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Physician Utilization, Risk-Factor Control, and CKD Progression Among Participants in the Kidney Early Evaluation Program (KEEP)

*Claudine T. Jurkovitz, MD, MPH,[1] Daniel Elliott, MD, MSCR,[1] Suying Li, PhD,[2] Georges Saab, MD,[3] Andrew S. Bomback, MD, MPH,[4] Keith C. Norris, MD,[5] Shu-Cheng Chen, MS,[2] Peter A. McCullough, MD, MPH,[6] and Adam T. Whaley-Connell, DO, MSPH,[7] on behalf of the KEEP Investigators**

Background: Chronic kidney disease (CKD) is a well-known risk factor for cardiovascular mortality, but little is known about the association between physician utilization and cardiovascular disease risk-factor control in patients with CKD. We used 2005-2010 data from the National Kidney Foundation's Kidney Early Evaluation Program (KEEP) to examine this association at first and subsequent screenings.

Methods: Control of risk factors was defined as control of blood pressure, glycemia, and cholesterol levels. We used multinomial logistic regression to examine the association between participant characteristics and seeing a nephrologist after adjusting for kidney function and paired *t* tests or McNemar tests to compare characteristics at first and second screenings.

Results: Of 90,009 participants, 61.3% had a primary care physician only, 2.9% had seen a nephrologist, and 15.3% had seen another specialist. The presence of 3 risk factors (hypertension, diabetes, and hypercholesterolemia) increased from 26.8% in participants with CKD stages 1-2 to 31.9% in those with stages 4-5. Target levels of all risk factors were achieved in 7.2% of participants without a physician, 8.3% of those with a primary care physician only, 9.9% of those with a nephrologist, and 10.3% of those with another specialist. Of up to 7,025 participants who met at least one criterion for nephrology consultation at first screening, only 12.3% reported seeing a nephrologist. Insurance coverage was associated strongly with seeing a nephrologist. Of participants who met criteria for nephrology consultation, 406 (5.8%) returned for a second screening, of whom 19.7% saw a nephrologist. The percentage of participants with all risk factors controlled was higher at the second screening (20.9% vs 13.3%).

Conclusion: Control of cardiovascular risk factors is poor in the KEEP population. The percentage of participants seeing a nephrologist is low, although better after the first screening. Identifying communication barriers between nephrologists and primary care physicians may be a new focus for KEEP.
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INDEX WORDS: Cardiovascular disease risk factors; chronic kidney disease; nephrologist care; primary care.

Chronic kidney disease (CKD) is a well-known risk factor for cardiovascular mortality and morbidity.[1,2] Cardiovascular disease (CVD) risk factors, such as hypertension, diabetes, and dyslipidemia, are highly prevalent and poorly controlled in patients with CKD.[3] Recent reports suggest that of patients with an estimated glomerular filtration rate (eGFR) <60 mL/min/1.73 m^2, only 37% of those with known hypertension achieved blood pressure control to a level $<130/80$ mm Hg,[4] and low-density lipoprotein cholesterol level was within the normal range for 17.9%.[3] Most people with early-stage CKD (eGFR >60 mL/min/1.73 m^2 with established proteinuria) are managed exclusively by primary care providers, with rates of nephrologist comanagement increasing as CKD progresses.[5-7] The National Kidney Foundation's Kidney Disease Outcomes Quality Initiative (KDOQI) guidelines recommend referral to and/or comanagement by nephrologists for patients with CKD stage 4, macroalbuminuria, hyperkalemia (potassium >5.5 mEq/L), or resistant hypertension or for patients at increased risk of CKD progression.[8-10]

From the [1]Christiana Care Health System, Center for Outcomes Research, Newark, DE; [2]Chronic Disease Research Group, Minneapolis Medical Research Foundation, Minneapolis, MN; [3]Renal Division, Washington University School of Medicine, St. Louis, MO; [4]Department of Medicine, Division of Nephrology, Columbia University College of Physicians and Surgeons, New York, NY; [5]Charles R. Drew University of Medicine and Science, Los Angeles, CA; [6]St. John Providence Health System, Providence Park Heart Institute, Novi, MI; and [7]Harry S Truman VA Medical Center and the Department of Internal Medicine, Division of Nephrology and Hypertension, University of Missouri-Columbia School of Medicine, Columbia, MO.

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Address correspondence to Claudine T. Jurkovitz, MD, MPH, Christiana Care Center for Outcomes Research, 131 Continental Dr, Ste 202, Newark, DE 19713. E-mail: cjurkovitz@christianacare.org

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Timely nephrologist referral has been associated with improved outcomes, including delayed progression to end-stage renal disease, decreased mortality before hemodialysis therapy initiation, and improved first-year survival on hemodialysis therapy.[11,12] However, little is known about the interplay of physician utilization, CVD risk-factor control, and kidney disease progression in people screened for CKD.

We used data from the Kidney Early Evaluation Program (KEEP), a community-based health screening program that enrolls participants at high risk of kidney disease, to: (1) assess CVD risk-factor control and physician utilization at baseline, (2) determine predictors of nephrology consultation in participants with identified indications for consultation or referral, and (3) explore CKD progression, CVD risk-factor control, and physician utilization in participants with recurrent KEEP screenings.

METHODS

KEEP Screening Procedures

KEEP is a free community-based health screening program that targets populations at high risk of kidney disease. KEEP recruitment methods have been described previously.[13,14] Eligible participants are 18 years or older with self-reported diabetes or hypertension or a first-degree relative with diabetes, hypertension, or kidney disease. People with kidney transplants or receiving regular dialysis therapy are excluded. After providing informed consent, participants complete the screening questionnaire, which consists of sociodemographic information, personal and family health history, smoking status, and information about participant primary care and specialty physicians. Height, weight, blood pressure, plasma glucose, microalbuminuria, and albumin-creatinine ratio (ACR) are measured. Blood samples are drawn from consenting participants and sent to a central laboratory.

Study Population

Because lipid measurements at KEEP screenings started in 2005, we limited our study population to participants enrolled in 2005-2010 for whom measurements of eGFR and albuminuria and information about diabetes, hypertension, and cholesterol were available. Because measurement of low-density lipoprotein cholesterol was not available until 2008, we used total cholesterol level to assess hypercholesterolemia.

Definition of Variables

Physicians

Participants who had seen a physician in the past year were considered to have a physician; those not meeting this time criterion were considered not to have a physician. A primary care practitioner was defined as a family practice physician, internist, obstetrician/gynecologist, gerontologist, nurse practitioner, or physician assistant. Seeing a nephrologist was defined as nephrologist consultation/care with or without a primary care practitioner or another specialist (cardiologist or endocrinologist).

Comorbid Conditions

Diabetes was defined as a history of diabetes (self-report or retinopathy), use of diabetes medications, or newly diagnosed diabetes (fasting blood glucose ≥126 mg/dL or nonfasting blood glucose ≥200 mg/dL) in the absence of self-report or medication use. Hypertension was defined as history of hypertension (self-report), use of hypertension medications, or newly diagnosed hypertension[15] defined as systolic blood pressure ≥130 mm Hg or diastolic blood pressure ≥80 mm Hg for persons with a history of diabetes or CKD; otherwise, systolic blood pressure ≥140 mm Hg or diastolic blood pressure ≥90 mm Hg. Hypercholesterolemia was defined as receiving medication for high cholesterol level or total cholesterol level >200 mg/dL.

CVD was defined as self-reported history of heart angina, heart attack, heart bypass surgery, heart angioplasty, stroke, heart failure, abnormal heart rhythm, or coronary heart disease. Body mass index was calculated as weight (in kilograms) divided by height (in meters) squared.

Kidney Function

Serum creatinine was measured and calibrated to the Cleveland Clinic Research Laboratory as previously described.[16] GFR was estimated using the CKD Epidemiology Collaboration (CKD-EPI) equation.[17] Microalbuminuria was defined as a spot urine ACR ≥30 mg/g, and macroalbuminuria as ACR >300 mg/g.

Kidney function stages were defined according to eGFR levels and KDOQI guidelines as follows[9]: normal kidney function, eGFR ≥60 mL/min/1.73 m^2 and ACR <30 mg/g; CKD stages 1-2, eGFR ≥60 mL/min/1.73 m^2 and ACR ≥30 mg/g; CKD stage 3, eGFR <60 and ≥30 mL/min/1.73 m^2; CKD stage 4, eGFR <30 and ≥15 mL/min/1.73 m^2; and CKD stage 5, eGFR <15 mL/min/1.73 m^2.

Outcomes

Control of all risk factors was defined as blood pressure control (systolic blood pressure <130 mm Hg and diastolic blood pressure <80 mm Hg if history of diabetes or CKD; otherwise, systolic blood pressure <140 mm Hg and diastolic blood pressure <90 mm Hg), blood glucose control (fasting blood glucose <126 mg/dL, nonfasting blood glucose <200 mg/dL, and hemoglobin A_{1c} <7%), and cholesterol control (≤200 mg/dL).

In addition to CKD stage 4 or higher, possible indications for nephrology consultation/referral were macroalbuminuria and risk factors for progression, such as type 2 diabetes with microalbuminuria in patients with eGFR <60 mL/min/1.73 m^2.[8] Castro et al[8] use diabetic retinopathy as a marker of CKD progression in patients with CKD stage 3, but we could not because of inconsistency in its collection in KEEP; we used diabetes with eGFR <60 mL/min/1.73 m^2 instead.

Likewise, we could not use hyperkalemia because it is not assessed in KEEP. Because medication and detailed clinical information are not collected, we could not infer about the presence of resistant hypertension.

Statistical Analysis

We used the Cochran-Armitage test of trend to analyze the distribution of participant characteristics according to CKD stages and χ^2 tests to evaluate the univariate association between type of physician and risk factors. We used logistic regression to examine the independent association between participant characteristics and all risk-factor control (dependent variable) and multinomial logistic regression for the independent association between participant characteristics and seeing a nephrologist (dependent variable) after adjusting for kidney function. Seeing a nephrologist was compared with seeing another physician or with not seeing a physician. To avoid decreasing the number of records used in the model because of missing data, we created an unknown category for each variable with missing data. Finally, we used paired *t* tests for continuous variables or McNemar tests for categorical vari-

ables to compare participant characteristics at first and second screening.

Data were analyzed using SAS, version 9.1 (www.sas.com).

RESULTS

Participant Population

A total of 101,439 participants were enrolled in KEEP between 2005 and 2010. Exclusion of participants who had undergone kidney transplant or were receiving hemodialysis (n = 272) and those with missing values for albuminuria, eGFR, hypertension, diabetes, or cholesterolemia (n = 11,158) resulted in a final cohort for analysis of 90,009.

Of 90,009 participants, 77.2% had no CKD, 8.0% had CKD stages 1-2, 13.9% had stage 3, and 0.9% had stages 4-5 (Table 1). Approximately one-fifth of the study population had not seen a physician in the last year; in the entire cohort, 61.3% had a primary care physician only, 2.9% had seen a nephrologist, and 15.3% had seen another specialist. Of participants with CKD stages 4-5, only 35.3% had seen a nephrologist.

Participants with advanced CKD (stages 3-5) were older and more likely to be white, have insurance, and have 12 years or fewer of education.

CVD Risk-Factor Control and Physician Utilization

Participants with advanced CKD were more likely to have CVD, hypertension, and hypercholesterolemia (Table 1). The presence of 3 risk factors (hypertension, diabetes, and hypercholesterolemia) was more prevalent with increasing stages of CKD. The rate of control was low; only 8.4% achieved target levels of all risk factors (blood pressure, glycemia, and cholesterolemia). Participants with CKD stages 1-2 were least likely to achieve target levels of all risk factors (6.0%), and those with CKD stages 4-5 were slightly more likely (9.0%). CVD risk-factor control varied little based on physician utilization; 7.2% of participants without a physician, 8.3% of those seeing only a primary care physician, 9.9% of those seeing a nephrologist, and 10.3% of those seeing another specialist achieved target levels of all risk factors. However, nephrologists and specialists were more likely than primary care physicians to see participants with 3 risk factors (28.3% and 30.9%, respectively, vs 17.3%; $P < 0.001$).

Results of multivariable analysis confirmed these results (Table 2). After adjusting for demographic and clinical characteristics, participants with CKD stages 1-2 remained 40% less likely to achieve target levels of all risk factors than participants without CKD. CVD risk-factor control was more likely for participants who had seen a physician in the last year than for those who had not, regardless of physician type. Odds ratios were 1.22 (95% confidence interval [CI], 1.14-1.32) for primary care physician, 1.48 (95% CI, 1.35-1.63) for specialist, and 1.52 (95% CI, 1.30-1.63) for nephrologist. Participants with hypertension and hypercholesterolemia were respectively 22% and 70% less likely to achieve target levels, and participants with diabetes were almost 60% more likely.

Consultation/Referral Indications and Physician Utilization

A total of 7,025 participants (7.8%) met at least one criterion for nephrology consultation/referral at baseline (Table 3). Of these, 12.3% reported seeing a nephrologist; 50.1%, a primary care physician only; and 29.1%, another specialist. As expected, participants with CKD stages 4-5 (eGFR <30 mL/min/1.73 m^2) were most likely to report seeing a nephrologist (35.3%) compared with 11.6% of those with macroalbuminuria and eGFR ≥ 30 mL/min/1.73 m^2 and 12.4% of diabetic participants with microalbuminuria and eGFR of 30-59 mL/min/1.73 m^2.

Results of the multivariable model assessing the likelihood of seeing a nephrologist versus seeing another physician and versus seeing no physician in participants who met criteria for consultation/referral are listed in Table 4. Because 25.7% of the data were missing, we created an unknown category for each variable with missing data. For both analyses, seeing a nephrologist was associated strongly with decreasing eGFR and increasing albuminuria. After controlling for these factors, several clinical and demographic characteristics also were associated with seeing a nephrologist. Compared with seeing another physician, predictors of seeing a nephrologist were male sex, other race (includes Asians and Pacific Islanders), insurance coverage, more than 12 years of education, family history of kidney disease, and CVD. Participants with diabetes were less likely to see a nephrologist than another physician. Compared with not seeing any physician, the strongest predictor was insurance coverage; this effect was even stronger than effects of eGFR of 30-59 mL/min/1.73 m^2 and albuminuria. Other predictors that remained significantly associated with seeing a nephrologist were male sex, more than 12 years of education, family history of kidney disease or hypertension, CVD, and hypertension. Native Americans were more likely to not have a physician.

Physician Utilization and CVD and Kidney Disease Progression Risk-Factor Control at Subsequent Screening

Of participants with at least one indication for consultation/referral, 406 (5.8%) returned for a second KEEP screening (Table 5). The average interval

Table 1. Characteristics of KEEP Participants, 2005-2010

	All	CKD				P[a]
		None	Stages 1-2	Stage 3	Stages 4-5	
No.	90,009	69,492	7,166	12,527	824	
Medical care						
No physician	20.5	22.7	20.0	9.4	9.7	<0.001
Primary care[b] only	61.3	62.6	59.2	56.7	37.1	<0.001
Nephrologist with or without primary care	2.9	1.6	3.4	7.7	35.3	<0.001
Other specialists[c] with or without primary care	15.3	13.0	17.4	26.2	17.8	<0.001
Mean age (y)	56.3	53.7	55.7	70.2	70.7	<0.001
Age ≥65 y	31.3	23.7	29.5	71.6	70.4	<0.001
Men	32.0	31.8	32.8	31.9	37.6	0.1
Race/ethnicity						
White	51.7	49.7	43.1	67.1	61.9	<0.001
African American	31.0	31.9	36.9	22.8	25.0	<0.001
Native American	2.0	1.9	3.3	1.7	2.2	0.5
Other	15.4	16.5	16.8	8.5	10.9	<0.001
Hispanic	12.4	13.5	13.7	5.9	7.0	<0.001
Any insurance	79.0	77.2	74.9	90.7	86.4	<0.001
Education ≤12 y	40.5	38.6	45.3	47.5	53.1	<0.001
Smoking (prior or current)	37.1	36.1	41.3	40.0	42.9	<0.001
Family history						
Kidney disease	16.8	16.9	18.4	15.7	19.0	0.2
Hypertension	81.1	82.1	79.8	76.5	72.8	<0.001
Diabetes	54.7	55.2	57.5	50.2	49.8	<0.001
History of CVD	26.9	23.5	30.3	42.1	49.9	<0.001
Mean BMI (kg/m^2)	30.3	30.2	31.6	30.0	29.6	<0.001
BMI ≥30 kg/m^2	44.6	44.1	51.5	43.8	40.8	0.1
Risk factors						
Hypertension	81.3	78.4	86.8	93.1	96.0	<0.001
Diabetes	33.5	29.8	47.9	44.6	53.8	<0.001
Hypercholesterolemia	57.0	55.3	57.3	66.2	60.4	<0.001
3 risk factors[d]	18.2	15.5	26.8	27.6	31.9	<0.001
2 risk factors	43.9	42.7	44.1	50.4	47.5	<0.001
1 risk factor only	29.3	31.7	23.3	20.4	19.5	<0.001
All risk factors controlled[e]	8.4	8.7	6.0	8.5	9.0	0.02

Note: Unless otherwise indicated, continuous variables are given as means; categorical variables are shown as percentages. Included KEEP participants with nonmissing values for eGFR and albuminuria and information about diabetes, hypertension, and hypercholesterolemia status.

Abbreviations: BMI, body mass index; CKD, chronic kidney disease; CVD, cardiovascular disease; eGFR, estimated glomerular filtration rate; KEEP, Kidney Early Evaluation Program.

[a]Test of trend.

[b]Family practice physician, internist, obstetrician/gynecologist, gerontologist, nurse practitioner, or physician assistant.

[c]Cardiologist or endocrinologist.

[d]Hypertension (self-reported history of hypertension, use of antihypertensive medications, or measured systolic blood pressure ≥130 mm Hg or diastolic blood pressure ≥80 mm Hg for persons with a history of diabetes or CKD; otherwise, systolic blood pressure ≥140 mm Hg or diastolic blood pressure ≥90 mm Hg), diabetes (self-reported history of diabetes, retinopathy, or fasting blood glucose ≥126 mg/dL or nonfasting blood glucose ≥200 mg/dL in the absence of self-report of medicine use), and hypercholesterolemia (receiving medication for high cholesterol level or total cholesterol level >200 mg/dL).

[e]In participants with at least one risk factor. Denominator: all participants with hypertension, diabetes, or hypercholesterolemia, as defined.

between screenings was 1.55 years (median, 1.02 years). Compared with participants who met criteria for consultation/referral but did not return (n = 6,619), those who returned were more likely to have a physician and to see a specialist ($P = 0.03$). They were older (72.3 vs 69.3 years; $P < 0.001$), more likely to be white (72.7% vs 63.5%; $P = 0.001$) and to have insurance (92.1% vs 88.1%; $P = 0.02$), and less likely

Table 2. Characteristics Independently Associated With Control of All Risk Factors

Variable	OR (95% CI)	*P*
No physician	1.00 (reference)	
Primary care only	1.22 (1.14-1.32)	<0.001
Nephrologist	1.52 (1.30-1.77)	<0.001
Specialist[a]	1.48 (1.35-1.63)	<0.001
Age	0.99 (0.99-1.00)	0.004
Men	1.08 (1.03-1.14)	0.004
Race/ethnicity		
White	1.00 (reference)	
African American	0.93 (0.87-0.98)	0.01
Native American	0.71 (0.59-0.87)	<0.001
Other	1.19 (1.10-1.29)	<0.001
Hispanic	1.12 (1.02-1.22)	0.02
Insurance coverage	0.96 (0.89-1.03)	0.2
Unknown (n = 2,765; 3.4%)	0.95 (0.82-1.10)	0.5
Education >12 y[b]	1.03 (0.97-1.08)	0.3
Unknown (n = 1,093; 1.3%)	0.67 (0.52-0.87)	0.003
Family history		
Kidney disease	1.03 (0.96-1.10)	0.5
Unknown (n = 5,824; 7.1%)	1.04 (0.94-1.16)	0.4
Hypertension	1.17 (1.09-1.25)	<0.001
Unknown (n = 6,063; 7.4%)	1.72 (1.55-1.92)	<0.001
Diabetes	1.01 (0.95-1.07)	0.8
Unknown (n = 5,448; 6.6%)	0.99 (0.89-1.12)	0.9
History of CVD	1.06 (0.99-1.12)	0.07
Unknown (n = 568; 0.7%)	1.39 (1.06-1.84)	0.02
BMI ≥25 kg/m^2	0.97 (0.91-1.03)	0.3
Unknown (n = 886; 1.1%)	0.86 (0.67-1.12)	0.3
Hypertension	0.88 (0.80-0.95)	0.003
Diabetes	1.57 (1.49-1.65)	<0.001
Hypercholesterolemia	0.30 (0.29-0.32)	<0.001
CKD		
None	1.00 (reference)	
Stages 1-2	0.60 (0.54-0.67)	<0.001
Stage 3	0.98 (0.91-1.06)	0.6
Stages 4-5	0.89 (0.69-1.14)	0.3

Note: OR is for all risk factors controlled. Participants with at least one CVD risk factor (hypertension, diabetes, or hypercholesterolemia), n = 82,313. C index = 0.698.

Abbreviations: BMI, body mass index; CI, confidence interval; CKD, chronic kidney disease; CVD, cardiovascular disease; OR, odds ratio.

[a]Cardiologist or endocrinologist.

[b]Reference is 12 years or less.

to smoke (35.2% vs 41.2%; $P = 0.02$). They were more likely to have CVD risk factors (hypertension, diabetes, and hypercholesterolemia; 64.5% vs 55.6%; $P < 0.001$) and CKD stage 3 (91.6% vs 80.8%; $P < 0.001$) and less likely to have CKD stages 4-5 (6.9% vs 11.9%; $P = 0.002$) and macroalbuminuria (5.4% vs 12.6%; $P < 0.001$). The proportion of participants who saw a nephrologist increased from 11.6% to 19.7% ($P < 0.001$) between screenings (Table 5). Participants were more likely to have all 3 CVD risk factors at the return visit (72.9% vs 64.5% at baseline; $P < 0.001$), largely due to more diagnoses of hypercholesterolemia; however, the percentage of participants with all risk factors controlled was higher at the second than at the first screening (20.9% vs 13.3%; $P = 0.002$).

DISCUSSION

We investigated CVD risk-factor control and physician utilization in KEEP participants and in the subset who returned for a subsequent screening. The major findings are: (1) generally poor risk-factor control and only modest improvement with advancing CKD, (2) low likelihood of nephrologist encounter despite clinical indications for consultation/referral at earlier CKD stages, (3) higher likelihood of a nephrologist visit after the first screening, and (4) improved CVD risk-factor control in returning participants.

Hypertension, diabetes, and hyperlipidemia are highly prevalent in patients with end-stage renal disease or CKD.[1,3] Of National Health and Nutrition Examination Survey (NHANES) participants with eGFR <60 mL/min/1.73 m^2, only 37% of those with known hypertension had normal blood pressure.[4] Likewise, both diabetes and hyperlipidemia control are poor in patients with CKD.[3] Secondary analyses of large clinical trials of statins for primary prevention of cardiovascular events show a beneficial effect in patients with CKD[18,19]; however, physicians have been reluctant to prescribe statins for fear of secondary effects[20] and due to lack of efficacy in randomized controlled trials of hemodialysis patients.[21]

As expected, we found that the prevalence of CVD risk factors increased with kidney disease severity. Risk-factor control is low (8.4%) in the KEEP population, possibly explaining the high rates of cardiovascular events and death reported previously.[22,23] Interestingly, participants with CKD stages 4-5 seem to have slightly better control of risk factors than those with less advanced CKD, possibly due to a larger proportion reporting nephrologist care. In the overall KEEP population, risk-factor control does not seem to depend on type of physician seen. However, nephrologists and other specialists are more likely to see patients with high levels of comorbidity, and controlling risk factors in such practice settings might be more difficult.

Almost 8% of KEEP participants met criteria for nephrologist consultation/referral. This probably is an underestimate because we could not include participants with resistant hypertension or hyperkalemia. In NHANES, Castro and Coresh[8] found in patients with CKD stage 3 that 18.6% met one of these referral

Table 3. Distribution of Medical Care by Referral Criteria

	All	Medical Care				P[c]
		No Physician	Primary Care Only[a]	Other Specialist[b] With or Without Primary Care	Nephrologist With or Without Other Specialist or Primary Care	
No.	90,009	18,467	55,182	13,735	2,625	
Criteria for nephrologist referral						
CKD stages 4-5	824	9.7	37.1	17.8	35.3	<0.001
Macroalbuminuria[d] at CKD stages 1-3	879	15.8	48.0	24.6	11.6	<0.001
Diabetes + microalbuminuria[e] at CKD stage 3	1,238	7.4	45.6	34.5	12.4	<0.001
Diabetes without albuminuria[f] at CKD stage 3	4,084	7.0	54.6	30.8	7.7	<0.001
Any of these criteria	7,025	8.5	50.1	29.1	12.3	<0.001

Note: Results are row percentages. For example, in participants with CKD stages 4-5, the percentage of participants who have no physician is 9.7. The denominator is number of participants with CKD stages 4-5. Categories are mutually exclusive.

Abbreviations: ACR, albumin-creatinine ratio; CKD, chronic kidney disease.

[a]Family practice physician, internist, obstetrician/gynecologist, gerontologist, nurse practitioner, or physician assistant.

[b]Cardiologist or endocrinologist.

[c]χ^2.

[d]ACR >300 mg/g.

[e]ACR of 30-300 mg/g.

[f]ACR <30 mg/g.

criteria. Another possible reason for our lower prevalence is that we did not limit our analysis to participants with CKD stage 3.

Only 12.3% of participants who met any referral criterion reported seeing a nephrologist. This low referral rate may be related to the low CKD awareness (10.0%) consistently reported in KEEP.[24] The referral rate increases to 19.7% at the second screening, which does not strongly support the notion that awareness increases nephrologist utilization. The decision to refer to a nephrologist depends on physician and participant factors, and one of the major goals of KEEP is to improve awareness of CKD in both these groups.

Primary care practitioner awareness of the KDOQI guidelines is a critical factor in nephrology referral decisions. Although distinguishing awareness from motivation is challenging, several investigators have attempted to assess knowledge of these guidelines among physicians. Navaneethan et al[25] recently found that only 36.5% of primary care practitioners were aware of CKD guidelines and only 31.8% used CKD stages for referral. In a cross-sectional survey of internists, geriatricians, and nephrologists, regarding referral of older patients, investigators reported that 100% of surveyed nephrologists, 31.3% of internists, and 57.1% of geriatricians were aware of the KDOQI guidelines related to referral.[26] A subsequent study showed that primary care physicians with more than 10 years in practice were least likely to recommend referral of patients with CKD but more likely to express a desire for collaborative care, yet the differences were small (89% vs 82%).[27,28] General internists who were aware of existing guidelines were 14 times more likely to recommend referral.[27]

In our analysis, after adjusting for kidney disease progression, participant factors associated with seeing a nephrologist included male sex, insurance coverage, more than 12 years of education, family history of kidney disease and CVD. Notably, participants with insurance coverage were nearly twice as likely to be referred to a nephrologist as those without insurance, compared with seeing another physician. These results are similar to results reported by other investigators, who found that patient characteristics such as age older than 65 years, female sex, and nonwhite race were significantly associated with nonreferral.[25]

Although the small group of participants who returned for a second screening seems to be a highly selected population of older participants with better socioeconomic status, only 19.7% reported having seen a nephrologist. Nevertheless, KEEP seems to have been successful in encouraging a nephrology visit because this is a 70% increase from the first screening. KEEP is actively engaged in a longitudinal program, inviting previous participants to return for a repeated examination. These results suggest that rescreening, in addition to focusing on participants with criteria for CKD progression, should focus on the most vulnerable participants (no health insurance, minority race/ethnicity, and low level of education). Finally, a large percentage of KEEP participants who meet criteria for referral have seen a physician in the year preceding the first screening. Although KEEP provides the screening results to consenting participants' physicians, lack of improvement or deteriora-

Table 4. Model Predicting Nephrology Consultation in Participants Who Met Criteria for Referral

Variable	Seeing Nephrologist vs Seeing Another Physician		Seeing Nephrologist vs Not Seeing a Physician	
	OR (95% CI)	*P*	OR (95% CI)	*P*
Age	0.97 (0.96-0.98)	<0.001	1.00 (0.99-1.01)	0.8
Men	1.45 (1.23-1.70)	<0.001	1.27 (1.00-1.60)	0.05
Race/ethnicity				
White	1.00 (reference)		1.00 (reference)	
African American	0.94 (0.78-1.14)	0.5	0.76 (0.58-1.00)	0.05
Native American	0.73 (0.42-1.27)	0.3	0.48 (0.24-0.97)	0.04
Other	1.39 (1.06-1.82)	0.02	0.87 (0.61-1.25)	0.5
Hispanic	0.78 (0.55-1.10)	0.2	0.76 (0.49-1.18)	0.2
Insurance coverage	1.95 (1.44-2.64)	<0.001	7.52 (5.33-10.63)	<0.001
Unknown (n = 342; 4.9%)	1.97 (1.24-3.14)	0.004	3.16 (1.82-5.47)	<0.001
Education >12 y[a]	1.21 (1.04-1.42)	0.01	1.31 (1.04-1.64)	0.02
Unknown (n = 100; 1.4%)	0.68 (0.32-1.47)	0.3	0.47 (0.19-1.19)	0.1
Family history				
Kidney disease	1.56 (1.27-1.91)	<0.001	1.40 (1.03-1.90)	0.03
Unknown (n = 701; 10.0%)	1.12 (0.84-1.51)	0.4	0.76 (0.51-1.15)	0.2
Hypertension	1.08 (0.88-1.33)	0.4	1.41 (1.05-1.89)	0.02
Unknown (n = 882; 12.6%)	1.27 (0.94-1.71)	0.1	1.03 (0.68-1.56)	0.9
Diabetes	1.06 (0.89-1.27)	0.5	1.09 (0.84-1.41)	0.5
Unknown (n = 661; 9.4%)	1.03 (0.74-1.44)	0.9	0.98 (0.61-1.57)	0.9
History of CVD	1.30 (1.11-1.52)	0.001	1.97 (1.56-2.49)	<0.001
Unknown (n = 42; 0.6%)	1.40 (0.51-3.81)	0.5	0.95 (0.27-3.28)	0.9
BMI ≥25 kg/m^2	0.91 (0.74-1.12)	0.4	1.22 (0.91-1.63)	0.2
Unknown (n = 53; 0.8%)	0.50 (0.18-1.41)	0.2	0.51 (0.14-1.87)	0.3
Hypertension	1.25 (0.85-1.85)	0.3	2.08 (1.28-3.37)	0.003
Diabetes	0.71 (0.55-0.92)	0.01	1.17 (0.80-1.69)	0.4
Hypercholesterolemia	1.08 (0.92-1.27)	0.3	1.08 (0.86-1.36)	0.5
CKD				
eGFR ≥60	1.00 (reference)		1.00 (reference)	
eGFR of 30-59	3.35 (2.19-5.15)	<0.001	3.45 (2.01-5.91)	<0.001
eGFR <30	14.61 (9.47-22.51)	<0.001	10.24 (5.88-17.82)	<0.001
No albuminuria	1.00 (reference)		1.00 (reference)	
ACR of 30-300	1.63 (1.36-1.95)	<0.001	1.53 (1.16-2.03)	0.003
ACR >300	2.19 (1.71-2.81)	<0.001	1.95 (1.33-2.86)	<0.001

Note: Results from multinomial logistic regression (n = 7,025).

Abbreviations and definitions: ACR, albumin-creatinine ratio (in mg/g); BMI, body mass index; CI, confidence interval; CKD, chronic kidney disease; CVD, cardiovascular disease; eGFR, estimated glomerular filtration rate (in mL/min/1.73 m^2); OR, odds ratio.

[a]Reference is 12 years or less.

tion remains prevalent at the second screening. Communication barriers between primary care physicians and specialists should be assessed, as should barriers to guideline implementation.

The definition of CKD based on a single eGFR and ACR measurement, not on measurements over 3 months, is a limitation inherent in the cross-sectional design of KEEP, as is ascertainment of ACR as the only marker of kidney damage. This definition may lead to overestimating CKD prevalence in our study population because some individuals with acute changes in kidney function may have been misclassified. The small number of participants who met criteria for kidney disease progression and returned for a second screening is another serious limitation. Because this is a self-selected group likely highly motivated for care, selection bias may have been introduced, and the improvement in percentage of nephrologist visits and risk-factor control may be overestimated. In addition, because of the small numbers of participants, we could not assess the impact of physician visits on clinical outcomes. However, these results provide insight into the effectiveness of screening regarding participant referral. Finally, we could

Table 5. Risk-Factor Control and CKD Progression in Participants Who Met Criteria for Nephrologist Referral and Returned for a Second KEEP Screening

	Met Criteria for Nephrologist Referral	KEEP Screening		*P*[a]
		First	Second	
No.	7,025	406	406	
Physician care				
No physician	8.5	5.2	3.5	0.2
Primary care only[b]	50.1	49.0	42.6	0.01
Nephrologist	12.3	11.6	19.7	<0.001
Other specialist[c] and primary care	29.1	34.2	34.2	1.0
Mean age (y)	69.4	72.3	73.9	<0.001
Age ≥65 y	69.9	80.3	83.3	<0.001
Men	34.2	32.8	32.8[d]	
Race/ethnicity				
White	62.8	72.7	72.7[d]	
African American	24.5	17.5	17.5[d]	
Native American	2.6	1.0	1.0[d]	
Other	10.1	8.9	8.9[d]	
Hispanic	7.3	6.2	6.2[d]	
Any insurance	88.1	91.7	92.3	0.5
Education ≤12 y	50.6	45.7	44.7	0.4
Smoking (former or current)	40.9	33.6	33.3	0.8
Family history of kidney disease	15.0	17.1	17.1[d]	
History of CVD	46.6	50.4	50.6	0.9
Mean BMI (kg/m^2)	31.3	30.9	30.7	0.1
BMI ≥30 kg/m^2	51.5	50.1	49.4	0.6
Hypertension	94.6	95.3	96.1	0.5
Diabetes	90.3	96.8	97.0	0.7
Hypercholesterolemia	64.1	68.7	78.1	<0.001
Presence of risk factors[e]				
3	55.6	64.5	72.9	<0.001
2	38.2	31.7	25.4	0.01
1	5.8	3.7	1.7	0.02
All risk factors controlled[f]	10.2	13.3	20.9	0.002
CKD stages 1-2	7.2	1.5	1.5	1.0
CKD stage 3	81.1	91.6	89.7	0.1
Criteria for nephrologist referral				
CKD stages 4-5	11.7	6.9	8.9	0.1
Macroalbuminuria[g]	12.5	5.4	6.2	0.5
Diabetes + microalbuminuria[h] at CKD stage 3	17.6	18.5	19.0	0.8
Diabetes without albuminuria[i] at CKD stage 3	58.1	69.2	66.0	0.1

Note: Unless otherwise indicated, values are percentages.

Abbreviations: ACR, albumin-creatinine ratio; BMI, body mass index; CKD, chronic kidney disease; CVD, cardiovascular disease; KEEP, Kidney Early Evaluation Program.

[a]Paired *t* test or McNemar test.

[b]Family practice physician, internist, obstetrician/gynecologist, gerontologist, nurse practitioner, or physician assistant.

[c]Cardiologist or endocrinologist.

[d]Values were the same for both screenings.

[e]Hypertension (self-reported history of hypertension, use of antihypertensive medications, or measured systolic blood pressure ≥130 mm Hg or diastolic blood pressure ≥80 mm Hg for persons with a history of diabetes or CKD; otherwise, systolic blood pressure ≥140 mm Hg or diastolic blood pressure ≥90 mm Hg), diabetes (self-reported history of diabetes, retinopathy, or fasting blood glucose ≥126 mg/dL or nonfasting blood glucose ≥200 mg/dL in the absence of self-report of medicine use), and hypercholesterolemia (receiving medication for high cholesterol level or total cholesterol level >200 mg/dL).

[f]In participants with at least one risk factor. Denominator: all participants with hypertension, diabetes, or hyperlipidemia, as defined.

[g]ACR >300 mg/g.

[h]ACR of 30-300 mg/g.

[i]ACR <30 mg/g.

assess parameters at only the screening and return screening; an analysis including interim data between these visits would likely further elucidate the nature of improvements (or lack thereof) in risk factors.

In conclusion, we found that a large number of participants met criteria for referral to a nephrologist and that control of cardiovascular risk factors was poor in the KEEP population, but seemed to improve after screening. Socioeconomic status, including insurance coverage, is a major patient-related determinant of nephrology consultation. Although KEEP was effective in increasing the percentage of participants seeing a nephrologist, the rate was low and probably overestimated in our sample. These results also highlight that a large percentage of the population who returned had seen a physician in the year before the second screening. Identifying the communication barriers between nephrologists and primary care physicians may be a new focus for KEEP, particularly with the current emphasis on accountable care organizations and medical home designations.

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