Implementation of a CKD Checklist for Primary Care Providers

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Abstract

Background and objectives CKD is associated with significant morbidity, mortality, and financial burden. Practice guidelines outlining CKD management exist, but there is limited application of these guidelines. Interventions to improve CKD guideline adherence have been limited. This study evaluated a new CKD checklist (a tool outlining management guidelines for CKD) to determine whether implementation in an academic primary care clinic improved adherence to guidelines.

Design, setting, participants, & measurements During a 1-year period (August 2012–August 2013), a prospective study was conducted among 13 primary care providers (PCPs), four of whom were assigned to use a CKD checklist incorporated into the electronic medical record during visits with patients with CKD stages 1–4. All providers received education regarding CKD guidelines. The intervention and control groups consisted of 105 and 263 patients, respectively. Adherence to CKD management guidelines was measured.

Results A random-effects logistic regression analysis was performed to account for intra-group correlation by PCP assignment and adjusted for age and CKD stage. CKD care improved among patients whose PCPs were assigned to the checklist intervention compared with controls. Patients in the CKD checklist group were more likely than controls to have appropriate annual laboratory testing for albuminuria (odds ratio [OR], 7.9; 95% confidence interval [95% CI], 3.6 to 17.2), phosphate (OR, 3.5; 95% CI, 1.5 to 8.3), and parathyroid hormone (OR, 8.1; 95% CI, 4.8 to 13.7) (P<0.001 in all cases). Patients in the CKD checklist group had higher rates of achieving a hemoglobin A1c target<7% (OR, 2.7; 95% CI, 1.4 to 5.1), use of an angiotensin-converting enzyme inhibitor or angiotensin-receptor blocker (OR, 2.1; 95% CI, 1.0 to 4.2), documentation of avoidance of non-steroidal anti-inflammatory drugs (OR, 4.1; 95% CI, 17.8 to 100.0), and vaccination for annual influenza (OR, 2.1; 95% CI, 1.1 to 4.0) and pneumococcus (OR, 4.7; 95% CI, 2.6 to 8.6) (P<0.001 in all cases).

Conclusions Implementation of a CKD checklist significantly improved adherence to CKD management guidelines and delivery of CKD care.

Introduction

CKD affects approximately 13% of adults in the United States and is associated with significant morbidity, mortality, and financial burden (1–3). Optimal CKD care involves diagnosis, slowing progression, treating complications, and renal replacement preparation (4). The Kidney Disease Improving Global Outcomes program established practice guidelines that address the multifaceted nature of CKD care (5). These guidelines include recommendations related to screening, modification of risk factors (such as hypertension, diabetes, and proteinuria), and management of complications (such as cardiovascular disease, anemia, and bone disease).

Since CKD practice guidelines were published, investigators have called for guideline utilization to “improve patient outcomes through recognition of CKD, vigilant monitoring, and appropriate interventions.” (6) However, studies have shown that primary care providers (PCPs) have limited knowledge of these guidelines (7–10). There have been few interventions to improve adherence to CKD guidelines.

One potential innovation to improve CKD care is a CKD checklist, a tool designed to promote adherence to established guidelines (11). The implementation of surgical checklists significantly reduced surgical complications and death (12). Checklists have been used in other areas of medicine, such as critical care related to ventilator care and catheter use, resulting in improved outcomes (13,14). Checklists eliminate some barriers associated with guideline implementation, such as a lack of knowledge, and provide a simplified format. We developed and piloted a CKD checklist in a primary care clinic to test its effect on the delivery of optimal CKD care.

Materials and Methods

Study Design

We conducted a prospective, nonrandomized study involving the implementation of a CKD checklist for...
patients with CKD stages 1–4 in a primary care clinic. The intervention group included patients with CKD receiving care from one of four PCPs; these providers were selected by the clinic’s medical director because they were not involved in similar ongoing quality improvement projects. The control group included patients with CKD receiving care from the remaining nine PCPs. The nonrandomized study design was formulated on the basis of feasibility considerations, specifically to avoid assigning PCPs already engaged in quality improvement projects with another ongoing project. The CKD checklist was designed primarily on the basis of national (Kidney Disease Outcomes Quality Initiative [KDOQI]) (2) and international (Kidney Disease Improving Global Outcomes and National Institute for Health and Care Excellence) (5,15) guidelines supported by level 1–2 evidence, as well as guidelines for smoking cessation, nephrotoxin avoidance, lipid management, and immunizations for which there exists strong, compelling evidence (see Figure 1). The final version was formulated according to feedback from PCPs within the practice regarding ease of use.

Education materials regarding CKD management and the checklist were provided to all 13 PCPs in a 30-minute lecture. We entered the CKD checklist into the electronic medical record before each patient’s clinic visit (see Figure 2). The CKD checklist was populated electronically with relevant information (testing already completed that year along with the results) by a study investigator or nursing staff. We sent providers an email reminder regarding

### CHRONIC KIDNEY DISEASE CHECKLIST FOR PCPs

CKD stage 1–4 defined as 1. two consecutive eGFRs between 15 and 60 separated by at least 90 days or 2. evidence of kidney damage as determined by urine markers of kidney damage, specifically proteinuria (urine protein dipstick 1+ or greater, spot urine albumin-creatinine ratio > 200 mg/g) measured on two consecutive dates separated at least 90 days with or without decreased GFR.

#### SLOWING PROGRESSION

- [ ] BP < 140/90
- [ ] HbA1c ≤ 7% in diabetic patients within 6 months
- [ ] Annual screen for proteinuria with spot urine albumin/creatinine
- [ ] On ACE-I or ARB* if diabetes or microalbumin/creatinine > 30 mg/g
- [ ] Smoking cessation discussion
- [ ] Discuss avoiding NSAIDs/nephrotoxins
- [ ] LDL < 100 within last year
- [ ] 5-year Pneumovax
- [ ] Yearly Influenza vaccine

#### TREATING COMPLICATIONS

- [ ] CBC, iron studies within last year
- [ ] Calcium, Phosphate, Parathyroid hormone (if GFR < 60 check every 6 months, if GFR < 30 check every 3 months)

#### REFERRAL TO NEPHROLOGY GUIDELINES

GFR < 30

- Persistent proteinuria despite ACE-I use
- Persistent hyperkalemia
- Resistant hypertension
- GFR decrease > 30% in 4 months without explanation
- Unclear etiology of CKD
- Anemia requiring erythropoietin stimulating agents
- Elevated Phosphate, Parathyroid hormone

Abbreviations: BP, blood pressure; HbA1c, hemoglobin A1c; ACE-I, angiotensin converting enzyme-inhibitor; ARB, angiotensin receptor blocker; NSAID, Nonsteroidal anti-inflammatory drugs; LDL, Low-density lipoprotein; CBC, Complete blood count; GFR, Glomerular filtration rate

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Figure 1. | CKD checklist for primary care providers. ACE-I, angiotensin-converting enzyme inhibitor; ARB, angiotensin-receptor blocker; CBC, complete blood count; HbA1c, hemoglobin A1c; NSAID, nonsteroidal anti-inflammatory drug.
patients with CKD checklists to complete the week of scheduled visits. The CKD checklist was reviewed, notated by the PCP, and maintained as a separate document from the clinic visit note within the medical record.

We conducted this study at the Gretchen and Edward Fish Center for Women’s Health, a primary care practice affiliated with Brigham and Women’s Hospital in Boston, Massachusetts. The institutional review board approved the study and waived the need for informed patient consent.

Patient Population and Data Sources
We analyzed 368 patients (105 in the intervention group and 263 in the control group) during a 1-year time period from August 2012 to August 2013. Inclusion criteria included the presence of CKD stages 1–4, defined as two consecutive eGFRs between 15 and 60 ml/min per 1.73 m² or two consecutive urine tests showing significant proteinuria (≥1+ on dipstick or urine microalbumin-to-creatinine ratio >30 mg/g) separated by ≥90 days (2). Exclusion criteria included eGFR <15 ml/min per 1.73 m² or RRT. We used the Brigham and Women’s Hospital Research Patient Data Registry and electronic medical record to determine adherence to CKD guidelines in both groups.

Measured Variables and Outcomes
We examined adherence to both process and quality measures by recording BP, medications (including angiotensin-converting enzyme inhibitors [ACE-Is] and angiotensin-receptor blockers [ARBs]), laboratory results, documentation of discussion about avoiding nonsteroidal anti-inflammatory drugs (NSAIDs), and vaccination for influenza and pneumococcus. Additional variables collected include demographic
characteristics and comorbid conditions. To isolate the effects of the checklist intervention on differences in the delivery of CKD care as opposed to differences across providers unrelated to the intervention, we performed two sensitivity analyses. First, we collected data from the year before (August 1, 2011—July 31, 2012) the checklist intervention to compare guideline adherence pre- and post-intervention. Second, we measured adherence to guidelines distinct from CKD care, including appropriate use of mammography, colonoscopy, abdominal ultrasonography, Papanicolaou smear, and tetanus vaccination (16–20).

Statistical Analyses
We used a Fisher exact test to compare categorical variables between groups and the Wilcoxon rank-sum test or t test for continuous variables. We compared guideline adherence before and after the intervention using the McNemar test for matched pairs. To adjust for correlation among patients of a given PCP, we used a random-effects logistic regression model with provider used as a random intercept and adjusted for age and CKD stage. We also examined whether sex, race, and an adapted Charlson comorbidity index incorporating hypertension (assigning a score of 1 to hypertension) (21,22) were confounders. A two-sided P value <0.05 was considered to represent a statistically significant difference. Statistical analyses were performed using SAS software, version 9.3 (SAS Institute, Cary, NC).

Results
Clinical Characteristics
The two provider groups did not significantly differ with respect to number of clinic sessions, patient volume, physician age, years in practice, and percentage of time dedicated to clinical practice. The providers were all women, had similar training in internal medicine, practiced in the same location, and had access to the same nephrologists. Patients whose PCPs were assigned to the CKD checklist intervention (checklist group) had clinical characteristics similar to those whose PCPs were not (control group) (Table 1). Patients were predominantly women, given that the clinic is a center for women’s health. The checklist group was older, more likely to have a history of malignancy and coronary artery disease, and had a higher serum creatinine concentration and systolic BP than the control group. Patients in the control group were seen more frequently during the study period than was the intervention group (median, 3 visits [interquartile range, 1–4] compared with two visits [interquartile range, 2–4; P=0.01]). Patients in the two groups were managed in a similar manner before the study period (i.e., prior to implementation in the checklist group or observation in the control group), with respect to comanagement by nephrology (defined as ongoing care by a nephrologist), CKD listed in the problem list, ACE-I or ARB use, and most laboratory testing (data not shown). Patients in the control group were more likely to have had a complete blood count (CBC; 42.6% versus 29.5%; P=0.02) and calcium (44.9% versus 28.6%; P<0.01) obtained before the study period.

Adherence to CKD Management guidelines
Table 2 depicts the effect of the CKD checklist on CKD-related care. Compared with the control group, patients in the checklist group had higher rates of adherence to many guidelines, including annual testing of albuminuria, CBC, iron studies, phosphate, parathyroid hormone (PTH), more frequent use of an ACE-I or ARB, higher rates of achievement of hemoglobin A1c=7%, higher rates of vaccination for influenza and pneumococcus, and higher rates of documentation of NSAID avoidance. We found no significant difference in achievement of BP control, LDL cholesterol level=100 mg/dl, or annual calcium testing. New recognition of CKD and referral to nephrology were significantly higher in the checklist group; all patients referred to nephrology met at least one of the criteria noted in the checklist. We conducted a random-effects logistic regression analysis to account for intragroup correlation by PCP assignment and adjusted for age and CKD stage; we found no significant change in our results other than a lack of significance for annual CBC testing (Figure 3). We also found that clinically relevant variables such as sex, race, and Charlson comorbidity index incorporating hypertension were not confounders when added to the univariate model. Additional analysis for effect modification showed that for the outcomes of annual urine microalbumin and annual phosphate testing, patients with later-stage CKD (stages 3–4) derived more benefit from the checklist intervention than patients with early-stage (stages 1–2) CKD. Finally, we examined guideline adherence by PCP to examine whether there were outlier providers within either group, and we found that the providers were homogenous within each group (data not shown).

Of the patients in the CKD checklist group, 21 patients did not receive the checklist intervention (the patient met criteria for CKD; a checklist was entered in the medical record, but the PCP did not use the checklist). The most common reasons for not using the CKD checklist were PCP perception that the checklist would not be appropriate because of patient age (n=6) or patient care goals (n=10); a clear reason was not provided for five patients. We performed an as-treated analysis to compare patients who actually received the checklist (n=84) with those who did not receive a checklist (n=284). Patients who received a CKD checklist had higher rates of guideline adherence across all metrics, except for BP target of ≤140/90 mmHg during the study period. In the as-treated analysis, 26.2% of patients had an ACE-I or ARB started or adjusted during the study period compared with 4.2% of patients who did not receive a CKD checklist (P<0.001); furthermore, 90% of those in the as-treated intervention group with a definitive indication (diabetes and/or proteinuria) for ACE-I/ARB therapy received treatment, compared with 32.1% in the control group (P=0.003). No adverse drug events (hyperkalemia, AKI, allergic reactions) occurred among patients with ACE-I/ARB therapy initiated or adjusted.

Sensitivity Analyses
Table 2 also shows the results of adherence to healthcare maintenance guidelines not specifically related to CKD care in the checklist and control groups. We determined the number of patients for whom a particular guideline was indicated on the basis of age and clinical history and the number of patients who had the appropriate test or immunization performed. We found no difference between the intervention and control groups in guideline adherence to colonoscopy, mammography, Papanicolaou smear, or abdominal ultrasonography. The only difference
between groups was in the administration of the tetanus vaccine, which was performed more frequently in the control group (48.6% versus 69.2%; P < 0.001).

Among the 105 patients included in the checklist intervention, 80 were seen by the same PCP in the year before inclusion in the study. We found significantly higher rates of adherence to most guidelines after the checklist intervention compared with the year before, except for achievement of BP target of <140/90 mmHg and nephrology referral (Table 3). This analysis reflects the changes over the study period within the intervention group.

Additional adjustment for baseline adherence to guidelines was performed within the random-effects logistic regression model and made no substantial difference to the findings presented in Figure 3.

**Discussion**

In this intervention trial of a CKD checklist in a primary care practice, we found improvements in the delivery of care to patients managed with a checklist. Implementation of a CKD checklist resulted in improved adherence to various CKD management guidelines that persisted after adjustment for age and CKD stage and after accounting for within-group correlation based on PCP assignment. We conducted sensitivity analysis illustrating that the observed
improvements were probably not due to differences in physician practice patterns but rather were attributable to the intervention.

The CKD checklist was designed primarily on the basis of guidelines for which there was strong evidence- and consensus-based support. Anemia and bone disease recommendations have been debated (23,24). Certain recommendations have received more widespread acceptance given the strength of existing evidence, particularly the control of BP, proteinuria, hemoglobin A1c, and the use of ACE-Is and ARBs (15). BP reduction has been convincingly shown to stem the progression of CKD (25–27). Increasing evidence suggests that a BP of 140/90 mmHg may be an appropriate target (28). There is also strong evidence that proteinuria reduction reduces the risk of CKD progression (29,30). ACE-Is and ARBs reduce proteinuria independently of BP (31,32). Large studies have shown that achieving a hemoglobin A1c level of 7% reduces proteinuria and the risk of CKD (33,34). Limited evidence exists for smoking cessation (35), lipid control (36), and the avoidance of nephrotoxic agents (37). However, lipid control and smoking cessation seem prudent in light of the high incidence of cardiovascular mortality. Finally, early immunization in the spectrum of CKD care has been associated with improved outcomes (38).

Despite the publication of CKD practice guidelines, adoption among PCPs and nephrologists has been limited (7–10). A survey involving 301 physicians who were presented a hypothetical with CKD showed that only 47% of nephrologists and 33% of internists could identify five of six laboratory tests indicated by guidelines (7). A study of 11,774 patients with stages 3–4 CKD in a primary care setting found low rates of adherence to many CKD practice guidelines, including annual urine protein (30%), target LDL cholesterol <100 mg/dl (44%), annual PTH (13%), and inappropriate drugs prescribed (26%) (9). Few studies have examined adherence to nephrology referral recommendations, which illustrate discrepancies among providers, resulting in late or inappropriate referral (39–41). In summary, studies have demonstrated that although guidelines have been established, opportunities to improve CKD care remain.

Interventions to improve adherence to CKD practice guidelines have been studied in a few settings. Southern California Kaiser Permanente developed an initiative to identify patients with CKD on the basis of KDOQI guidelines and alert PCPs, and found that nephrology visits increased modestly from 20% to 24% (42). The Upstate New York Practice-Based Research Network study examined computer decision-making support based on guidelines

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**Table 2. Adherence to CKD guidelines**

<table>
<thead>
<tr>
<th>Guideline Adherence</th>
<th>Control Group (n=263)</th>
<th>Checklist Group (n=105)</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>BP ≤140/90 mmHg during study period</strong></td>
<td>209 (79.5)</td>
<td>84 (80.0)</td>
<td>&gt;0.99</td>
</tr>
<tr>
<td><strong>HbA1c ≤7% during study period</strong></td>
<td>141 (53.6)</td>
<td>81 (77.1)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td><strong>Annual urine MALB/creatinine ratio obtained</strong></td>
<td>73 (27.8)</td>
<td>77 (73.3)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td><strong>Receiving ACE-I or ARB during study period</strong></td>
<td>128 (48.7)</td>
<td>71 (67.6)</td>
<td>0.001</td>
</tr>
<tr>
<td><strong>NSAID avoidance discussed during study period</strong></td>
<td>17 (6.5)</td>
<td>75 (71.4)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td><strong>LDL cholesterol ≤100 mg/dl during study period</strong></td>
<td>134 (51.0)</td>
<td>58 (55.2)</td>
<td>0.49</td>
</tr>
<tr>
<td><strong>Annual influenza vaccine given</strong></td>
<td>127 (48.3)</td>
<td>71 (67.6)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td><strong>5-yr pneumococcal vaccine given</strong></td>
<td>73 (27.8)</td>
<td>69 (65.7)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td><strong>Annual CBC obtained</strong></td>
<td>219 (83.3)</td>
<td>98 (93.3)</td>
<td>0.01</td>
</tr>
<tr>
<td><strong>Annual iron studies obtained</strong></td>
<td>50 (19.0)</td>
<td>38 (36.2)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td><strong>Annual calcium obtained</strong></td>
<td>242 (92.0)</td>
<td>102 (97.1)</td>
<td>0.10</td>
</tr>
<tr>
<td><strong>Annual phosphate obtained</strong></td>
<td>93 (35.4)</td>
<td>69 (65.7)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td><strong>Annual PTH obtained</strong></td>
<td>43 (16.4)</td>
<td>64 (61.0)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td><strong>CKD newly recognized</strong></td>
<td>2 (0.8)</td>
<td>43 (41.0)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td><strong>Patient referred to nephrology</strong></td>
<td>0 (0)</td>
<td>10 (9.5)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td><strong>Non–CKD-related guidelines, n/n (%)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Colonoscopy</td>
<td>168/232 (72.4)</td>
<td>67/102 (65.7)</td>
<td>0.24</td>
</tr>
<tr>
<td>Mammography</td>
<td>167/212 (78.8)</td>
<td>64/91 (70.3)</td>
<td>0.14</td>
</tr>
<tr>
<td>Papanicolaou smear</td>
<td>91/111 (82.0)</td>
<td>26/39 (66.7)</td>
<td>0.07</td>
</tr>
<tr>
<td>Abdominal ultrasonography</td>
<td>9/18 (50.0)</td>
<td>1/6 (16.7)</td>
<td>0.34</td>
</tr>
<tr>
<td>Tetanus</td>
<td>182/263 (69.2)</td>
<td>51/105 (48.6)</td>
<td>&lt;0.001</td>
</tr>
</tbody>
</table>

HbA1c, hemoglobin A1c; NSAID, nonsteroidal anti-inflammatory drug.

aCKD listed in the problem list for the first time over the course of the study period.
bPatient newly referred to nephrology during the study period.
cDenominator for each test represents population for which testing is indicated.
in primary care clinics and found that the recognition of CKD and diagnosis of anemia improved substantially (43). These two studies focused on improving recognition of CKD as opposed to addressing comprehensive CKD guidelines. Algorithms have been developed to promote adherence to CKD guidelines (44,45). However, none have been validated, and most are cumbersome to follow. The CKD checklist meets several requirements: (1) incorporation of guidelines for which there is evidence-based support, (2) design targeted toward the appropriate specialty (i.e., the primary care–specific checklist includes nephrology referral guidelines), and (3) a format accessible to clinicians (46).

Several points warrant additional discussion. First, it is important to address why the CKD checklist did not affect hypertension control. The most likely reason is that this intervention was not comprehensive enough to address all factors associated with lack of BP control, particularly adherence to antihypertensive agents and dietary factors (47). Although the CKD checklist may improve clinician inertia, the most effective hypertension interventions include education and BP monitoring (48). Second, the lack of significant improvement in annual calcium measurement in the intention-to-treat analysis is probably due to the high rate of adherence before implementation of the checklist (likely reflecting inclusion of serum calcium in the routine basic metabolic panel). Third, LDL control was not significantly improved in the intention-to-treat analysis, although it was in the as-treated analysis. As with BP, factors such as diet and medication adherence are not addressed with a checklist. Finally, it is important to emphasize that the success of a CKD checklist depends on consideration of provider workflowurinary bladder content and dietary factors (47). Although the CKD checklist may improve clinician inertia, the most effective hypertension interventions include education and BP monitoring (48). Second, the lack of significant improvement in annual calcium measurement in the intention-to-treat analysis is probably due to the high rate of adherence before implementation of the checklist (likely reflecting inclusion of serum calcium in the routine basic metabolic panel). Third, LDL control was not significantly improved in the intention-to-treat analysis, although it was in the as-treated analysis. As with BP, factors such as diet and medication adherence are not addressed with a checklist. Finally, it is important to emphasize that the success of a CKD checklist depends on consideration of provider workflow and strategic implementation. Although we adopted a checklist model, other features, such as automatic entry into the electronic medical record, autopopulation, and weekly reminders, constitute a form of clinical decision support. Before implementation of this study, PCPs were asked about practice patterns and preferences regarding incorporation of the checklist into their workflow, and this was critical to the success of the intervention. There may be providers who are “early adopters” and take the initiative to incorporate the CKD checklist into their workflow; most providers will require system support to facilitate use. This could come in the form of an electronic medical record that identifies patients meeting criteria for CKD and automatically populates a progress note with a CKD checklist, or a medical assistant who helps the provider complete the checklist during an annual visit. Regardless of the approach, it is clear from this study that strategic implementation can lead to the success of a CKD checklist in improving guideline adherence.

<table>
<thead>
<tr>
<th></th>
<th>Odds Ratio and 95% CL</th>
<th>OR</th>
<th>LCL</th>
<th>UCL</th>
</tr>
</thead>
<tbody>
<tr>
<td>BP &lt;140/90</td>
<td>0.91</td>
<td>0.52</td>
<td>1.57</td>
<td></td>
</tr>
<tr>
<td>HbA1c &lt;= 7</td>
<td>2.89</td>
<td>1.43</td>
<td>5.08</td>
<td></td>
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<tr>
<td>Urine MALB/creat</td>
<td>7.87</td>
<td>3.93</td>
<td>17.24</td>
<td></td>
</tr>
<tr>
<td>On ACE-I or ARB</td>
<td>2.07</td>
<td>1.03</td>
<td>4.17</td>
<td></td>
</tr>
<tr>
<td>NSAID Avoidance</td>
<td>41.7</td>
<td>17.8</td>
<td>100</td>
<td></td>
</tr>
<tr>
<td>Annual LDL &lt; 100</td>
<td>1.1</td>
<td>0.63</td>
<td>1.98</td>
<td></td>
</tr>
<tr>
<td>Annual Flu Vaccine</td>
<td>2.09</td>
<td>1.08</td>
<td>4.03</td>
<td></td>
</tr>
<tr>
<td>5-year Pneumovax</td>
<td>4.72</td>
<td>2.59</td>
<td>8.62</td>
<td></td>
</tr>
<tr>
<td>Annual CBC</td>
<td>2.35</td>
<td>0.88</td>
<td>6.45</td>
<td></td>
</tr>
<tr>
<td>Annual Iron Studies</td>
<td>2.38</td>
<td>1.43</td>
<td>3.97</td>
<td></td>
</tr>
<tr>
<td>Annual Calcium</td>
<td>2.08</td>
<td>0.47</td>
<td>9.29</td>
<td></td>
</tr>
<tr>
<td>Annual Phosphate</td>
<td>3.52</td>
<td>1.49</td>
<td>8.33</td>
<td></td>
</tr>
<tr>
<td>Annual PTH</td>
<td>8.06</td>
<td>4.78</td>
<td>13.7</td>
<td></td>
</tr>
</tbody>
</table>

Figure 3. Forest plot depicting adjusted effect of CKD checklist on adherence to CKD management guidelines. The random effects logistic regression model accounts for within-group correlation by primary care provider assignment and is adjusted for age and CKD stage (1–4). Odds ratio (OR)>1 (to right of solid vertical line) reflects increased adherence in patients assigned to the CKD checklist. Results for avoidance of nonsteroidal anti-inflammatory drugs avoidance cannot be seen in the figure because the OR is 41.7 (95% confidence limit [95% CL], 17.8 to 100), which is beyond the scale of the figure. LCL, lower confidence limit; PTH, parathyroid hormone; UCL, upper confidence limit; urine MALB/creat, urine microalbumin-to-creatinine ratio. ORs presented are based on 263 patients in the control group and 105 patients in the checklist group.
Despite the potential limitations, our study indicates that the implementation of a CKD checklist can significantly improve adherence to various CKD management guidelines and improve the delivery of CKD care.

Disclosures
None.

References

Potential limitations warrant mention. The major limitation of this study was the potential bias introduced based on PCP agreement to use the CKD checklist (i.e., those who participated may be more motivated to provide appropriate care independent of checklist use). We sought to address this by educating all providers in the practice regarding project goals and evidence regarding CKD management. We also performed sensitivity analyses that showed no differences in rates of adherence to non-CKD-related guidelines and improvements within the intervention group before and after the intervention. One limitation related to NSAID avoidance is the possibility that the observed improvement reflected documentation only, rather than an improvement in care. Another limitation involves the possibility of the Hawthorne effect, in which knowledge of study participation leads to behavior changes affecting the outcome of interest (49,50). Both provider groups were aware of the study, which may mitigate potential bias. Because involvement with other quality-improvement projects was a selection criterion for control group providers, it is possible that the observed differences resulted from the control group’s focus on other initiatives rather than an effect of the checklist. Finally, although we examined some outcome measures (such as BP control, LDL control, immunization administration, and NSAID avoidance), other important outcomes (such as control of proteinuria and progression of CKD) require longer-term follow-up, which was beyond the scope of this study. We recognize the importance of pursuing further steps, such as conducting a randomized controlled trial of multiple clinics over the course of several years and measuring outcomes (e.g., proteinuria control, CKD progression, and mortality).

Table 3. Adherence to CKD management guidelines in the intervention group, before and after implementation

<table>
<thead>
<tr>
<th>Guideline Adherence</th>
<th>Before Intervention n=80</th>
<th>After Intervention n=80</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>BP ≤140/90 mmHg during study period</td>
<td>53 (66.3)</td>
<td>62 (77.5)</td>
<td>0.05</td>
</tr>
<tr>
<td>HbA1c ≤5% during study period</td>
<td>30 (37.5)</td>
<td>62 (77.5)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Annual urine MALB/creatinine ratio obtained</td>
<td>20 (25.0)</td>
<td>60 (75.0)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Receiving ACE-I or ARB during study period</td>
<td>45 (56.3)</td>
<td>57(71.3)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>NSAID avoidance discussed during study period</td>
<td>8 (10.0)</td>
<td>58 (72.5)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>LDL cholesterol ≤100 mg/dl during study period</td>
<td>32 (40.0)</td>
<td>43 (53.8)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Annual influenza vaccine given</td>
<td>42 (52.5)</td>
<td>54 (67.5)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>5-yr pneumococcal vaccine given</td>
<td>23 (28.8)</td>
<td>52 (65.0)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Annual CBC obtained</td>
<td>62 (77.5)</td>
<td>76 (95.0)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Annual iron studies obtained</td>
<td>16 (20.0)</td>
<td>31 (38.8)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Annual calcium obtained</td>
<td>74 (92.5)</td>
<td>78 (97.5)</td>
<td>0.005</td>
</tr>
<tr>
<td>Annual phosphate obtained</td>
<td>16 (20.0)</td>
<td>52 (65.0)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Annual PTH obtained</td>
<td>13 (16.3)</td>
<td>49 (61.3)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>CKD newly recognizeda</td>
<td>2 (2.3)</td>
<td>34 (42.3)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Patient referred to nephrologyb</td>
<td>4 (0.1)</td>
<td>9 (11.3)</td>
<td>0.25</td>
</tr>
</tbody>
</table>

Values are expressed as number (percentage).
aCKD listed in the problem list for the first time over the course of the study period.
bPatients newly referred to nephrology during the study period.


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See related editorial, “Checklists as Computer Decision Support at the Point of Care: A Step Forward in the Recognition and Treatment of CKD by Primary Care Physicians,” on pages 1505–1506.