

Recommendations for a Clinical Decision Support for the Management of Individuals with Chronic Kidney Disease

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Background and objectives: Care for advanced CKD patients is suboptimal. CKD practice guidelines aim to close gaps in care, but making providers aware of guidelines is an ineffective implementation strategy. The Institute of Medicine has endorsed the use of clinical decision support (CDS) for implementing guidelines. The authors' objective was to identify the requirements of an optimal CDS system for CKD management.

Design, setting, participants, and measurements: The aims of this study expanded on those of previous work that used the facilitated process improvement (FPI) methodology. In FPI, an expert workgroup develops a set of quality improvement tools that can subsequently be utilized by practicing physicians. The authors conducted a discussion with a group of multidisciplinary experts to identify requirements for an optimal CDS system.

Results: The panel considered the process of patient identification and management, associated barriers, and elements by which CDS could address these barriers. The panel also discussed specific knowledge needs in the context of a typical scenario in which CDS would be used. Finally, the group developed a set of core requirements that will likely facilitate the implementation of a CDS system aimed at improving the management of any chronic medical condition.

Conclusions: Considering the growing burden of CKD and the potential healthcare and resource impact of guideline implementation through CDS, the relevance of this systematic process, consistent with Institute of Medicine recommendations, cannot be understated. The requirements described in this report could serve as a basis for the design of a CKD-specific CDS.

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Chronic kidney disease (CKD) is an increasingly common condition that can progress to end-stage renal disease (ESRD), resulting in large health and resource burdens (1,2). Early and appropriate care consistent with practice guidelines during the stages before ESRD can delay or limit progression, and improves outcomes even if ESRD develops (3).

However, given poor adherence to these current CKD practice guidelines, care for advanced CKD patients is not optimal (4-6). These CKD practice guidelines aim to close gaps in care (7,8); however, simply making providers aware of guidelines has long proven to be an ineffective strategy for improving care. Several guideline implementation tools and implementation strategies have been used to promote adherence to clinical guidelines but have had limited success (9). The problem of

guideline implementation has been attributed to several factors, including lack of awareness, inertia of previous practice, and lack of time required for implementing guidelines (10-12).

In seeking to address the problem of implementing guidelines in clinical practice, groups including the Institute of Medicine (13) have endorsed the use of clinical decision support (CDS), defined as the "act of providing clinicians, patients and other health care stakeholders with pertinent knowledge and/or person-specific information, intelligently filtered or presented at appropriate times, to enhance health and health care" (14). Examples of CDS include providing reminders of required chronic disease management services to clinicians within an electronic health record system, providing cancer screening recommendations to patients within a web-based personal health record system, and delivering patient-specific recommendations to clinicians within a computerized provider order entry system.

Practical guidance on the design, development, and deployment of CDS systems is available from an implementation workbook published by the Healthcare Information and Management Systems Society (15) This workbook organizes the

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process of CDS implementation into six concrete steps and provides worksheets and examples for accomplishing them. The steps are (1) identify stakeholders and determine goals and objectives; (2) catalog the available information systems infrastructure; (3) select CDS interventions to achieve the goals and objectives; (4) specify and validate the proposed interventions and implementation plan, then develop the implementations and logistics; (5) test and launch the CDS interventions; and (6) evaluate the intervention impact, then enhancing as needed.

CDS systems have tremendous potential to facilitate improvements in the management of CKD; however, they are neither routinely used nor widely available. In kidney disease, they have been predominantly used for providing guidance regarding medication dosage (16). Individual CDS applications have also been developed for assisting with the management of several common comorbidities associated with CKD, including hypertension (17) and diabetes mellitus (18). However, there are few, if any, CDS systems available that optimally support the comprehensive care of patients with CKD.

Given the need for CDS to improve CKD management and the lack of an existing solution to meet this need, our primary objective was to identify the requirements of an optimal CDS system for CKD management according to existing guidelines. In addition, our secondary goal was to develop a systematic strategy that could be used by other individuals interested in identifying the requirements of a CDS system for the management of other chronic medical conditions.

Materials and Methods

The aims of this study expanded on previous work that used a methodology termed facilitated process improvement (FPI) toward the development and implementation of an evidence-based CKD guideline and a patient management toolkit (Appendix A) (19,20). The FPI approach is based on principles of total quality management but differs from it in one significant way. In FPI, an expert workgroup performs groundwork and develops a set of quality improvement tools that can be selected and customized by practitioners who have insufficient time or training to develop the tools. Tools are developed by the workgroup through an understanding of the settings in which quality improvement tools will be used, processes of care in different settings, process failures, and root causes of process failures. Tools developed through this systematic process include options that can potentially meet the needs of a range of practices with varying resource availability (*e.g.* in terms of information technology or support staff). FPI proposes that, because national experts perform all of the preliminary work, practitioners simply select and customize tools that meet their unique needs.

During the current project, the FPI concept was expanded by an internal workgroup (authors of this report). Our goals were to build on our previous understanding of the process of identifying and managing CKD, as well as recognizing process failures and root causes related to CDS use in CKD. We developed requirements of a CDS system that could address these root causes through two steps.

First, we identified existing CDS systems for CKD management. For this purpose, we extended an existing (1996 to 2003) literature search on CDS conducted by two researchers on our team (D.L. and K.K.) (21) to include 2003 to 2007, and limited the results to CKD-related applications. This search was supplemented by reviews of reference lists contained in seed articles. We also sought to identify abstracts presented at a 2006 national meeting convened by the American Society of

Nephrology and the American Medical Informatics Association. Finally, as another means to identify extant CDS applications, we searched through gray literature.

Second, with an understanding of the existing state of CDS in CKD, we conducted a brainstorming session with a group of multidisciplinary experts. (Appendix B) This panel possessed experience and expertise in a wide range of disciplines relevant for our project.

In preparation for a one-day brainstorming session, the internal workgroup developed a list of general assumptions about the context in which a CDS would be used for identifying and managing CKD (Table 1). This list was presented to the expert advisory panel at the initiation of the workshop.

The workshop was moderated by D.M. and was divided into time segments for orientation, brainstorming, refining recommendations, and validating recommendations (22,23). All participants were repeatedly invited to offer recommendations and were advised that no ideas would be wrong or unacceptable. Initially, participants were asked to write down their ideas anonymously on individual Postit notes that were then organized on easel sheets. Participants were advised that their ideas would not be judged or criticized during brainstorming. Later they were encouraged to combine ideas or to improve on them with new items. Finally, the participants consolidated all the ideas into thematically related groups.

Participants reviewed the final listing of all of the ideas related to general CDS requirements and those related to the specific-use case that had been discussed. Then, after the workshop, the internal workgroup convened several times to review workshop outcomes, make data analysis decisions, and develop the current report. Conclusions were drawn from the results and debated until a consensus was reached.

Table 1. Assumptions related to the use of clinical decision support systems for chronic kidney disease management in the United States

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- Electronic health records (EHR) will not be in widespread use in the U.S. for some time
 - Clinicians will not adopt new technology unless (i) it is financially advantageous (or at least cost neutral) or (ii) use is mandated
 - Clinician use of technology will not be mandated in the U.S. for some time
 - There will be a diversity of EHR systems used in the U.S. for some time
 - Clinicians would like to provide better care to their patients if they can do so easily
 - A useful clinical decision support systems (CDS) for use in CKD must support a full spectrum of information technology infrastructures & data availability
 - All clinicians will have access to a fax machine
 - Most clinicians will have access to a personal computer (PC) with an Internet connection
 - Many patients will not have Internet access
 - It is reasonable to restrict the intended audience of the CDS system to clinicians with PCs and Internet access in their work areas/exam rooms
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Results

The search for extant CDS systems for CKD (*i.e.* the systematic literature search, the search of meeting presentations and abstracts, and the search of the gray literature) led to the identification of a relatively small volume of literature related to CDS applications in CKD (Table 2). In summary, four published articles were found, all of which focused on CDS as a tool for the prevention of medication errors in patients with abnormal renal function (16,24–27). Only one published abstract was found (28). Although it described a CDS system geared toward management of CKD, it focused on supporting the initial management of referred patients by primary care providers in the United Kingdom. Finally, four CDS applications were found, some of which have the potential to serve as CDS systems for CKD care (29–33). However, the information we retrieved from the websites did not provide adequate details to confirm that the applications addressed the entire spectrum of barriers to implementing CDS that we had previously identified.

Next, our 1-day workshop included 12 multidisciplinary experts. The entire panel agreed that the prerequisite assumptions (Table 2) possessed reasonable face validity for the goals of this project. Guided by the facilitator, the group then identified several requirements of an optimal CDS system for CKD management that considered the following: (1) the process of CKD patient identification and management, (2) barriers associated with this process, and (3) mechanisms by which a CDS could address these barriers. Then, the advisory panel and the internal workgroup grouped these requirements according to a high-level classification scheme. This was based on a similar scheme that researchers in this group (D.L. and K.K.) have used previously when describing the features of CDS systems. (Table 3) (21) A CDS system that supports most or all of these features would be desirable for facilitating CKD management. It should be noted that most of the

requirements identified through the workshop are applicable to the management of many chronic medical conditions other than CKD, especially those that require involvement of more than one physician specialist and ancillary providers, as well as active participation by the patient.

The brainstorming and open discussions related to three central themes: (1) requirements of an optimal CDS System for CKD, (2) specific clinical knowledge needs related to CKD management that should be supported by a CDS system in a typical use case scenario (the comanagement of a patient with CKD by a general internist and a consulting nephrologists), and (3) key requirements for the successful implementation of a CDS system in practices caring for CKD patients (in contrast to the requirements of a CDS system itself).

In addition to the requirements of a CDS system for CKD, the specific knowledge needs for CKD management were discussed during the workshop in the context of a representative use scenario (the comanagement of a patient with CKD by a general internist and a consulting nephrologists). These discussions allowed the group to identify the specific knowledge needs related to CKD management that should be supported by a CDS system for CKD. (Table 4) Of note, these information needs overlap significantly with the information needs identified through the one-on-one interviews and focus group conducted with clinicians during our prior work (*i.e.* during the development of the *Advanced CKD Patient Management Toolkit*).

Finally, the group also developed a set of core requirements that would be critical to the successful implementation of a CDS system. These included (1) establishing a business case for implementation and ongoing support, (2) securing institutional support, (3) securing support of local opinion leaders, and (4) introducing a CDS system as a component of an overall revamping of clinical workflows.

Table 2. Results of a search for applications of clinical decision support (CDS) for the management of CKD

Search strategy	Studies/applications retrieved	Area of decision support addressed by study/application
Search for published literature search (1966 to 2007)	Galanter <i>et al.</i> (2005)/24 Nash <i>et al.</i> (2005)/25 Rind <i>et al.</i> (1994)/26 Oppenheim <i>et al.</i> (2002)/27	Preventing medication errors in individuals with renal disease
Abstracts presented at the American Society of Nephrology and American Medical Informatics meetings (2006–2007)	Oppenheim <i>et al.</i> (2002)/27	CDS for primary care providers; includes guidelines for referral and management
Gray literature for CDS applications in CKD ^a	InferMed Ltd./29 Raghavan <i>et al.</i> /30 Gamewood Inc./31 Allscripts/32	AREZZO/anemia management Darwin/dialysis Gamewood/wide range of CKD management issues Allscripts/limited range of CKD management issues

^aThis list is not a comprehensive list of all CDS applications available. AREZZO decision support technology is based on the PRO *forma* language and method, and can be used for designing and executing computerized clinical guideline applications.

Table 3. Requirements of an optimal clinical decision support (CDS) system for CKD

Requirement	Examples of how a CDS system could fulfill the requirement
General system	
be capable of integrating with existing IT systems to facilitate use of existing electronic data and workflow integration	Allow CDS system to be integrated within an underlying EHR, CPOE, or e-prescribing system
employ a flexible, scalable, and standards-based software architecture to enable deployment of the system in various clinical and IT environments	Use a services-oriented architecture leveraging software services whose functionality and interfaces have been standardized by the HL7-OMG Healthcare Services Specification Project(32) Use applicable interoperability standards (<i>e.g.</i> , HL7 standards, SNOMED CT, LOINC) where possible. Decouple knowledge base from front-end CDS applications
allow clinician user groups to customize clinical management algorithms to reflect local policies and preferences	Allow a clinician user group to treat hypertension more or less aggressively than recommended by JNC7 guidelines
be a net time-saver to use or require minimal time to use	Facilitate creation of appropriate clinical documentation based on data collected for the purposes of providing CDS Pre-fetch required data to ensure fast access to CDS recommendations when needed Electronically collect appropriate information from patients, either from their homes or in the clinic waiting room
be financially neutral or beneficial for clinicians to implement and use	Save time, <i>e.g.</i> , through automated note generation Support clinicians' billing needs, <i>e.g.</i> , through automated claims generation and/or provision of decision support on billing optimization Enable improved performance on pay-for-performance metrics
support appropriate secondary uses of data	Support billing, reporting, and research needs Support epidemiologic surveillance, health services research, and the identification of patients eligible for clinical trials
safeguard patient health information using appropriate security and privacy safeguards	Allow only authorized and authenticated users to access clinical records Ensure data are stored in accordance with regulations on the persistency of clinical documentation
Clinician-system interaction	
provide the decision support automatically as a part of clinician workflow where possible and appropriate	Provide CKD care recommendations within the default patient summary screen within an EHR system
provide the decision support as recommendations rather than as assessments where possible and appropriate	Instead of simply noting that a patient is in need of more intensive hypertension management, recommend a specific therapeutic course
provide the decision support at the time and location of clinical decision making	Provide care recommendations during a clinical encounter rather than as recommendations delivered in the mail
provide a clear, intuitive, and noncluttered user interface	Do not show supportive information (<i>e.g.</i> , research evidence underlying recommendation) unless specifically requested by the user
be easy to access from various locations	Enable clinicians to access the system from home through a secure Internet connection
allow users or user groups to customize the clinician-system interaction experience where appropriate	Allow user or user group to customize whether to display the status of all monitored conditions (<i>e.g.</i> , all CKD comorbidities) or to display the status only if the patient is in need of corrective action

Table 3. (Continued)

Requirement	Examples of how a CDS system could fulfill the requirement
be judicious about the use of a “push” methodology so as to avoid “alert fatigue”	Configure the drug interaction module of an e-Prescribing system so that alert pop-ups are only generated if the interaction is significant and clinically meaningful
deliver fast response times	Pre-fetch required data to ensure fast access to CDS recommendations when needed
minimize clinician data entry	Retrieve patient data required for determining a patient’s CKD needs from an EHR system
allow simple, point-of-care entry of relevant data that are not otherwise collected in a structured electronic format	Allow user to manually enter data on an influenza vaccine that was administered in a different state
prompt clinician to document reason for not following system recommendations	Require clinician to enter a reason for why a patient with CKD and hypertension should not be prescribed an ACE inhibitor or ARB.
distribute decision support messages to appropriate individuals using the communication methods most appropriate for the clinical situation at hand	Page appropriate clinician if serum electrolyte analysis identifies dangerous electrolyte imbalance versus send email for a missed appointment.
document the communications generated as a result of a CDS inference, as well as actions taken in response to the communications	Document that a clinician did not add a second anti-hypertensive medication as recommended by the CDS system because the patient refused on financial grounds.
Clinician communication content	
allow for clear identification of which clinician or clinical practice is responsible for a given aspect of patient care	Allow users to make clear whether the management of a patient’s hypertension is primarily the responsibility of the referring general internist or the consulting nephrologist
identify a patient’s current status within clinical management algorithms	Note whether a patient is in need of planning for vascular access.
prioritize care needs and identify the most important issues that need to be addressed during a given clinical encounter	Identify vascular access planning as the most important issue to address during a given visit for a patient with CKD
provide accurate and up-to-date assessments or recommendations that do not conflict with any other assessments or recommendations made by the system	Review and update the underlying knowledge base periodically, and rigorously test the system both before and after deployment.
allow user to easily identify how the CDS system arrived at the stated conclusion. Make sure the origin of data (e.g., clinical note, billing data, patient-reported data) is clear.	When displaying a GFR, allow user to easily understand the algorithm used to calculate the GFR and to view the raw data inputs used for the calculation (e.g., age, gender, race, and date and value of last serum creatinine test).
allow CDS algorithms to be customized or turned off for specific patients or providers to the extent allowed by the relevant administrative entity	Allow a clinical practice within a health system to customize the CDS algorithms in use at their practice, to the extent allowed by the health system.
make it clear that the system is simply an aid and that all clinical decisions are deferred to the clinician	Allow most CDS system recommendations to be overridden by a clinician.
provide easy access to context-relevant educational materials for clinicians	When recommending an ACE inhibitor for the management of hypertension, provide a link to the clinical practice guideline serving as the source of the recommendation.
provide easy access to the level of evidence associated with a patient management algorithm, the methodology used to develop the algorithm, and the evidence base supporting these algorithms	Provide a link next to a CKD care management recommendation that allows clinicians to find out that the recommendation is based on a meta-analysis of seven large randomized controlled trials and that the methodology used to generate the underlying algorithm is based on the approach used by the American College of Physicians.

Table 3. (Continued)

Requirement	Examples of how a CDS system could fulfill the requirement
collect information on patient adherence to therapy and make this information available to the patient's clinicians	Use pharmacy claims data to notify the clinician that a patient appears to be non-adherent to the prescribed medication regimen for hypertension
generate performance feedback reports	Allow a clinician to generate on-demand reports on the proportion of his patients who have both CKD and hypertension and are prescribed an ACE inhibitor or ARB.
generate reports on outlier patients requiring recall	Allow a clinic manager to generate on-demand reports on patients who meet clinic-defined criteria for active recall into the clinic
Patient decision support	
allow patients and their caregivers to view and understand their care needs through a patient portal	Allow patients to log into a secure Web site to identify the health interventions required to optimize their health maintenance and disease management
"push" care advice where appropriate	If patients are significantly overdue on important care needs, email these patients to check the patient portal to review their overdue care needs.
provide easy access to context-relevant educational materials for patients that are appropriate for the patients' literacy and language. Also, if possible, make educational materials reflect patients' motivation for success.	When recommending an ACE inhibitor for the management of hypertension to a clinician, provide links to Spanish patient information sheets on the drug. Provide educational modules within a patient portal.
assess patients' educational understanding of their condition.	Incorporate an educational assessment component in the patient portal and provide references to appropriate educational references based on patient performance on the assessments.
Auxiliary	
facilitate patient-clinician communication	If reimbursement models support it, allow patients to securely email their clinicians to ask questions.
facilitate clinician-clinician communication	Facilitate the transfer of appropriate information between referring clinician and consulting clinician
engage and leverage non-clinicians in the clinical care team	Support the provision of required care through standing orders that are administered by nurses without clinician involvement
enable iterative enhancement through capture of appropriate metrics and user feedback	Allow users to easily provide feedback on how the system can be improved Create reports on why clinicians are over-riding system recommendations and investigate whether an underlying clinical algorithm should be altered for recommendations that are consistently over-ridden

Clinician, physician or physician extender; ACE, angiotensin converting enzyme; ARB, angiotensin II receptor blocker; CPOE, computerized provider order entry; EHR, electronic health record; GFR, glomerular filtration rate; HL7, Health Level 7; JNC7, The Seventh Report of the Joint National Committee on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure; OMG, Object Management Group; SNOMED CT, systematized nomenclature of medicine clinical terms; LOINC, logical observation identifiers names and codes.

These key requirements are likely to facilitate the implementation of any CDS system aimed at improving the management of any chronic medical condition, not just practices managing CKD.

Discussion

The Roadmap for National Action on Clinical Decision Support states, "The goal of CDS is to provide the right informa-

tion, to the right person, in the right format, through the right channel, at the right point in workflow to improve health and health care decisions and outcomes. CDS should involve input from and be well accepted by end-users, and should support rather than detract from their workflow." It also states that "CDS should involve input from and be well accepted by end-users," and that it should "make business sense" (14).

Table 4. Knowledge needs for CKD management that should be supported by a CDS system (comanagement of a patient with CKD by a general internist and a consulting nephrologist)

Clinical task	Knowledge need
Identify patient as having CKD	CKD screening guidelines for patients with varying risk factors for CKD
Stage patients	Patient-specific screening recommendations
Diagnose primary cause	CKD stages and criteria for staging
Establish co-management plan between primary care clinician and nephrologist	Algorithms for working up patient with CKD to identify primary cause
	Information required by nephrologist from primary care clinician
	Information required by primary care clinician from nephrologist
	The clinician who is responsible for specific aspects of the patient's care (e.g., hypertension or hyperlipidemia management)
Manage comorbid conditions (hypertension, dyslipidemia, diabetes)	Algorithms for managing comorbid conditions
	Patient-specific care recommendations with regard to these conditions
Monitor progression of CKD	CKD monitoring guidelines
Plan for permanent vascular access	Patient-specific monitoring recommendations
	Permanent vascular access planning guidelines
Establish and implement patient education plan, adjusting for literacy and language	Patient-specific planning recommendations
	CKD patient education guidelines
	Patient-specific educational priorities and educational materials
Identify reasons for patient non-compliance with management plan and adjust management accordingly	Patient-specific reasons for non-compliance

These recommendations are based on evidence that suggests that certain CDS features lead to a significant increase in the proportion of patients receiving appropriate, guideline-based care (34). A systematic review of features of CDS systems critical for improving clinical practice also demonstrates that automatic provision of decision support as part of clinician workflow, provision of recommendations rather than just assessments, provision of decision support at the time and location of decision making, and use of a computer to generate decision support lead to improved patient care (21).

We believe that, through a systematic process, we have developed a pragmatic set of recommendations that are aligned with those suggested by the developers of the Roadmap. The recommendations that we have derived address the three pillars of the Roadmap that are expected to help fully realize the promise of CDS: best knowledge is available when needed (Pillar 1), tools produce significant value while making financial and operational sense to end-users and purchasers (Pillar 2), and interventions and clinical knowledge undergo continuous improvement (Pillar 3).

We have accomplished this through a process similar to FPI, which is in turn based on standard quality improvement principles. Our methods include our prior work related to the development of a set of tools, a literature search to explore existing CDS applications in the field, our discussions as an internal workgroup,

and the workshop with our multidisciplinary advisory panel. Through this spectrum of activities, we have identified several requirements of a CDS for use in CKD management: general system requirements, clinician–system interaction requirements, requirements related to clinician communication, patient decision support requirements, and auxiliary requirements for a CDS in the context of CKD management. In addition, we have stipulated the knowledge needs for the most typical use case scenario in CKD management (*i.e.* the comanagement of a patient with CKD by a general internist and a consulting nephrologists).

Other researches have emphasized that ideal information systems should support knowledge-based decisions, possess evaluation/ reporting capability, evolve with the health care system, be sustainable, and be nonintrusive. They also claim that the major barriers to optimal use of decision support are that it does not fit into workflow; is slow and inflexible; and is associated with problems of information overload, lack of data integration (35). A decision-support system aimed at coordinating care of several chronic diseases should provide a consistent interface across various chronic diseases, and should be modifiable and expandable (36,37). A recent review of CKD in the United Kingdom (34) defines salient issues related to “information strategy” for CKD. These include integrating clinical records and calculating GFR, using existing patient data to automate CKD identification, pro-

viding performance feedback to providers, and using a decision support system. We note that the recommendations set forth by our advisory panel meet the information needs stated by Keble et al.

An existing literature review describes several determinants of successful dissemination and implementation of innovations. These include features of the innovation (*e.g.*, compatibility, low complexity, adaptability), characteristics of the system in which the innovation is expected to be implemented (*e.g.*, system antecedents, leadership, and vision), and the implementation process itself (*e.g.*, dedicated resources, attention to human resource issues, feedback) (39). The results of our brainstorming session include several of these factors, and we believe that they are critical for successful adoption of a CDS in CKD.

We believe that a CDS developed on the basis of the requirements stipulated by our advisory panel will satisfy recommendations of other researchers in the field, and meet the needs of a wide spectrum of users: health care system administrators, nephrologists, non-nephrologists, ancillary providers and CKD patients. Local information technology groups often build customized CDS applications that may be used within their existing electronic medical record systems or as independent CDS systems. As some of them decide to design CKD-specific CDS, they may seek advice from clinicians who could propose many of the requirements described in this report.

The systematic process that we have described in this report also responds to the “gap between the current state of CDS and

the full promise of CDS” (40). As such, our approach toward developing credible recommendations for a CDS should serve as guidance to other individuals interested in identifying the requirements of a CDS system for the management of any other chronic medical condition through relatively minor modifications to the CKD-specific CDS.

Despite their broad range of expertise and extensive experience, it is possible that our advisory panel of 12 members may not have uncovered the entire spectrum of CDS requirements for CKD management. These gaps may be discovered only when the specifications developed here are moved to the next phase: an actual CDS system implementation on the basis of recommendations in this report. Nevertheless, we believe that during this exercise we have developed a pragmatic process that should be used as the preliminary step for the development of any CDS application.

Conclusion

In conclusion, we consider our approach toward developing recommendations for a CDS for management of individuals with CKD to be pragmatic and realistic. The results of our brainstorming session results are aligned with the suggestions of the Roadmap for National Action on Clinical Decision Support. Finally, considering the growing burden of CKD and the potential healthcare and resource impact of guideline implementation through a CDS, the relevance of this first systematic step in its development cannot be understated.

Appendix A. Tools included in the advanced CKD patient management toolkit

Tool (intended user)	Intent of tool
Metatool (physician practice intending to use advanced CKD toolkit)	Serve as a “directory” of tools, provide insight for tool selection and strategies for tailoring to local circumstances
Assessment tool: patient identification (physician practice identifying advanced CKD patients)	Assess existing practice performance
Assessment tool: patient management (physician practice managing advanced CKD patients)	Assess existing practice performance
Physician education material (nephrologists)	Promote education by identifying patients, using GFR, comanaging patients, and introducing tools
Awareness letter ^a (nephrologist to colleagues)	Raise awareness of CKD, introduce concept of comanagement, promote education
CKD identification and action plan card ^a (referring physicians/physician extenders/nephrologists)	Promote identification of patients, appropriate timing of consult or referral to nephrologist, and use of guidelines
CKD identification and action plan poster (referring physicians/physician extenders/nephrologists)	Promote identification of patients, appropriate timing of consult or referral to nephrologist, and use of guidelines

Appendix A. (Continued)

Tool (intended user)	Intent of tool
GFR calculator ^a (referring physicians/ physician extenders/ nephrologists)	Identify CKD patients on the basis of GFR instead of serum creatinine
CKD chart flags/stickers (referring physicians/physician extenders/ nephrologists)	Flag medical records of patients with advanced CKD
Referring physician faxback form ^a (nephrologist to referring physician, faxed back to nephrologist)	Assure nephrologists obtain important clinical data; allow referring physician to clarify the purpose of referral
CKD postconsult letter ^a (nephrologist to referring physician)	Communicate comanagement plan to referring physician
Advanced CKD patient management flow sheet (physician managing advanced CKD patients)	Serve as a reminder and a standing order; serve as a data repository for use with evaluation tool for patient management
Advanced CKD algorithms ^a (physician/provider managing advanced CKD patients)	Provide implementation guidelines at point of care
Nephrology CPT codes ^a (nephrologists and providers managing advanced CKD patients)	Provide nephrology CPT reference codes and documentation guidelines
Supplemental tools (includes eDrugsRenal ^a and PDA Downloads for Tools ^a) (referring physicians/Physician extenders/ nephrologists)	Help provide dosage adjustments for patients with CKD and useful web sites for PDA programs
Patient diary (personal health record) (Patient)	Serve as a patient education and self-management tool; serve as both a patient reminder and a patient- initiated physician reminder
CKD class resources ^a (practice and patient)	Provide resources for CKD classes and for patient education and self-management
Patient education resources ^a (patient and caregiver)	Serve as a resource for patient education tools
Venipuncture reminder card (patient)	Remind patient and health care providers to protect arm veins in nondominant arm for future vascular access
Vascular access passport (patient)	Provide patient with information on catheter and vascular access placements
Postimplementation evaluation tool: Patient identification (practice identifying advanced CKD patients)	Evaluate impact of tools on patient identification and nephrology consult/referral
Postimplementation evaluation tool: Patient management (practice managing advanced CKD patients)	Evaluate impact of tools on patient management

Note: Although we use the term “nephrologist,” this group of providers includes all physicians who manage advanced CKD patients.

^aThese tools are suitable for downloading into a hand-held PC device (refer to Palm downloads at www.renalmd.org).

Appendix B

Participants in Decision Support Systems for Chronic Kidney Disease Advisory Meeting

Meenal Patwardhan – Principal Investigator, Methodologist
 David Matchar – Investigator, Internist
 Uptal Patel – Investigator, Nephrologist
 David Lobach – Investigator, Endocrinologist
 Kensaku Kawamoto – Investigator, Community & Family Medicine - Informatics
 Asif Ahmad – Advisor, VP & Chief Information Officer, DUHS
 David Edelman – Advisor, Internist
 Robert Gutman – Advisor, Nephrologist
 Paul Lee – Advisor, Ophthalmologist
 Franklin Maddux – Advisor, Nephrologist
 Maureen Velazquez – Advisor, Strategic Services Assoc., Hosp Cost Acct/Finance Mgt
 Kimberly Yarnall – Advisor, Internist
 Dev Kalyan – Advisor, Lawyer
 Robert Annechiarico – Advisor, Director of Cancer Center Biostatistics and Information
 David Butterly – Advisor, Nephrologist
 William Haley – Advisor, Nephrologist
 John Middleton – Advisor, Nephrologist
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Disclosures

The Principle Investigator, Meenal Patwardhan, maintained a full-time position in Duke University Medical Center during the project period 01/01/2007-04/30/07. This study was supported by Abbott Laboratories.

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