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Association Between Lack of Health Insurance and Risk of Death and ESRD: Results From the Kidney Early Evaluation Program (KEEP)

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Background: Uninsured adults in the United States have poor access to health care services and worse health outcomes than insured adults. Little is known about the association between lack of insurance and chronic kidney disease (CKD) progression to end-stage renal disease (ESRD) or death in patients at high risk of kidney disease. We used 2000-2011 data from the National Kidney Foundation's Kidney Early Evaluation Program (KEEP) to examine this association.

Methods: The study population included KEEP participants younger than 65 years. Outcomes were time to ESRD (chronic kidney failure treated by renal replacement therapy) and time to death. Incident ESRD was ascertained by linkage to the US Renal Data System, and vital status, by linkage to the Social Security Administration Death Master File. We used Cox proportional hazard regression to examine the association between insurance and risk of death or ESRD after adjusting for demographic variables.

Results: Of 86,588 participants, 27.8% had no form of insurance, 10.3% had public insurance, and 61.9% had private insurance; 15.0% had CKD (defined as estimated glomerular filtration rate <60 mL/min/1.73 m^2 or urine albumin-creatinine ratio ≥ 30 mg/g), 63.3% had hypertension, and 27.7% had diabetes. Of participants with CKD, 29.3% had no health insurance. Participants without insurance were younger, more likely to be Hispanic and to have 12 or fewer years of education, and less likely to have seen a physician in the past year. After adjustment for demographic characteristics, uninsured KEEP participants were 82% more likely than privately insured participants to die (HR, 1.82; 95% CI, 1.56-2.12; $P < 0.001$) and 72% more likely to develop ESRD (HR, 1.72; 95% CI, 1.33-2.22; $P < 0.001$). The association between insurance and outcomes varied by CKD stage.

Conclusions: Lack of insurance is an independent risk factor for early death and ESRD in this population at high risk of kidney disease. Considering the high morbidity and mortality and increasing cost associated with ESRD, access to appropriate health insurance coverage is warranted.

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INDEX WORDS: Chronic kidney disease; end-stage renal disease; health insurance; mortality; public health.

Access to health care services in the United States is limited for uninsured adults, who receive less appropriate care and whose health outcomes are poorer compared with insured adults.[1-3] An analysis of the Health and Retirement Study (HRS), a longitudinal survey of noninstitutionalized adults in the United States, reported that lack of health insurance was associated with higher mortality in white adults.[4] In an analysis of the Third National Health and Nutrition Examination Survey (NHANES III), investigators found that blood pressure was 59% more likely to be controlled in hypertensive participants with private health insurance than in those without health insurance.[5] In addition, uninsured patients with diabetes or hypertension are less likely than insured patients to take their medications and therefore more likely to develop worse outcomes.[3] Likewise, uninsured patients with chronic kidney disease (CKD) are less likely than insured patients to be treated for hypertension or to receive angiotensin inhibitors.[1] Whether lack of insurance in patients at high risk of kidney disease also is more likely to be associated with CKD

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progression to end-stage renal disease (ESRD) or death is unknown.

The Kidney Early Evaluation Program (KEEP) is a voluntary kidney disease screening program enrolling adults at high risk of kidney disease. The prevalence of CKD in KEEP, defined as estimated glomerular filtration rate (eGFR) <60 mL/min/1.73 m^2 or eGFR ≥60 mL/min/1.73 m^2 with albuminuria, is almost 26%, and 77% of participants have health insurance coverage.[6] The prevalence of CKD and comorbid conditions may be even higher for participants who do not have health insurance. This analysis aimed to characterize the burden of disease in KEEP participants without insurance and compare time to ESRD and time to death between participants with and without insurance.

METHODS

KEEP Screening Procedures

KEEP is a free community-based health screening program run by the National Kidney Foundation (NKF) that targets populations at high risk of kidney disease. KEEP recruitment methods have been described previously.[7,8] 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 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 on participant primary care and specialty physicians. Height, weight, blood pressure, plasma glucose level, and albumin-creatinine ratio (ACR) are measured at the screening. Blood samples are drawn from consenting participants and sent to a central laboratory.

Analysis of KEEP data was approved by the Institutional Review Board at Hennepin County Medical Center, Minneapolis, MN.

Study Population

Because most KEEP participants 65 years or older are eligible for Medicare, we limited our study population to participants younger than 65 years enrolled in 2000-2011, for whom measurements of eGFR, albuminuria status, and demographic and clinical information such as diabetes, hypertension, and cardiovascular disease (CVD) status and body mass index (BMI), were available.

Definition of Variables

Health Insurance Status

The sequence of questions regarding health insurance status was as follows: "Do you have health insurance (answers: yes or no)." "If yes, please specify (answers: Medicare, Medicaid, HMO [health maintenance organization], veterans' benefits, private, other, and don't know)."

We defined public source of coverage as Medicare, Medicaid, veterans' benefits, or a combination of these, including the association of Medicare with non–government-sponsored insurance. All other categories were defined as private source of coverage.

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, nonfasting blood glucose ≥200 mg/dL, or hemoglobin A_{1c} ≥7%) in the absence of self-report or medication use. Glycemic control was defined as fasting blood glucose level <126 mg/dL or nonfasting blood glucose level <200 mg/dL, and hemoglobin A_{1c} level <7%. Hypertension was defined as history of hypertension (self-report), use of hypertension medications, or newly diagnosed hypertension,[9] 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. Blood pressure control was defined as systolic blood pressure <130 mm Hg and diastolic blood pressure <80 mm Hg if there was a history of diabetes or CKD; otherwise, systolic blood pressure <140 mm Hg and diastolic blood pressure <90 mm Hg. CVD was defined as self-reported history of cardiac angina, heart attack, cardiac bypass surgery, cardiac angioplasty, stroke, heart failure, abnormal heart rhythm, or coronary heart disease. BMI 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.[10] GFR was estimated using the CKD Epidemiology Collaboration (CKD-EPI) equation.[11] Kidney function stages were defined according to eGFR and NKF-KDOQI (Kidney Disease Outcomes Quality Initiative) guidelines as follows[12]: 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

The primary outcome measures were time to ESRD (defined as chronic kidney failure treated by renal replacement therapy [ie, receiving maintenance dialysis or undergoing transplant]) and time to death. Incident ESRD was ascertained by linkage to the US Renal Data System (USRDS). The USRDS identifies >90% of patients who receive incident dialysis or undergo kidney transplant.[13] The last ESRD date in this analysis was December 31, 2011. For the ESRD outcome, we followed up each participant from the screening date until the development of ESRD and censored at death date, age 65 years, or December 31, 2011.

Vital status was ascertained by linkage to the Social Security Administration Death Master File. We defined survival time as the time of the first KEEP screening until death and censored at age 65 years or the end of follow-up through December 31, 2011.

Statistical Analysis

We used χ^2 tests and *t* tests to compare participant characteristics by insurance status (public, private, and no insurance) and CKD stage. Crude rates of death and ESRD per 1,000 person-years were calculated. We used Cox proportional hazard regression to examine the independent association between insurance status and risk of death or ESRD (dependent variables) after adjusting for demographic variables, including age, race, ethnicity, education level, and smoking status. Because most people in the United States obtain Medicare coverage when they reach the age of 65 years, we censored participants who reached age 65 years in the models. We tested the proportional hazards assumption by plotting the log(−log[survival rate]) against the log of survival time. All analyses were stratified by CKD stage. Although hypertension, diabetes, CVD, albuminuria, BMI, and eGFR are in the causal pathway between insurance status and death or ESRD and might not be considered as confounders, we performed a secondary

analysis including these variables in the models, with the rationale that some patients may have obtained public insurance such as Medicare for disability because of stroke, heart failure, limb amputation, or other reason.

Data were analyzed using SAS, version 9.1 (SAS Institute Inc).

RESULTS

Study Population

A total of 150,685 participants were enrolled in KEEP 2000-2011. After exclusion of those who had undergone kidney transplant or were receiving hemodialysis (n = 51), 150,634 participants were eligible for the study; of these, 106,212 were younger than 65 years. Excluding participants with missing values for insurance status, eGFR, albuminuria, age, race, sex, ethnicity, education, smoking status, diabetes status, hypertension status, BMI, and CVD status resulted in a final cohort for analysis of 86,588.

Compared with participants who were included in the analysis, those who were excluded (n = 19,624) were more likely to be African American (42.5% vs 34.5%), Hispanic (20.3% vs 14.6%, $P < 0.001$), and smokers (39.4% vs 37.5%; $P < 0.001$), and have 12 or fewer years of education (15.9% vs 12.2%; $P < 0.001$). Excluded participants also were less likely to have public insurance (9.2% vs 10.3%) or no insurance (22.7% vs 27.8%) and more likely to have private insurance (68.2% vs 61.9%; $P < 0.001$ overall).

Characteristics of Participants

Of 86,588 participants, 27.8% had no form of insurance, 10.3% had some form of public insurance, and 61.9% had private insurance; 15.0% had CKD (8.3%, stages 1-2; 6.3%, stage 3; and 0.4%, stages 4-5), 63.3% had hypertension, and 27.7% had diabetes (Table 1). Of participants with public insurance (n = 8,927), 54.2% had Medicare only or in combination with Medicaid or other insurance, 28.6% had Medicaid only, and 17.2% had veterans' benefits. Participants with no insurance were younger and more likely to be Hispanic and have 12 or fewer years of education. Participants with public insurance were older than those with private or no insurance; more likely to be men, African American, and smokers; and much more likely to have comorbid conditions such as CKD, hypertension, diabetes, and CVD. Of participants without insurance, those with hypertension were the least likely to achieve target levels of blood pressure, but those with diabetes were the most likely to achieve glycemic control. Participants with public insurance were the most likely to achieve blood pressure control. As expected, physician use was lower for participants without insurance. Only 66.0% of those without insurance had seen a physician in the past year versus 92.2% of those with public insurance and 87.0% of those with private insurance ($P < 0.001$).

Of participants with CKD (stages 1-5), 29.3% (n = 3,805) had no health insurance, 15.4% (n = 1,999) had public insurance, and 55.3% (n = 7,194) had private insurance.

Although the percentage of participants with CKD stages 4-5 without health insurance was high (32.6%), a large majority had seen a physician in the last year (91.6%; Table 2). The percentage of patients with public insurance increased as kidney function worsened, likely related to Social Security for disability and Medicaid eligibility in many states. As expected, comorbid conditions such as hypertension, diabetes, and CVD were more prevalent with increasing CKD stages. More than 96% of participants with CKD stages 4-5 had hypertension, but only 40.8% achieved target levels of blood pressure. Likewise, ~59% of participants with CKD stages 4-5 had diabetes, but only 16% achieved glycemic control (Table 2).

Risk of Death According to Insurance Status and CKD

Crude mortality rates increased with advancing CKD stages regardless of whether participants had insurance (Table 3). Mortality at any CKD stage was highest for patients with public insurance. Results of the Cox proportional hazard analysis confirmed these results (Table 3). After adjusting for demographic characteristics, KEEP participants without insurance remained 82% more likely to die than those with private insurance ($P < 0.001$). This increased risk was statistically significant for participants without CKD ($P < 0.001$) and with CKD stages 1-2 ($P = 0.004$) and 3a ($P = 0.01$), but not CKD stages 3b or 4-5, likely due to small sample sizes. Results from the broader stratification by eGFR showed that uninsured participants with eGFRs of 30-59 mL/min/1.73 m^2 (CKD stage 3) were 86% more likely to die than those with private insurance ($P = 0.03$). Overall, participants with public insurance remained more than 3 times as likely to die as those with private insurance ($P < 0.001$). Adjustment for hypertension, diabetes, CVD, BMI, and albuminuria attenuated the strength of association for each category, but the overall effect remained similar. Further adjustment with eGFR did not substantially modify hazard ratios (HRs; Table 3). The interaction between insurance and eGFR was not statistically significant ($P = 0.4$).

Risk of ESRD by Insurance Status and CKD

As expected, crude rates of ESRD were very low in participants with eGFR ≥45 mL/min/1.73 m^2 (CKD stage 3a) and increased dramatically as kidney function worsened (Table 4). After adjustment for demographic characteristics, participants without insurance

Table 1. Characteristics of the KEEP Population Younger Than 65 Years by Insurance Status

		Insurance			
	All	None	Public	Private	P[a]
No. of participants	86,588	24,035 (27.8)	8,927 (10.3)	53,626 (61.9)	
Age (y)	48.1 ± 11.4	46.4 ± 11.8	50.6 ± 11.6	48.4 ± 11.1	<0.001
Male sex	27,149 (31.4)	8,140 (33.9)	3,225 (36.1)	15,784 (29.4)	<0.001
Race					<0.001
White	38,733 (44.7)	8,892 (37.0)	3,600 (40.3)	26,241 (48.9)	
African American	29,910 (34.5)	7,178 (29.9)	3,903 (43.7)	18,829 (35.1)	
Native American	2,827 (3.3)	968 (4.0)	335 (3.8)	1,524 (2.8)	
Asian	5,587 (6.5)	1,773 (7.4)	336 (3.8)	3,478 (6.5)	
Other	9,531 (11.0)	5,224 (21.7)	753 (8.4)	3,554 (6.6)	
Hispanic	12,595 (14.6)	7,007 (29.2)	932 (10.4)	4,656 (8.7)	<0.001
Education ≤12 y	10,537 (12.2)	5,558 (23.1)	1,788 (20.0)	3,191 (6.0)	<0.001
Smoking (former or current)	32,468 (37.5)	9,497 (39.5)	4,338 (48.6)	18,633 (34.8)	<0.001
CKD stages 1-5	12,998 (15.0)	3,805 (15.8)	1,999 (22.4)	7,194 (3.4)	<0.001
CKD stage					<0.001
None	73,590 (85.0)	20,230 (84.2)	6,928 (77.6)	46,432 (86.6)	
Stages 1-2	7,162 (8.3)	2,357 (9.8)	966 (10.8)	3,839 (7.2)	
Stage 3a	4,417 (5.1)	1,068 (4.4)	686 (7.7)	2,663 (5.0)	
Stage 3b	1,036 (1.2)	255 (1.1)	249 (2.8)	532 (1.0)	
Stages 4-5	383 (0.4)	125 (0.5)	98 (1.1)	160 (0.3)	
ACR ≥30 mg/g	8,548 (9.9)	2,798 (11.7)	1,278 (14.5)	4,472 (8.4)	<0.001
ACR ≥300 mg/g	854 (1.0)	333 (1.4)	161 (1.8)	360 (0.7)	<0.001
BMI (kg/m^2)	30.8 ± 7.2	30.6 ± 7.3	32.5 ± 8.0	30.6 ± 7.0	<0.001
Hypertension[b]	54,775 (63.3)	14,708 (61.2)	6,611 (74.1)	33,456 (62.4)	<0.001
Blood pressure controlled	24,761 (45.2)	6,295 (42.8)	3,409 (51.6)	15,057 (45.0)	<0.001
Diabetes[b]	24,002 (27.7)	6,858 (28.5)	3,702 (41.5)	13,442 (25.1)	<0.001
Blood glucose controlled	5,606 (23.4)	1,745 (25.4)	853 (23.0)	3,008 (22.4)	<0.001
CVD	14,385 (16.6)	3,738 (15.6)	2,584 (29.0)	8,063 (15.0)	<0.001
Last saw a physician					<0.001
Within the past y	70,765 (81.7)	15,866 (66.0)	8,231 (92.2)	46,668 (87.0)	
1-2 y ago	9,439 (10.9)	4,185 (17.4)	441 (4.9)	4,813 (9.0)	
>2 y ago	5,961 (6.9)	3,774 (15.7)	214 (2.4)	1,973 (3.7)	
Missing	423 (0.5)	210 (0.9)	41 (0.5)	172 (0.3)	

Note: Values for categorical variables given as number (percentage); values for continuous variables given as mean ± standard deviation. Data from 2000-2011; includes those with nonmissing values for age, sex, race, ethnicity, health insurance status, CKD, and information about diabetes, hypertension, smoking, education, and BMI.

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

[a]The χ^2 test or *t* test.

[b]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 level ≥126 mg/dL or nonfasting blood glucose level ≥200 mg/dL or hemoglobin A_{1c} level ≥7% in the absence of self-report of medicine use.

were 72% more likely to begin renal replacement therapy than those with private insurance ($P < 0.001$), and those with public insurance were 2.7 times as likely ($P < 0.001$). The association between insurance and ESRD differed by CKD stage. At stage 3b, the risk of renal replacement therapy initiation was 2.9 times as high for participants without insurance as for those with private insurance ($P < 0.001$) and 3.1 times as high for those with public insurance ($P < 0.001$). At stages 4-5, HRs for the no-insurance and public-insurance categories were <1, although not statistically significant. Adjustment for hypertension, diabetes, CVD, BMI, and albuminuria attenuated the strength of association for each category, but the models seem unstable; HRs for albuminuria varied from 7.35 (95% confidence interval [CI], 3.44-15.71)

Table 2. Characteristics of the Population by CKD Stage

	No CKD (eGFR ≥60 & ACR <30)	CKD Stages 1-2 (eGFR ≥60 & ACR ≥30)	CKD Stage 3a (eGFR = 45-59)	CKD Stage 3b (eGFR = 30-44)	CKD Stages 4-5 (eGFR <30)	*P*[a]
No. of participants	73,590	7,162	4,417	1,036	383	
No insurance	20,230 (27.5)	2,357 (32.9)	1,068 (24.2)	255 (24.6)	125 (32.6)	<0.001
Public insurance	6,928 (9.4)	966 (13.5)	686 (15.5)	249 (24.0)	98 (25.5)	
Other insurance	46,432 (63.1)	3,839 (53.6)	2,663 (60.3)	532 (51.4)	160 (41.9)	
Age (y)	47.5 ± 11.4	47.9 ± 11.3	55.8 ± 7.7	56.8 ± 7.3	53.5 ± 9.4	<0.001
Male sex	23,035 (31.3)	2,262 (31.6)	1,402 (31.7)	310 (29.9)	140 (36.7)	0.2
Race						<0.001
White	32,986 (44.8)	2,645 (36.9)	2,404 (54.4)	557 (53.8)	141 (37.0)	
African American	25,187 (34.2)	2,861 (40.0)	1,390 (31.5)	323 (31.2)	149 (38.8)	
Native American	2,296 (3.1)	352 (4.9)	123 (2.8)	36 (3.5)	20 (5.2)	
Asian	4,833 (6.6)	479 (6.7)	191 (4.3)	54 (5.2)	30 (7.8)	
Other	8,288 (11.3)	825 (11.5)	309 (7.0)	66 (6.4)	43 (11.2)	
Hispanic	11,021 (15.0)	1,080 (15.1)	354 (8.0)	83 (8.0)	57 (15.1)	<0.001
Education ≤12 y	8,697 (11.8)	1,101 (15.4)	518 (11.7)	144 (13.9)	77 (20.3)	<0.001
Smoking (former or current)	26,975 (36.7)	2,996 (41.8)	1,845 (41.8)	479 (46.2)	173 (45.1)	<0.001
ACR ≥30 mg/g	0 (0.0)	7,162 (100.0)	753 (18.3)	352 (36.5)	281 (80.1)	<0.001
ACR ≥300 mg/g	0 (0.0)	481 (6.7)	124 (3.0)	100 (10.4)	149 (42.3)	<0.001
BMI (kg/m^2)	30.5 ± 7.1	32.3 ± 8.0	31.8 ± 7.1	33.2 ± 7.7	31.3 ± 6.9	<0.001
Hypertension[b]	43,599 (59.3)	5,952 (83.1)	3,880 (87.8)	975 (94.1)	369 (96.4)	<0.001
Blood pressure controlled	19,504 (44.7)	2,525 (42.4)	2,092 (53.9)	489 (50.2)	151 (40.8)	<0.001
Diabetes[b]	18,458 (25.1)	3,157 (44.1)	1,626 (36.8)	535 (51.6)	226 (58.9)	<0.001
Blood glucose controlled	4,614 (25.0)	505 (16.0)	349 (21.5)	102 (19.1)	36 (15.9)	<0.001
CVD	11,429 (15.5)	1,417 (19.8)	1,065 (24.1)	344 (33.2)	130 (33.9)	<0.001
Last saw a physician						<0.001
Within past y	59,521 (80.9)	5,988 (83.6)	3,929 (89.0)	976 (94.2)	351 (91.6)	
1-2 y ago	8,395 (11.4)	684 (9.6)	310 (7.0)	38 (3.7)	12 (3.1)	
>2 y ago	5,324 (7.2)	446 (6.2)	153 (3.5)	20 (1.9)	18 (4.7)	
Missing	350 (0.5)	44 (0.6)	25 (0.6)	2 (0.2)	2 (0.5)	

Note: Values for categorical variables given as number (percentage); values for continuous variables given as mean ± SD. With nonmissing values for age, sex, race, ethnicity, health insurance status, CKD, and information about diabetes, hypertension, smoking, education, and BMI.

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

[a]The χ^2 or *t* test.

[b]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 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 level ≥126 mg/dL or nonfasting blood glucose level ≥200 mg/dL or hemoglobin A_{1c} level ≥7% in the absence of self-report of medicine use.

to 14.40 (95% CI, 4.49- 46.19) for CKD stages 3a and 4-5, respectively, and reached 36.75 (95% CI, 26.29-51.38) for the overall model (Table 4).

Because the interaction between eGFR and insurance was significant ($P = 0.04$), we did not include eGFR in the overall model as a confounder. In addition, because HRs associated with insurance in the full models could not be calculated for participants with CKD stages 4-5 for the outcome of death and for those with CKD stage 3b for the outcome of ESRD, we focused the discussion on results of models adjusted for only demographic variables.

DISCUSSION

We investigated the effect of not having health insurance on the risk of death and ESRD in KEEP participants younger than 65 years. The major findings are: (1) KEEP participants without insurance are at higher risk of death than participants with private insurance, and (2) KEEP participants without insurance are at higher risk of ESRD than participants with private insurance.

In 2010, a total of 49.9 million people, or 16.3% of the total population, and 49.1 million, or 18.4% of

Table 3. Rates of Death by Health Insurance Status

Stratified by CKD Stage

			CKD Stage			
	Overall	No CKD	1-2	3[a]	3[b]	4-5
No. of participants	86,588	73,590	7,162	4,417	1,036	383
No. of events	1,020	625	196	113	54	32
Person-years	365,730.34	313,589.99	30,302.08	16,927.09	3,569.77	1,333.43
Rate per 1,000 person-years	2.79	1.99	6.47	6.68	15.13	24.00
No insurance	3.17	2.32	6.78	7.37	14.25	23.62
Public insurance	8.10	5.14	16.15	17.04	32.71	37.60
Private insurance	1.88	1.47	4.18	4.13	8.28	18.33
HR[a] (95% CI) unadjusted						
No insurance vs private	1.73 (1.50-2.01)	1.63 (1.36-1.96)	1.66 (1.19-2.33)	1.80 (1.12-2.87)	1.77 (0.84-3.74)	1.36 (0.57-3.25)
Public insurance vs private	4.42 (3.81-5.14)	3.60 (2.94-4.40)	3.97 (2.82-5.59)	4.18 (2.72-6.42)	4.12 (2.21-7.68)	2.20 (0.96-5.04)
HR[b] (95% CI) adjusted for only demographic variables						
No insurance vs private	1.82 (1.56-2.12)	1.68 (1.39-2.04)	1.66 (1.18-2.36)	1.84 (1.13-2.98)	1.91 (0.89-4.10)	1.46 (0.59-3.64)
Public insurance vs private	3.22 (2.76-3.76)	2.58 (2.09-3.18)	3.22 (2.27-4.57)	3.63 (2.34-5.65)	3.43 (1.81-6.50)	1.91 (0.79-4.65)
HR [c,d] (95% CI) adjusted for variables potentially in the causal pathway						
No insurance vs private	1.65 (1.42-1.93)	1.65 (1.37-2.00)	1.59 (1.12-2.25)	1.55 (0.94-2.57)	2.10 (0.88-5.05)	—
Public insurance vs private	2.40 (2.04-2.82)	2.30 (1.86-2.84)	2.74 (1.92-3.91)	2.35 (1.44-3.85)	1.87 (0.89-3.96)	—
HR[d] (95% CI) adjusted for the above variables + eGFR						—
No insurance vs private	1.66 (1.43-1.94)	1.65 (1.36-1.99)	1.60 (1.13-2.26)	1.56 (0.94-2.57)	2.07 (0.86-4.97)	—
Public insurance vs private	2.37 (2.01-2.78)	2.30 (1.86-2.84)	2.73 (1.91-3.90)	2.33 (1.43-3.81)	1.89 (0.89-4.01)	—

Stratified by eGFR

	eGFR ≥60	eGFR = 30-59 (CKD stage 3)	eGFR <30 (CKD stages 4-5)
HR[b] (95% CI) adjusted for only demographic variables			
No insurance vs private	1.76 (1.49-2.08)	1.86 (1.24-2.80)	1.46 (0.59-3.64)
Public insurance vs private	2.89 (2.42-3.45)	3.82 (2.66-5.47)	1.91 (0.79-4.65)

Abbreviations: CI, confidence interval; CKD, chronic kidney disease; eGFR, estimated glomerular filtration rate (in mL/min/1.73 m^2); HR, hazard ratio.

[a]Unadjusted.

[b]Models adjusted for age, sex, race, ethnicity, education, and smoking.

[c]Models adjusted for age, sex, race, ethnicity, education, smoking, hypertension, diabetes, cardiovascular disease, albuminuria, and body mass index.

[d]At CKD stages 4-5, all deaths are in participants with hypertension regardless of whether they had insurance. The HR for hypertension is close to infinity, resulting in an unreliable model.

those younger than 65 years, lacked health insurance in the United States.[14] Hall et al[1] reported that among NHANES participants with CKD defined as ACR ≥30 mg/g or eGFR of 15-60 mL/min/1.73 m^2, 23.3% of those younger than 50 years were uninsured. We found that 27.8% of KEEP participants younger than 65 years and 29.3% of those with CKD lacked health insurance. The percentage of KEEP participants younger than 65 years without health insurance is higher than the percentage of NHANES participants, probably due to KEEP being a voluntary screening program that is appealing to people because it offers a free comprehensive health evaluation and referral services if needed.

Uninsured people in general have less access to preventive services and are more likely to have uncontrolled hypertension and diabetes.[5,15-17] Likewise, uninsured KEEP participants were less likely to have seen a physician in the last year and less likely to achieve target levels of blood pressure than those with insurance. We postulate that physician encounters for KEEP participants may have occurred in the urgent care/emergency department or hospital and not necessarily in the outpatient setting; thus, physician contact may not be a good proxy for preventive care. Interestingly, participants with public insurance were the most likely to achieve blood pressure control, probably related to >90% having seen a physician in the past year.

Table 4. Rates of ESRD by Health Insurance Status

Stratified by CKD Stage

			CKD Stage			
	Overall	No CKD	1-2	3[a]	3[b]	4-5
No. of participants	86,588	73,590	7,162	4,417	1,036	383
No. of events	341	23	65	43	62	148
Person-years	364,858.95	313,533.01	30,177.23	16,833.57	3,426.75	880.41
Rate per 1,000 person-years	0.94	0.07	2.15	2.55	18.09	169.24
No insurance	1.15	0.10	2.38	3.33	26.35	163.40
Public insurance	2.36	0.19	2.93	4.29	28.03	168.26
Private insurance	0.65	0.05	1.86	1.89	10.61	170.99
HR[a] (95% CI) unadjusted						
No insurance vs private	1.77 (1.38-2.27)	2.25 (0.89-5.71)	1.36 (0.79-2.34)	1.80 (0.90-3.62)	2.58 (1.40-4.77)	0.89 (0.61-1.29)
Public insurance vs private	3.62 (2.76-4.74)	4.10 (1.40-12.0)	1.69 (0.85-3.36)	2.34 (1.09-5.00)	2.72 (1.47-5.02)	0.89 (0.59-1.35)
HR[b] (95% CI) adjusted for only demographic variables						
No insurance vs private	1.72 (1.33-2.22)	2.01 (0.75-5.35)	1.29 (0.73-2.26)	1.35 (0.65-2.81)	2.88 (1.55-5.36)	0.89 (0.60-1.33)
Public insurance vs private	2.74 (2.08-3.62)	3.06 (1.01-9.27)	1.45 (0.72-2.92)	1.95 (0.89-4.29)	3.14 (1.67-5.88)	0.91 (0.59-1.40)
HR[c,d] (95% CI) adjusted for variables potentially in the causal pathway						
No insurance vs private	1.15 (0.88-1.51)	1.89 (0.71-5.00)	1.17 (0.67-2.04)	0.87 (0.39-1.94)	—	0.73 (0.47-1.14)
Public insurance vs private	1.54 (1.14-2.07)	2.57 (0.84-7.83)	1.25 (0.62-2.52)	1.41 (0.62-3.19)	—	0.98 (0.62-1.55)

Stratified by eGFR

	eGFR ≥60	eGFR = 30-59 (CKD stage 3)	eGFR <30 (CKD stages 4-5)
HR[b] (95% CI) adjusted for only demographic variables			
No insurance vs private	1.77 (1.09-2.90)	2.09 (1.31-3.35)	0.89 (0.60-1.33)
Public insurance vs private	2.13 (1.18-3.85)	3.10 (1.92-5.00)	0.91 (0.59-1.40)

Abbreviations: CI, confidence interval; CKD, chronic kidney disease; eGFR, estimated glomerular filtration rate (in mL/min/1.73 m^2); ESRD, end-stage renal disease; HR, hazard ratio.

[a]Unadjusted.

[b]Models adjusted for age, sex, race, ethnicity, education, and smoking.

[c]Models adjusted for age, sex, race, ethnicity, education, smoking, hypertension, diabetes, cardiovascular disease, albuminuria, and body mass index.

[d]At CKD stage 3b, all the ESRD outcomes are for participants with hypertension regardless of whether they had insurance. The HR for hypertension is close to infinity, resulting in an unreliable model.

Control of blood glucose levels was low (23.4%) in diabetic KEEP participants, possibly reflecting other factors influencing the self-identified need to attend a KEEP screening. Similar findings were reported from NHANES, but the rate of glycemic control overall was higher in both insured and noninsured participants (~56% and 53%, respectively).[18] In our analysis, blood glucose levels seemed slightly better controlled in participants without insurance, probably because they were younger and may have had diabetes for a shorter time.

Not surprisingly, in participants with public insurance (Medicare for most), the burden of disease (diabetes, hypertension, and CVD) was much higher than in those with private or no insurance. In adults younger than 65 years, Medicare eligibility is conditioned by the presence of disability, most often associated with poor health status.

As expected, crude rates of death increased as kidney function worsened. Our results are similar to those described by Hall et al[19] in a study of CKD in an urban poor community. They found that the mortality rate in patients with CKD stages 3-5 was approximately 17 deaths per 1,000 person-years. Higher mortality rates associated with lack of health insurance have been reported previously.[4,20] Uninsured KEEP participants in our study population overall were 82% more likely to die than participants with private insurance. The adjusted risk of death for uninsured participants was consistently higher regardless of early CKD (stages 1-2), CKD stage 3a, or no CKD than for privately insured participants. The burden of disease in our study population, which includes diabetes, hypertension, and CVD, increases as eGFR decreases, likely decreasing the relative effect of insurance in patients with CKD stages 4-5.

In NHANES, Wilper et al[20] found in participants younger than 65 years that the adjusted risk of death was 40% higher for the uninsured. McWilliams et al[4] reported the same result from an analysis of the HRS. The lower mortality differences in these studies may be due to the inclusion of more confounders in the Cox proportional models, such as drinking status, employment status, exercise, and other. Both studies excluded people with public insurance. As expected, mortality is much higher for KEEP participants with public insurance than for those with private insurance.

Crude rates of ESRD increased as kidney function worsened in our study population. Similar to our results, Hall et al,[19] in their study of CKD in an urban poor community, found that the ESRD rate in patients with CKD stages 3-5 was approximately 10 events per 1,000 person-years. Overall, uninsured KEEP participants in our study population were 72% more likely to develop ESRD than privately insured participants. The adjusted HRs for no insurance versus private insurance were not statistically significant at any CKD stage except stage 3b. This probably is due to the low number of events at early CKD stages, as evidenced by results of the broader stratification by eGFR. Interestingly, the adjusted HRs seemed to decrease at low eGFRs. Possibly, at CKD stages 4-5, participants without insurance delay renal replacement therapy initiation because of poor access to care. Uninsured patients with CKD also are referred to a nephrologist later than insured patients, and the late referral results in higher dialysis morbidity and mortality.[21,22]

Our study has several limitations. The most important is related to the representativeness of the study population. Data were collected through a voluntary screening program and not a random sample survey. Consequently, selection bias possibly may have influenced this analysis because participation may be related to demographic and socioeconomic factors. 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. All analyses were based on the assessment of health insurance status at the first screening. Because few KEEP participants undergo repeated screenings, we were unable to measure the effect of gaining or losing insurance coverage after the first assessment. We tried to mitigate this issue by limiting our population to participants younger than 65 years and by censoring at age 65 years. Although participants were stratified as insured (public and private) and uninsured, we were unable to assess the underinsured, who may report having insurance but have restricted access to care and medications based on the type of insurance, and could contaminate our stratification. Finally, we could not include some known confounders of the association between insurance and death, such as household income, drug and alcohol use, and exercise, because these are not systematically collected in KEEP.

In conclusion, we found that lack of insurance was an independent risk factor for early death and ESRD in adults younger than 65 years at high risk of kidney disease. Considering the high morbidity and mortality and increasing cost associated with ESRD, access to appropriate health insurance coverage is warranted in this high-risk population. A recent study showed that mortality rates decreased in states that expanded Medicaid coverage to the same group as that gaining coverage under the Affordable Care Act.[23] One therefore would hope that uninsured KEEP participants, who represent a high-risk population with a high burden of disease, similarly may benefit from the Affordable Care Act, which should improve access and coverage for scheduled outpatient visits.

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