Kidney Medicine

External Validation of the Kidney Failure Risk Equation Among Urban Community-Based Chinese Patients With CKD

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Rationale & Objective: The Kidney Failure Risk Equations have been proven to perform well in multinational databases, whereas validation in Asian populations is lacking. This study sought to externally validate the equations in a community-based chronic kidney disease cohort in China.

Study Design: A retrospective cohort study.

Setting & Participants: Patients with and estimated glomerular filtration rate (eGFR) < 60 mL/min/1.73 m^2 dwelling in an industrialized coastal city of China.

Exposure: Age, sex, eGFR, and albuminuria were included in the 4-variable model, whereas serum calcium, phosphate, bicarbonate, and albumin levels were added to the previously noted variables in the 8-variable model.

Outcome: Initiation of long-term dialysis treatment.

Analytical Approach: Model discrimination, calibration, and clinical utility were evaluated by Harrell's C statistic, calibration plots, and decision curve analysis, respectively.

Results: A total of 4,587 participants were enrolled for validation of the 4-variable model, whereas 1,414 were enrolled for the 8-variable model. The median times of follow-up were 4.0 (interquartile range: 2.6-6.3) years for the 4-variable model and 3.4 (2.2-5.6) years for the 8-variable model. For the 4-variable model, the C statistics were 0.750 (95% CI: 0.615-0.885) for the 2-year model and 0.766 (0.625-0.907) for the 5-year model, whereas the values were 0.756 (0.629-0.883) and 0.774 (0.641-0.907), respectively, for the 8-variable model. Calibration was acceptable for both the 4-variable and 8-variable models. Decision curve analysis for the models at the 5-year scale performed better throughout different net benefit thresholds than the eGFR-based (<30 mL/min/1.73 m^2) strategy.

Limitations: A large proportion of patients lack albuminuria measurements, and only a subset of population could provide complete data for the 8-variable equation.

Conclusions: The kidney failure risk equations showed acceptable discrimination and calibration and better clinical utility than the eGFR-based strategy for incidence of kidney failure among community-based urban Chinese patients with chronic kidney disease.

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Chronic kidney disease (CKD) is an important public health problem worldwide, leading to increased morbidity and mortality.[1] In addition, CKD could progress to kidney failure, thus requiring lifelong kidney replacement treatment to sustain life. A recent survey conducted by the Global Kidney Health Atlas estimated that the median prevalence of kidney replacement treatment was 759 per million population as of 2018.[2] Another study predicted that the number of individuals with kidney failure would surge in Asia with a conservatively projected 2.162 million patients by 2030.[3] In China, the prevalence of hemodialysis and peritoneal dialysis has ever been increasing over the past decade and reached 384.41 per million population for hemodialysis and 34.98 per million population for peritoneal dialysis in 2017, as shown in a nationwide insurance claims database study.[4,5]

Accurate and reliable risk evaluation of CKD prognosis can be helpful for physicians to make decisions concerning treatment opportunity and therapeutic strategy. Several prediction models have been developed, and some of them are of considerable accuracy.[6] Among the widely validated models for the prediction of risk of kidney failure among patients with CKD, the kidney failure risk equation (KFRE) stands out based on good performance in terms of discrimination and calibration.[7,8] The KFRE consists of a series of equations predicting the 2-year and 5-year risks of kidney failure among patients with reduced kidney function (estimated glomerular filtration rate [eGFR] <60 mL/min/1.73 m^2). The 4-variable model includes age, sex, eGFR, and the urinary albumin-creatinine ratio (uACR), and serum calcium, phosphate, bicarbonate, and albumin levels represent additional factors included in the 8-variable model. Chinese patients with CKD may exhibit different etiologic patterns and undergo different clinical management than their western counterparts.[4] Previous validating studies of KFRE among Chinese patients were restricted to specific patients with IgA nephropathy or glomerular diseases.[9,10] Based on the electronic health record data of the China Kidney Disease Network (CK-NET)-Yinzhou study of community-dwelling residents in an eastern coastal area of China, the present study aimed to validate the accuracy of the KFRE and provide evidence for their potential clinical usage.[8,11]

PLAIN-LANGUAGE SUMMARY

Accurate and reliable risk evaluation of chronic kidney disease (CKD) prognosis can be helpful for physicians to make decisions concerning treatment opportunity and therapeutic strategy. The kidney failure risk equation is an outstanding model for predicting risk of kidney failure among patients with CKD. However, the equation is lacking validation among Chinese populations. In the current study, we demonstrated that the equation had good discrimination among an urban community-based cohort of patients with CKD in China. The calibration was also acceptable. Decision curve analysis also showed that the equation performed better than a traditional kidney function-based strategy. The results provide the basis for using predictions derived from the kidney failure risk equation to improve the management of patients with CKD in community settings in China.

METHODS

Source Population

The source population is derived from the population registered in the Regional Health Information System in Yinzhou district of Ningbo City of Zhejiang province in China. The area is located 230 km south of Shanghai and had a population of 1.42 million in 2019. The Regional Health Information System has integrated data of demographic, health checks, disease surveillance and management, laboratory test results, and charge and claims of health insurance and health care utilization (outpatient visits and hospitalizations with diagnoses and procedures).[12] Since 2018, we have established a comprehensive CKD registry system based on data from permanent residents of the district (1.02 million out of the total 1.42 million population) termed the CK-NET-Yinzhou study.[11] Between May 1, 2008, and December 31, 2019, 85,519 patients with CKD were identified by International Classification of Diseases (ICD) codes or laboratory testing results from the 976,409 individuals registered in electronic health record-based system.[13]

The institutional review board of Peking University First Hospital approved the study (ID: 2019[24]), and a waiver of consent was obtained because of the retrospective data-only nature of the study. This study adhered to the transparent reporting of a multivariable prediction model for individual prognosis or diagnosis (TRIPOD) reporting guidelines.

Study Participants

Among the identified 85,519 adult patients with CKD, we involved only those with eGFR of <60 mL/min/1.73 m^2 for ≥ 2 times separated by a period of ≥ 3 months to <2 years as the study sample to align with the criteria of study population for developing KFREs (CKD stages 3-5). The date for the first eGFR of <60 mL/min/1.73 m^2 was assigned as the index date. Those who missed the variables used in the KFRE were deleted. In addition, we excluded patients who had already received maintenance dialysis treatment on the index date or who initiated dialysis within 3 months after the index date (given the high possibility of having already entered kidney failure before the index date). The flow diagram of study participant selection is provided in Figure 1.

Exposure

We included the same predictors with the same units as used in the KFRE.[8] The 4-variable model of the KFRE includes age, sex, eGFR, and uACR, whereas the 8-variable model additionally includes serum calcium, phosphate, bicarbonate, and albumin levels. The laboratory test variables (except for serum creatinine, which defined the index date) were extracted within 1 year before the index date, with the closest result being used. eGFR was calculated using the serum creatinine-based Chronic Kidney Disease Epidemiology Collaboration (CKD-EPI) formula.[14] As only 312 of the 4,612 participants (128 of the 1,414 participants in the 8-variable model) had the uACR measured within the specified time window, we used recommended equations to convert values for the urinary protein-creatinine ratio (n = 5) or urine dipstick protein (n = 4,295) into uACR.[15]

Outcome

The outcome of this study was the initiation of maintenance dialysis (including hemodialysis and peritoneal dialysis), identified according to the service items in medical billing. Hemodialysis was identified by claims records of hemodialyzer and related operations, whereas peritoneal dialysis was identified by claims records of peritoneal dialysis fluid. Text-based diagnosis and ICD codes were also used to ascertain dialysis-related diagnoses. The ICD-10 codes for dialysis are listed in Table S1. If the diagnosis of acute kidney injury was detected (the ICD-10 codes are listed in Table S2), the concurrent dialysis would not be treated as outcome.[5] Because the 3 main types of health insurance systems (the Urban Employee Basic Medical Insurance, the Urban Residents Basic Medical Insurance, and the New Cooperative Medical Care Scheme with coverage of more than 95% residents) have all been linked to the Regional Health Information System of Yinzhou, the accuracy for the identification of dialysis is expected to be high. Emigration to other areas, death, or reaching the prespecified time length (2 or 5 years) of the KFRE were censored. In the sensitivity analysis, death was taken into account as a competing risk event.

Statistical Analysis

Continuous variables are presented as mean ± standard deviation or median (interquartile range), as appropriate,

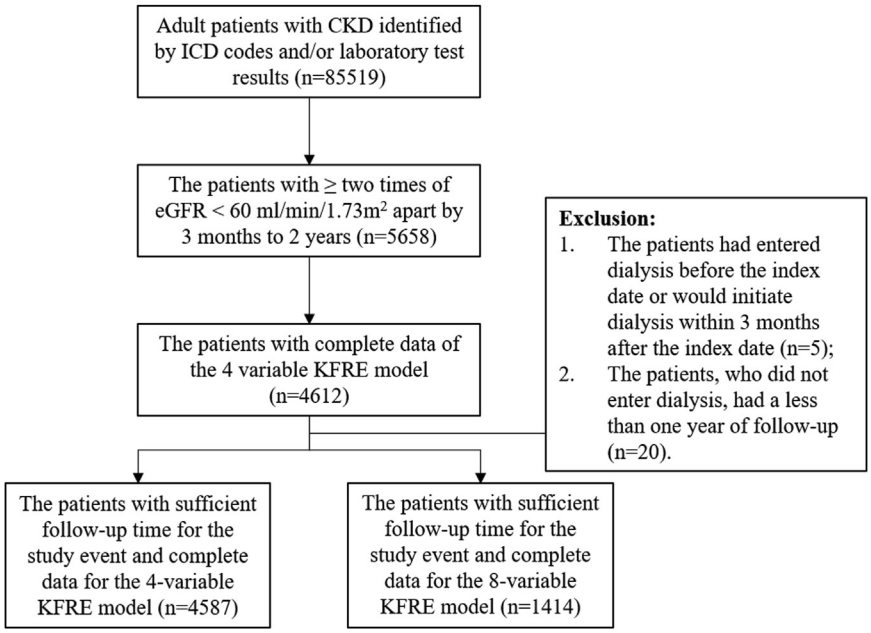

Figure 1. Flow diagram of the study participants. CKD, chronic kidney disease; eGFR, estimated glomerular filtration rate; ICD: International Classification of Diseases; KFRE, Kidney Failure Risk Equation.

whereas categorical variables are presented as frequency (proportion). The non-North American calibrated models of the KFRE were used (Item S1).[7] We assessed the performance of the model using discrimination and calibration. Harrell's C statistic was computed to evaluate discrimination with the 95% confidence intervals (CIs) estimated using the bootstrap resampling method. Because censoring for death will overestimate the risk of the cumulative incidence of kidney failure, the Fine and Gray competing risk model was used (setting follow-up time for death as infinity) as a sensitivity analysis for estimating Harrell's C statistic, thereby indicating no possibility of kidney failure after death.[16,17] Among the smaller population with the complete set of the 8 variables, category-free net reclassification improvement (NRI) and integrated discrimination improvement (IDI) were employed to evaluate the reclassification after the inclusion of the serum measurements in the 8-variable model compared with the 4-variable model. We compared the predicted and the observed risk of kidney failure (calculated using crude cumulative incidence functions to account for the competing risk of death) within each decile of the predicted risk, and the calibration plot was depicted. To assess the clinical utility of the model, decision curve analysis was conducted in comparison with the "treat all" or "treat none" strategy as well as the eGFR cutoff of <30 mL/min/1.73 m^2. The x-axis of decision curve analysis represents the range of threshold probability, which is set a priori, whereas the y-axis provides the net benefit given the specific threshold probability by accounting for both true-positive and false-positive rates.[18] Because we focused on the management of patients with CKD in a primary care setting, the intervention of our study includes increasing the frequency of follow-up of kidney function and albuminuria, referral to nephrologists, and initiation of treatment, such as using a renin-angiotensin-aldosterone system inhibitor. Considering that the long-term model is more relevant for the purpose, we only evaluated the clinical utility for the 5-year models with the upper limit of threshold probability set at 0.20. In addition, the sensitivity and specificity of referring patients were compared using different KFRE risk thresholds (3%, 5%, and 15%) proposed in previous studies and to meet the requirement of a resource limited situation and eGFR of <30 mL/min/1.73 m^2.[19,20] R version 4.0.4 (R Foundation for Statistical Computing) was used with the reference of software packages and codes described in the article by Zhou et al.[21]

RESULTS

Baseline Characteristics and Outcomes of the Studied Population

A total of 4,587 participants were enrolled for the validation of the 4-variable model, whereas 1,414 patients were assessed using the 8-variable model. Among the larger population, the mean age was 74 ± 12 (full range: 18-102) years with 52.3% male (2,398 of 4,587). The median follow-up time was 4.0 (interquartile range: 2.6-6.3) years. In total, 227 (4.9%) patients reached kidney failure with maintenance dialysis, among which 89 (1.9%) events occurred within 2 years and 174 (3.8%) within 5 years. During the time period, we recorded 680 events of kidney failure-free all-cause mortality for the 5-year model and 389 for the 2-year model. A comparison of patients' characteristics between the current China validation cohort

and the original KFRE cohorts is presented in Table 1. The population in the current cohort was comparatively older with higher blood pressure levels but lower proportions of advanced CKD (G4 and G5 stage) and A2- and A3-level albuminuria. We also presented the characteristics of the population for the validation of the 8-variable model (Table S3). Among the smaller population, 103 (7.3%) patients reached kidney failure with maintenance dialysis after a median follow-up time of 3.4 (interquartile range: 2.2-5.6) years, among which 74 (5.2%) events happened within 2 years and 100 (7.1%) within 5 years. Regarding all-cause mortality, excluding the events that happened after kidney failure, 321 events were recorded over 5 years after the study baseline, and 205 were recorded over the first 2 years.

Discrimination and Calibration

The Harrell's C statistic values for the 2-year and 5-year models were 0.750 (95% confidence interval [CI]: 0.615-0.885) and 0.766 (95% CI: 0.625-0.907), respectively, when 4 variables were included and 0.756 (95% CI: 0.629-0.883) and 0.774 (95% CI: 0.641-0.907), respectively, when 8 variables were included. Based on the population with complete data for the 8 variables (N = 1,414), the differences in the Harrell's C statistic between the 4-variable and 8-variable models were not significant (*P* values for the 2-year and 5-year models were 0.20 and 0.60, respectively). The indexes of NRI and IDI also did not show any difference (Table 2, Fig 2). In the sensitivity analysis accounting for the competing risk of death, the Harrell's C statistic for the models were comparatively better than those in the traditional Cox regression model (Table S4). The comparison between the predicted risk and observed risk showed that calibration was acceptable for both the 4-variable and 8-variable models (Fig 3).

Clinical Utility Analysis

Both the 4-variable and the 8-variable 5-year models had higher net benefit than the treatment strategy based on an

Table 1. Characteristics of Participants in Current China Validation Cohort and the Original KFRE Cohorts

Characteristics	Current Cohort	Original KFRE Cohort for Derivation	Original KFRE Cohort for Validation
Setting	Primary care in an urban area, China	Nephrology referral clinic, Canada	Nephrology referral clinic, Canada
Number of patients	4,587	3,449	4,942
Age (y)	74 ± 12	70 ± 14	69 ± 14
≥65	3,731 (81)	2,447 (71)	3,292 (67)
<65	856 (19)	1,002 (29)	1,650 (33)
Male sex	2,398 (52)	1,946 (56)	2,833 (57)
Physical examination			
Systolic BP (mm Hg)[a]	156 ± 17	130 ± 22	138 ± 24
Diastolic BP (mm Hg)[a]	92 ± 16	71 ± 12	74 ± 13
Weight (kg)	64 ± 12	76 ± 18	79 ± 20
Comorbid conditions			
Diabetes	1,516 (33)	1,278 (37)	1,907 (38)
Vascular disease	NA	1,386 (40)	1,305 (26)
History of current or previous smoking	NA	776 (23)	1,149 (23)
Laboratory data			
eGFR (mL/min/1.73 m^2)	47 ± 11	36 ± 13	31 ± 11
30-59	4,146 (90)	2,303 (67)	2,407 (49)
15-29	367 (8)	926 (27)	2,095 (42)
15	74 (2)	220 (6)	440 (9)
Serum creatinine (mg/dL)	1.41 ± 0.58	2.23 ± 1.31	2.30 ± 0.84
Urinary albumin-creatinine ratio (mg/g)			
<30	3,577 (78)	814 (24)	973 (20)
30-299	723 (16)	1,124 (33)	1,915 (39)
≥300	287 (6)	1,511 (43)	2,054 (41)
Observation time for kidney failure events, y	5.60 ± 3.00	2.07 ± 2.05	3.05 ± 1.74
Kidney failure events	227 (4.9)	386 (11)	1,177 (24)
Dialysis	227 (100)	358 (93)	1,123 (95)
Transplantation	0 (0)	28 (7)	54 (5)
Mortality	680 (15)	NA	NA

Abbreviations: BP, blood pressure; eGFR, estimated glomerular filtration rate; KFRE, kidney failure risk equation; NA, not available.
Data are presented as mean ± standard deviation, frequency (percentage), or median (interquartile range), as appropriate.
[a]The numbers of missing are 533 for systolic BP and 533 for diastolic BP.

Table 2. Harrell's C Statistic, Category-Free NRI, and IDI of Applying KFRE in the Current Cohorts

Models	Harrell's C Statistic (95% Confidence Interval)	Net Reclassification Index (95% Confidence Interval)	Integrated Discrimination Index (95% Confidence Interval)
2-y 4-variable model	0.750 (0.615-0.885)	NA	NA
5-y 4-variable model	0.766 (0.625-0.907)	0.002 (−0.137 to 0.116)[a]	0.279 (−0.156 to 0.622)[a]
2-y 8-variable model	0.756 (0.629-0.883)	NA	NA
5-y 8-variable model	0.774 (0.641-0.907)	−0.001 (−0.129 to 0.116)[a]	0.136 (−0.251 to 0.546)[a]

Abbreviations: IDI, integrated discrimination index; KFRE, kidney failure risk equation; NA, not available; NRI, net reclassification index.
[a]The NRI or IDI comparing 2-year/5-year 8-variable models to 2-year/5-year 4-variable models was provided based on the 1,414 patients with complete data of the 8-variable model.

eGFR cutoff of <30 mL/min/1.73 m^2 throughout the threshold probabilities (Fig 4). When the 2 risk-based models were compared, the 8-variable model was able to provide higher net benefit starting from a threshold probability of close to 5% until reaching about 20% compared with the 4-variable model (Fig S1). The risk-based referral strategies (≥3% or ≥5%) showed remarkably higher sensitivity than the eGFR-based strategies (<30 mL/min/1.73 m^2) for both the 4-variable and 8-variable models, whereas the specificity was inferior among the former models (Table 3).

DISCUSSION

In this validation study based on patients with moderately to severely reduced kidney function from the primary care settings of an industrialized coastal area of China, we found good discriminative ability and acceptable calibration of the KFRE for predicting risk of kidney failure with replacement therapy. There is no difference between the 4-variable and 8-variable models in the study in terms of both discrimination and calibration, but only a subpopulation with complete data for the laboratory measures was used for the comparison.

The KFRE was originally developed and validated in 2 Canadian cohorts of nephrology-referred patients with CKD stage 3-4.[8] Thereafter, the model was extensively validated in the participating cohorts of the large-scale CKD prognosis consortium (CKD-PC) (23,829 cases of kidney failure were involved), showing consistent good performance among the various studies.[7] To improve the accuracy of the model for adoption among non-North American populations, a recalibration factor that lowered the baseline risk of kidney failure was introduced in the CKD-PC study.[7] Despite large efforts for the validation and recalibration of the KFRE, Asian populations were less representative in the studies; for example, only 2 small studies conducted in Japan (the Gonryo study and the Okinawa study) were involved in the CKD-PC study.[22,23] Individual validation studies may also not abound specifically among Asians. Regarding Chinese, as far as we know, only one study based on a multicenter IgA nephropathy cohort and another study based on a glomerular disease-specific cohort provided data for validation.[9,10] Therefore, the current study represents another effort to replicate the KFRE based on a CKD cohort that stemmed from primary care settings in China, and the patients had lower uACR and higher eGFR values than the original KFRE-establishing cohorts. Consistent with the previous studies based on the non-North American equations with lower risk calibration, we also observed that the discrimination was sufficiently good

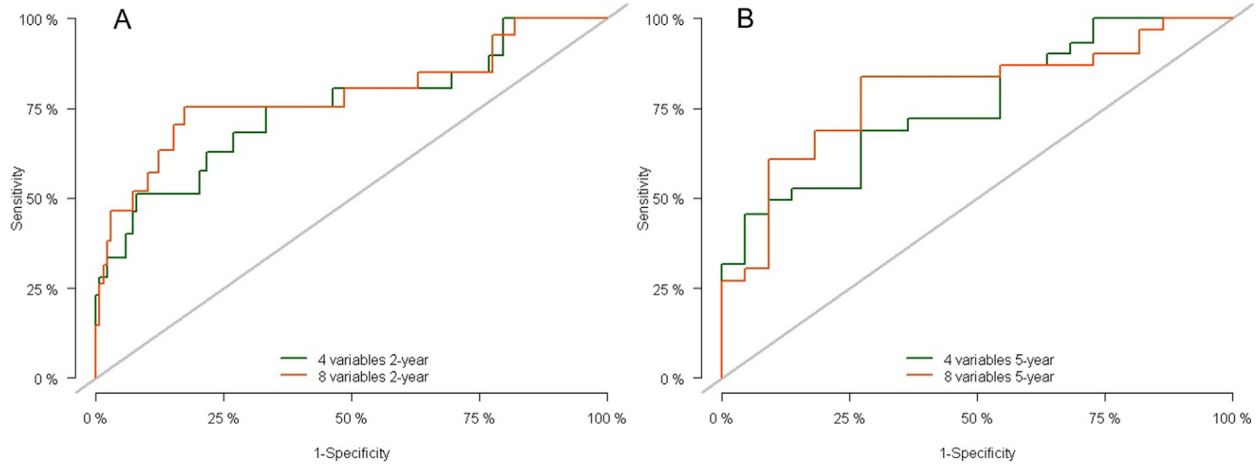

Figure 2. The receiver operating characteristics curve for the validation of kidney failure risk equation. (A) The 2-year 4-variable (green line) and 8-variable (orange line) models. (B) The 5-year 4-variable (green line) and 8-variable (orange line) models.

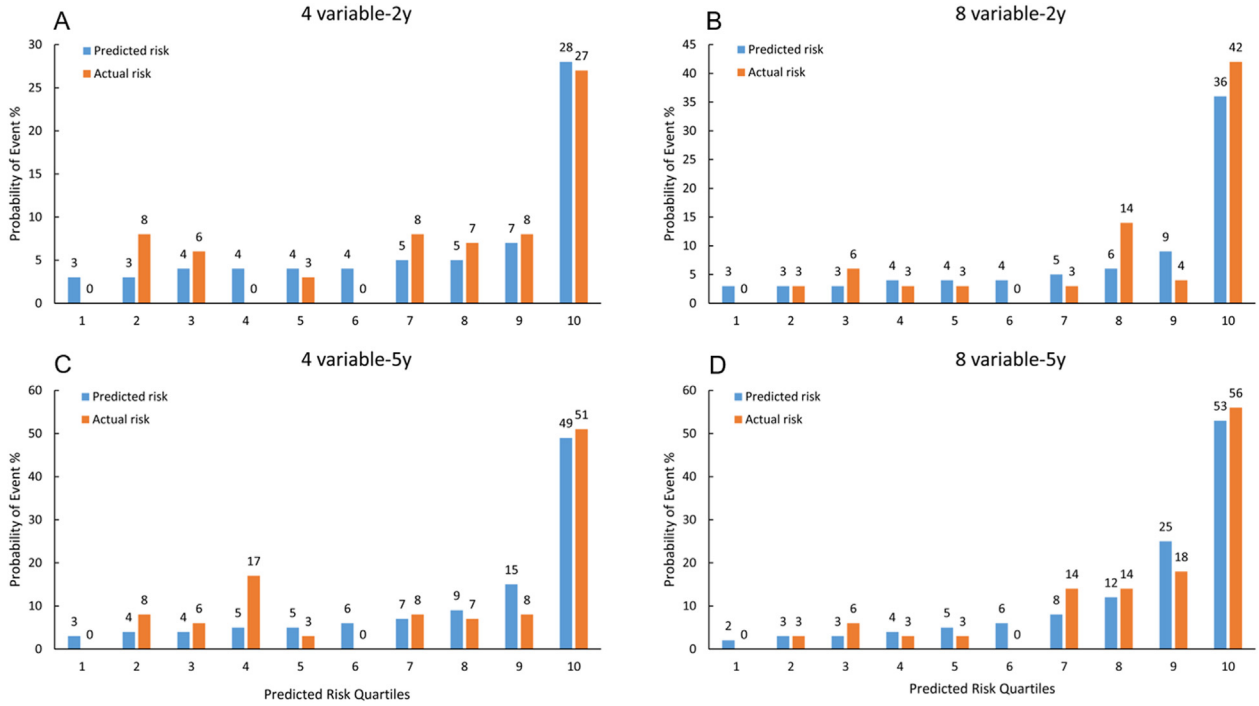

Figure 3. Calibration plot between the predicted risk based on the kidney failure risk equation and the observed risk of the current validation cohorts. (A) The 2-year predicted risk based on the 4-variable model (blue volumes) versus the observed risk (orange volumes). (B) The 2-year predicted risk based on the 8-variable model (blue volumes) versus the observed risk (orange volumes). (C) The 5-year predicted risk based on the 4-variable model (blue volumes) versus the observed risk (orange volumes). (D) The 5-year predicted risk based on the 8-variable model (blue volumes) versus the observed risk (orange volumes). The number above each column represents the predicted and the observed number of events.

(Harrell's C statistic was above 0.75) and that the calibration was acceptable.

The majority of the population in our study was above 65 years (81% for validation of the 4-variable models and 85% for that of the 8-variable models), so the competing risk from death could be a significant problem influencing the predictive ability of the model because many patients might have died before entering kidney failure. In the context of survival analysis, simply censoring for death would not eliminate the possibility for the occurrence of kidney failure, thus leading to the overestimation of the risk.[16] Although the CKD-PC validation study reported only a neglectable difference in the absolute predicted risk between the Cox model and competing risk model (<1.7% through all categories of risk groups), another comprehensive validation study of the KFRE based on 2 large

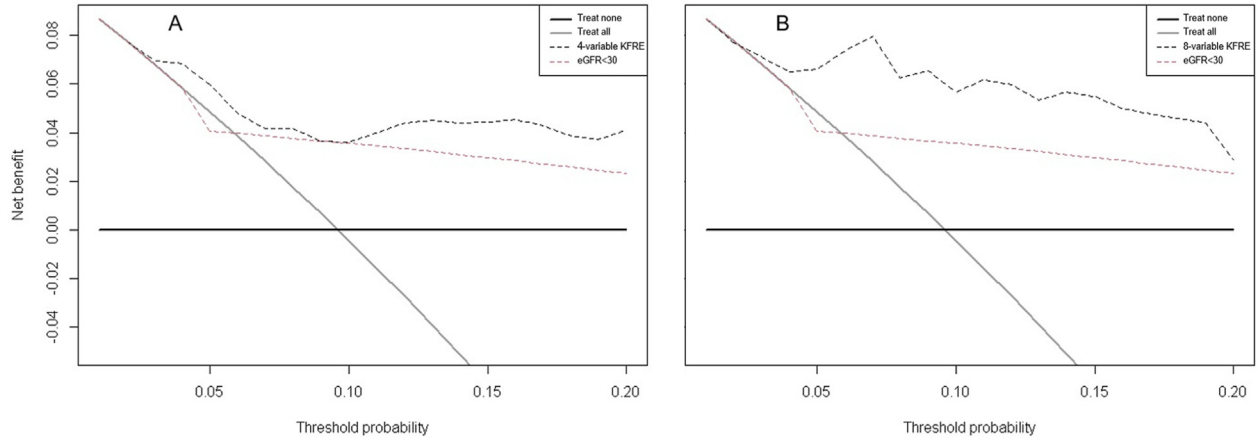

Figure 4. The decision curve analysis curve for the validation of the 4-variable and 8-variable 5-year kidney failure risk equation. (A) The 5-year 4-variable model. (B) The 5-year 8-variable model.

Table 3. Sensitivity and Specificity of Five-Year Kidney Failure Risk Prediction for Different Risk Classification Criteria

Measure[a]	≥3%	≥5%	≥15%	eGFR <30 mL/min/1.73 m²
4-variable KFRE (N = 4,587)				
Sensitivity	0.927 (0.857-0.964)	0.813 (0.723-0.878)	0.542 (0.442-0.638)	0.699 (0.605-0.779)
Specificity	0.211 (0.190-0.234)	0.640 (0.613-0.665)	0.901 (0.883-0.916)	0.886 (0.868-0.902)
8-variable KFRE (N = 1414)				
Sensitivity	0.875 (0.794-0.927)	0.833 (0.746-0.895)	0.604 (0.504-0.696)	0.757 (0.666-0.829)
Specificity	0.405 (0.379-0.432)	0.647 (0.621-0.673)	0.868 (0.849-0.885)	0.854 (0.833-0.872)

Abbreviations: eGFR, estimated glomerular filtration rate; KFRE, kidney failure risk equation.
[a]Sensitivity refers to the percentage of patients developing kidney failure who have been classified as high risk. Specificity refers to the percentage of patients not developing kidney failure who have been classified as low risk. Figures in parentheses refer to 95% confidence intervals.

European cohorts with exclusively older adults (≥65 years) found more remarkable overprediction (10%-18% relative excess) of risk of kidney replacement therapy (KRT) when applying the 5-year KFRE; however, a different study setting may significantly contribute to the variation.[24] Following the methods used in the above European study, we took the competing risk of death into account when evaluating calibration of the KFRE.

In current study, we did not find that the 8-variable models performed significantly better than the 4-variable models in terms of discrimination. In a previous study conducted based on a European cohort of patients with CKD stages 3-5, Peeters et al[25] reported that better performance of the 8-variable prediction model than the 4-variable model can only be observed among patients with CKD stage 3 rather than those with more advanced CKD stage 4. Our study consisted mainly of patients with CKD stage 3, but we failed to detect the difference between the more complicated model and the simple one. In addition, only a subset of patients in our study provided the required laboratory data, which may have diminished the study power. Further studies with sufficient sample size, eg, affording at least 200 cases of the study event as suggested by Collins et al,[26] may be needed to provide more valid evidence regarding the use of the more complicated models. Given that data are more readily available for the 4-variable model, if the request of more laboratory data in the 8-variable model does not bring remarkable improvement in discriminative ability, the 4-variable model, with the advantage of simplicity, is considered more suitable for use in clinical practice. Another issue that may influence the accuracy of applying the KFRE lies in the fact that quantitative albuminuria is less representative than the semiquantitative dipstick proteinuria in our study, as is the case in many studies around the world.[7,15,27]

The Kidney Disease Improving Global Outcomes guideline has recommended using prediction models, among which include the KFRE, to help triage nephrology referral or early preparation of KRT.[28] Because the majority of patients at high risk of CKD and kidney failure (patients with hypertension and/or diabetes) are managed at primary care, individualized evaluation and informed decision for treatment or nephrology referral should be of great importance in this setting. In the current study, we used data mainly obtained from routinely collected primary care-based health check or outpatient encounter databases, so our study results may provide preliminary information informing the potential use of risk predictions for the management of patients with CKD. Given that only age and sex are added to the routinely used eGFR and uACR metrics for stratifying patients with CKD, the 4-variable KFRE model may be easily incorporated into the existing clinical process for the management of CKD. However, whether clinical decisions facilitated using prediction models could improve the outcome of CKD should be evaluated by pragmatic clinical trials or before–after comparison studies as suggested by Grams et al.[29]

Although our study bears some advantages such as using a locally representative study sample of patients with CKD and performing a comprehensive evaluation regarding the performance of the equations, some limitations should be mentioned. First, routinely collected clinical data tend to have more problems with respect to data quality, compared with the research-based cohort. In our study, as mentioned above, a large proportion of patients undergo dipstick proteinuria rather than albuminuria measurements, and only a subset of the population could provide complete data for the 8-variable equation, which may have led to some degree of inaccuracy.[30] Second, although the health insurance policy for reimbursement of medical expenses may have allowed most local permanent residents with kidney failure to fulfill their need for KRT treatment, we cannot exclude the possibility of losing some cases because of out-of-town KRT treatment or receiving conservative therapy alone, thus leading to certain underestimation of incidence of the study event. Third, the study findings were based on a developed area in China, so it cannot be readily generalized to other areas of China.

In conclusion, we reported acceptable performance for the use of the KFRE in predicting risk of kidney failure with replacement therapy among community-based urban patients with CKD stages 3-5 in an eastern coastal area of China. Further studies from various settings in China are needed to evaluate the accuracy of KFRE as well as the effect of using the equations to prevent the progression of CKD.

SUPPLEMENTARY MATERIALS

Supplemental File (PDF)

Figure S1: The decision curve analysis curve for validation of the 4-variable and 8-variable 5-year kidney failure risk equation based on the population with complete data for the 8-variable model (N = 1,414).

Item S1: Forms of the kidney failure risk equation.

Table S1: The ICD-10 Codes Used for Identifying Dialysis Patients.

Table S2: The ICD-10 Codes Used for Identifying Patients With Acute Kidney Injury.

Table S3: Characteristics of Participants in the Current Study for Validation of the 8-Variable KFRE and the Original Cohorts for Developing and Validating the KFRE.

Table S4: Harrell's C Statistic, Category-Free NRI, and IDI of Applying the KFRE in the Current Cohorts Based on the Competing Risk Model.

ARTICLE INFORMATION

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