

# Facility-Level Variations in Kidney Disease Care among Veterans with Diabetes and CKD

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## Abstract

**Background and objectives** Facility-level variation has been reported among veterans receiving care for various diseases. We studied the frequency and facility-level variations of guideline-recommended practices in patients with diabetes and CKD.

**Design, setting, participants, & measurements** Patients with diabetes and concomitant CKD (eGFR 15–59 ml/min per 1.73 m<sup>2</sup>, measured twice, 90 days apart) receiving care in 130 facilities across the Veterans Affairs Health Care System were included (*n*=281,223). We studied the proportions of patients (facility-level) receiving recommended core measures and facility-level variations of these study outcomes using median rate ratios, adjusting for various patient and provider-level factors. Median rate ratio quantifies the degree to which care may vary for similar patients receiving care at two randomly chosen facilities, with <1 being no variation and >1.2 as substantial variation between the facilities. Study outcomes included measurement of urine albumin-to-creatinine ratio/urine protein-to-creatinine ratio and blood hemoglobin concentration, prescription of statins and angiotensin-converting enzyme inhibitors/angiotensin receptor blockers, BP<140/90 mm Hg, and referral to a Veterans Affairs nephrologist (only for those with eGFR<30 ml/min per 1.73 m<sup>2</sup>).

**Results** Among those with eGFR 30–59 ml/min per 1.73 m<sup>2</sup>, proportion of patients receiving recommended core measures (median and interquartile range across facilities) were 37% (22%–47%) for urine albumin-to-creatinine ratio/urine protein-to-creatinine ratio, 74% (72%–79%) for hemoglobin measurement, 66% (62%–69%) for angiotensin-converting enzyme inhibitor/angiotensin receptor blocker prescription, 85% (74%–87%) for statin prescription, 47% (42%–53%) for achieving BP<140/90 mm Hg, and 13% (7%–16%) for meeting all outcome measures. Adjusted median rate ratios (95% confidence intervals) were 5.2 (4.1 to 6.4), 2.4 (2.1 to 2.6), 1.3 (1.2 to 1.3), 1.2 (1.2 to 1.3), 1.4 (1.3 to 1.4), and 4.1 (3.3 to 5.0), respectively. Median rate ratios were qualitatively similar in an analysis restricted to those with eGFR 15–29 ml/min per 1.73 m<sup>2</sup>.

**Conclusions** Among patients with diabetes and CKD, at facility-level, ordering of laboratory tests, and scheduling of nephrology referrals in eligible patients remains suboptimal, with substantial variations across facilities.

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## Introduction

In the United States, prevalence of CKD remains high and diabetes is the leading cause of ESKD (1). Hypertension is highly prevalent among adults with diabetes and CKD. CKD and diabetes are independently associated with incident cardiovascular disease and death. In a population-based study, Tonelli *et al.* (2) reported that the rate of first myocardial infarction was higher in those who had both CKD and diabetes than in those with either disease alone. Health care expenditures are higher for those with CKD and substantially higher for those with CKD and multiple comorbid conditions (3). Thus, appropriate and timely management of CKD and its complications in those with diabetes and other comorbidities is critical to improve outcomes for this population.

The Veterans Affairs (VA) Health System is the largest integrated health care system in the country.

Among veterans with diabetes, >10% had concomitant diagnosis of kidney disease in a prior study (4). Previous studies have also reported that over one third of veterans who initiated chronic dialysis (between January 2000 and December 2001) were not receiving appropriate predialysis nephrology care (5). On the other hand, recent reports indicate that the receipt of predialysis nephrology care was associated with lower mortality among veterans (6). Several programs have been implemented to improve the quality of care delivered to the VA CKD population (7,8). However, less is known about whether care for patients with CKD varies across various facilities in this large health care system, and the magnitude of any such variation in care. Studying these potential variations in practice patterns is critical as it would help identify potential correlates and patterns of care that fails to conform with clinical practice guidelines.

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These, in turn, could facilitate quality improvement efforts in clinical practice settings that currently do not meet the recommended standards. Therefore, we aimed to study the frequency and facility-level variation of several guideline-recommended practices among a national sample of veterans with diabetes and CKD.

## Materials and Methods

### Patient Population

We identified patients with diabetes mellitus (DM) and concomitant CKD (defined as those with eGFR < 60 ml/min per 1.73 m<sup>2</sup>, measured twice, 90 days apart) with a primary care visit (index primary care visit) in 130 VA health care facilities or their associated community-based outpatient clinics between October 2013 and September 2014. These 130 facilities are larger medical centers located in different regions of the United States. If a patient had multiple primary care visits during the study interval, then the most recent primary care visit during the study interval was taken as the index primary care visit. Details about the parent cohort (which included veterans with diabetes followed during this time period) have been described previously (9). We identified patients as having DM if any of the following were documented: two outpatient or one inpatient diagnosis code indicating DM, from the International Classification of Diseases, Ninth Revision, Clinical Modification (codes 250.xx, 357.2, 366.41); filled prescription for oral DM medication or insulin; had a fasting glucose  $\geq$  126 mg/dl, hemoglobin A1C > 6.5%, or two or more outpatient blood glucose readings > 200 mg/dl on two different days (10,11). On the basis of a chart review of 100 random patients, we found a positive predictive value of 94% for the diagnosis of diabetes using this algorithm (11). We excluded patients if they had a history of metastatic cancer or a history of hospice care.

### Kidney Function

We applied the CKD Epidemiology Collaboration equation to patients with available outpatient serum creatinine measurements to calculate eGFR (12). The most recent creatinine measurement closest to the index primary care visit was used to calculate eGFR. CKD was defined according to the current guidelines as follows: stage 3 CKD (eGFR 30–59 ml/min per 1.73 m<sup>2</sup>) and stage 4 CKD (eGFR 15–29 ml/min per 1.73 m<sup>2</sup>). We excluded patients with eGFR < 15 ml/min per 1.73 m<sup>2</sup>, those receiving dialysis, or those with history of kidney transplant.

### Covariates

We identified patient demographics (age, sex, and race) and past medical history of hypertension from the VA administrative data sources including the VA purchased care files. Race was self-reported. The International Classification of Diseases diagnosis and procedure codes were used along with procedure terminology codes to identify presence of cardiovascular diseases (ischemic heart disease, peripheral arterial disease, or ischemic cerebrovascular disease) as described in prior studies (11,13,14). We used patient-level factors to calculate the Diagnostic Cost Group (DCG) relative risk score (RRS) for each patient. The DCG RRS has been used and validated in prior studies as a

surrogate marker for overall disease burden (13,15,16). A patient with a DCG RRS score of 1.5, for example, reflects a 50% greater expected cost of care and a 50% greater disease burden compared with an “average” patient (DCG RRS score of 1). We also assessed facility and system of care variables, including receipt of care from a physician versus advanced practice provider (*i.e.*, a nurse practitioner or a physician assistant), receipt of care at a teaching versus nonteaching facility, and the number of primary care visits and the number of nephrology visits in 12 months before the index primary care visit. We also included use of Medicare insurance by veterans as a covariate.

### Outcomes

On the basis of the Veterans Affairs/Department of Defense (VA/DoD) CKD guidelines (updated in 2008 and 2014), outcomes of interest were chosen (17). We assessed the percent of patients who received the following CKD care metrics in the 12 months after the index primary care visit, unless specified otherwise, as our outcomes variables: (1) urinary albumin-to-creatinine ratio or urine protein-to-creatinine ratio (UACR/UPR) measurement (including up to 1 month before the index primary care visit), (2) blood hemoglobin levels measurement (including up to 1 month before the index primary care visit), (3) angiotensin-converting enzyme inhibitor (ACEI)/angiotensin receptor blocker (ARB) prescription either 12 months before or after the index primary care visit, (4) statin prescription either 12 months before or after the index primary care visit (as a proxy for lipid management recommended in the guideline), (5) systolic BP/diastolic BP < 140/90 mm Hg in the 6 months after the index primary care visit, (6) outpatient visit with a nephrologist in the 12 months after the index primary care visit (only for those with stage 4 CKD), and (7) percent of patients who met all of the above-mentioned criteria.

Relevant laboratory parameters for these outcomes were obtained from the VA Decision Support System National Data Extracts Laboratory Results file.

### Statistical Analyses

Patient-, provider-, and facility-related characteristics of patients with diabetes and CKD (eGFR 15–59 ml/min per 1.73 m<sup>2</sup>) were tabulated. First, we calculated the proportion of patients at each of the facility meeting each of the outcomes described above. To further assess the extent of facility-level variation, we constructed a multivariable hierarchical regression model to determine median rate ratio (MRR) to assess the magnitude of facility-level variation in the care delivered for above-mentioned measures. These hierarchical models adjusted for clustering of patients within facilities and modeled individual facilities as random effects and patient characteristics as fixed effects within each facility. This allows patients with similar baseline characteristics from different facilities to be compared with each other, as well as controlling for confounding.

MRR quantifies the magnitude of variation in care whereby two facilities would differ in treating a similar patient for ordering of relevant laboratory tests, use of statins and ACEIs or ARBs, BP control, and nephrology visits and their combination (16,18). For example, an MRR

of 1 suggests no facility-level variation, whereas an MRR of 1.50 suggests that between two similar patients treated at two randomly chosen facilities, a patient at one facility was 50% more likely to receive recommended care compared with a patient at a separate facility with similar characteristics. On the basis of previous literature, an MRR of  $\geq 1.2$  generally indicate significant variation in care (9,16,17). MRRs for individual outcomes were initially derived from an unadjusted model, followed by a model adjusting for patient factors; for example, age, sex, race (white versus others), history of hypertension, history of cardiovascular disease (including ischemic heart disease, peripheral artery disease, or ischemic stroke), use of insulin, use of Medicare insurance, DCG RRS, and eGFR. We then adjusted for patient-level variables described above and other provider and facility-level variables (provider type: physician versus advanced practice provider, receipt of care at a teaching versus nonteaching facility, and the number of primary care visits in the prior 12 months) to assess the degree of residual facility-level variation in the care of patients with CKD. The resultant MRR from these adjustments indicate how much of the variation in above-mentioned metrics persists despite adjusting for variables described above. Provider-type details and DCG RRA data were missing for a smaller number of providers (Table 1) and data were not imputed. We conducted the following sensitivity analyses: (1) by considering BP<130/80 mm Hg as a care indicator and (2) UACR measurement within 18 months after the index primary care visit.

SAS version 9.1.3 (SAS Institute, Inc., Cary, NC) and Stata version 14 (StataCorp, College Station, TX) were used for analysis. Approval for the protocol was obtained from the institutional review boards at Baylor College of Medicine and the Michael E. DeBakey VA Medical Center.

## Results

### Patient Characteristics

From a total of 1,483,164 patients in the cohort with DM, 281,223 were included in the study after excluding those with limited life expectancy, metastatic cancer, those receiving dialysis or history of kidney transplant, and those with eGFR <15 or  $\geq 60$  ml/min per 1.73 m<sup>2</sup> (Figure 1). The majority of the patients (Table 1) were white (83%) and were predominantly men (98%). Cardiovascular disease was present in 55% of the study cohort and 91% of the patients had hypertension. The median number of patients at each facility was 1831 (interquartile range [IQR], 400–3262). Overall, 40% of the patients received care at a teaching facility and 75% patients had a physician provider as their assigned primary care provider.

### Stage 3 CKD

**Facility-Level Variation in UACR/UPR, and Blood Hemoglobin Measurement.** Among patients with diabetes and stage 3 CKD ( $n=254,985$ ), the proportion of patients having UACR/UPR measured in the 12 months after the index primary care visit was 37% (IQR, 22%–47%) (Figure 2, Table 2). The fully adjusted MRR was 5.2 (95% confidence interval [95% CI], 4.1 to 6.4) indicating an unexplained 520% difference in the probability of two similar patients with CKD receiving UACR/UPR measurement at

**Table 1. Characteristics of patients in the Veterans Affairs Health system with diabetes and CKD**

Variables	Stage 3 CKD, $n=254,985$	Stage 4 CKD, $n=26,238$
<b>Age, yr, %</b>		
18–44	0.13	0.21
45–64	14	14
$\geq 65$	86	86
<b>Men, %</b>	98	98
<b>Race, %</b>		
White	83	80
Black	14	18
Other	3.0	3.0
Diagnostic Cost Group RRS, mean (SD)	2 (3)	3 (4)
History of cardiovascular disease, % <sup>a</sup>	55	65
History of hypertension, %	91	93
Receiving care at a teaching facility, %	40	41
Receiving care from a physician provider <sup>b</sup> , %	75	76
Number of primary care visits, mean (SD)	6 (6)	7 (7)
eGFR, mean (SD)	48 (8)	24 (4)
Use of ACEIs or ARBs, %	64	59
Use of statins, %	85	84
UACR/UPR measurement, %	33	29
Hemoglobin measurement, %	74	72
BP<130/80 mm Hg, %	32	34
BP<140/90 mm Hg, %	47	49

RRS, relative risk score; ACEI, angiotensin-converting enzyme inhibitor; ARB, angiotensin receptor blocker; UACR, urine albumin-to-creatinine ratio; UPR, urine protein-to-creatinine ratio.

<sup>a</sup>History of cardiovascular disease includes a history of ischemic heart disease, peripheral artery disease, or ischemic cerebrovascular disease.

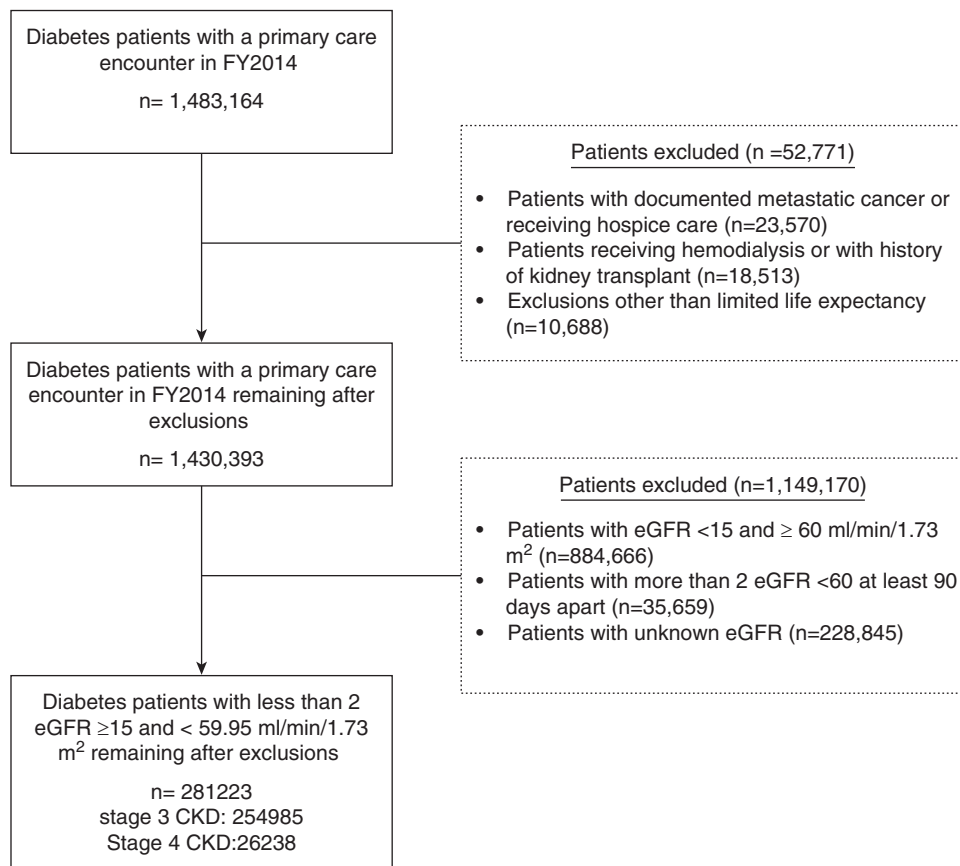
<sup>b</sup>Missing data: provider type:  $n=3804$  (stage 3 CKD),  $n=446$  (stage 4 CKD); Diagnostic Cost Group RRS (stage 3 CKD): 4517, Diagnostic Cost Group RRS (stage 4 CKD): 464.

two random facilities. When adjusted for covariates, the MRR was 2.4 (95% CI, 2.1 to 2.6) for measurement of blood hemoglobin, highlighting significant residual facility-level variation in the probability of two similar patients with CKD having these laboratory measurements performed at two different VA facilities.

**Facility-Level Variation in BP Control.** The proportion of patients (median) with BP control (BP<140/90 mm Hg) was 47% (IQR, 42%–53%) (Figure 2, Table 2). The unadjusted MRR was 36 (23 to 55), which was attenuated to 1.4 (95% CI, 1.3 to 1.4) when adjusted for patient-level variables. Further adjustment for provider and facility-level variables did not change the extent of facility-level variation in BP control.

**Facility-Level Variation in Statin Use.** The proportion of patients (median) with a statin prescription in the 12 months before or after the index primary care visit was 85% (IQR, 74%–87%) (Figure 2, Table 2). The fully adjusted MRR was 1.2 (95% CI, 1.2 to 1.3).

**Facility-Level Variation in ACEI/ARB Use.** The proportion of patients (median) with a ACEI/ARB prescription in the 12 months before or after the index primary care visit was 66% (IQR, 62%–69%) (Figure 2, Table 2). The fully adjusted MRR was 1.3 (95% CI, 1.2 to 1.3).



**Figure 1.** | Flow chart showing patient selection and various exclusions. FY, fiscal year.

**Facility-Level Variation for All Core-Measures.** The proportion of patients (median) meeting all of the above-mentioned measures was 13% (IQR, 7%–16%) (Figure 2, Table 2). The fully adjusted MRR was 4.1 (95% CI, 3.3 to 5.0) when adjusted for patient and provider- and facility-level factors.

#### Stage 4 CKD

Proportion of patients receiving various core measures and the facility-level variations for these measures in those with stage 4 CKD are presented in Figure 3 and Table 3. These results are similar to the findings from the models that included stage 3 CKD population only.

#### Sensitivity Analyses

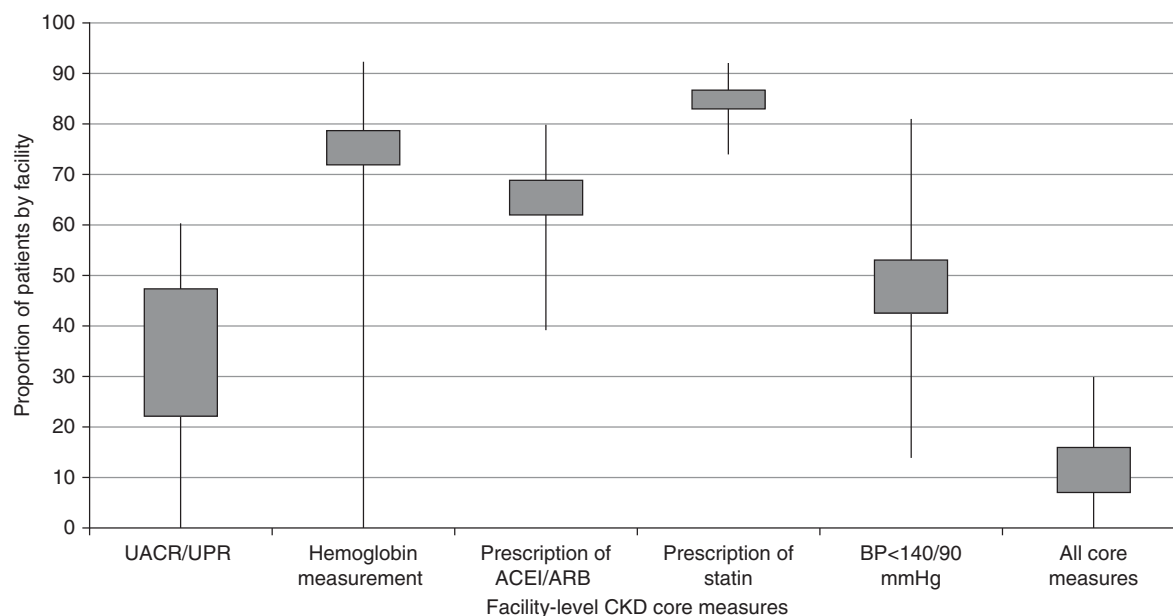
We repeated the above analyses by considering BP < 130/80 mm Hg as a core measure (instead of BP < 140/90 mm Hg) and results similar to the primary analyses were noted. Among those with stage 3 CKD, the unadjusted MRR for BP < 130/80 mm Hg was 1.4 (95% CI, 1.0 to 1.9), which was attenuated to 1.4 (95% CI, 1.3 to 1.4) when adjusted for patient-level and provider and facility-level variables. Among those with stage 4 CKD, the unadjusted MRR was 2.9 (95% CI, 2.5 to 3.2), which was attenuated to 1.4 (95% CI, 1.3 to 1.5) when adjusted for patient-level, provider, and facility-level variables. We conducted an additional sensitivity analysis by considering UACR measurement within 18 months of the index primary

care visit. Fully adjusted MRRs were 5.0 (95% CI, 4.1 to 6.3) for stage 3 and 3.3 (95% CI, 2.8 to 3.9) for stage 4 CKD.

#### Discussion

Facility-level variation has been reported among veterans receiving care for various conditions at VA facilities (9,19,20). Current clinical guidelines provide specific recommendations to deliver appropriate evidence-based care for the CKD population (21). For the United States veteran population, evidence-based pre-ESKD guidelines for primary care were issued in 2001 and have been updated regularly as new evidence emerges, with a first update in 2008 and again in 2014 (17,22). Our analysis included patients who received care in the entire VA health care system during the years 2013–2014. These data suggest that adherence to various guideline-recommended core measures in patients with CKD remains suboptimal, with modest facility-level variations for some measures and larger facility-level variation for others. It is unclear if these variations improved after the issuance of the most recent updated guidelines, as various concerted efforts focusing not just on CKD care but other disease conditions (such as telehealth for hypertension and diabetes control) are being implemented to improve the care delivered to the veterans (7,23). Although there are ongoing efforts to study the practice patterns for CKD care across the globe, studies addressing these issues are limited in the United States (24).





**Figure 2.** | Proportion of patients at facility-level with CKD stage 3 receiving CKD core measures.

Albuminuria is recognized as an independent cardiovascular risk factor and is associated with all-cause mortality among the CKD population (25). In patients with diabetes (irrespective of the presence or absence of CKD), the American Diabetes Association recommends annual assessment of urinary albumin excretion (26). However, we noted that percentage of patients who had UACR

measured within 12 months of index primary care visit was low (37% for stage 3 CKD and 29% for stage 4 CKD). It is important to note that we only considered UACR (or microalbumin-to-creatinine ratio in those without UACR) and UPR. The VA/DoD guidelines (2008 update) recommended the use of dipstick measurement followed by confirmation with UACR/UPR. Because we were not able

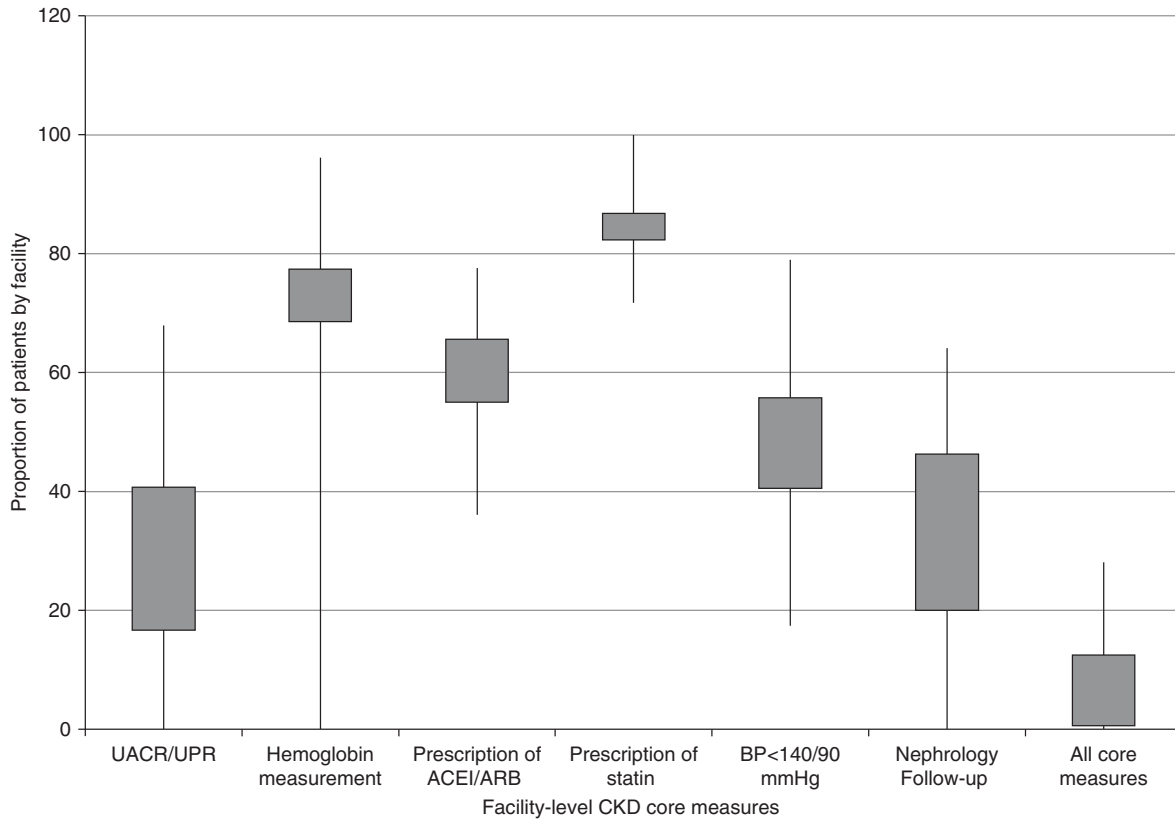
**Table 2.** Facility-level variation in care among patients with diabetes and stage 3 CKD (eGFR 30–59 ml/min per 1.73 m<sup>2</sup>)

Measures of CKD Care	Proportion of Patients Receiving Core Measures in %, Median (Interquartile Range)	MRR (95% CI), Unadjusted	MRR (95% CI), Adjusted for Patient-Level Variables <sup>a</sup>	MRR (95% CI), Fully Adjusted <sup>b</sup>
UACR/UPR measurement in the 12 mo after the index primary care visit	37 (22–47)	1400 (543 to 3230)	5.2 (4.0 to 6.4)	5.2 (4.1 to 6.4)
Hemoglobin measurement in the 12 mo after the index primary care visit	74 (72–79)	132 (70 to 232)	2.3 (2.0 to 2.5)	2.4 (2.1 to 2.6)
Prescription of ACEIs/ARBs either 12 mo before or after the index primary care visit	66 (62–69)	14 (10 to 19)	1.3 (1.2 to 1.3)	1.3 (1.2 to 1.3)
Prescription of statins either 12 mo before or after the index primary care visit	85 (74–87)	2.8 (2.5 to 3.2)	1.23 (1.2 to 1.3)	1.2 (1.2 to 1.3)
Patients with at least one BP reading <140/90 mm Hg in the 6 mo after the index primary care visit	47 (42–53)	36 (23 to 55)	1.4 (1.3 to 1.5)	1.4 (1.3 to 1.4)
Patients meeting all measures	13 (7–16)	17 (12 to 24)	4.1 (3.3 to 5.0)	4.1 (3.3 to 5.0)

MRR, median rate ratio; 95% CI, 95% confidence interval; UACR, urine albumin-to-creatinine ratio; UPR, urine protein-to-creatinine ratio; ACEI, angiotensin-converting enzyme inhibitor; ARB, angiotensin receptor blocker.

<sup>a</sup>MRR adjusted for patient's age, sex, race (white versus other), history of hypertension, history of cardiovascular disease, diagnostic cost group relative risk score (continuous) of patients, insulin use, use of Medicare, and eGFR (patient-level variables).

<sup>b</sup>MRR adjusted for variables above, plus teaching versus nonteaching facility, receipt of care from a physician versus nonphysician primary care provider, and the number of primary care visits 1 year before the index primary care visit (facility- and provider-level variables).



**Figure 3. | Proportion of patients at facility-level with CKD stage 4 receiving CKD core measures.**

to discern the indication for ordering dipstick studies (commonly ordered to rule out urinary tract infections, kidney stones, *etc.*), we did not include dipstick measurements.

Over 60% of the study population were on ACEI or ARBs and there appears to be only modest variation for ACEI/ARB prescription across the facilities. Statins are recommended for all patients with diabetes, and for all patients with CKD aged >50 years (27). In this analysis, statins were prescribed for 85% of the patients suggesting higher guideline concordant care. It is unclear if some of these patients had previously experienced adverse effects that could have led to the discontinuation of statins in some patients. Statins may not have been prescribed by health care providers because of other competing demands in some of these patients with high illness burden. However, it is important to note that we noted only modest facility-level variation for statin prescriptions among patients with CKD. Complete blood count is routinely ordered for various reasons and not solely for the monitoring of anemia associated with CKD; hence, the proportion of patients who had hemoglobin measured was high, but still significant facility-level variation was noted for the CKD population.

Although ideal BP targets have been a matter of debate, recent guidelines recommend BP < 140/90 mm Hg for CKD population (28). Within 6 months of the index visit, we noted 47% of patients with stage 3 CKD and 49% of patients with stage 4 CKD had BP < 140/90 mm Hg. It is important to note that there were variations between facilities (MRR 1.40), suggesting that there exists a gap in attainment of lower BP

along with substantial variation in the care of these patients across VA facilities. A sensitivity analysis considering a higher-target BP < 130/80 mm Hg yielded similar results.

Using data that included veterans receiving care in 2010, Fung *et al.* noted that 38% of study population with advanced CKD (eGFR ≤ 30 ml/min per 1.73 m<sup>2</sup>) were followed by a nephrologist before reaching ESKD, and receipt of nephrology care was associated with lower mortality (6). Using more recent data, in those with diabetes and eGFR 15–29 ml/min per 1.73 m<sup>2</sup>, 38% of patients were seen by a VA nephrologist. It is important to note that the Kidney Disease Improving Global Outcomes and VA/DoD CKD guidelines recommend that all patients with eGFR < 30 ml/min per 1.73 m<sup>2</sup> should be referred to a nephrologist (17,21). Our data highlight an opportunity for improvement in nephrology referrals and identifies substantial variation in nephrology care of patients with CKD across facilities. Although we took several patient and practice variables into account, factors such as patient adherence to provider recommendation and proximity to clinics with a VA nephrologist were not considered. For instance, nephrology care is not available at all VA facilities (*n*=22) and veterans with CKD living in rural areas may not be able to see a VA nephrologist in a timely manner. Recently, Doyle and Streeter (29) studied the distribution of veterans in areas where there are potentially inadequate supplies of health professionals. They noted that approximately 23% of veterans reside in health professional shortage counties along with

**Table 3. Facility-level variation among patients with diabetes and stage 4 CKD (eGFR 15–29 ml/min per 1.73 m<sup>2</sup>)**

Measures of CKD Care	Proportion of Patients Receiving Recommended Care Measures in %, Median (Interquartile Range)	MRR (95% CI), Unadjusted	MRR (95% CI), Adjusted for Patient-Level Variables <sup>a</sup>	MRR (95% CI), Fully Adjusted <sup>b</sup>
UACR/UPR measurement in the 12 mo after the index primary care visit	29 (17–41)	9.7 (7.2 to 13)	3.2 (2.7 to 3.7)	3.2 (2.7 to 3.7)
Hemoglobin measurement in the 12 mo after the index primary care visit	73 (69–77)	5.4 (4.3 to 6.5)	1.9 (1.7 to 2.1)	1.9 (1.7 to 2.1)
Prescription of ACEIs/ARBs either 12 mo before or after the index primary care visit	61 (55–66)	3.2 (2.7 to 3.6)	1.3 (1.2 to 1.4)	1.3 (1.2 to 1.4)
Prescription of statins either 12 mo before or after the index primary care visit	85 (82–87)	1.6 (1.5 to 1.7)	1.2 (1.1 to 1.2)	1.2 (1.1 to 1.2)
Patients with at least one BP reading <140/90 mm Hg in the 6 mo after the index primary care visit	49 (41–56)	3.8 (3.2 to 4.5)	1.4 (1.3 to 1.5)	1.4 (1.3 to 1.5)
Patients seen by a nephrologist in the 12 mo after the index primary care visit	38 (20–46)	8.0 (6.1 to 10.2)	4.6 (3.6 to 5.7)	4.6 (3.6 to 5.8)
Patients meeting all measures	5 (1–13)	2.6 (2.3 to 2.9)	3.7 (2.9 to 4.4)	3.6 (2.9 to 4.3)

MRR, median rate ratio; 95% CI, 95% confidence interval; UACR, urine albumin-to-creatinine ratio; UPR, urine protein-to-creatinine ratio; ACEI, angiotensin-converting enzyme inhibitor; ARB, angiotensin receptor blocker.

<sup>a</sup>MRR adjusted for patient's age, sex, race (white versus other), history of hypertension, history of cardiovascular disease, diagnostic cost group relative risk score (continuous) of patients, insulin use, use of Medicare, and eGFR (patient-level variables).

<sup>b</sup>MRR adjusted for variables above, plus teaching versus nonteaching facility, receipt of care from a physician versus nonphysician primary care provider, and the number of primary care visits 1 year before the index primary care visit (facility- and provider-level variables).

considerable variation across the different states in the country, suggesting that increasing access to non-VA care would not necessarily overcome the problem. Although practice variations between different facilities have not been previously examined for CKD care, other metrics, such as proportion of patients who were prescribed statins and ACEIs or ARBs, are similar if not better compared with Medicare data (30). Further, nephrology referrals have improved over time at other centers after implementation of eGFR reporting with laboratory results and referral rates noted here are in line with others (31).

Strengths of our study include a large contemporary national sample (2013–2014) of patients with diabetes and CKD. In addition, we accounted for several potential confounders including kidney function. However, this analysis is subject to several important limitations. Our study was limited to veterans who received care in the VA health care system, hence it is unclear if such variations would exist in other health care systems. On the other hand, it is likely that the magnitude of variation in care could be even large outside the VA health care system because access in the VA health care system is generally more homogenous compared with other health care systems. Furthermore, despite having an index primary care visit in the VA health care system, we were not able to capture the details of care received (simultaneously) by veterans at non-VA facilities. This could influence the rates of these measures (underestimating the core measures assessed in our study). Dual use of VA and Medicare-covered services has shown to be associated with higher rates and timely visit to nephrologist (32). We adjusted for use of Medicare insurance but lacked other insurance data

to conduct additional analysis. Further, physicians often order urine albumin alone (without random urine creatinine), resulting in underestimating the practice pattern for UACR measurement. We did not have comprehensive data about allergic reaction/other adverse event with ACEI/ARB use underestimating the prescription rates. Although VA facilities did not have uniform implementation of automated eGFR reporting across its facilities, eGFR is now being reported across all of the laboratories; however, it is unclear if the same equation (Modification of Diet in Renal Disease versus CKD Epidemiology Collaboration equation) is used to report eGFR across the facilities (33). This could have led to variations in practice patterns as they tend to identify different cohorts. In addition, we did not have various facility-level characteristics, such as access to virtual care (e-consults, telehealth) data, local referral policy, and other individual facility-level policies that could have influenced the results (7).

In summary, this study results show that in our study population with diabetes and CKD, at facility-level, adherence to CKD care indicators are similar to other cohorts for some variations but not for others, along with substantial variations across facilities. There are ongoing efforts at a national level to improve CKD care, and our results point out potential areas where additional efforts and programs could be implemented to address practice-level variations noted among VA facilities.

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