Action plan for determining and monitoring the prevalence of chronic kidney disease

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Chronic kidney disease (CKD) continues to remain high globally, up to 13.4% by one estimate. Although the number, geographic distribution, size, and quality of the studies examining CKD prevalence and incidence have increased over the past decade, the global capacity for CKD surveillance is still far less developed than that for hypertension, diabetes, and cardiovascular disease. Estimating CKD prevalence is constrained by inadequate standardization of serum creatinine and urine albumin assays, heterogeneity in study designs, lack of national registries in many countries, incomplete adoption of disease classification guidelines, and inconsistent use of evidence-based equations for estimating glomerular filtration rate.

Goal 1: Improve monitoring of CKD prevalence. To achieve this, disseminate the rationale for CKD prevalence monitoring, achieve uniform measurement of CKD markers, promote inclusion of CKD measurements in all large chronic disease cohorts and health surveys, harness administrative claims data for CKD surveillance, and incorporate the new CKD classification system in the International Classification of Diseases.

Goal 2: Improve CKD monitoring of populations underrepresented in studies to date. To achieve this, establish registries of chronic dialysis and transplantation in all countries; establish registries for special CKD groups, such as children, patients with rare diseases, and patients with special etiologies of CKD.

Goal 3: Improve identification of individuals with CKD. To achieve this, implement the Kidney Disease: Improving Global Outcomes guidelines for screening and testing, carry out randomized studies on screening strategies, ensure that estimated glomerular filtration rate is reported with all reports of serum creatinine, and leverage new software for identification and follow-up of CKD cases.

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Chronic kidney disease (CKD) continues to be a global public health problem because of its high prevalence, major impact on patients, high cost to society, poor public awareness, and shortage of clinical trials. This article expands on the recently published International Society of Nephrology CKD Roadmap[1] in *The Lancet* and describes issues related to CKD determination, monitoring, and prevalence in different regions and countries. We summarize the current state of estimating CKD prevalence, gaps in knowledge, stakeholders affected, and paths forward (Table 1).

Current state

Prevalence of CKD. The worldwide prevalence of CKD stages 1–5 is estimated to be up to 13.4% (95% confidence

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Table 1 | Action plan for determining and monitoring the prevalence of chronic kidney disease[1]

Goals	Activities	Partners	Possible deliverables
1. Monitor CKD prevalence	Disseminate the rationale for monitoring CKD prevalence	Ministries of health Policy experts Health care administrators Third-party payers	Published position statement National kidney policies Clarify the different measures of CKD burden (RRT, CKD stages, health care utilization, kidney mortality, costs) in general population and high-risk groups
	Achieve uniform CKD marker measurements in CKD prevalence studies	IFCC Diagnostic manufacturers Proficiency Testing and External Quality Assurance providers Reference Laboratories The Joint Committee for Traceability in Laboratory Medicine organizational members The National Institute of Standards and Technology	Published position statement Develop and share quality control procedures and materials
	Promote inclusion of CKD measurement and awareness in all large chronic disease cohorts and health surveys	Organizers of large studies, registries, such as WHO STEPS (102 countries), CVD, diabetes, oncology surveillance, and studies	Inventory of studies including and not including CKD and CKD awareness Task force to identify key contacts and include CKD and CKD awareness reporting
	Develop a plan to harness claims data for CKD surveillance	Health care providers Aggregators of health data (e.g., US Medicare, national health data repositories)	Established collaborations with regional and national societies and registries Workshop to assess feasibility and define action plan details Encourage validation of diagnostic codes in different regions Develop a plan to monitor strengths and limitations of claims data over time
	Incorporate the new CKD classification into WHO ICD coding	The WHO ICD-11 Revision Steering Group	Incorporation into the ICD-11
2. Establish CKD registries in special populations	Establish registries of chronic dialysis and transplantation in all countries	Established registries in Europe and North America as well as in Singapore, Morocco, Tunisia, Columbia, Argentina, and Uruguay GKHA[37] of the International Society of Nephrology	Inventory of CKD registries as part of the GKHA project[37] Task force to explore the development of a generic software application Define minimal dataset required for these registries, facilitate implementation, suggest methods to assess comprehensiveness Encourage the use and usefulness of the registries to enhance policy, observational research, and clinical trials
	Establish registries for special CKD groups, such as, children, rare diseases, special etiologies, and regions where CKD appears to be endemic (i.e., hotspots)	Established registries Special disease interest groups	Inventory of CKD registries as part of the GKHA project[37] Task force to explore the development of a generic software application to facilitate the establishment of CKD registries Define criteria for when a registry is high priority Encourage impactful use of the registries to enhance policy, observational research, and clinical trials
3. Identify individuals with CKD in high-risk groups	Implement KDIGO CKD guidelines for screening and testing	KDIGO Implementation Strategies Work Group	Implementation surveys Case finding strategies in high-risk groups to be implemented in most countries
	Carry out randomized studies to expand the evidence base for CKD screening strategies	CKD investigators	Research reports (focus on high-risk groups by condition, ethnicity, and region)
	Ensure that wherever serum creatinine concentration is measured, eGFR is reported	Clinical chemists (IFCC) EMR companies	Focused extension of the GKHA project[37] IFCC committees, National and international laboratory professional groups and health care institutions
	Develop and share protocols and electronic decision support tools for the identification and follow-up of CKD cases	EMR experts KDIGO Implementation Strategies Work Group	Workshops to assess feasibility Deployment of guidelines on novel web platforms

CKD, chronic kidney disease; CVD, cardiovascular disease; eGFR, estimated glomerular filtration rate; EMR, electronic medical records; GKHA, Global Kidney Health Atlas; ICD, International Classification of Disease; IFCC, International Federation of Clinical Chemists; KDIGO, Kidney Disease: Improving Global Outcomes; RRT, renal replacement therapy; WHO STEPS, World Health Organization STEPwise approach to Surveillance.

interval [CI]: 11.7 to 15.1), according to a meta-analysis of 44 country prevalence studies.[2] CKD was defined and staged according to the first Kidney Disease: Improving Global Outcomes (KDIGO) classification[3]: urine albumin-to-creatinine ratio of >30 mg/g or estimated glomerular filtration rate (eGFR) of <60 ml/min per 1.73 m^2 were defined as CKD, irrespective of duration. The lack of data on persistence of the condition for >90 days is likely to inflate prevalence estimates as it does for other conditions when based on a single visit (e.g., diabetes based on a single fasting glucose). An eGFR of >90 ml/min per 1.73 m^2 defines stage 1, 60 to 89 is stage 2; 30 to 59 is stage 3, 15 to 29 is stage 4, and <15 is stage 5. The majority of global CKD is stage 3. The prevalence of each of the 5 stages, in increasing order, is 3.5%, 3.9%, 7.6%, 0.4%, and 0.1%.

Prevalence is slightly higher in low- and middle-income countries than in high-income countries and in women than in men. Breaking down prevalence estimates by age and sex, a second meta-analysis of 33 prevalence studies estimated that the worldwide prevalence of CKD stages 1 to 5 was 10.4% in men (95% CI: 9.3 to 11.9) and 11.8% in women (95% CI: 11.2 to 12.6).[4] In high-income countries, the prevalence was 8.6% (95% CI: 7.3 to 9.8) in men and 9.6% (95% CI: 7.7 to 11.1) in women, whereas in low- and middle-income countries, it was 10.6% (95% CI: 9.4 to 13.1) in men and 12.5% (95% CI: 11.8 to 14.0) in women. Both meta-analyses acknowledged the significant variability in population composition, measurement methods, and study designs, which limits our ability to make meaningful direct comparisons of prevalence between regions.

Prevalence can also be stratified into general population cohorts and high-risk cohorts, defined as individuals having a diagnosis of diabetes, hypertension, or cardiovascular disease. A study of convenience samples from 12 countries in 6 world regions arrived at a prevalence of 14.3% (95% CI: 14.0 to 14.5) in general populations and 36.1% (95% CI: 34.7 to 37.6) in high-risk populations.[5] Unfortunately, the awareness of CKD remains low. Only 6% of the affected individuals in general populations and 10% of the affected individuals in high-risk populations were aware that they met the criteria for CKD.[5]

In the United States, several decades of rising CKD prevalence[6] reached a plateau in the mid-2000s.[7] However, the CKD prevalence in high-risk groups, including African Americans and diabetic patients, continues to rise. While the US studies are among the best in design, assay standardization and documentation of duration of CKD (the criterion of >3-month duration required in the definition of CKD is often not testable in one-time surveys) limit the robustness of inferences.

Prevalence of dialysis and transplantation. Renal replacement therapy (RRT), which refers to dialysis and kidney transplantation, is the treatment for end-stage renal disease (ESRD). RRT prevalence is often used as a surrogate estimate for ESRD prevalence, although this approach ignores patients receiving conservative care. A meta-analysis of 123 country-level prevalence studies estimated that at least 4.902 million patients worldwide needed RRT in 2010.[8] However, only 2.618 million patients had received RRT, suggesting that approximately half of the patients with ESRD might have experienced premature death from inadequate RRT accessibility. Of the 2.618 million patients who received RRT, 2.050 million (78%) had received dialysis, and 0.568 (22%) were living with a functioning kidney transplant.[8]

Not surprisingly, the availability of RRT depends on gross national income[9] and life expectancy and not on the prevalence of diabetes or hypertension.[8] This suggests that the current knowledge on variations in ESRD prevalence between countries is mostly a reflection of economic variations, which reflect the ability to provide treatment. The provision and maintenance of hemodialysis in resource-poor settings is constrained by the shortage of dialysis units, restriction of dialysis units to urban centers, low quality of dialysis units, frequency of electrical power outages, and absence of government subsidy or health insurance to offset the high cost of dialysis to the patient.[10] Of the 2.618 million patients who received RRT, 92.8% resided in high-income and upper-middle-income countries, whereas only 7.2% resided in low-income and lower-middle-income countries—a 70-fold prevalence gradient.[8] The largest treatment gaps exist in Africa, where 9% to 16% of ESRD patients have access to RRT and in Asia, where 17% to 34% of ESRD patients have access to RRT.[8] Of note, in China, India, Indonesia, Pakistan, and Nigeria, which collectively comprise half of the world's population, only 25% of the patients requiring RRT receive it.[8]

RRT use is projected to more than double between 2010 and 2030 from 2.618 million to 5.439 million,[8] mostly attributable to the economic development leading to greater access to dialysis and transplantation. The greatest growth is projected to occur in Asia, with a rise from 0.968 million in 2010 to 2.162 million in 2030, followed by Africa, with a rise from 0.083 million in 2010 to 0.236 million in 2030. This projected explosion in prevalence underscores the urgency with which knowledge gaps in CKD and ESRD prevalence must be addressed.

Knowledge gaps

The most deep-seated problem hampering efforts in estimating CKD prevalence today is the inadequate standardization in sampling and measurement methods in country-specific studies pooled for global estimates. Unfortunately, even a 0.04 mg/dl higher mean serum creatinine can contribute to meaningful changes (5% lower eGFR, 23% higher stage G3 CKD, and 12% higher overall CKD prevalence estimate for the US).[11] A systematic review of 82 CKD prevalence studies between 2003 and 2014 found that with respect to the serum creatinine assay, 67% used the Jaffe assay, which suffers from interference by other substances, a handful used modified Jaffe or compensated Jaffe (which adds a mathematical correction for "pseudochromogens"), and only 13% used the more specific creatinine enzymatic assay.[12] Only

29% of the studies calibrated their serum creatinine assays to the international standard (isotope dilution mass spectrometry). With respect to estimating GFR, the CKD Epidemiology Collaboration equation was used in 52% of the studies, and the updated Modification of Diet in Renal Disease Study equation, which produces slightly higher prevalence estimates than CKD Epidemiology Collaboration equation,[13] was used in 75% of the studies[12] (percentages exceed 100% as some studies used both equations). Thirty-nine percent of the prevalence studies reported a 95% CI.[12]

Dramatic variations in CKD prevalence have been documented across several studies. In Europe, a 5-fold difference was observed between studies in Norway and Italy on the low end and Germany on the high end.[14] It remains unclear how much of this variation was due to research methods versus true population differences. Without careful laboratory standardization, it is difficult to make inferences about CKD prevalence differences across time and location.

It is difficult to quantify the precise burden of ESRD because of the shortage of national registries, especially in low- to middle-income countries.[15] Even among countries with national registries, RRT prevalence may be underestimated,[15] as patients who do not receive long-term RRT are seldom registered or counted.[10] Although there are at least 144 renal registries worldwide, a systematic review found that only 48 of these had comprehensive patient-level and aggregate-level data accessible for external research use.[16] The majority of the 48 registries did not include information on patient ethnicity, education, employment, insurance, dialysis access, dialysis start, complications, quality of life, and treatment costs.[16] Less than half of the 48 registries met the criteria for data accessibility, which was defined as having annual reports, publications, and aggregate data accessible via websites, publicly available materials, or with assistance from registry staff.

Furthermore, even among existing studies, there is a widespread variation in study design and methods that queried the accuracy of CKD and ESRD prevalence estimates. CKD and ESRD prevalence studies often rely on convenience rather than random sampling and on regional rather than national coverage. Prevalence estimates for large countries are sometimes based on the registry of a single urban center. Urine measures for CKD are more difficult to standardize and suffer from high physiological variations, with morning albumin-to-creatinine ratio being lower than daytime ratio, and substantial day-to-day variations.[17] Use of dipsticks provides even lower accuracy. Few studies fully stage CKD by cross-classifying GFR and albumin-to-creatinine ratio categories, as recommended by the most recent international guidelines.[18] Finally, chronicity is not confirmed in most studies, leading to overestimation in some prevalence figures.[19,20]

Goal 1: monitor CKD Prevalence

Activity 1: disseminate a clear rationale for monitoring CKD prevalence. An essential step in making progress in any agenda is engaging stakeholders in understanding its rationale to positively influence stakeholders' attitudes and beliefs toward adoption. The 5 key reasons laid out in Table 2 provide a solid foundation for making the case for improved monitoring of CKD prevalence, which should be tailored to the interests of the specific stakeholder and setting.

Activity 2: achieve uniform measurement of CKD markers in CKD prevalence studies. Significant inter-laboratory variations in serum creatinine measurement exist internationally.[21] Unfortunately, even relatively small errors in serum creatinine measurements can have a substantial impact on inferences about CKD prevalence.[22]

The most reliable approach for achieving actual serum creatinine measurements is the universal implementation of calibration traceability to higher-order reference materials. The release of serum creatinine reference materials by the National Institute of Standards and Technology Standard Reference Material 967[23] makes this possible for assay manufacturers and quality control efforts. For serum creatinine assays, we call for the increased adoption of enzymatic

Table 2 | Key reasons for monitoring chronic kidney disease prevalence

Reasons for monitoring CKD	Potential gains of CKD monitoring
The diagnosis of CKD heralds the possibility of need for dialysis and transplantation in the future	Early intervention prevents patients, families, and health systems from suffering high financial and emotional costs associated with dialysis and transplantation
Management of CKD differs by stage	Characterization of CKD by cause, GFR, and albuminuria allows health care providers to prescribe treatment that adheres to evidence-based guidelines at each stage
Most of CKD is unrecognized[5,49]	Identifying previously undiagnosed CKD allows patients to take ownership of their disease and allows health care providers to slow the progression of disease and prevent complications. Furthermore, tracking the balance between recognized and unrecognized CKD allows public health professionals to distinguish strategies targeting disease unawareness versus disease burden
CKD prevalence is high globally[2]	Quantification of macro-level disease burden allows health systems to reallocate proportionate funding and health care resources to patients so that they receive the needed care
The rising global prevalence of obesity[50] and diabetes,[51] as well as the aging population,[52] will drive a further rise in CKD prevalence	Projection of macro-level trends allows health systems to budget and allocate proportionate resources so that these patients will receive the needed care

CKD, chronic kidney disease; GFR, glomerular filtration rate.

techniques over Jaffe techniques, which suffer from higher measurement variability.[24] While the more specific and accurate enzymatic serum creatinine assays are more expensive than Jaffe techniques, decreasing costs will reduce barriers to the use of enzymatic assays.[25] Small studies with limited means for implementing standardization and large studies seeking to improve standardization could ship all or a subset of samples to a known reference laboratory.

Proteinuria assays are difficult to standardize since the mix of proteins can vary from patient to patient; hence, a single protein, albumin, is used as a marker of renal dysfunction. This is measured as the albumin-to-creatinine ratio from a morning urine sample. A leading candidate reference material for urine albumin, which has been developed by the Japanese Society of Clinical Chemistry and the Japanese Committee for Clinical Laboratory Standards,[26] is not yet available.[27]

Activity 3: promote inclusion of CKD marker measurements and awareness in all large chronic disease cohorts and health surveys. Great efficiency is achieved by monitoring multiple conditions in a single survey. The cost of drawing a valid random sample, recruiting participants, and measuring covariates is shared by all diseases studied: the incremental cost of including and standardizing measurements of serum creatinine concentration and albuminuria should be modest compared with the total cost of the survey and the importance of CKD (high prevalence, high risk, and often growing burden). A systematic effort to ensure the inclusion of CKD measures in large ongoing or planned chronic disease studies could markedly increase the global database on CKD. It will be important to identify large surveys, which can advance our knowledge with relatively modest investment and make the case to the scientists and funders of these surveys to include CKD assessment. CKD awareness can also be measured by questionnaires and at low cost, although the measurement of awareness is hindered by participants' limited understanding and ability to answer questions about their kidneys.

Activity 4: develop a plan to harness claims data for CKD surveillance. As electronic medical records are becoming a standard worldwide, the potential for aggregating information is high. Although insurance claims and the International Classification of Disease (ICD) codes for various medical conditions are very insensitive, missing a majority of diseases, they are quite specific.[28,29] However, even unvalidated disease codes can provide important clues to the evolving CKD epidemic. For example, a study in China using ICD-10 diagnoses for 19 million tertiary hospital discharges in a national hospital quality monitoring database found that diabetes-associated CKD overtook glomerulonephritis-associated CKD in hospitalizations in China in 2011.[30]

When electronic medical records contain laboratory data such as serum creatinine and urine albumin, researchers can retroactively apply standardized definitions and staging of CKD to large populations, even if the stage was not specified in the ICD coding. For example, using claims data with associated electronic medical records laboratory data, the Stockholm CREAtinine Measurement investigators tracked CKD prevalence in over 1 million people in the Stockholm region and showed that even in a high-income country with universal health coverage, not all patients with advanced CKD receive a nephrology consult.[31] Given the high cost of organizing dedicated research studies and the increasing computerization of health care, developing methods to increase the validity of imperfect health care utilization data is a promising option for improving the global CKD surveillance. Using large but unvalidated databases in conjunction with focused validation studies could help in achieving this.[32]

Activity 5: incorporate the new CKD classification system in the World Health Organization ICD coding. ICD is the diagnostic standard for reporting diseases around the world and the foundation for identifying and tracking disease trends. Therefore, it is vital that ICD codes for CKD reflect the most recent evidence-based guidelines issued by KDIGO.[18] ICD-10 currently allows classifying CKD into 5 stages, with a residual category for "unspecified" CKD,[33] as illustrated in Table 3. We urge the 11th edition of ICD to consider adding a dimension for albuminuria category, subdivide stage 3, and allow for specification of CKD etiology.

As ICD-11 is being drafted for release in 2018, we are pleased to see the division of stage 3 into 3a and 3b,[34] as illustrated in Table 4. This system could be further detailed by including a dimension for albuminuria category. In addition, the GE00 heading would be better renamed from "kidney failure" to "kidney insufficiency" or "decreased kidney function".

However, requiring the inclusion of CKD etiology under the GE00 section would lead to a "code explosion" with considerable redundancy with other conditions in the glomerular disease and GE (other kidney diseases, e.g., GE30 or autosomal polycystic kidney disease) sections. Therefore, it would be sensible to describe chronic kidney conditions by a pair of mutually independent codes: one for numerical stage (GE00.21–26) and another for etiology, using various codes throughout glomerular disease and GE sections. A potential candidate for a uniform scheme for coding etiologies has been issued by the European Renal Association-European Dialysis and Transplant Association after careful development in collaboration with the International Health Terminology Standards Development Organization.[35] This scheme for coding etiologies has been seamlessly incorporated into the Systematized Nomenclature of Medicine Clinical Terms

Table 3 | Existing International Classification of Disease-10 codes for chronic kidney disease

Code	Diagnosis
N18	Chronic kidney disease
N18.1	Chronic kidney disease, stage 1 (GFR, ≥90 ml/min per 1.73 m^2)
N18.2	Chronic kidney disease, stage 2 (GFR, 60–89 ml/min per 1.73 m^2)
N18.3	Chronic kidney disease, stage 3 (GFR, 30–59 ml/min per 1.73 m^2)
N18.4	Chronic kidney disease, stage 4 (GFR, 15–29 ml/min per 1.73 m^2)
N18.5	Chronic kidney disease, stage 5 (GFR, 0–14 ml/min per 1.73 m^2)
N18.9	Chronic kidney disease, unspecified

GFR, glomerular filtration rate.

Table 4| Beta draft of the International Classification of Disease-10 codes for chronic kidney disease

Code	Diagnosis
GE00.2	CKD
GE00.21	CKD, stage 1 (GFR, ≥90 ml/min per 1.73 m^2)
GE00.22	CKD, stage 2 (GFR, 60–89 ml/min per 1.73 m^2)
GE00.23	CKD, stage 3a (GFR, 45–59 ml/min per 1.73 m^2)
GE00.24	CKD, stage 3b (GFR, 30–44 ml/min per 1.73 m^2)
GE00.25	CKD, stage 4 (GFR, 15–29 ml/min per 1.73 m^2)
GE00.26	CKD, stage 5 (GFR, 0–14 ml/min per 1.73 m^2)
GE00.2Z	CKD, unspecified

CKD, chronic kidney disease; GFR, glomerular filtration rate.

collection.[35] Incorporation into ICD-11 would not just increase the level of detail but also unify the nomenclature used in predominant international clinical terminology and clinical classification systems.

Goal 2: establish CKD registries in underrepresented populations

Activity 1: establish registries of chronic dialysis and transplantation in all countries. National kidney societies are best equipped to take the lead in establishing RRT registries in countries, with the long-term and ultimate goal of establishing CKD registries. This would require fostering a comprehensive partnership with respective ministries of health and generating buy-in from dialysis and transplant centers. Health authorities and health administrators stand to benefit from the systematic collection of dialysis and transplantation information as it would simplify and improve the allocation of health resources. In countries with established registries, researchers and registry administrators can benefit from the filling-in of previously incomplete data for research purposes. Efforts in establishing and improving registries ultimately benefit patients as lessons are learned about factors determining their morbidity, mortality, and quality of life.

Outside of Europe and North America, stakeholders can look toward high-quality renal registries, as identified by Liu *et al.*[16], in Singapore, Australia, New Zealand, Morocco, Tunisia, Colombia, Argentina, and Uruguay. The Latin American Society of Nephrology and Hypertension serves as a role model through its seminar offerings and sustained efforts to create and improve the quality of renal registries in Latin America.[36] A global inventory of CKD registries could be maintained as part of the International Society of Nephrology's Global Kidney Health Atlas.[37] The International Society of Nephrology can help by offering to advise less experienced regions regarding protocol, infrastructure, logistics, and technology issues. A task force should be convened to explore the development of generic renal registry software with unified data standards to streamline the data collection and reduce overhead costs for all new registries.

Complete registries are important as they allow for informative studies on variations in RRT availability and highlight disparities in RRT access that can be addressed.[38] When registries achieve a state of completeness and quality, it opens doors for higher-level regional data integration, as demonstrated by the new EURODOPPS initiative, a bilateral exchange of information between the Dialysis Outcomes and Practice Patterns Study and the European Renal Association-European Dialysis and Transplant Association Registry.[39] The overall goal should be high-quality care and optimized prevention efforts. Due to cost and logistics, the expansion of registries beyond dialysis and transplantation requires limitation to special groups.

Activity 2: establish registries for special CKD groups, e.g., children, rare diseases, special etiologies, and regions where CKD appears to be endemic. In certain populations, CKD poses a special risk or specific opportunity for clinical trials and prevention efforts. Identifying these populations and establishing specific registries would greatly facilitate targeted efforts for improved care and prevention, as well as vital clinical trials. For example, autosomal dominant polycystic kidney disease and NephCure foundations in the US energize efforts for the identification and treatment of polycystic kidney disease and focal segmental glomerulosclerosis, respectively. Likewise, advanced CKD (very low GFR or high proteinuria) patients at highest risk could benefit from registries.

Goal 3: identify individuals with CKD

Activity 1: implement KDIGO guidelines for screening and testing. When CKD is identified, the urine albumin level should also be measured to stage CKD by eGFR, albuminuria category, and etiology, as detailed in the 2012 KDIGO guidelines.[18] Unfortunately, the implementation of guidelines often lags. The issuance of guidelines has little effect on the physician's behavior,[40] unless incentives and disincentives are modified in accordance with the awareness-agreement-adoption-adherence model.[41]

The recent Implementation Strategies Conference convened by KDIGO resolved to translate KDIGO guidelines into different languages and provide slide sets, speaker kits, algorithms, clinical guides, and priority suggestions with future publications.[42] In developing countries requiring resource-sensitive guidelines, adaptations can be made under the jurisdiction of national kidney societies. Care must be given to avoid discordance with guidelines issued by other cardiovascular, renal, and infectious disease organizations in the country. The Implementation Strategies Conference noted that clinical case-style presentations illustrating updates in recommended management were particularly well received.[42] Country-based guideline adaptations are most effectively disseminated via local publications, workshops, and sessions at existing conferences, with the option of continuing medical education credits. This effort can be strengthened by "train the trainer" initiatives[43] to conduct on-site workshops to increase the guideline adoption at major clinical sites.

Activity 2: carry out randomized studies to expand the evidence base for screening strategies. CKD screening may be beneficial in individuals with diabetes, hypertension, cardiovascular disease, structural renal tract disease, multisystem diseases with renal involvement (e.g., systemic lupus

erythematosus), and a family history of kidney failure and hereditary kidney disease, as well as in those of old age and those using nephrotoxic drugs.[18] However, at this time, there is insufficient evidence to recommend universal CKD screening in asymptomatic individuals.

Ideally, screening strategies should be developed and tested in a randomized setting so that the efficacy can be validly measured. To date, there are no randomized population-based studies testing the validity and clinical outcomes of CKD screening by either eGFR or albuminuria testing. This can be pursued with cluster randomized trials, stepped wedge randomized trials, and time-series studies.

Activity 3: ensure that whenever serum creatinine concentration is measured, eGFR is reported. It is not appropriate to report serum creatinine alone because its relation to GFR depends on a multitude of non-GFR determinants affecting the generation, tubular secretion, and extrarenal elimination of serum creatinine. The serum creatinine level is all too often used in clinical practice without eGFR presented alongside. Clinical laboratories should provide eGFR whenever the serum creatinine concentration is measured and should specify the equation used. eGFR should be calculated using the 2009 CKD Epidemiology Collaboration creatinine equation.[44] Fortunately, this is already the standard in much of the world. Because this is a calculation, not an assay or technique, this can be implemented at a minimal cost in the remaining laboratories.

Activity 4: develop and share protocols and electronic decision support for the identification and follow-up of CKD cases. Progression at each CKD stage, including its initial diagnosis, is defined on the basis of objective laboratory data readily available in health records, a feature which makes CKD especially amenable to clinical performance enhancement with electronic innovations. The health information technology can be used to track CKD patients and trends within health systems, identify CKD patients needing additional care, identify CKD patients for research, and deliver guideline-directed care reminders.[45] In a reality where practice in CKD management deviates considerably from the published guidelines,[46] an interactive and freely accessible electronic resource such as ckdpathway.ca[47] can supplement the aforementioned strategies in the uptake of guidelines by physicians.

KDIGO could deploy its guidelines on a structured and extended markup language-based online guideline publication platform such as Making Grade the Irresistible Choice (MAGIC), allowing for semi-automated generation of decision aids linked to guideline recommendations,[48] which can be integrated directly into electronic health record systems.

Conclusions

In summary, CKD and RRT prevalence continues to remain high and is likely to increase globally. The global capacity for CKD surveillance has improved but is still far less developed compared with that for hypertension, diabetes, and cardiovascular disease. To improve this situation, the working group has identified 3 overarching goals with associated goal-directed activities. First, to improve monitoring of CKD prevalence, we believe it will be critical to disseminate the rationale for CKD prevalence monitoring; achieve uniform CKD marker measurements; promote inclusion of CKD measurements in all large chronic disease cohorts and health surveys; harness claims data for CKD surveillance; and incorporate the new CKD classification system in ICD. Second, to improve CKD monitoring of underrepresented populations, it will be critical to establish registries of chronic dialysis and transplantation in all countries, and to establish registries for special CKD groups, such as children, patients with rare diseases, and patients with special etiologies of CKD. Third, to improve the identification of individuals with CKD, it will be critical to implement KDIGO guidelines for screening and testing; carry out randomized studies on screening strategies; ensure that eGFR is reported with all reports of serum creatinine concentrations; and leverage electronic technologies for the identification and follow-up of CKD cases.

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