

Disparities in Electronic Health Record Patient Portal Use in Nephrology Clinics

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Abstract

Background and objectives Electronic health record (EHR) patient portals allow individuals to access their medical information with the intent of patient empowerment. However, little is known about portal use in nephrology patients. We addressed this gap by characterizing adoption of an EHR portal, assessing secular trends, and examining the association of portal adoption and BP control (<140/90 mmHg).

Design, setting, participants, & measurements Patients seen between January 1, 2010, and December 31, 2012, at any of four university-affiliated nephrology offices who had at least one additional nephrology follow-up visit before June 30, 2013, were included. Sociodemographic characteristics, comorbidities, clinical measurements, and office visits were abstracted from the EHR. Neighborhood median household income was obtained from the American Community Survey 2012.

Results Of 2803 patients, 1098 (39%) accessed the portal. Over 87% of users reviewed laboratory results, 85% reviewed their medical information (*e.g.*, medical history), 85% reviewed or altered appointments, 77% reviewed medications, 65% requested medication refills, and 31% requested medical advice from their renal provider. In adjusted models, older age, African-American race (odds ratio [OR], 0.50; 95% confidence interval [95% CI], 0.39 to 0.64), Medicaid status (OR, 0.53; 95% CI, 0.36 to 0.77), and lower neighborhood median household income were associated with not accessing the portal. Portal adoption increased over time (2011 versus 2010: OR, 1.38 [95% CI, 1.09 to 1.75]; 2012 versus 2010: OR, 1.95 [95% CI, 1.44 to 2.64]). Portal adoption was correlated with BP control in patients with a diagnosis of hypertension; however, in the fully adjusted model this was somewhat attenuated and no longer statistically significant (OR, 1.11; 95% CI, 0.99 to 1.24).

Conclusion While portal adoption appears to be increasing, greater attention is needed to understand why vulnerable populations do not access it. Future research should examine barriers to the use of e-health technologies in underserved patients with CKD, interventions to address them, and their potential to improve outcomes.

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Introduction

CKD contributes to substantial morbidity and mortality, particularly among vulnerable populations (1–11). Patient activation (the “knowledge, skills and confidence” needed to actively engage in care) (12) is a critical feature of CKD management, wherein BP self-monitoring, dietary modification, medication adherence, nephrotoxin avoidance, and patient-provider collaboration are essential (13–16). Enabling patients with CKD to easily access their medical information is a novel approach to facilitate patient engagement and activation (17). In other chronic disease settings, empowering patients in this fashion improves disease knowledge, enhances patient-provider communication, and increases adherence to treatment (18–23).

The United States government passed the Health Information Technology for Economic and Clinical Health (HITECH) Act (“meaningful use”) in 2009 to encourage providers to implement electronic health

records (EHRs) and to promote EHR capabilities likely to improve care (24). Stage 1 of meaningful use required that providers offer patients timely electronic access to their health information, while stage 2 mandated that providers allow patients to view, download, and transmit their health information and to securely message their providers electronically (24,25). Many providers have adopted patient portals to accomplish these objectives (26). Portals are personalized health record applications tethered to a provider’s EHR. Most portals allow patients to review problem lists, laboratory results, and medications; schedule appointments; request prescription refills; and securely message their providers, thereby facilitating self-monitoring, self-care, and communication (17,20–23,27). However, differences in Internet access (*i.e.*, the digital divide), computer literacy and Internet proficiency, as well as patient attitudes may limit portal adoption (28–31).

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Few data characterize the use of EHR portals in nephrology patients. We sought to address this gap by examining portal use, including secular trends, in university-affiliated general nephrology clinics. Given previous literature indicating that underserved groups are less likely to use EHR portals (32–36), we hypothesized that race, neighborhood median household income, and insurance status would be associated with portal use and of particular concern in view of documented CKD disparities in these groups (1–11). In addition, we believed that BP control, a key modifiable outcome that affects CKD progression, would depend on patient adherence, self-monitoring, and patient-provider communication. Thus, we hypothesized that portal adoption would be independently associated with BP control in patients with a diagnosis of hypertension.

Materials and Methods

Portal Implementation

Four university-affiliated nephrology offices in western Pennsylvania with 24 attending providers activated a free patient portal tethered to an existing ambulatory EHR (Epic, Verona, WI) in May 2009. Office staff members routinely invited patients to sign up for the portal during the check-in process and provided access codes and instructions to interested individuals. Fliers and pamphlets written at a fifth- to sixth-grade level advertising the patient portal were displayed. After obtaining an access code, individuals had to go online and follow the short instructions to set up their secure account.

Study Setting and Design

We examined a retrospective cohort of outpatients followed at four general nephrology clinics from January 1, 2010, to December 31, 2012. We excluded the initial 7-month period after portal rollout to ensure familiarity with the portal and resolution of any difficulties encountered during rollout. Patient eligibility criteria were age ≥ 18 years, one nephrology office visit between January 1, 2010, and December 31, 2012, and at least one additional office visit before June 30, 2013, to ensure nephrologist continuity. The additional 6-month window ensured adequate follow up opportunities for patients first seen near the end of 2012. The University of Pittsburgh institutional review board approved this study.

Portal Use

Portal adoption was defined as one or more logins after the first renal office visit within the cohort period. Portal use was characterized by abstracting electronic patient activity logs and categorizing actions into the following bins: appointment-related tasks (*i.e.*, reviewing, canceling, confirming, or scheduling appointments), medical information-related tasks (*i.e.*, reviewing the problem list, allergies, family and social history, immunizations, health maintenance schedule, vital signs, or health snapshot which incorporates several of these separate fields), laboratory-related tasks (*i.e.*, reviewing laboratory results or upcoming orders), medication-related tasks (*i.e.*, reviewing the medication list or requesting prescription refills), and requests

for medical advice *via* secure messaging. Patients could perform more than one task per session and could complete multiple distinct activities within a single category during the same session (*e.g.*, reviewing prior laboratory results and upcoming laboratory tests during a single session constituted two laboratory-related tasks). The portal sent alerts to a patient's email address when new information or test results became available from any university-affiliated provider. Because tests related to a single visit often result over several days, patients may receive multiple alerts for a single set of tests. Alerts were also sent 1 week before scheduled appointments with an affiliated provider.

Covariates

As previously described (37,38), we abstracted sociodemographic characteristics, comorbidities, clinical measurements, laboratory values, and outpatient visit dates from the EHR for the cohort period. Briefly, race was self-reported and categorized as white, black, or other. Because of a limited number of nonwhite, nonblack patients, we dichotomized race as black or nonblack. Insurance status was categorized as private, Medicare, medical assistance/Medicaid, or self-pay. Comorbidities were determined on the basis of their presence on the patient's problem list, as a billing diagnosis on two outpatient encounters, or active use of a specified medication (Supplemental Table 1) (7,37,39–47). The university-affiliated health system mandates that providers enter all prescriptions electronically and maintain an up-to-date medication list. Comorbidities were used to calculate a Charlson comorbidity index (CCI) score (48). Neighborhood median household income was obtained by linking residential ZIP codes (excluding post office boxes) to the American Community Survey 2012 (49).

CKD stage was categorized according to the National Kidney Foundation's 2002 staging system (50). The four-variable Modification of Diet in Renal Disease study equation, which was used by local laboratories, was applied to determine baseline eGFR (51,52). Baseline urine dipsticks (performed routinely at each site with each office visit) were used to categorize albuminuria, with values $\geq 1+$ deemed positive (7). Baseline values were defined as the earliest available value concurrent with or after a nephrology office visit within the cohort period. In most patients, these values were from the day of the office visit.

Nephrology and non-nephrology outpatient visits (within the university system) were abstracted from the EHR. Because a primary care provider (PCP) within the university setting could affect portal use, this was also included as a covariate.

BP Control

The association between BP control and portal use was examined in patients with a baseline diagnosis of hypertension (HTN). HTN was identified on the basis of two outpatient billing diagnoses, a problem list diagnosis, or the use of an antihypertensive medication (37–39,41–44). For patients with a diagnosis of HTN, all recorded office BP values from the cohort period were abstracted from the EHR. Clinic protocols require staff to record a seated BP

upon placing the patient in an examination room. These are overwhelmingly automated cuff readings. If two BP values were recorded on the same day, the mean value was used as the BP for that day. Because optimal BP values in CKD remain controversial (53,54), the less restrictive goal of <140/90 mmHg was used. This ensured a BP goal that all providers could be expected to target.

Statistical Analyses

Sociodemographic characteristics, comorbidities, clinical measurements, and laboratory values were described using standard descriptive statistics. Continuous variables were compared using the Wilcoxon rank-sum test and categorical variables were compared using the chi-square test.

Logistic regression was used to assess the independent association between sociodemographic and clinical factors and portal use. Covariates for adjustment were chosen according to clinical significance and possible effect on portal adoption (1,3–8,10,11,13–15,29,31,33,34,36,54–63). Sociodemographic variables were age, sex, race, marital status, insurance status, neighborhood median household income, tobacco use, and follow-up duration. Clinical factors were HTN, hyperlipidemia, nephrolithiasis, history of kidney transplant, CCI, proteinuria, eGFR, number of nephrology visits, number of non-nephrology visits, and presence of a university-affiliated PCP. Neighborhood median household income and length of follow-up were non-normally distributed and natural log transformed. Age, number of nephrology visits, and number of non-nephrology visits were included in the model as nonlinear terms using restricted cubic splines with knots.

Temporal trends were assessed using logistic regression to examine the association between year of cohort entry and portal use while adjusting for sociodemographic and clinical variables. In addition, interactions between age, race, or insurance status and year of entry were examined to determine whether these variables modified temporal trends.

Mixed-effects logistic regression models were used to assess the independent association of portal adoption and BP control. This approach used repeated BP measures collected over time while using a clinically meaningful BP outcome (above or below the clinical target). This was done by dichotomizing each follow-up BP value for each patient as controlled (*i.e.*, <140/90 mmHg) or uncontrolled. Most patients had multiple follow-up BPs and contributed controlled and uncontrolled BPs to the analysis. The model adjusted for correlated data (due to repeated BP measures by patient), the baseline systolic and diastolic BP value, baseline covariates, provider visits, and follow-up time. Age, number of nephrology visits, and number of non-nephrology visits were included in the model as nonlinear terms using restricted cubic splines with knots. Interaction terms between portal use and age, race, marital status, neighborhood median household income, and insurance status were also tested in the fully adjusted model.

Sensitivity analyses replaced the CCI with its individual components and excluded kidney transplant patients. All analyses used two-sided *P* values <0.05 for significance. Analyses were performed using R software, version 3.1.2 (64).

Results

Nearly 40% of patients used the EHR portal (Table 1). Portal users were younger and were more likely to be non-black, to be married, to have private insurance, and to have higher neighborhood median household income. Users were less likely to have diabetes, coronary artery disease, or congestive heart failure but were more likely to have had a kidney transplant.

Portal users logged in a median of 18 times per year, and most completed a variety of tasks *via* the portal (Table 2). For example, 77% of users reviewed their medications, 65% requested medication refills, and 87% reviewed their laboratory results or upcoming laboratory orders, and patients performed these activities repeatedly (Table 2). Requests for medical advice were less common; 416 (38%) users submitted a request for medical advice to a provider within the health system, including 342 (31%) users who submitted a request to their renal provider. Patients requested medical advice from their providers relatively infrequently (Table 2). The median number of medical advice requests directed to a nephrology provider was two per patient (Figure 1).

In the multivariable fully adjusted analyses, older age, black race, unmarried status, Medicaid or Medicare insurance (versus private), and lower neighborhood median household income were associated with not using the portal (Figure 2 and Supplemental Table 2). The observed associations were minimally affected by adjustments for confounders (Table 3). A general odds ratio (OR) and 95% confidence interval (95% CI) could not be provided for age and neighborhood median household income (because of nonlinear effects or the need for natural log transformation, respectively); the influence of these variables is depicted in Figure 3. In sensitivity analyses, excluding kidney transplant recipients or replacing the CCI with its components did not qualitatively alter the findings.

In adjusted models examining for secular trends, portal adoption increased in more recent years (2011 versus 2010: OR, 1.38 [95% CI, 1.09 to 1.75]; 2012 versus 2010: OR, 1.95 [95% CI, 1.44 to 2.64]). This effect did not vary by age, race, or insurance status (data not shown). In analyses stratified by year, disparities in portal adoption by age, race, and insurance status were qualitatively unchanged (data not shown).

To examine the potential health effect of portal use, we examined the association with BP control during the cohort period. We excluded patients without a baseline diagnosis of HTN (*n*=316) or who had only a single BP measurement during the cohort period (*n*=14). This left 2473 patients (88% of the cohort) with 38,420 available BP measurements. Patients had a median of 6 BP readings (interquartile range, 3–12). More portal users had BP values available for analysis, especially at longer follow-up intervals (Supplemental Table 3). In general, portal users had a modestly larger number of BP measurements during the study (Supplemental Table 4). Approximately 35% of all BP values were ≥140/90 mmHg; 2075 (84%) patients had at least one BP value ≥140/90 mmHg, while 2342 (94%) patients had at least one BP value <140/90 mmHg. The median of the proportion of patient BP values that were at goal over time is shown in Supplemental Figure 1. Portal use was independently associated with BP control (OR, 1.15; 95% CI,

Table 1. Baseline characteristics				
Characteristic	Overall cohort	Portal user	Nonuser	P Value ^d
Patients, <i>n</i> (%)	2803	1098 (39)	1705 (61)	
Age (yr)	61±17	58±16	63±18	<0.001
Women	1387 (49)	549 (50)	838 (49)	0.66
Race				
White	2200 (78)	952 (87)	1248 (73)	<0.001
Black	519 (19)	114 (10)	405 (24)	
Other	84 (3)	32 (3)	52 (3)	
Married	1512 (54)	688 (63)	824 (48)	<0.001
Insurance				<0.001
Private	1309 (47)	625 (57)	684 (40)	
Medicaid	201 (7)	51 (5)	150 (9)	
Medicare	1108 (40)	361 (33)	747 (44)	
Self-pay/uninsured	185 (7)	61 (6)	124 (7)	
Median household income (\$1000)	46.8 (38.7–58.3)	48.7 (39.7–63.2)	45.6 (37.6–55.6)	<0.001
Diabetes mellitus	1101 (39)	395 (36)	706 (41)	0.004
Hypertension	2487 (89)	977 (89)	1510 (89)	0.73
Hyperlipidemia	1730 (62)	706 (64)	1024 (60)	0.02
Coronary artery disease	623 (22)	217 (20)	406 (24)	0.01
Congestive heart failure	342 (12)	99 (9)	243 (14)	<0.001
Cerebrovascular disease	715 (26)	299 (27)	416 (24)	0.09
Peripheral vascular disease	358 (13)	134 (12)	224 (13)	0.46
Tobacco use	450 (16)	131 (12)	319 (19)	<0.001
CKD stage^a				0.006
Preserved eGFR/no proteinuria	331 (12)	151 (14)	180 (11)	
1 and 2	320 (12)	137 (13)	183 (11)	
3a	665 (24)	280 (26)	385 (23)	
3b	750 (27)	291 (27)	459 (28)	
4	499 (18)	168 (15)	331 (20)	
5 (non-dialysis-dependent)	155 (6)	54 (5)	101 (6)	
Kidney transplant	376 (13)	211 (19)	165 (10)	<0.001
Nephrolithiasis	300 (11)	137 (12)	163 (10)	0.02
Charlson comorbidity index	5.7±2.3	5.6±2.3	5.7±2.3	0.25
Systolic BP (mmHg)	129 (118–142)	128 (118–140)	130 (120–142)	0.002
Diastolic BP (mmHg)	76 (68–82)	77 (70–84)	75 (68–82)	0.02
Serum creatinine ^b (mg/dl)	1.5 (1.1–2.0)	1.4 (1.0–1.9)	1.5 (1.1–2.1)	<0.001
eGFR ^b (ml/min per 1.73 m ²)	44 (30–62)	47 (32–66)	42 (29–60)	<0.001
Dipstick proteinuria (≥1+) ^c	1032 (37)	362 (33)	670 (39)	<0.001
Median follow-up duration (yr)	2.3 (1.2–3.3)	2.7 (1.5–3.3)	2.1 (1.1–3.2)	<0.001
Nephrology office visits/yr	2.9 (1.8–5.2)	2.7 (1.8–4.3)	3.1 (1.9–5.8)	<0.001
University-affiliated PCP	1375 (49)	623 (57)	752 (44)	<0.001
Outpatient visits with a university-affiliated provider (excluding nephrology)	9 (3–19)	11 (4–23)	8 (2–17)	<0.001
Baseline ACEi/ARB use	1161 (41)	462 (42)	699 (41)	0.57

Continuous variables are presented as means±SDs or medians and interquartile ranges. Categorical variables are expressed as frequencies and percentages. ACEi/ARB, angiotensin-converting enzyme inhibitor/angiotensin receptor blocker.

^a*n*=2720. When CKD staging could not be performed because of missing eGFR/dipstick, International Classification of Diseases, Ninth Revision, billing codes were used to categorize CKD stage if available.

^b*n*=2668.

^c*n*=2742.

^dChi-square or Wilcoxon-Mann-Whitney test used as appropriate.

1.02 to 1.29) after adjustment for age, sex, race, marital status, insurance status, neighborhood median household income, tobacco use, follow-up duration, and baseline systolic and diastolic BP. In the fully adjusted model (also controlling for hyperlipidemia, nephrolithiasis, history of kidney transplant, CCI, proteinuria, eGFR, number of nephrology and outpatient visits, and university-affiliated PCP), the association was somewhat attenuated (OR, 1.11; 95% CI, 0.99 to 1.24) and no longer significant. The

association did not vary by age, race, marital status, insurance status, or neighborhood median household income (data not shown). In sensitivity analyses, excluding kidney transplant recipients from the fully adjusted model resulted in a borderline significant association between portal use and BP control (OR, 1.14; 95% CI, 1.00 to 1.29; *P*=0.05). Replacing the CCI with its components did not meaningfully affect the results (data not shown).

Task	Users Who Performed Task, n (%)	Rate of Task Performance per Year ^a
Login	1098 (100)	18.1 (4.4–45.9)
Appointment related	928 (85)	8.1 (2.6–22.8)
Medical information related	934 (85)	4.0 (1.0–25.0)
Laboratory related	957 (87)	21.7 (7.3–51.3)
Medication related	896 (82)	3.6 (1.2–8.2)
Request for medical advice (any provider)	416 (38)	1.8 (0.76–5.3)

Data restricted to portal users.
^aData are expressed as median (interquartile range).

Discussion

Less than half of patients seen in four general nephrology clinics used the EHR-tethered patient portal. Most users accessed the portal many times and completed several tasks, suggesting that they found the portal convenient for reviewing their information and navigating the healthcare system. Although portal adoption increased across all groups in later cohort years, vulnerable groups were still less likely to use the patient portal. For example, Medicaid patients had 47% lower odds (versus the privately insured), blacks had 50% lower odds (versus nonblacks), and 80-year-old patients had 71% lower odds (versus 40-year-old patients) of portal use. In addition, portal adoption showed a borderline association with BP control in patients with HTN.

Although our study confirms significant portal adoption, underserved populations were often left behind. These findings comport with earlier studies in non-nephrology settings (32–36). While the increase in portal adoption across groups in more recent years suggests progress, the continued differences in portal adoption among nephrology patients are disquieting because socioeconomic and racial disparities in CKD outcomes are well

documented (1–11). Disparities in the use of patient portals and emerging e-health technologies may reinforce or widen extant disparities. Our results are also notable because they represent a contemporary cohort (2010–2012) that coincides with a decline in the digital divide (57,61).

These findings highlight the need to ensure adequate resource allocation by health systems and government organizations to allow vulnerable populations to benefit from patient portals and other novel e-health applications. Unfortunately, our study design precluded an assessment of potential barriers and facilitators to portal use. However, determinants of portal adoption are likely to include patient comfort and proficiency with use of the Internet, experiences with Internet applications, available features, anticipated benefits, provider enthusiasm, patient engagement/activation, health literacy, communication preferences, and trust in the provider and health system (18,28,33–35,55,58,62,65,66). By anticipating digital deficiencies in older adults and underserved populations, healthcare organizations can develop onsite and remote training activities to enhance uptake of these new technologies (18,21,67–69). Organizations should also consider developing freely available, user-friendly applications that extend

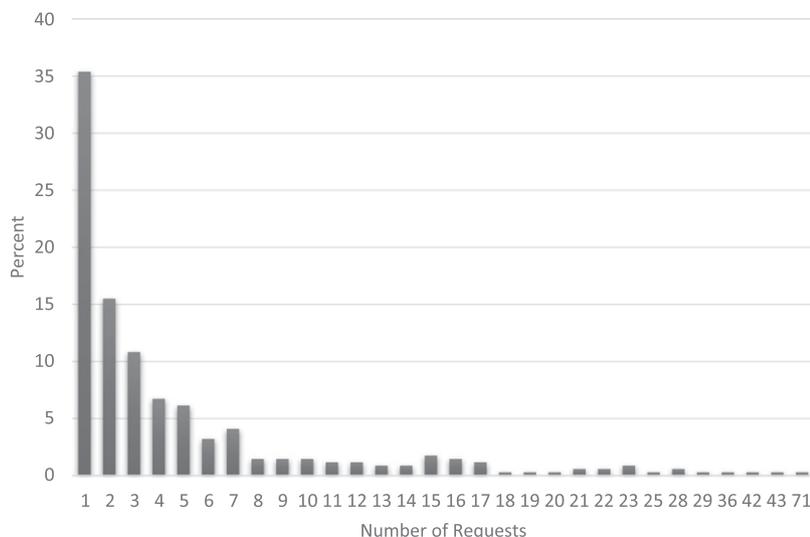


Figure 1. | Frequency of medical advice requests to renal providers over median follow-up of 2.5 years.

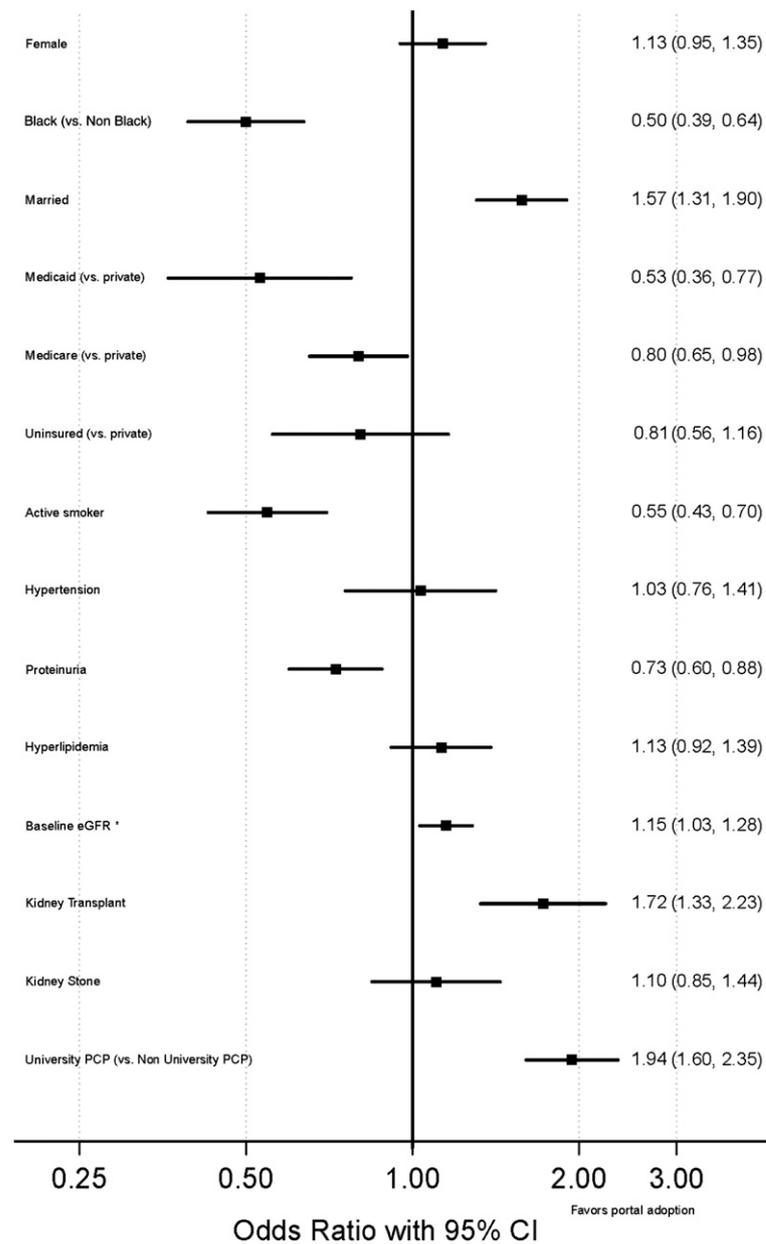


Figure 2. | Odds of portal use in fully adjusted model. Proteinuria defined as $\geq 1+$ on dipstick. Model also adjusts for age, neighborhood median household income, Charlson comorbidity index, number of nephrology visits, and duration of follow-up. Because of nonlinear effects or log transformation, a generalized odds ratio cannot be provided for these variables. 95% CI, 95% confidence interval; PCP, primary care provider. *per 30 ml/min per 1.73 m² increase.

access to smartphones early in the rollout period. Frequently, these devices are the primary source of internet access for underserved communities (63). Because portal users frequently reviewed their laboratory results and medical information, studies are needed to understand how to tailor the information provided to optimize patient comprehension, especially in the setting of limited health literacy. In addition, research is needed to understand the features that nonadopters perceive as most beneficial (58,66). Such information could inform targeted marketing efforts and may help ensure more equitable use of portals or other e-health technologies.

Using patient portals to access one's medical information improves disease knowledge, adherence, and self-efficacy; patient-provider communication; and coordination of care (18–22,60,70,71). These benefits are key aspects of the chronic care model and are critical to the long-term management of CKD (13,16,72,73). Portals may be particularly valuable in complex, chronic disease states, for which they offer patients the opportunity to review medications, laboratory results, and clinical guidance repeatedly and at their convenience (23,74). The ability to query providers and receive written responses may be similarly helpful.

Table 3. Factors independently associated with electronic health record portal use

Variable	OR (95% CI)		
	A	B	C
Age ^a (80 yr versus 40 yr)	0.35 (0.28 to 0.44)	0.29 (0.22 to 0.38)	0.29 (0.21 to 0.38)
Sex (female versus male)	1.14 (0.97 to 1.35)	1.13 (0.94 to 1.34)	1.13 (0.95 to 1.35)
Black versus nonblack	0.52 (0.42 to 0.66)	0.50 (0.39 to 0.64)	0.50 (0.39 to 0.64)
Marital status (married versus unmarried)	1.50 (1.26 to 1.80)	1.57 (1.30 to 1.89)	1.57 (1.31 to 1.90)
Insurance status			
Medicaid versus private	0.56 (0.39 to 0.81)	0.53 (0.36 to 0.77)	0.53 (0.36 to 0.77)
Medicare versus private	0.79 (0.65 to 0.96)	0.80 (0.65 to 0.98)	0.80 (0.65 to 0.98)
Self-pay versus private	0.76 (0.54 to 1.09)	0.81 (0.56 to 1.16)	0.81 (0.56 to 1.16)
Median household income (per \$40,000 versus \$20,000) ^b	1.57 (1.30 to 1.90)	1.53 (1.26 to 1.86)	1.53 (1.26 to 1.86)

Model A: adjusted for age, sex, race, marital status, insurance status, neighborhood median household income, tobacco use, and length of follow-up; model B: variables for model A as well as hypertension, hyperlipidemia, nephrolithiasis, history of kidney transplant, proteinuria, eGFR, number of nephrology visits, number of non-nephrology outpatient visits, and university-affiliated primary care provider; model C: variables for models A and B as well as Charlson comorbidity index. OR, odds ratio; 95% CI, 95% confidence interval.

^aThe reported odds ratio is comparison specific because of nonlinear effects.

^bThe reported odds ratio is comparison specific because of natural logarithmic transformation.

Our study revealed a borderline association between BP control and portal use. This may have been facilitated by improvements in self-monitoring, patient-provider communication, refilling medications, or adherence to lifestyle modifications and antihypertensive medications. Prior studies examining the effect of patient portals on BP have yielded mixed results. A small randomized controlled trial that examined a diabetes patient portal with recommendations that were shared with providers demonstrated that individuals in the portal group were more likely to have an antihypertensive medication initiated or adjusted (59). Yet, the difference in BP between groups was not significant (59). Another small randomized controlled trial examining EHR portals in primary care patients with HTN found no change in BPs; however, only 50% of individuals in the intervention group used the portal at least once (62). Because portal use may itself serve as a marker of patient

engagement, additional studies are needed to confirm our findings and to explore other potential health benefits in a nephrology setting. For example, portals can be modified to include CKD educational information (17,75), medication safety checks in the setting of impaired renal function (76), dietary guidance (77), and checklists and reminders regarding kidney transplant evaluation (17). Randomized controlled trials are needed to overcome potential confounding due to patient-level variables (*e.g.*, health literacy, patient activation) that we could not discern.

Two common and related provider concerns regarding portal implementation are the lack of remuneration for time spent and the potential for patient “abuse” (19,78). Although we did not assess the provider burden, the patterns of use suggest that the overwhelming majority of patients are judicious in messaging providers. These findings complement surveys suggesting that providers

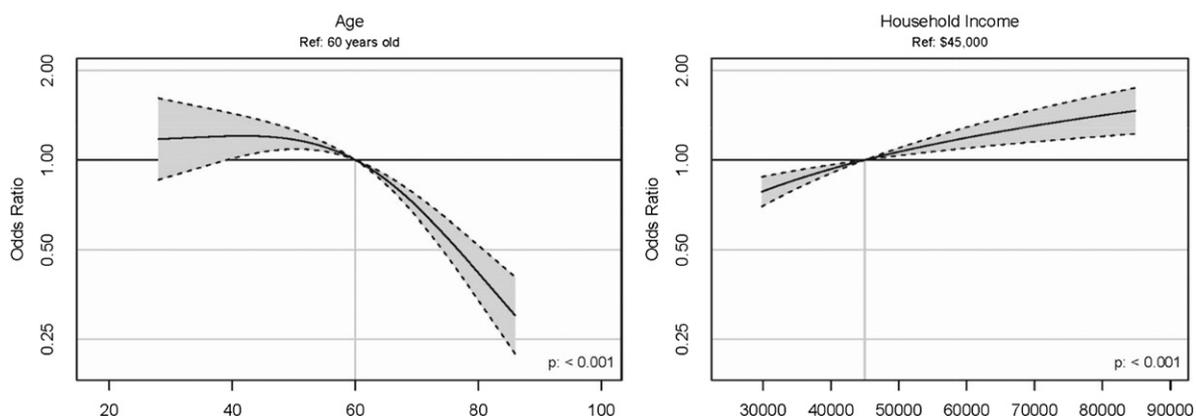


Figure 3. | Association of age and neighborhood median household income with portal use in fully adjusted model. Because of nonlinear effects, age incorporates restricted cubic splines and knots. Solid line and shaded region depict point estimate and 95% confidence interval, respectively.

perceive little change in workload following portal implementation (78,79).

Our findings should be interpreted in light of a few limitations. First, our study design is susceptible to residual confounding (e.g., cognitive deficits, patient activation) and ascertainment bias (e.g., less frequent BP measurements in poorly adherent patients). Second, for most portal functions, we could not determine whether the patient was performing tasks related to their CKD or other health conditions (e.g., diabetes mellitus, HTN). However, we believe CKD self-care should be viewed in the patient-centered context of health self-care. Indeed, patients with CKD frequently have multiple comorbidities that are risk factors for or complications of kidney disease. Third, variables recorded in the EHR, including BP, may be misclassified. However, a prior study demonstrated reasonable agreement between EHR-recorded and research visit BP values (80) and misclassification would be expected to bias toward the null. Fourth, we did not examine whether portal use affected more salient clinical outcomes such as progression to ESRD. Finally, this was a single-center study limiting generalizability. Larger, longer studies with additional clinical outcomes are necessary to delineate the potential benefits of patient portals in a nephrology setting.

In conclusion, nearly 40% of nephrology patients used an EHR portal to perform a variety of tasks, including to schedule appointments, review laboratory results, refill medications, and send a message their renal provider. Portal adoption increased over time in all groups; however, vulnerable groups were substantially less likely to use the portal. These differences in adoption raise concerns of widening disparities in CKD outcomes.

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Disclosures

None.

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