Physician and Patient Tools to Improve Chronic Kidney Disease Care

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ABSTRACT

OBJECTIVES: To determine if electronic health record (EHR) tools and patient engagement can improve the quality of chronic kidney disease (CKD) care.

STUDY DESIGN: Randomized controlled trial.

METHODS: We enrolled 153 primary care physicians caring for 3947 high-risk and 3744 low-risk patients with stage III CKD across 13 ambulatory health centers in eastern Massachusetts. Intervention physicians received a set of electronic alerts during office visits recommending risk-appropriate CKD care. Patients of intervention physicians also received tailored educational mailings. For high-risk patients, we assessed for a visit with a nephrologist and prescription of an angiotensin-converting enzyme (ACE) inhibitor or angiotensin receptor blocker (ARB) during the 12-month study period. For low-risk patients, we assessed for a urine microalbumin screening and prescription of an ACE inhibitor or ARB during the 12-month study period.

RESULTS: Among high-risk patients, those in the intervention arm were significantly more likely to have an office visit with a nephrologist compared with those in the control arm (45% vs 34%; P <.001). Among low-risk patients, those in the intervention arm were significantly more likely than those in the control arm to have received urine microalbumin testing (45% vs 21%; P <.001). There was no difference between the intervention and control arms in rates of prescription of an ACE inhibitor or ARB in either the high-risk patient group (76% vs 79%; P = .17) or the low-risk patient group (64% vs 65%; P = .57).

CONCLUSIONS: A combined program of EHR tools and patient engagement improved some areas of CKD care, but substantial gaps remain.

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Chronic kidney disease (CKD) affects more than 25 million Americans, or more than 10% of the adult population.[1] Effective management of moderate-stage CKD is needed to reduce the high mortality rates and extensive costs associated with progression to more advanced kidney failure.[2-7]

Many challenges exist to improving care for CKD,[8,9] which remains a frequently unrecognized condition by both primary care physicians (PCPs)[10-14] and their patients.[1,15-17] Just 12% of patients with stage III or IV CKD are aware of their diagnosis, and just 63% of PCPs can correctly identify the presence of CKD.[18] However, monitoring for disease progression, using appropriate medications, and involving nephrologists early can improve CKD outcomes.[19]

This highlights the need for healthcare systems to develop a systematic approach to treating this condition that supports primary care providers and nephrologists.[7] Electronic health records (EHRs) present an opportunity to deliver appropriate care by identifying patients with CKD, stratifying the patient population, and facilitating tailored treatment and care coordination among patients, primary care, and nephrology.[20] We conducted a randomized controlled trial to assess the impact of a comprehensive set of EHR tools and patient engagement materials to improve the management of CKD.

METHODS

Study Design

This 18-month trial was conducted from 2011 to 2013, with patient enrollment occurring during the initial 6 months and all patients followed for 12 months after enrollment. We randomly assigned PCPs to receive alerts within the EHR during office visits for patients with CKD and mailed educational materials to patients of physicians in the intervention arm. The Human Studies Committee at Brigham and Women's Hospital approved the study protocol, and a waiver of informed consent was approved for physicians and patients. The trial was registered at ClinicialTrials.gov (ID NCT01203813).

TAKEAWAY POINTS

We randomized 153 primary care physicians caring for nearly 8000 patients with chronic kidney disease (CKD) to receive an intervention that combined electronic decision support tools, patient engagement materials, and collaboration between primary care and nephrology.

- Awareness of CKD is low among patients and physicians.
- The intervention was favorably received by physicians and patients.
- We improved some measures of CKD care.
- We developed a practical population-based approach to assist accountable care organizations that are seeking to engage collaboration between primary care and specialty care to improve the quality of CKD care.

Study Population

We conducted our study at Harvard Vanguard Medical Associates, an integrated multispecialty group practice in eastern Massachusetts caring for approximately 300,000 adult patients. The system has significant experience in population health management, such as participation as a Pioneer Accountable Care Organization. The practices use a common EHR (Epic Systems; Verona, Wisconsin) that captures clinical notes, electronic diagnosis codes, specialty referrals, medication prescriptions, and laboratory test results. This system has delivered automated reporting of estimated glomerular filtration rate (eGFR), computed using the Modification of Diet in Renal Disease (MDRD) Study equation. The EHR does not provide decision support for patients with CKD. Nephrology services are provided by 8 nephrologists employed by the group practice.

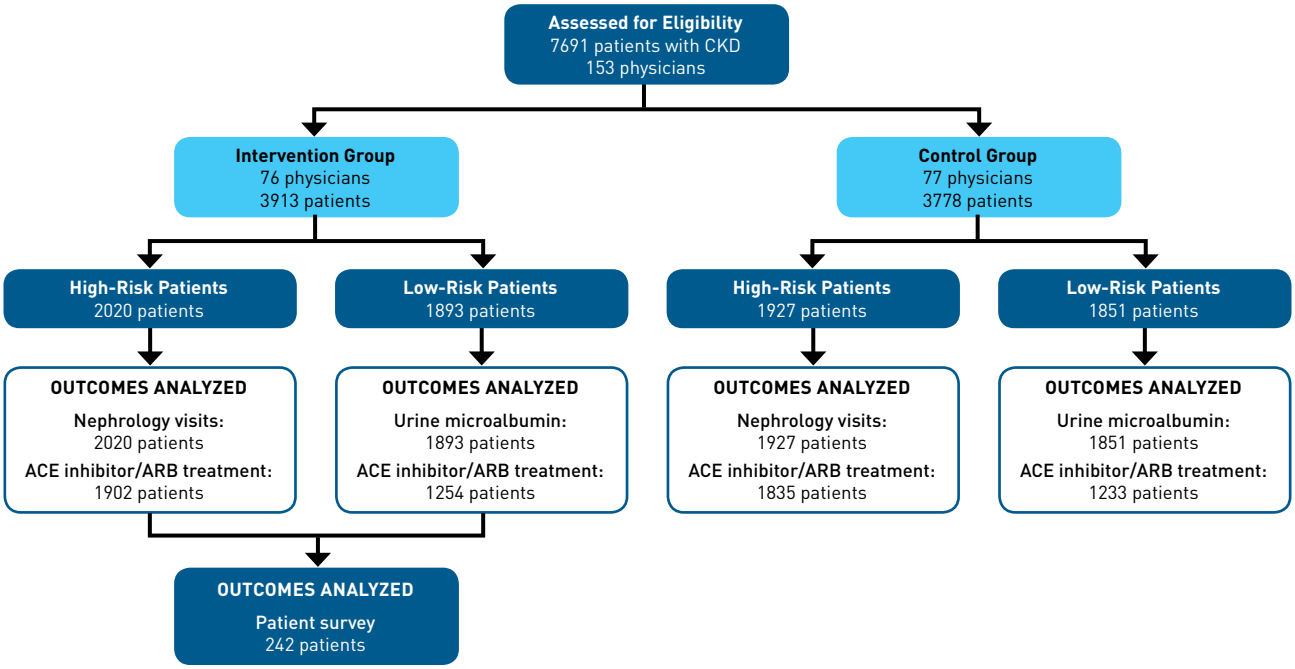
We enrolled 153 physicians across 13 health centers and 7691 patients aged 18 to 80 years with an established diagnosis of stage III CKD (**Figure**). The diagnosis was based on meeting each of the following criteria: 1) the presence of an office visit with a PCP within the group practice within the prior 18 months, 2) the presence of at least 2 eGFR results between 30 and 60 mL/min/1.73m^2 within the prior 5 years, 3) the qualifying abnormal eGFR results were separated by at least 90 days, and 4) the most recent eGFR was less than 60 mL/min/1.73m^2.

Randomization and Interventions

The intervention was randomized at the individual physician level. Within each health center, we paired clinicians based on their number of eligible patients with CKD and then randomly assigned 1 physician in each pair to the intervention arm.

Based on local consensus and emerging data on the importance of both eGFR and albuminuria,[21] we stratified patients with stage III CKD according to their risk of complications and identified relevant treatment targets. Our local consensus was achieved prior to the publication of recent guidelines by the Kidney Disease: Improving

FIGURE. CONSORT Diagram of Patient and Physician Eligibility and Randomization



ACE indicates angiotensin-converting enzyme; ARB, angiotensin receptor blocker; CKD, chronic kidney disease.

Global Outcomes (KDIGO) initiative[7] and involved gathering input from both primary care and nephrology leadership within our multispecialty group practice using current data on predictors of mortality for patients with CKD. "High-risk" patients were defined as those with either 1) at least 1 eGFR of less than 45 mL/min/1.73m^2 in the prior 5 years or 2) at least 1 eGFR of at least 45 mL/min/1.73m^2 but less than 60 mL/min/1.73m^2, in combination with the presence of diabetes or albuminuria (urine microalbumin >30 mcg/mg or spot protein to creatinine ratio >0.15 mcg/mg). All other patients—specifically, those with an eGFR of at least 45 mL/min/1.73m^2 but less than 60 mL/min/1.73m^2 and no history of diabetes or albuminuria—were considered "low-risk". We identified our treatment targets using the same process, and for high-risk patients, we recommended use of an angiotensin-converting enzyme (ACE) inhibitor or angiotensin receptor blocker (ARB), as well as referral to a nephrologist. For low-risk patients, we recommended use of an ACE inhibitor or ARB, as well as annual monitoring of urine microalbumin to assess for disease progression and risk stratification.

All EHR alerts were displayed when physicians accessed the electronic ordering module of the patient chart. During office visits with high-risk patients, PCPs received up to 2 alerts. The first alert recommended a referral to a nephrologist if no such specialty office visit had occurred in the prior 12 months (**eAppendix A** [eAppendices available at **ajmc.com**]). The second alert recommended prescription of an ACE inhibitor or ARB if the patient carried a diagnosis of hypertension or albuminuria, had not been prescribed the medication in the last 12 months, and had no documented allergy to such medication.

During office visits with low-risk patients, PCPs received up to 2 alerts. The first was the same ACE inhibitor alert used for high-risk patients. The second recommended overdue annual laboratory tests, including those for urine microalbumin, serum creatinine, low-density lipoprotein (LDL) cholesterol, 25-hydroxy (OH) vitamin D, parathyroid hormone, calcium, phosphorus, and hemoglobin.

Our intervention included a mailed outreach program to promote patient engagement. We encouraged PCPs in the intervention arm to enroll patients using 2 strategies. First, all electronic reminders also prompted physicians to enroll patients in the mailed outreach program (**eAppendix B**). Second, for those physicians who did not respond to the request to enroll a patient via the electronic alert, we sent a follow-up postcard within 1 month of the office visit requesting them to enroll the patient. We required physicians to enroll patients to ensure that patients received a diagnosis of CKD from their care team prior to receiving any mailings.

The outreach program consisted of quarterly mailings to patients that provided tailored treatment recommendations based on detailed extracts from their EHR. The mailings were based on educational materials developed by the National Kidney Disease Education Program (**eAppendix C**).[22] These mailings provided recommendations specific to CKD for managing blood pressure, appropriate use of ACE inhibitors or ARBs, education on current medications, and recommendations for overdue laboratory tests or follow-ups on previously abnormal results.

Physicians in the control group received no EHR alerts, and their patients were not eligible to receive the mailed outreach program.

Outcomes and Follow-Up

The primary study end points were based in part on the KDIGO guidelines and extracted from the EHR. Among high-risk patients, the primary end points included an office visit to a nephrologist during the 12-month study period and the prescription of an ACE inhibitor or ARB during the 12-month study period for those with hypertension and/or microalbuminuria and no documented allergy. The primary study end points among low-risk patients included the presence of a urine protein test during the 12-month study period and the prescription of an ACE inhibitor or ARB for those with hypertension and/or microalbuminuria and no documented allergy. We also assessed secondary outcomes of rates of annual serum creatinine, LDL cholesterol, hemoglobin, phosphorus, 25-OH vitamin D, calcium, and parathyroid hormone testing. Physicians and patients were not blinded to intervention status, although all outcomes data were collected without respect to intervention status.

Patient and Physician Surveys

We surveyed all patients in the intervention arm who were enrolled in the outreach program (n = 1002) by their PCP. Patients used a 4-point ordinal scale from "definitely yes" to "definitely no" to report on whether the mailings gave them choices to think about for treating CKD, helped them set specific CKD treatment goals, and helped them understand their medications for CKD. Patients also reported on whether their doctor or another health professional had told them that they had weak or failing kidneys, and they used a 5-point ordinal scale from "strongly agree" to "strongly disagree" to report agreement with their diagnosis of CKD. Finally, patients used a 5-point scale from "excellent" to "poor" to rate the CKD care they received. The survey was administered via a single mailing at the end of the intervention and achieved a 24% (n = 242) response rate.

We surveyed 153 study physicians at the completion of the intervention. Physicians used a 5-point ordinal scale from "always" to "never" to report on the frequency with which they informed patients of a new diagnosis of CKD once they recognized it was present. Physicians also reported on the eGFR threshold at which they felt comfortable informing their patients of a diagnosis of CKD. Intervention physicians also rated the effectiveness of the electronic alerts, patient mailings, and collaboration with nephrology on improving the quality of CKD care among their patients ("very effective," "somewhat effective," or "not effective"). The survey was implemented via an initial paper mailing, followed by a reminder email to nonresponders and a final paper mailing at 4 weeks, achieving a 73% (n = 111) response rate.

TABLE 1. Baseline Patient Demographics

	Intervention (n = 3913)	Control (n = 3778)	*P*
Sociodemographic features			
Age, years, mean (SD)	69.9 (10.5)	69.9 (10.3)	.99
Male, n (%)	1647 (42)	1646 (44)	.20
Race/ethnicity, n (%)			.06
White	3064 (78)	2889 (76)	
Black	412 (11)	394 (10)	
Asian	97 (2)	130 (3)	
Hispanic	75 (2)	85 (2)	
Other	128 (3)	150 (4)	
Missing	137 (4)	130 (3)	
Insurance, n (%)			.11
Commercial	1132 (29)	1050 (28)	
Medicare FFS	1105 (28)	1089 (29)	
Medicare Advantage	1293 (33)	1319 (35)	
Medicaid	114 (3)	105 (3)	
Self-pay	269 (7)	215 (7)	
Risk factors, n (%)			
Diabetes	1242 (32)	1309 (35)	.01
Hypertension	2983 (76)	2920 (77)	.28
Most recent eGFR, mean (SD)	50.8 (9.0)	50.7 (8.1)	.54

eGFR indicates estimated glomerular filtration rate; FFS, fee-for-service.

Statistical Analysis

Balance between patient demographic characteristics in the intervention and control arms was checked using a *t* test for patient age, Fisher exact tests for binary variables, and χ^2 tests for categorical variables. We analyzed the impact of the intervention by fitting logistic regression models using the generalized estimating equation approach to account for clustering of patients within clinics, with performance of each of our prespecified outcomes as the dependent variable and intervention status as the primary independent variable. The models were implemented using the GENMOD procedure in SAS version 9.3 (SAS Institute; Cary, North Carolina).

We conducted post hoc analyses to understand the importance of exposure to the intervention components. These included the subset of patients in the intervention arm who received the outreach mailings, as well as patients with varying numbers of office visits (0, 1-3, and >3) to their PCP during the intervention period. For the outreach mailing analyses, we used propensity score stratification to compare the appropriate set of patients in the control arm with the subset of patients in the intervention arm who received mailings. A propensity score model was created separately for each clinic, using the following variables as predictors of receiving a mailing: patient sex; race/ethnicity; insurance type; prior nephrology visit; current treatment with an ACE inhibitor or ARB; baseline eGFR; and presence of diabetes, cardiovascular disease, or hypertension. Patients from the intervention arm who received a mailing were then compared, through stratification, with patients from the control arm who had a similar probability (ie, were within the same 5% propensity interval) of receiving a mailing. Outcomes among patient groups were compared using the same clustered logistic regression models described earlier, adjusting for correlation within clinicians, time on study, and propensity strata.

RESULTS

Baseline Characteristics

We randomized 153 PCPs caring for 7691 adult patients with stage III CKD, including 3947 high-risk patients and 3744 low-risk patients (**Table 1**). The median number of patients enrolled per PCP was 47 (interquartile range, 26-69).

Primary Outcomes

Among high-risk patients, those in the intervention arm were significantly more likely to have an office visit with a nephrologist during the 12-month study period compared with those in the control arm (45% vs 34%; $P < .001$) (**Table 2**). Among low-risk patients, those in the intervention arm were significantly more likely than those in the control arm to have received urine microalbumin testing in the prior 12 months (45% vs 21%; $P < .001$). There was no difference between the intervention and control arms in rates of prescribing an ACE inhibitor or ARB in either the high-risk patient group (76% vs 79%; $P = .17$) or the low-risk patient group (64% vs 65%; $P = .57$).

Secondary Outcomes

Among both high- and low-risk patients, those in the intervention arm had higher rates of annual testing compared with those in the control arm for phosphorus, vitamin D, and parathyroid hormone. High-risk patients also had higher annual testing rates for calcium in the intervention arm compared with the control arm (Table 2).

Exposure to Intervention Components

Intervention physicians enrolled 1002 (26%) patients into the patient mailing program, including 647 (32%) high-risk patients and 355 (19%) low-risk patients. With the exception of ACE inhibitor or ARB therapy and testing of microalbumin in high-risk patients, both high- and low-risk patients in the intervention arm who received patient mailings were significantly more likely than propensity-stratified control arm patients to achieve all primary and secondary study outcomes (**Table 3**).

Among all study patients, 41% had 4 or more office visits to their PCP during the study period, 51% had 1 to 3 visits, and 7% had no primary care visits. Regardless of intervention status, rates of annual

TABLE 2. Outcomes for Patients With Stage III CKD, According to Intervention Status

	High-Risk (n = 3947)			Low-Risk (n = 3744)		
	Intervention (n = 2020)	Control (n = 1927)	*P*	Intervention (n = 1893)	Control (n = 1851)	*P*
Primary outcomes, % (95% CI)						
Annual nephrology visit	45 (41-49)[a,b]	34 (31-38)[a,b]	<.001[a,b]	17 (14-20)[a]	11 (9-13)[a]	.001[a]
ACE inhibitor/ARB prescription	76 (74-79)[b]	79 (76-81)[b]	.17[b]	64 (60-67)[b]	65 (61-68)[b]	.57
Annual urine microalbumin	71 (69-74)	70 (67-72)	.35	45 (40-50)[a,b]	21 (18-25)[a,b]	<.001[a,b]
Secondary outcomes, % (95% CI)						
Annual eGFR	89 (88-90)	89 (88-90)	.90	82 (80-83)	80 (77-82)	.20
Annual LDL cholesterol	82 (80-84)	83 (82-85)	.24	72 (70-75)	70 (66-73)	.19
Annual hemoglobin	73 (71-76)	73 (70-75)	.63	61 (58-64)	61 (57-64)	.87
Annual phosphorus	49 (45-54)[a]	38 (35-42)[a]	<.001[a]	23 (19-27)[a]	13 (11-16)[a]	<.001[a]
Annual 25-OH vitamin D	53 (49-57)[a]	45 (41-48)[a]	.002[a]	31 (27-35)[a]	24 (21-27)[a]	.004[a]
Annual calcium	75 (71-78)[a]	69 (65-72)[a]	.01[a]	59 (54-63)	54 (49-58)	.11
Annual parathyroid hormone	49 (45-54)[a]	39 (35-43)[a]	<.001[a]	24 (20-28)[a]	14 (12-17)[a]	<.001[a]

ACE indicates angiotensin-converting enzyme; ARB, angiotensin receptor blocker; CKD, chronic kidney disease; eGFR, estimated glomerular filtration rate; LDL, low-density lipoprotein; OH, hydroxy.
[a]Statistically significant results at $P < .05$.
[b]Primary study end points.

TABLE 3. Outcomes for Patients With Stage III CKD, According to Receipt of Patient Outreach Mailings

	High-Risk (n = 2574)			Low-Risk (n = 2206)		
	Intervention With Mailings (n = 647)	Propensity-Stratified Control (n = 1927)	*P*	Intervention With Mailings (n = 355)	Propensity-Stratified Control (n = 1851)	*P*
Primary outcomes, % (95% CI)						
Annual nephrology visit	66 (59-71)[a]	39 (34-43)[a]	<.001[a]	32 (26-39)[a]	12 (10-14)[a]	<.001[a]
ACE inhibitor/ARB prescription	84 (80-87)	81 (79-83)	.19	73 (66-79)	67 (63-71)	.13
Annual urine microalbumin	76 (71-81)	71 (68-73)	.07	58 (51-65)[a]	23 (19-27)[a]	<.001[a]
Secondary outcomes, % (95% CI)						
Annual eGFR	97 (95-98)[a]	91 (90-93)[a]	<.001[a]	91 (88-94)[a]	84 (82-86)[a]	.001[a]
Annual LDL cholesterol	90 (87-93)[a]	86 (84-87)[a]	.01[a]	82 (77-86)[a]	74 (70-77)[a]	.01[a]
Annual hemoglobin	85 (81-89)[a]	76 (73-79)[a]	<.001[a]	74 (68-79)[a]	64 (61-67)[a]	.003[a]
Annual phosphorus	72 (66-77)[a]	43 (39-48)[a]	<.001[a]	48 (40-56)[a]	15 (13-18)[a]	<.001[a]
Annual 25-OH vitamin D	71 (65-77)[a]	49 (45-53)[a]	<.001[a]	53 (46-60)[a]	25 (22-29)[a]	<.001[a]
Annual calcium	88 (83-91)[a]	73 (69-76)[a]	<.001[a]	76 (70-81)[a]	57 (52-61)[a]	<.001[a]
Annual parathyroid hormone	71 (65-76)[a]	44 (40-48)[a]	<.001[a]	49 (42-56)[a]	16 (14-19)[a]	<.001[a]

ACE indicates angiotensin-converting enzyme; ARB, angiotensin receptor blocker; CKD, chronic kidney disease; eGFR, estimated glomerular filtration rate; LDL, low-density lipoprotein; OH, hydroxy.
[a]Statistically significant results at $P < .05$.

nephrology visits, receiving prescription of ACE inhibitor or ARB therapy, and annual urine protein monitoring were all significantly lower among patients with no primary care visits compared with either group of patients with at least 1 visit (Table 4). In addition, the intervention effect varied according to the number of PCP office visits during the study period, demonstrating no significant intervention effect among those patients with 0 visits and larger intervention effect sizes for those with at least 1 visit.

Physician and Patient Surveys

More than half (61%; n = 138) of intervention patients who received outreach mailings reported being told by a doctor or health

TABLE 4. Primary Outcomes for Patients With Stage III CKD, According to Number of PCP Visits

	0 PCP Visits			1-3 PCP Visits			≥4 PCP Visits		
	Intervention	Control	*P*	Intervention	Control	*P*	Intervention	Control	*P*
High-risk patients									
Sample size, n	139	125		922	847		959	955	
Annual nephrology visit, % (95% CI)	13 (9-21)	20 (14-28)	.18	45 (40-50)[a]	33 (29-37)[a]	<.001[a]	54 (48-59)[a]	42 (37-46)[a]	<.001[a]
ACE inhibitor/ARB prescription, % (95% CI)	31 (24-40)[a]	44 (36-52)[a]	.03[a]	77 (74-80)	80 (76-83)	.22	81 (78-83)	82 (80-85)	.36
Low-risk patients									
Sample size, n	158	150		1086	1087		649	614	
Annual urine microalbumin, % (95% CI)	15 (10-23)	11 (7-19)	.39	45 (40-51)[a]	21 (17-25)[a]	<.001[a]	60 (53-66)[a]	29 (24-35)[a]	<.001[a]
ACE inhibitor/ARB prescription, % (95% CI)	35 (27-43)	33 (24-44)	.77	63 (59-68)	65 (61-70)	.60	69 (66-73)	70 (65-74)	.89

ACE indicates angiotensin-converting enzyme; ARB, angiotensin receptor blocker; CKD, chronic kidney disease; PCP, primary care physician.
[a]Statistically significant results at *P* <.05.

professional that they had weak or failing kidneys. In logistic regression models that considered patient age, sex, and race; comorbid conditions (diabetes, hypertension, and cardiovascular disease); and CKD features (high- vs low-risk status and nephrology consultation), the absence of diabetes (odds ratio [OR], 1.9; 95% CI, 1.1-3.2), a nephrology visit prior to the intervention period (OR, 2.6; 95% CI, 1.6-4.3), and a nephrology visit during the intervention period (OR, 3.5; 95% CI, 2.1-5.9) were all associated with patients reporting being told that they had weak or failing kidneys.

More than half (63%; n = 142) of intervention patients strongly or somewhat agreed with their diagnosis of CKD, whereas 18% (n = 41) strongly or somewhat disagreed with their diagnosis of CKD. Two-thirds (67%; n = 136) of intervention patients rated their care for CKD as excellent or very good. A majority (89%; n = 177) of patients reported that the outreach mailings definitely or somewhat gave them choices to think about for treating their CKD, 82% (n = 162) felt the mailings helped them set specific goals for CKD treatment, and 81% (n = 153) felt the mailings helped them understand their medications for CKD.

Intervention and control physicians were similarly likely to report that they always or usually informed their patients of a diagnosis of CKD (87% vs 75%; *P* = .12). A higher percentage of intervention physicians compared with control physicians reported feeling comfortable establishing a diagnosis of CKD using a threshold eGFR of less than 60 (56% vs 39%; *P* = .07, adjusted for within-clinic correlation), although the difference was not statistically significant. Three-quarters (75%) of physicians in the intervention group reported that our electronic reminders were somewhat or very effective at improving the quality of CKD care among their patients, 84% reported the patient mailings were somewhat or very effective, and 92% reported that collaboration with nephrology was somewhat or very effective.

DISCUSSION

In a large randomized controlled trial of patients with stage III CKD, we demonstrated that a quality improvement program consisting of electronic decision support combined with mailed patient self-management support tools significantly improved quality of care, including use of nephrology referrals and laboratory testing. In particular, our intervention resulted in increased screening rates for urine microalbumin, identifying patients who warrant more aggressive management given the importance of microalbuminuria in predicting disease progression.

Our study findings demonstrated that a large population of patients with CKD can be effectively triaged, with care being shared between primary care and nephrology. Prior interventions to improve CKD care have involved small sample sizes, lacked a randomized design, or showed only modest intervention effects. Southern California Kaiser Permanente implemented a large population-based program to improve CKD care but observed an increase in visits to nephrologists from 20% to just 24% over a 5-year period.[23] Similarly, a study of electronic prompts recommending referral to a nephrologist for patients with eGFR of less than 45 found that the prompts did not impact referral patterns.[24] A study of a paper-based CKD checklist found that it was associated with improvement in CKD care, although it involved only 4 PCPs within a single health center.[25]

Our study findings also highlighted the importance of patient engagement in the management of CKD. We found that a large proportion of patients responding to the survey had not been informed of their CKD, which is consistent with prior research.[15] In our study, nephrology consultation was associated with increased patient awareness of their disease. This supports prior findings that accurate diagnosis, likely followed by messaging from a trusted physician, can increase patient awareness.[26] The National Kidney

Foundation and various federal agencies have also supported population-based programs to improve awareness of CKD, including detection and treatment.[27,28] Our program builds on these efforts by combining a program to increase diagnosis and awareness with a set of EHR tools embedded within the workflows of a delivery system to support proactive CKD management.

We also found that nearly one-fifth of patients did not agree with being diagnosed with CKD at the conclusion of our intervention. This general finding is critical to understanding the foundation of development of CKD management programs: the need to first partner with patients in the diagnosis of kidney disease. Our post hoc analyses identified the patient mailings as being of substantial importance in the effectiveness of the intervention. Patients who received these mailings were more likely to achieve the study end points compared with control-arm patients, and the magnitude of these effects was larger than that observed for intervention-arm patients who did not receive the mailings.

We also need to focus on engaging primary care in the management of CKD. Although physicians endorsed strong support for our intervention, only half of physicians in the intervention arm felt comfortable establishing the diagnosis of CKD based on currently recommended criteria. However, our post hoc analyses highlight the importance of primary care, because patients with at least 1 visit to their PCPs were much more likely to receive higher-quality care.

Although we had significant success with this program, it is important to note that we did not impact prescribing of ACE inhibitors and ARBs among all patients. Our lack of intervention effect may have been due to the relatively high rates of prescribing ACE inhibitors and ARBs in both study arms. This suggests that physicians may not require additional intervention, given that there is less room to demonstrate improvement in prescribing. In addition, it may be that the remaining patients not treated with ACE inhibitors or ARBs were deemed at higher risk of the complications of such treatment, outweighing the estimated benefits.

Limitations

Our study has important limitations. We focused on a chronic condition in which the clinical recommendations are changing and remain under some debate,[29,30] including recommendations around defining high-risk patients, which patients to refer to nephrologists, and the precise monitoring parameters for metabolic bone disease with parathyroid hormone and vitamin D testing. Our internal consensus guidelines did end up being slightly different from the published guidelines.

We used the MDRD equation to estimate GFR, which may tend to underestimate GFR and identify a lower-risk population. A recent analysis by the Kaiser Permanente system, which also employs Epic and the MDRD equation, found that use of the CKD Epidemiology Collaboration equation can identify a more targeted patient population that is at higher risk of long-term complications of CKD.[31]

We also did not have additional information on PCP characteristics, such as time in clinical practice, that may have played a role in our study outcomes. Our patient survey analyses were limited by the lack of information from patients in the control group, which was due to our desire to avoid surveying patients about a diagnosis they may not have received from their physician team. Future surveys should focus on alternative methods to assess the entire population and achieve higher response rates to ensure representative information. In addition, future interventions should focus on how to reach broader patient populations, including those with limited literacy.

Finally, we did not evaluate long-term outcomes, such as mortality or disease progression, as our intervention was just 12 months' duration and such outcomes take years to present. We did attempt to apply widely used process measures of CKD care, but we recognize that there is active debate regarding which process measures have the best links to clinical outcomes.

CONCLUSIONS

We developed an innovative intervention combining electronic decision support and patient outreach that improved quality of care in some areas. Future work should explore how EHRs can be used to improve provider and patient decision making and further collaboration among patients, PCPs, and specialist physicians as part of a comprehensive effort to improve health outcomes and value. ■

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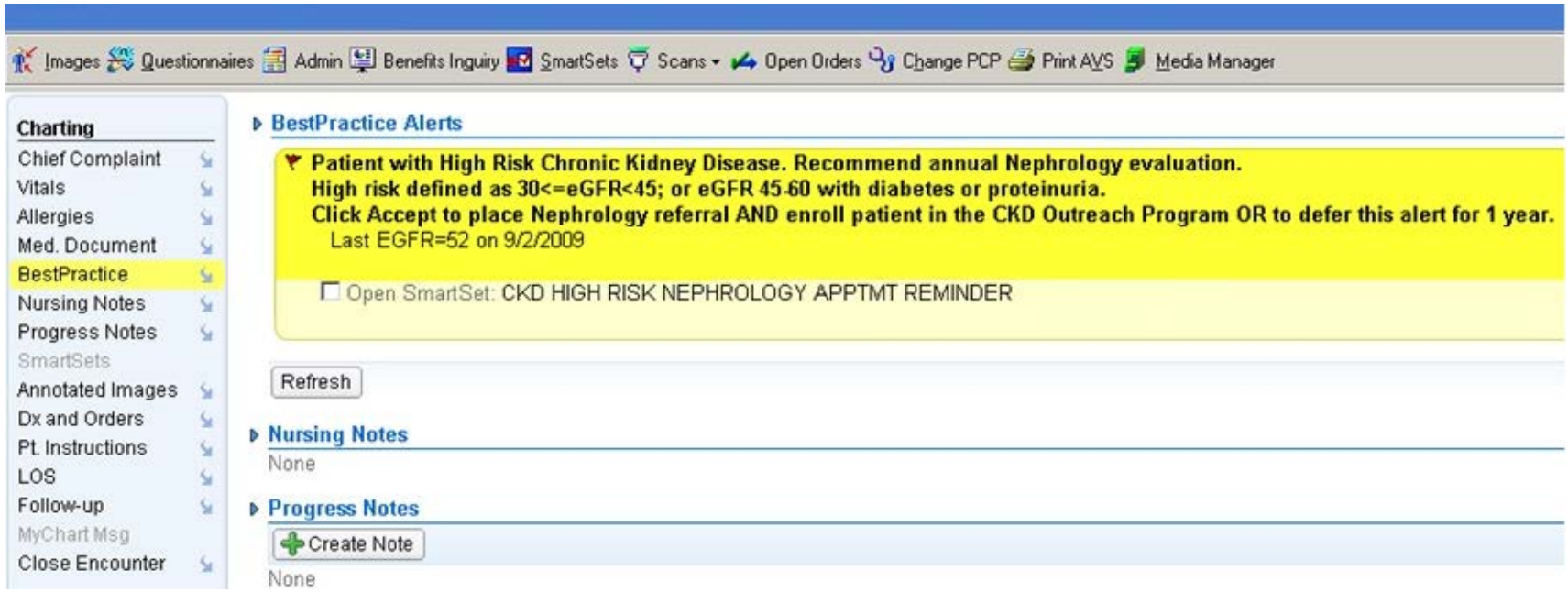
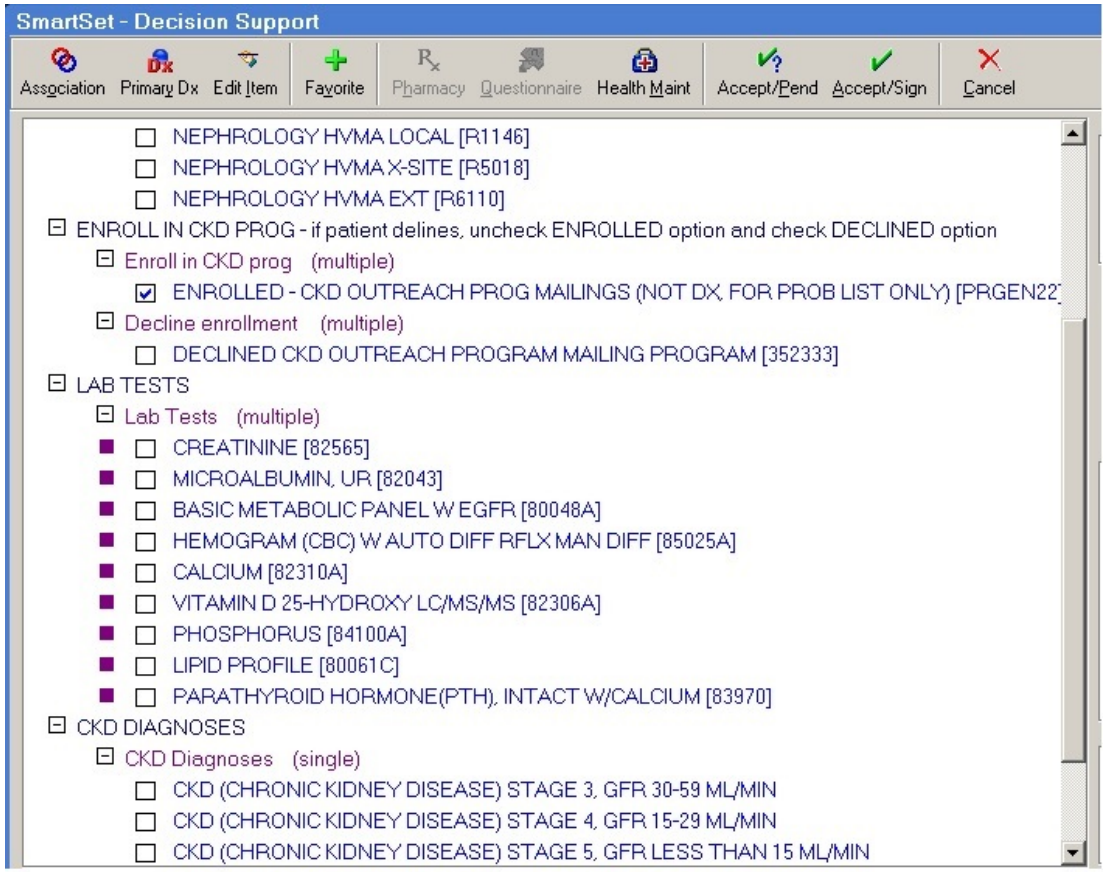
eAppendix A. Sample Alert Recommending Nephrology Referral for High-Risk Patient



eAppendix B. Sample Ordering Template Facilitated by the Chronic Kidney Disease Alerts



eAppendix C. Sample Mailed Outreach Materials

Date

FirstName LastName
Address 1
Address 2
City, State Zip Code

Dear Mr. LastName,

I am writing to you with important updates about your *chronic kidney disease*. This is based on the most up to date information from your medical chart here at Harvard Vanguard. I have included information on:

- Your level of kidney disease
- Your blood pressure
- Your recent blood and urine tests for kidney disease

We have made recommendations specifically for you based on this information. This includes ways to keep your kidneys healthy, including what tests and treatments you may need.

Please do not hesitate to contact me with any questions.

Sincerely,

MYCHART, MD

How well are your kidneys working?

Explaining Your Kidney Test Results

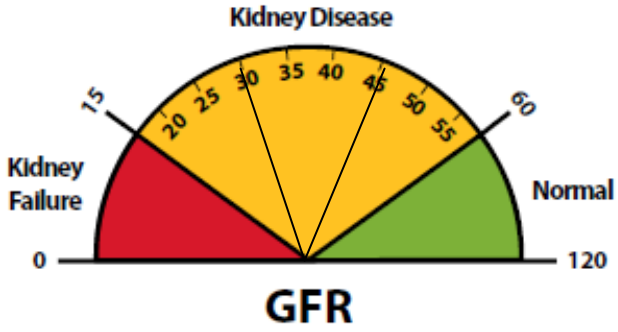
Your GFR Results

Your **most recent** GFR result was:

- 41 on 6/3/2010

Your **lowest** GFR result was:

- 40 on 2/17/2009



What is GFR ("glomerular filtration rate")?

GFR measures how well your kidneys clear waste and extra water from the body. *The goal is to keep the GFR from going lower.*

- A GFR of 60 or higher is in the normal range
- A GFR below 60 may mean kidney disease
- A GFR of 15 or lower may mean kidney failure

An important point about your GFR:

Your GFR can go up and down, sometimes going up into the normal range. Please look at both your lowest GFR and your most recent GFR.

What Are My Personal Risks For Kidney Failure?

- Diabetes: It is very important to control your blood sugar to protect the kidneys. Your most recent Hemoglobin A1c result was 6.2 on 6/3/2010.
- High blood pressure
- Low GFR (less than 45)

Based on your risks above, you should see a kidney specialist (nephrologist) at least once per year. Our records show that you have not yet had a visit with a kidney specialist. Please call 781-306-5300 to schedule this appointment.

How can I protect my kidneys?

Goal #1: Keep your blood pressure as low as possible.

Goal #2: Treat kidneys with special blood pressure medicines (called "ACE" or "ARB" medicines) to keep protein from leaking into the urine.

Goal #3: Avoid using medicines that harm the kidneys, especially "NSAIDS" (Motrin, Advil, Ibuprofen, Naprosyn, Aleve).

Blood Pressure

Why is blood pressure so important?

High blood pressure can damage blood vessels in the body. If the blood vessels in the kidney are damaged, they may not be able to filter wastes out of your body.

Your last blood pressure on 6/3/2010 was 142/76.

- This is above your goal for blood pressure. The goal is less than 130/80 ("130 over 80").
- Please review the information in this mailing to bring down your blood pressure.

Urine Protein

What is urine protein?

Protein (also called "albumin") is normally found in the blood. A healthy kidney does not let protein pass into the urine. A damaged kidney lets some protein pass into the urine. The less protein in your urine, the better!

Your last urine protein (albumin) result on 6/3/2010 was 22.1.

- Your last result is up to date.
- Your urine protein level is normal.

Medication

You are being prescribed an "ACE" or "ARB" medication.

- This medicine is called Lisinopril Oral and is very important for your kidneys.

What Other Tests Do I Need for Kidney Disease?

These tests should all be checked at least once per year:

Test Performed	Your recent results are…		The goal is…	Your last result is…
"Bad" (LDL) cholesterol	121 *6/9/2009*	132 *6/3/2010*	Less than 100	High
Hemoglobin (blood count)	15.4 *6/9/2009*	14.9 *6/3/2010*	Higher than 10.0	Normal
Calcium	9.1 *6/9/2009*	9.9 *6/3/2010*	Between 8.4 and 9.5	High
Vitamin D			Between 30 and 100	No result available
Parathyroid hormone			Between 35 and 70	No result available
Phosphorous			Less than 4.6	No result available

What Medicines Am I Taking For My Kidney Disease?

Medication Name	This medicine is for…
Lisinopril 5 mg Tab	A special blood pressure pill that also treats urine protein
Hydrochlorothiazide 25 mg Tab	Blood pressure
Simvastatin 20 mg Tab	Cholesterol

What should I do next?

- Your blood pressure is high. Please look in the brochure for more advice.
- You are overdue for these lab tests, please contact my office to have them done:
  - Vitamin D
  - Parathyroid hormone
  - Phosphorous
- Please call me to talk about these lab results:
  - "Bad" (LDL) cholesterol
  - Calcium
- Schedule an appointment with a kidney specialist by calling 781-306-5300.

Chronic Kidney Disease and My Lifestyle

What can I do to stay healthy and keep my kidney disease from getting worse?

- Make sure you understand your doctor's recommendations. **This includes medicines to lower blood pressure.**
- Follow a low salt diet.
- Choose foods that are healthy for your heart, like lean cuts of meat, skinless chicken, seafood, vegetables, and beans.
- Get regular exercise.
- Lose weight if your doctor recommends it.

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781-221-2500

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617-661-5500

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Concord Hillside Medical Associates
978-287-9300

Copley
617-859-5000

Kenmore
617-421-1000

Lynnfield Medical Associates
978-532-2800

Medford
781-306-5100

Peabody
978-977-4000

Post Office Square
617-654-7000

Quincy
617-774-0600

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Harvard Vanguard Medical Associates is a multispecialty medical group practice with offices across eastern Massachusetts, and an affiliate of Atrius Health.

Harvard Vanguard accepts most major health plans including Aetna, Blue Cross Blue Shield of Massachusetts, Fallon Community Health Plan, Harvard Pilgrim Health Care, Neighborhood Health Plan, Tufts Health Plan, and Tufts Medicare Preferred.

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CKD 04/11-10M

Chronic Kidney Disease

A Plan to Take Control of Your Disease

Harvard Vanguard Medical Associates
Atrius Health

Chronic Kidney Disease: The Basics

What does it mean to have Chronic Kidney Disease (CKD)?

You have two kidneys, and their main job is to filter waste and extra water out of your blood to make urine. CKD means that your kidneys are damaged and can't filter the blood like they should.

People with Chronic Kidney Disease can develop:

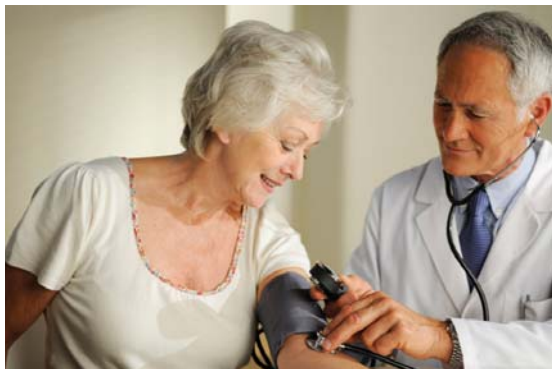
- High blood pressure
- Heart disease
- Bone disease
- Anemia (low red cells)

How can I treat my Chronic Kidney Disease?

CKD is often a "progressive" disease, which means it can get worse over time. There are a few very important steps to keep your kidneys as healthy as possible:

- Keep your blood pressure below 140/80 ("140 over 80").
- Choose foods with less salt.
- If you have diabetes, control your blood sugar.

Your doctor may prescribe medicines to lower your blood pressure. They should be taken every day. ***Let your doctor know if you are not able to take them as prescribed.***



Low Salt Diet

Salt (sodium) can raise your blood pressure.

- Count your salt during the day.
- Limit salt to less than 2000 mg per day.
- Read the labels on the food you buy.

Look for low salt foods, which have less than 140 mg salt (sodium) per serving.

Nutrition Facts

Serving Size: 100 grams (100g)

Amount Per Serving	
Calories 49	Calories from Fat 14
	% Daily Value*
Total Fat 1.6 g	**2%**
Saturated Fat 0.5 g	**2%**
Trans Fat 0.5 g	**2%**
Cholesterol 6 mg	**2%**
Sodium 338 mg	**14%**
Potassium 169 mg	**5%**
Total Carbohydrate 6.8 g	**2%**
Dietary Fiber 0.6 g	**2%**
Sugars 0.39 g	
Sugar Alcohols 0.6 g	
Protein 2 g	
Vitamin A 960 IU	19%
Vitamin C 27 mg	45%
Calcium 11 mg	1%
Iron 0.2 mg	1%

This food has too much salt!

Other Tips

- Avoid salted snacks like chips.
- Do not add extra salt to your food at the table.
- Cook without salt or soy sauce. Try herbs and spices instead.
- Limit canned and frozen foods.

What tests do I need to track my chronic kidney disease?

Check blood pressure

- Every office visit

Check kidney function

- Blood glomerular filtration rate (GFR) test
- Urine protein (albumin) test

Check for heart disease

- Blood cholesterol test

Check for anemia

- Blood hemoglobin

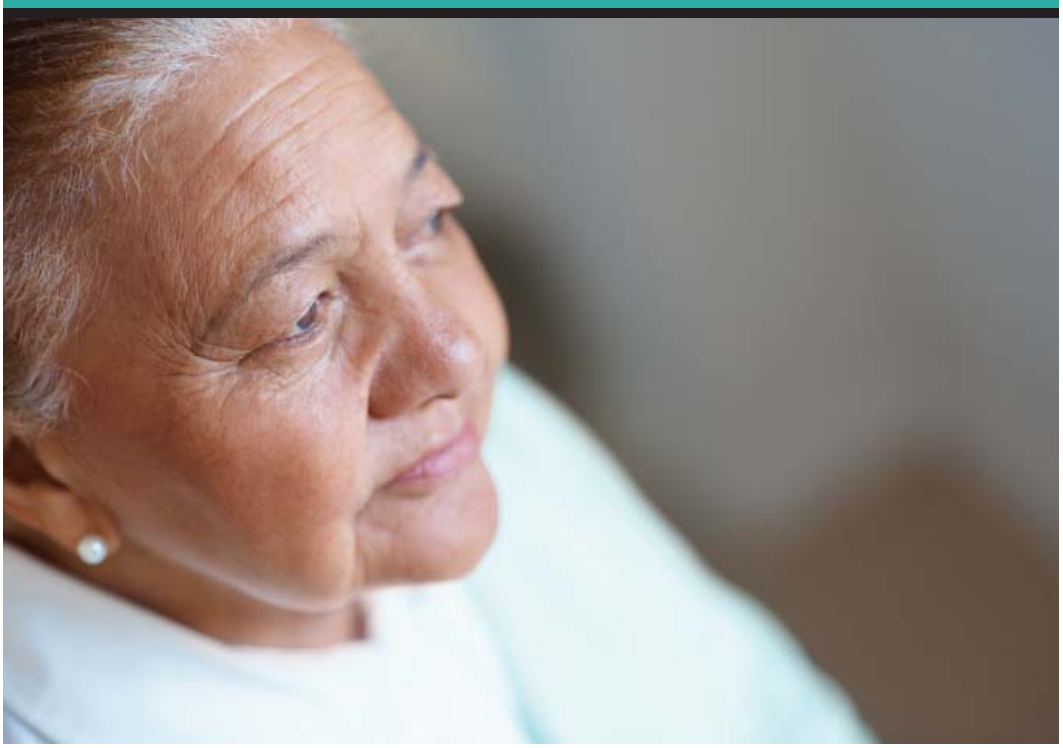
Check for bone disease

- Vitamin D
- Calcium
- Phosphorous

Have you had all of your tests done for chronic kidney disease *this year*? Make sure to check with your doctor.

Sign up for MyHealth Online at www.harvardvanguard.org and you can look up all of your kidney disease test results on your home computer.

Chronic Kidney Disease

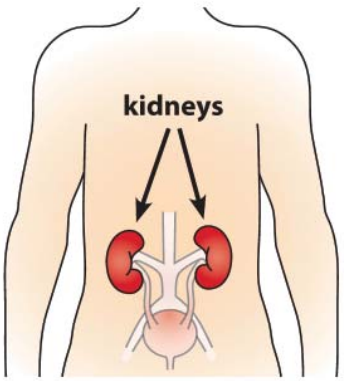


What Does It Mean For Me?

Harvard Vanguard
Medical Associates
Atrius Health

Chronic Kidney Disease: The Basics

You've been told that you have Chronic Kidney Disease (CKD). What does that mean? And what does it mean for your health and your life? This booklet will help answer some of these questions.



You have two kidneys, each about the size of your fist. Their main job is to filter waste and excess water out of your blood to make urine. They also maintain the body's chemical balance, and help control blood pressure.

Chronic kidney disease means that your kidneys are damaged and can't filter blood like they should. This can cause wastes to build up in your body.

It is called "chronic" kidney disease because it does not go away. Chronic kidney disease is often a "progressive" disease, which means it can get worse over time. Sometimes it can lead to kidney failure. The only treatment option for kidney failure is dialysis or a kidney transplant.

You can take steps to keep your kidneys healthier longer:

- **Keep your blood pressure below 140/80 (which is read as "140 over 80")**
- **Choose foods with less salt (sodium)**
- **If you have diabetes, control your blood sugar**

How does my doctor know that I have Chronic Kidney Disease?

Chances are you feel normal. Chronic kidney disease is called a "silent" disease, because many people don't have any symptoms until their kidneys are about to fail. The only way to know how your kidneys are doing is with blood and urine tests.

1. **A blood test checks your GFR.** GFR stands for glomerular (glow-MAIR-you-lure) filtration rate. This tells how well your kidneys are filtering.

2. **A urine test checks for albumin.** Albumin is a protein that can pass into the urine when the kidneys are damaged.

What causes Chronic Kidney Disease?

Diabetes and high blood pressure are the most common causes of kidney disease but there are other causes too. Your doctor may do other tests to figure out what is causing your chronic kidney disease.

Can Chronic Kidney Disease affect my health in other ways?

People with chronic kidney disease can develop:

- High blood pressure
- Heart attack and stroke
- Anemia (low number of red blood cells)
- Bone disease

What medicines are used to treat kidney disease?

People with kidney disease often take medicines to:

- Lower blood pressure
- Lower protein in the urine
- Lower cholesterol

Controlling blood pressure is very important. The goal is to keep your blood pressure below 140/80 (usually stated as "140 over 80"). Many people need to take several medicines to get to this blood pressure goal. If you have side effects or want to stop the medicines for any reason, be sure to discuss this with your doctor first.

Medicine is just one step to lowering your blood pressure and cholesterol. You should also:

- Get regular exercise. Talk with your doctor about what is best for you.
- Lose weight if your doctor recommends it.

Do I need to change my medicines?

Some medicines are not safe for people with kidney disease. Other medicines need to be taken in smaller doses. Tell your provider about all the medicines you take, including over-the-counter medicines. **AVOID** common over-the-counter pain killers such as Ibuprofen, Advil, Motrin, Naprosyn, and Aleve. It is okay to take Tylenol for your aches and pains.

Chronic Kidney Disease and My Lifestyle

People with chronic kidney disease can and should continue to live their lives in a normal way but you need to watch what you eat.

Do I need to change what I eat?

What you eat may help to slow down CKD and keep your body healthier. Some points to keep in mind:

Choose and prepare foods with less salt (sodium). Try not to add salt at the table.

Read the Nutrition Facts Label on the food you buy. Check the salt (sodium) to help you pick the right foods and drinks.

Choose foods that are healthy for your heart, like lean cuts of meat, skinless chicken, seafood, fruits, vegetables, and beans.

Maintain a Low Salt Diet

Nutrition Facts

Serving Size: 100 grams (100g)

Amount Per Serving	
Calories 49	Calories from Fat 14
	% Daily Value*
Total Fat 1.6 g	**2%**
Saturated Fat 0.5 g	**2%**
Trans Fat 0.5 g	**2%**
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Protein 2 g	
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Vitamin C 27 mg	45%
Calcium 11 mg	1%
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This food has too much salt!

Salt (sodium) can raise your blood pressure.

- Count your salt during the day.
- Limit salt to less than 2000 mg per day.
- Look for food with less than 140 mg of salt (sodium) per serving.
- Avoid salted snacks like chips.
- Limit canned and frozen foods.

Keep your kidneys as healthy as possible!

- Keep your blood pressure lower than 140/80.
- Take your blood pressure medicines every day.
- Eat less salt.
- Get regular exercise.

These steps will keep your kidneys as healthy as possible and will help to prevent heart attacks and stroke.

What will help to track my kidney disease?

The blood and urine tests used to find kidney disease are also used to monitor it. Other tests performed are in the table below. These tests should all be checked at least once per year:

Test Performed	Reason for Test
Blood pressure	Keep kidneys healthy
GFR Urine protein (albumin)	Monitor kidney function
Cholesterol	Check for heart disease
Hemoglobin	Check for anemia
Vitamin D Calcium Phosphorous	Check for bone disease

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West Roxbury
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