates of testing for albuminuria. Promoting dual testing in high-risk patients will help to improve disease management and patient outcomes.

STRENGTHS AND LIMITATIONS OF THIS STUDY

⇒ This study used the Veterans Health Administration (VHA) data that provided a comprehensive assessment of dual testing in the Veterans Affairs Health Care System.
⇒ This study captured patients' races/ethnicities, comorbidities and laboratory information.
⇒ Although we reported the proportions of testing for patients followed by specialists, we could not discern which providers ordered testing for a given patient.
⇒ Testing that occurred outside the VHA system and testing ordered but not completed were not captured in this study.
⇒ For this analysis, any urine albumin testing was considered as evidence for evaluation of albuminuria, not necessarily accompanied by a test for urinary creatinine.

INTRODUCTION

Chronic kidney disease (CKD) is defined by a reduction in the glomerular filtration rate (GFR) or the presence of albuminuria, persisting for at least 90 days.[1] Therefore, dual testing through the use of serum creatinine (SCr), combined with urine albumin (UAlb) or urine albumin/creatinine ratio (UACR), is essential to diagnose CKD with the recognition that both low GFR and albuminuria are independently and multiplicatively associated with all-cause and cardiovascular disease (CVD) mortality.[2] Although the American Diabetes Association guidelines recommend annual testing for SCr and albuminuria among patients with diabetes mellitus (DM),[3] current cardiovascular society guidelines do not strongly endorse testing among patients

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with other major risk factors for CKD, including hypertension (HTN) and heart failure (HF),[4 5] and UAlb testing may be overlooked in real-world settings.

A recent Kidney Disease Improving Global Outcomes (KDIGO) conference highlighted the importance of dual GFR and albuminuria testing among all patients with major CKD risk factors, including CVD.[6] The resulting consensus document emphasised that CKD is a condition meeting the WHO criteria for screening among people with established risk factors[7]; and that early CKD screening and management is an 'equity imperative,' since CKD disproportionately affects disadvantaged populations; and that contemporary treatment options for CKD are expanding.

In this study, we have sought to (1) define time trends in outpatient dual testing with SCr and UAlb for CKD across the USA in the Veterans Health Administration (VHA), particularly among veterans with comorbidities predisposing them to CKD and (2) examine the influence of patient-level factors, including age, sex and race, as well as centre-level variation, on current dual testing practices. We hypothesised that the percentage of patients undergoing dual testing would be less than 40% overall, but anticipated an increase over time in the entire cohort (given the influence of practice guidelines), with variation in dual testing practices occurring by age, sex, race, comorbidities and VHA centre.

METHODS

Patient and public involvement

The CDC Kidney Disease Surveillance System team has an Advisory Group that has had representation by the American Association of Kidney Patients from 2007 to 2021. In addition, one of the team members has had personal experience with end-stage kidney disease and regularly provides patient perspectives to the team for this project.

Study population and variables

This study used US VHA data from 2009 to 2018. We included every individual with any inpatient or outpatient visit to the VHA during the study period in the analysis and formed 10 retrospective annual patient cohorts (2009–2018). For each calendar year, subjects' demographics, CKD status and comorbidities were assessed in the selection period, the year prior to the calendar year; and subjects' dual testing was assessed within the calendar year. We defined dual testing as receiving UAlb and SCr testing in the outpatient setting within a calendar year. These tests were not necessarily performed on the same day. Demographic variables included age, sex and self-reported race as documented in the electronic health record. Patient comorbidities including DM, CKD and HTN were ascertained from diagnosis codes (International Classification of Diseases, 9th and 10th editions),[8] outpatient laboratory values (we defined CKD by a single value of estimated GFR (eGFR) <60 mL/min/1.73 m^2 or UACR >30 mg/g; we defined DM by either a single value of serum glucose ≥200 mg/dL (≥11.1 mmol/L) or haemoglobin A1c ≥6.5% (≥48 mmol/mol)), and outpatient prescriptions for antidiabetic and antihypertensive medications (online supplemental table 1). We used the most recent SCr value obtained in any given year, from outpatient and inpatient measurements, to calculate eGFR and classify eGFR level. Laboratory measurements of primary interest included SCr and UAlb measured in the outpatient setting within each calendar year. Specialist visits to nephrologists, diabetologists and cardiologists were determined on an annual basis by categorising each encounter according to the provider type specified in the VHA data. We categorised VHA centres (n=129) by complexity level, based on a VHA model incorporating variables such as patient population, clinical services complexity, educational activities and research programmes.[9] Complexity level 1 corresponds to large centres with extensive subspecialty care, teaching and research, and complexity level 3 corresponds to smaller centres with less subspecialty care and little or no teaching or research.

Statistical methods

For each calendar year, we determined the percentage of patients undergoing outpatient dual testing (SCr and UAlb) and the percentages of patients undergoing outpatient SCr or UAlb testing only. Percentages of patients undergoing dual testing were plotted from 2009 to 2018. A logistic regression model with adjustment of the year variable was used to analyse time trends of dual testing of SCr and UAlb in outpatient settings for the entire cohort, for demographic subgroups, for patients with HTN, for patients with DM and those who saw diabetologists, for patients with CKD and those who saw nephrologists and for patients with CVD and those who saw cardiologists.

To assess variation in VHA centre-level testing, we summarised the percentage of patients undergoing outpatient dual testing by centre and created measures based on the quintiles. We also assessed dual testing based on VHA centre complexity level. We applied a mixed effect logistic model accounting for facility clustering, based on a randomly selected 10% sample of each annual cohort, to examine the associations of centre-level variation, comorbidities and demographics (including age, race and sex) with dual testing practices. Facility clustering was adjusted by random intercepts. SAS V.9.4 and R V.4.1.2 were used to perform data management and all statistical analyses.

RESULTS

The study sample included 69 102 389 veteran observations (total unique veterans: 10 859 944; mean observations per year: 6.9 million) from 2009 to 2018. Patient characteristics are summarised in table 1 and online supplemental table 2 with frequency data. Patient characteristics on an annual basis are reported in online supplemental table 3. Overall, the population was 91.1% male, 62.9% white and the mean age was 62.3±16.0 years (table 1). Over the

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Table 1 Characteristics of the Veterans Health Administration study population, 2009–2018 (69 102 389 veteran observations in 10 859 944 unique veterans)

	All patients	SCr only	SCr and UAlb	UAlb only	Neither SCr nor UAlb
	69 102 389	39 983 677 (58.5%)	13 663 648 (19.8%)	153 566 (0.2%)	14 520 233 (21.00%)
Age (years, mean±SD)	62.3±16.0	62.8±15.4	65.6±11.6	64.6±13.2	57.9±19.7
20–29	4.70%	3.70%	0.90%	1.70%	10.90%
30–39	6.80%	6.30%	2.20%	3.50%	12.20%
40–49	9.10%	9.00%	5.90%	7.60%	12.30%
50–59	16.50%	17.10%	16.50%	17.50%	15.00%
60–69	31.40%	32.40%	42.00%	36.20%	19.50%
70+	31.50%	31.50%	32.60%	33.50%	30.20%
Male	91.10%	92.20%	95.30%	94.60%	84.40%
Race/ethnicity (%)					
White	62.90%	65.70%	65.90%	57.90%	52.30%
Black	14.60%	14.90%	16.50%	18.50%	11.90%
Hispanic	5.30%	5.70%	5.10%	5.70%	4.30%
Asian	0.70%	0.60%	0.70%	1.00%	1.00%
American Indian/Alaska Native	0.50%	0.50%	0.50%	0.70%	0.50%
Pacific Islander	0.70%	0.60%	0.80%	0.70%	0.70%
Other/unknown	15.40%	12.10%	10.50%	15.50%	29.30%
Hypertension	64.10%	69.90%	87.00%	76.20%	28.50%
Chronic kidney disease, based on diagnosis codes	13.00%	13.00%	25.10%	12.40%	2.40%
Kidney function*					
eGFR >90 mL/min/1.73 m^2	21.10%	28.20%	23.20%	12.00%	0.90%
60–90	35.50%	45.10%	46.00%	23.90%	1.20%
30–60	14.70%	17.10%	23.80%	9.60%	0.40%
15–30	1.30%	1.50%	2.20%	0.60%	0.04%
<15, not on dialysis	0.20%	0.20%	0.20%	0.10%	0.01%
Dialysis	0.60%	0.70%	0.60%	0.30%	0.20%
Transplant	0.20%	0.20%	0.30%	0.20%	0.10%
eGFR value missing	26.50%	7.00%	3.80%	53.30%	97.10%
Diabetes mellitus	32.30%	25.90%	75.40%	70.40%	10.20%
Cardiovascular disease†	35.50%	38.70%	50.10%	32.60%	13.00%
Centre complexity					
1a	43.60%	44.40%	42.30%	29.10%	40.40%
1b	21.80%	22.30%	19.10%	22.20%	20.80%
1c	18.00%	16.80%	21.40%	25.10%	17.30%
2	7.70%	7.40%	8.00%	8.60%	7.60%
3	8.80%	8.80%	8.80%	14.90%	8.60%

p<0.001 for all baseline characteristics.
*eGFR calculated based on serum creatinine tests in both inpatient and outpatient settings.
†Includes coronary artery disease, heart failure, peripheral arterial disease, stroke and dysrhythmia, as defined by the US Renal Data System.[8]
eGFR, estimated glomerular filtration rate; SCr, serum creatinine; UAlb, urine albumin.

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study period, the percentage of patients in the 30–39 and 70+ years age groups increased, and the percentage in the 50–59 years group declined, while the percentages of patients in other age groups did not change (online supplemental figure 1A). White patients accounted for 56.6% of observations in 2009 and 66.0% in 2018, black patients accounted for 12.2% in 2009 and 16.6% in 2018, and the percentage of patients defined as 'other/unknown race' declined from 25.4% in 2009 to 9.0% in 2018 (online supplemental figure 1B). The percentage of male patients decreased from 91.7% in 2009 to 90.0% in 2018 (online supplemental figure 1C).

HTN was documented in 64.1% of patients, followed by CVD (35.5%), DM (32.3%) and CKD (13.0%). Approximately 20% of patients received outpatient dual testing in a given calendar year, while 59% received SCr testing only. About 21% of patients received neither SCr testing nor UAlb testing within a given calendar year. Among patients receiving dual testing in a given year, 87.0% had HTN, 75.4% had DM, 50.1% had CVD and 25.1% had CKD (table 1).

Outpatient SCr testing was performed in approximately 78% of all patients during each year and was stable over the study period, while outpatient dual testing increased from 17.4% in 2009 to 21.2% in 2018 (p=0.0016 for trend, figure 1A). Among patients with HTN, dual testing increased from 25.5% to 28.9% (p<0.0001, figure 1B). Among patients with a diagnosis of DM, dual testing rose from 45.6% in 2009 to 47.7% in 2018 (p=0.0008, figure 1C). Among patients seen by diabetologists, no significant change in dual testing occurred over the study period (49.1% in 2009 and 49.5% in 2018, p=0.5077, figure 1D). In patients with CKD, dual testing increased from 35.4% in 2009 to 41.0% in 2018 (p<0.0001, figure 1E). Likewise, in patients seen by nephrologists, dual testing increased from 39.9% in 2009 to 46.5% in 2018 (p=0.0002, figure 1F). Among patients with CVD, dual testing rose from 27.1% in in 2009 to 30.1% in 2018 (p<0.0001 figure 1G). Patients seen by cardiologists exhibited a similar increase in dual testing, from 30.9% in 2009 to 33.5% in 2018 (p=0.0006; figure 1H).

The median proportion of patients receiving outpatient dual testing increased from 17% to 21% from 2009 to 2018 (figure 2). Dual testing varied substantially among VHA centres (n=129, figure 2), from 12% to 38% in 2009 and from 16% to 44% in 2018 (figure 2).

Based on the mixed effect logistic model (table 2), patients with DM were much more likely to have outpatient dual testing than patients without DM (OR 10.40, 95% CI 10.34 to 10.45, p<0.0001). Patients with HTN were also more likely to have dual testing than those without HTN (OR 1.41, 95% CI 1.40 to 1.42, p<0.0001), as were those with coronary artery disease (OR 1.13, 95% CI 1.12 to 1.13, p<0.0001). Patients with HF were less likely to undergo dual testing (OR 0.93, 95% CI 0.93 to 0.94, p<0.0001).

With regard to demographic characteristics, men were more likely to have outpatient dual testing than women

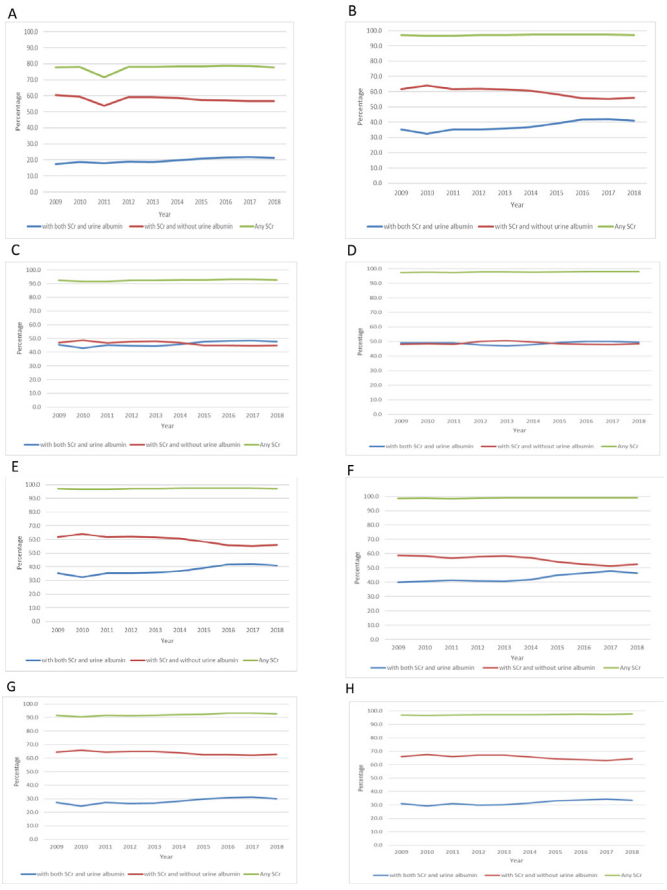

Figure 1 Trends in dual serum creatinine (SCr) and urine albumin testing among Veterans Health Administration patients, 2009–2018. (A) All patients. (B) Patients with hypertension. (C) Patients with diabetes mellitus. (D) Patients seen by diabetologists. (E) Patients with chronic kidney disease. (F) Patients seen by nephrologists. (G) Patients with cardiovascular disease. (H) Patients seen by cardiologists.

(OR 1.21, 95% CI 1.20 to 1.23, table 2), although dual testing increased in both sexes over time (online supplemental figure 2C). Compared with white patients, black patients were less likely to have dual testing (OR 0.93, 95% CI 0.92 to 0.93, p<0.0001, table 2), American Indian/Alaska Native and Pacific Islander patients had comparable dual testing (OR 1.00, 95% CI 0.97 to 1.03 and OR 1.00, 95% CI 0.98 to 1.03, respectively), and Asian and Hispanic patients were more likely to undergo dual testing (OR 1.13, 95% CI 1.10 to 1.16; OR 1.06, 95% CI 1.04 to 1.07; p<0.0001 for both, table 2). Over the study period, dual testing increased in all racial groups, with the largest increase observed in the black population (from 20.0% in 2009 to 24.0% in 2018; online supplemental figure 2B). Also, dual testing increased in all age groups over time (online supplemental figure 2A). Compared with patients under age 60 years, those of age 60–69 years were more likely to have dual testing (OR 1.13, 95% CI 1.12 to 1.14), while patients aged 80 years or older were less likely to receive dual testing (OR 0.69, 95% CI 0.68 to 0.69). Centre complexity was not associated with differences in dual testing. However, centre quintile was independently

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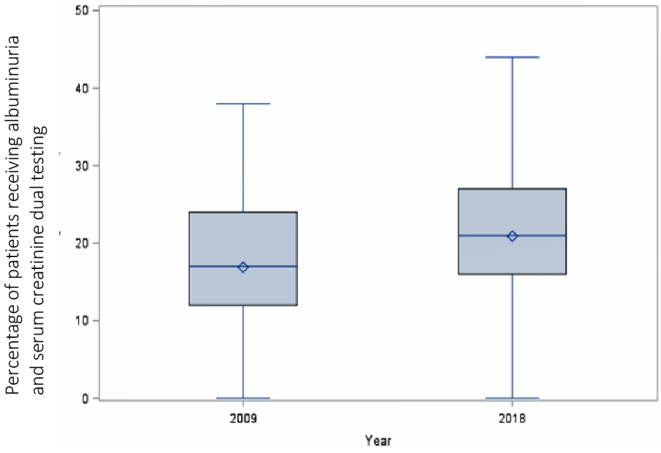

Figure 2 Percentage of patients receiving dual testing among Veterans Health Administration centres 2009 vs 2018.*The box and whisker plot shows the position of the minimum, lower quartile, median, upper quartile and maximum (2019: 0.2%, 12%, 17%, 24% and 38%; 2018: 0.3%, 16%, 21%, 27%, 44%).

associated with dual testing (OR 1.67, 95% CI 1.66 to 1.68, p<0.0001; table 2). In other words, a patient in the highest quintile of facility dual testing was 67% more likely to receive dual testing than a patient in the lowest quintile, after adjusting for patient characteristics.

DISCUSSION

This study shows that outpatient dual testing for CKD with SCr and UAlb increased from 17% to 21% among individuals seeking healthcare in the VHA between 2009 and 2018. However, even among patients with high-risk conditions including DM and CVD, less than half of the patients received dual testing in any given year. Patients were most likely to receive dual testing during the seventh decade of life. Black patients were less likely to receive dual testing than patients of other races. Although some VHA centres performed more dual testing than others, we did not find an association between centre complexity and dual testing.

UAlb testing represents a crucial component of the definition and diagnosis of CKD, especially in its earlier stages when SCr is typically in the normal range. Albuminuria is an established risk factor for all-cause and CVD mortality.[2 10] In the VHA population in particular, prior work has shown that albuminuria, especially among patients with normal or mildly reduced eGFR, is an independent risk factor for mortality.[11] Moreover, the detection of albuminuria identifies patients at higher risk of faster eGFR decline[12 13] and major adverse cardiovascular events.[2]

Annual screening for albuminuria with UACR has long served as the standard of care in DM,[3] and dual SCr and albuminuria testing is now a quality measure promoted by the National Quality Forum and the National Committee for Quality Assurance for care of patients with DM.[14] Patients with DM in our population were much more likely to undergo dual testing than patients without DM, suggesting that providers are more attuned to these practice recommendations. Although

Table 2 Patient and facility characteristics associated with outpatient dual serum creatinine and urine albumin testing by mixed effect logistic model among US Veterans*

Variable	Adjusted OR (95% CI)	P value
Patient level		
Male sex (reference: female)	1.21 (1.20 to 1.23)	<0.0001
Age (reference: <60 years)		
60–69	1.13 (1.12 to 1.14)	<0.0001
70–79	1.00 (0.99 to 1.01)	0.57
≥80	0.69 (0.68 to 0.69)	<0.0001
Race/ethnicity (reference: white)		
Black	0.93 (0.92 to 0.93)	<0.0001
Hispanic	1.06 (1.04 to 1.07)	<0.0001
American Indian/Alaska Native	1.00 (0.97 to 1.03)	0.08
Asian	1.13 (1.10 to 1.16)	<0.0001
Pacific Islander	1.00 (0.98 to 1.03)	0.28
Others/unknown, missing	0.92 (0.91 to 0.93)	<0.0001
Kidney function† (reference: eGFR >90 mL/min/1.73 m^2)		
60–90	1.03 (1.02 to 1.03)	<0.0001
30–60	0.97 (0.96 to 0.98)	<0.0001
15–30	0.65 (0.64 to 0.67)	<0.0001
<15, not on dialysis	0.29 (0.27 to 0.30)	<0.0001
Dialysis	0.16 (0.16 to 0.17)	<0.0001
Transplant	0.36 (0.34 to 0.37)	<0.0001
eGFR value missing	0.11 (0.11 to 0.12)	<0.0001
Diabetes mellitus	10.40 (10.34 to 10.45)	<0.0001
Hypertension	1.41 (1.40 to 1.42)	<0.0001
Coronary artery disease	1.13 (1.12 to 1.13)	<0.0001
Heart failure	0.93 (0.93 to 0.94)	<0.0001
Dysrhythmia	0.87 (0.87 to 0.88)	<0.0001
Stroke	0.94 (0.94 to 0.95)	<0.0001
Peripheral vascular disease	0.99 (0.98 to 1.00)	<0.01
Other cardiac conditions	0.78 (0.77 to 0.79)	<0.0001
Nephrology visit within same calendar year	1.65 (1.63 to 1.68)	<0.0001
Year	1.03 (1.03 to 1.03)	<0.0001
Facility level		
Centre dual testing rank (quintile, ascending)	1.67 (1.66 to 1.68)	<0.0001
Complexity level (reference: 1a)		
Complexity 1b	0.87 (0.53 to 1.44)	0.5839
Complexity 1c	1.03 (0.64 to 1.64)	0.9132
Complexity 2	1.01 (0.59 to 1.74)	0.9588
Complexity 3	1.14 (0.71 to 1.84)	0.5778

*Mixed effect logistic model based on a randomly selected 10% sample of each annual US veteran cohort from 2009 to 2018 (n=6910239). Facility clustering is adjusted by random intercepts.
†eGFR value calculated based on serum creatinine tests in both inpatient and outpatient settings.
eGFR, estimated glomerular filtration rate.

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current HTN guidelines advocate for use of specific pharmacotherapy—namely, ACE inhibitors and angiotensin receptor blockers—among patients with albuminuria, they consider UAlb testing an optional part of the workup for end-organ damage from HTN.[4] A recent analysis based on a national laboratory database, including over 28 million patients, showed lower rates of dual testing for CKD in at-risk patients—only 28.7% of patients with DM and 10.5% of patients with HTN were tested at least once between 2013 and 2019.[15] As in our population, rates of dual testing increased modestly over time (from 10.7% in 2013 to 15.2% in 2018).

In recent years, the intersection of CKD and CVD has drawn increased attention in the realms of clinical research and practice, partly because of the advent of sodium-glucose cotransporter (SGLT inhibitors) and glucagon-like peptide 1 receptor antagonists, which have both kidney and cardiovascular benefits among patients with DM.[16–20] SGLT inhibitor therapy reduces cardiovascular death and HF hospitalisation among patients with HF, irrespective of the presence of DM,[21 22] and is now part of the standard medical armamentarium for HF.[5] SGLT inhibitors reduce the incidence of adverse kidney outcomes and slow the decline in eGFR among patients with HF.[22] Though routine screening for albuminuria in the HF population is not currently a widespread practice, it may help to identify patients at the highest risk of adverse kidney and CVD outcomes who can, therefore, benefit most from pharmacological intervention.[23]

Our findings suggest that patients with HF, in particular, are slightly less likely to have dual testing than patients without HF. Fluctuations in eGFR commonly occur among patients with HF in both acute and chronic settings and are often ascribed to cardiorenal syndrome, with the implication that reduced kidney perfusion and venous congestion secondary to haemodynamic derangements are entirely responsible. In this context, intrinsic kidney disease may go under-recognised if providers do not screen for the presence of albuminuria, and opportunities to intervene could be missed. Although hospitalised patients with acute kidney injury (AKI) are at high risk of developing incident or progressive CKD, and patients with AKI in the context of HF hospitalisation are at increased risk of short-term and long-term mortality, postdischarge assessment for albuminuria is often overlooked.[24 25]

As articulated in the recent KDIGO document,[6] dual SCr and UAlb testing among patients with HTN and other forms of CVD is inexpensive, non-invasive and likely to be cost-effective. However, recent global data from the CKD-Prognosis Consortium have shown UACR screening rates of only 35.1% among patients with DM and 4.1% among patients with HTN.[26] From the standpoint of implementation, several factors may limit the uptake of dual SCr and UAlb testing in clinical practice. Provider inertia, or the perception that screening for CKD is outside one's domain, may play a role. Although patients often grasp the importance of blood testing for tracking kidney function, they may not understand or appreciate the importance of urine testing for albuminuria. On a purely practical level, if a provider orders dual SCr and UAlb testing but the patient cannot provide a urine sample when he or she arrives at the laboratory, the UAlb order may go unfulfilled. Clinical decision support embedded within the electronic medical record (EMR), including best practice advisories, could be one means of encouraging providers to order dual testing, particularly in patients with multiple CKD risk factors.[27] Outpatient clinic staff could advise patients to come prepared to give urine samples, much in the way that patients are advised to fast prior to serum lipid testing. Laboratory technicians could alert providers regarding uncollected urine samples, or automatic EMR-based notifications could be generated for SCr results without associated UAlb results. The efficacy of EMR-based solutions may be limited by alert fatigue,[28] but concomitant patient and provider education could complement such measures.

Our findings illustrate centre-level variation in dual SCr and UAlb testing practices, irrespective of centre complexity. Similarly, a recent study demonstrated significant facility-level variation in dialysis use within the VHA system, with an adjusted median rate ratio of 1.40. High-use facilities were less likely to serve patients from zip codes with high median income and more likely to serve patients who did not receive nephrology care in the previous year, while low-use facilities served more elderly patients and those living in non-metropolitan areas.[29] Factors that could have potentially influenced dual SCr and UAlb testing patterns in our cohort include local subspecialty presence and expertise, care coordination, case mix and laboratory logistics. Establishing clearer standards for dual testing among patients without diabetes might be expected to result in less variation.

We found that black patients and women were less likely to receive dual testing than others, after adjusting for comorbidities and centre-level variation. One potential reason for this finding could be implicit bias on the part of clinicians.[30] Further studies evaluating this discrepancy could be beneficial. The VHA serves an increasing proportion of women and a significant proportion of Veterans from minority communities, and as such, strives to achieve equity in care processes. The VHA operates as a learning health system, offering opportunities for widespread and coordinated data-driven quality improvement efforts.[31]

Our study's primary strength lies in the analysis of over a decade of national VHA data in nearly 7 million veterans each year, with well-captured comorbidity, pharmacy, laboratory and race/ethnicity data. On the other hand, our study has limitations. The VHA population is predominantly male, and findings may not be generalisable to other populations and practice settings. The focus on outpatient dual testing may have contributed to selection bias in the study population, as patients receiving predominantly inpatient care likely had a higher burden of comorbidities. The precise temporal association

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between SCr and UAlb testing was not captured in this analysis, such that some patients receiving dual testing within a calendar year did not have simultaneous SCr and UAlb testing. Testing that occurred outside the VHA system did not appear in our dataset, so actual dual testing rates among study subjects may have been higher than reflected by the analysis. We had limited provider-level data; although we reported the proportions of testing for patients followed by specialists, we could not discern which providers ordered testing for a given patient. Data on UACR testing per se were not the focus, so analyses dealt with any UAlb testing. Finally, laboratory tests that were ordered but not completed are not reflected in this dataset.

Future directions

Further study may be beneficial to assess which subgroups of patients might most benefit from deliberate dual SCr and UAlb testing. To achieve this, researchers may perform prospective studies to establish the optimal intervals for dual testing to maximise the detection of CKD and to ensure that appropriate pharmacological interventions are effective at reducing albuminuria and slowing kidney and CVD progression. In considering team-based approaches to care, responsibility for dual SCr and UAlb testing might be coordinated among primary and specialty care in the VHA, with effective use of decision support tools integrated in existing processes of care, panel management to facilitate laboratory testing outside of standard clinical encounters and telemedicine.

CONCLUSION

Dual testing for CKD with SCr and UAlb increased between 2009 and 2018. However, this practice occurred in less than half of people with high-risk comorbidities such as DM and CVD in any given year. Black and female veterans were less likely to receive dual testing. In the era of promising new treatments, not conducting simple tests like UAlb to identify those at risk of progressive CKD and CVD could represent a lost opportunity to prevent these conditions and their complications, improve clinical outcomes and increase equity in processes of care for US veterans.

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REFERENCES

1 Kidney Disease: Improving Global Outcomes (KDIGO) CKD Work Group. KDIGO 2012 clinical practice guideline for the evaluation and management of chronic kidney disease. *Kidney Int Suppl* 2013;3:1–150.
2 van der Velde M, Matsushita K, Coresh J, *et al*. Lower estimated glomerular filtration rate and higher albuminuria are associated with all-cause and cardiovascular mortality. A collaborative meta-analysis of high-risk population cohorts. *Kidney Int* 2011;79:1341–52.
3 American Diabetes Association. 11. Microvascular Complications and Foot Care: *Standards of Medical Care in Diabetes—2021*. *Diabetes Care* 2021;44:S151–67.

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4 Whelton PK, Carey RM, Aronow WS, *et al*. 2017 ACC/AHA/AAPA/ABC/ACPM/AGS/APhA/ASH/ASPC/NMA/PCNA guideline for the prevention, detection, evaluation, and management of high blood pressure in adults: a report of the American College of Cardiology/American Heart Association task force on clinical practice guidelines. *Hypertension* 2018;71:e13–115.
5 Heidenreich PA, Bozkurt B, Aguilar D, *et al*. 2022 AHA/ACC/HFSA guideline for the management of heart failure. *Journal of the American College of Cardiology* 2022;79:e263–421.
6 Shlipak MG, Tummalapalli SL, Boulware LE, *et al*. The case for early identification and intervention of chronic kidney disease: conclusions from a Kidney Disease: Improving Global Outcomes (KDIGO) Controversies Conference. *Kidney Int* 2021;99:34–47.
7 WHO Regional Office for Europe. Screening programmes: a short guide. Available: https://apps.who.int/iris/bitstream/handle/10665/330829/9789289054782-eng.pdf [Accessed 18 May 2022].
8 United States Renal Data System. *USRDS annual data report: epidemiology of kidney disease in the United States*. Bethesda, MD: National Institutes of Health, National Institute of Diabetes and Digestive and Kidney Diseases, 2020.
9 National Academies of Sciences, Engineering, and Medicine. *Facilities staffing requirements for the Veterans Health Administration resource planning and methodology for the future*. Washington, DC: The National Academies Press, 2020. Available: https://doi.org/10.17226/25454
10 Chronic Kidney Disease Prognosis Consortium, Matsushita K, van der Velde M, *et al*. Association of estimated glomerular filtration rate and albuminuria with all-cause and cardiovascular mortality in general population cohorts: a collaborative meta-analysis. *Lancet* 2010;375:2073–81.
11 O'Hare AM, Hailpern SM, Pavkov ME. Prognostic implications of the urinary albumin to creatinine ratio in veterans of different ages with diabetes. *Arch Intern Med* 2010;170:930.
12 Young BA, Katz R, Boulware LE, *et al*. Risk Factors for rapid kidney function decline among African Americans: the Jackson Heart Study (JHS). *Am J Kidney Dis* 2016;68:229–39.
13 Nichols GA, Déruaz-Luyet A, Brodovicz KG, *et al*. Kidney disease progression and all-cause mortality across estimated glomerular filtration rate and albuminuria categories among patients with vs. without type 2 diabetes. *BMC Nephrol* 2020;21:167.
14 Quality ID #119 (NQF 0062): diabetes: medical attention for nephropathy. Available: https://qpp.cms.gov/docs/QPP_quality_measure_specifications/CQM-Measures/2020_Measure_119_MIPSCQM.pdf [Accessed 18 May 2022].
15 Alfego D, Ennis J, Gillespie B, *et al*. Chronic kidney disease testing among at-risk adults in the U.S. remains low: real-world evidence from a national laboratory database. *Diabetes Care* 2021;44:2025–32.
16 Perkovic V, Jardine MJ, Neal B, *et al*. Canagliflozin and renal outcomes in type 2 diabetes and nephropathy. *N Engl J Med* 2019;380:2295–306.
17 Zinman B, Wanner C, Lachin JM, *et al*. Empagliflozin, cardiovascular outcomes, and mortality in type 2 diabetes. *N Engl J Med* 2015;373:2117–28.
18 Neal B, Perkovic V, Mahaffey KW, *et al*. Canagliflozin and cardiovascular and renal events in type 2 diabetes. *N Engl J Med* 2017;377:644–57.
19 Marso SP, Daniels GH, Brown-Frandsen K, *et al*. Liraglutide and cardiovascular outcomes in type 2 diabetes. *N Engl J Med* 2016;375:311–22.
20 Marso SP, Bain SC, Consoli A, *et al*. Semaglutide and cardiovascular outcomes in patients with type 2 diabetes. *N Engl J Med* 2016;375:1834–44.
21 McMurray JJV, Solomon SD, Inzucchi SE, *et al*. Dapagliflozin in patients with heart failure and reduced ejection fraction. *N Engl J Med* 2019;381:1995–2008.
22 Packer M, Anker SD, Butler J, *et al*. Cardiovascular and renal outcomes with empagliflozin in heart failure. *N Engl J Med* 2020;383:1413–24.
23 Zelniker TA, Raz I, Mosenzon O, *et al*. Effect of dapagliflozin on cardiovascular outcomes according to baseline kidney function and albuminuria status in patients with type 2 diabetes: a prespecified secondary analysis of a randomized clinical trial. *JAMA Cardiol* 2021;6:801–10.
24 Jentzer JC, Bihorac A, Brusca SB, *et al*. Contemporary management of severe acute kidney injury and refractory cardiorenal syndrome: JACC council perspectives. *J Am Coll Cardiol* 2020;76:1084–101.
25 Matheny ME, Peterson JF, Eden SK, *et al*. Laboratory test surveillance following acute kidney injury. *PLoS ONE* 2014;9:e103746.
26 Shin J-I, Chang AR, Grams ME, *et al*. Albuminuria testing in hypertension and diabetes: an individual-participant data meta-analysis in a global consortium. *Hypertension* 2021;78:1042–52.
27 Khoong EC, Karliner L, Lo L, *et al*. A pragmatic cluster randomized trial of an electronic clinical decision support system to improve chronic kidney disease management in primary care: design, rationale, and implementation experience. *JMIR Res Protoc* 2019;8:e14022.
28 Lee EK, Wu TL, Senior T, *et al*. Medical alert management: a real-time adaptive decision support tool to reduce alert fatigue. AMIA Annu Symp Proc 2014;2014:845–54.
29 Bradshaw C, Thomas I-C, Montez-Rath ME, *et al*. Facility-level variation in dialysis use and mortality among older veterans with incident kidney failure. *JAMA Netw Open* 2021;4:e2034084.
30 FitzGerald C, Hurst S. Implicit bias in healthcare professionals: a systematic review. *BMC Med Ethics* 2017;18:19.
31 Kilbourne AM, Elwy AR, Sales AE, *et al*. Accelerating research impact in a learning health care system: VA's quality enhancement research initiative in the choice act era. *Med Care* 2017;55 Suppl 7 Suppl 1:S4–12.

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