

Supplementary Online Content

Tangri N, Stevens LA, Griffith J, et al. A predictive model for progression of chronic kidney disease to kidney failure. *JAMA*. 2011;305(15):1553-1559.

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This supplementary material has been provided by the authors to give readers additional information about their work.

eEquation. Applying the Five Year Kidney Failure Risk Prediction to an Individual Patient

The equation of the five year kidney failure risk predictor is:

$$\begin{aligned}
 P &= 1 - S_0(t)^{\exp f(x)} \\
 &= 1 - S_{ave}(t=1826)^{\exp(\bar{x}) - f_0(x)} \\
 &= 1 - S_{ave}(t=1826)^{\exp\{-0.49360 * [(GFR/5) - 7.22] + 0.16117 * (\text{male} - 0.56) + 0.35066 * [\ln(\text{ACR}) - 5.2775] - 0.19883 * [(\text{age}/10) - 7.04] - 0.33867 * (\text{albumin} - 3.99) + 0.24197 * (\text{phosphorous} - 3.93) - 0.07429 * (\text{bicarbonate} - 25.54) - 0.22129 * (\text{calcium} - 9.35)\}} \\
 &= 0.07
 \end{aligned}$$

where

$$\begin{aligned}
 f(x) &= B_1(x_1 - \bar{x}_1) + \dots + B_\rho(x_\rho - \bar{x}_\rho) \\
 f(x) &= (B_1\bar{x}_1 + \dots + B_\rho\bar{x}_\rho) - (B_1x_1 + \dots + B_\rho x_\rho)
 \end{aligned}$$

$S_{ave}(t=1826)$ is the five-year survival rate for an individual with the average value of covariates in the risk equation ($x_1 \dots x_\rho$) and was 0.929 in the development dataset.

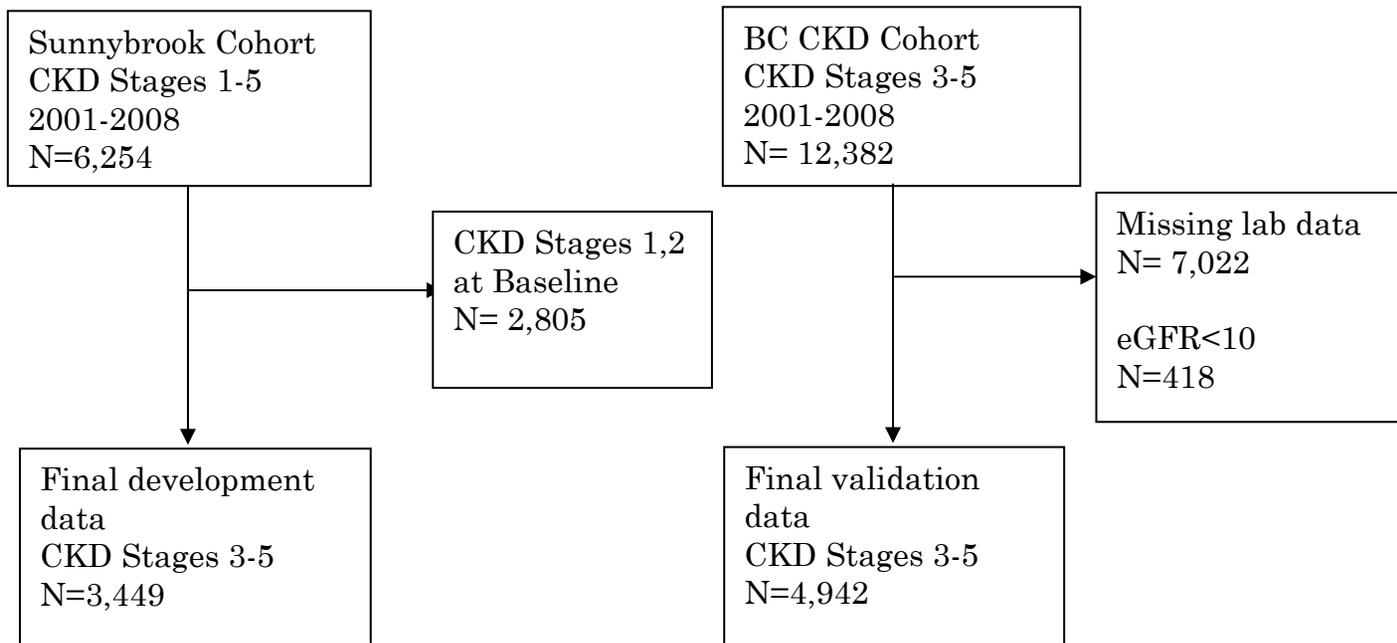
$B_1 \dots B_\rho$ are the regression coefficients

$(B_1\bar{x}_1 + \dots + B_\rho\bar{x}_\rho)$ represent the sum of the average values for the risk factors

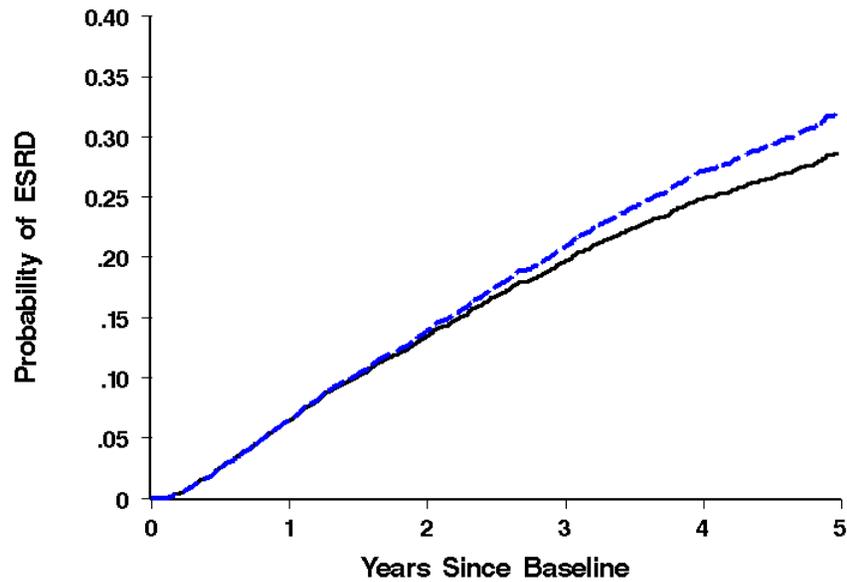
$(B_1x_1 \dots + B_\rho x_\rho)$ represent the sum of the individual's risk factors

Please see attached spreadsheet for risk calculations.

eFigure 1. Derivation of Development and Validation Datasets



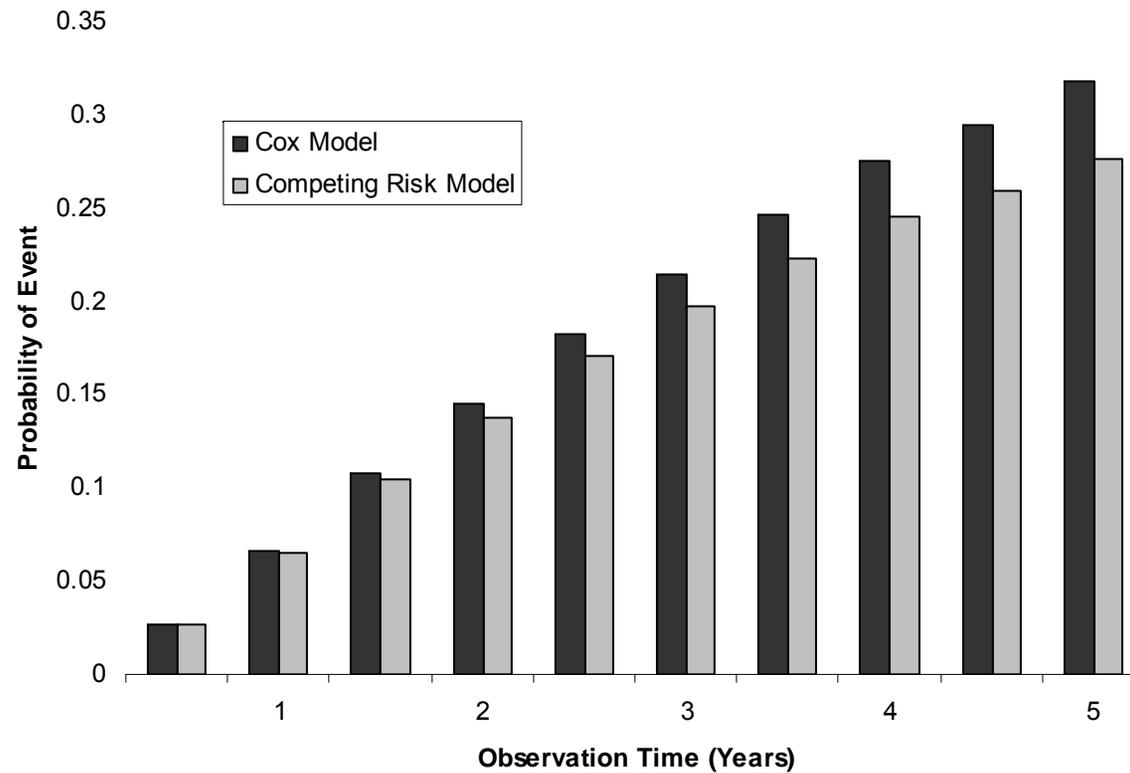
eFigure 2. Comparison of the Kaplan Meier Curve and the Cumulative Incidence Curve



No at risk	4942	4451	3435	2095	1351	746
Events	0	321	663	894	1035	1101

Comparison of the Kaplan Meier curve (solid black line) and the cumulative incidence curve (broken blue line). The Kaplan Meier curve represents the observed probability of kidney failure censored for death before kidney failure. The cumulative incidence curve represents the observed probability of kidney failure (death before kidney failure considered as a competing event rather than censored).

eFigure 3. Comparison of the Mean Predicted Probability of the Cox Model and the Competing Risk Model in the Validation Cohort According to Observation Time



All participants are included in each bar (n=4,942).

eTable 1. Variables Considered for Inclusion in the Prediction Models in the Development Dataset

Variable (n)
Demographics
Age (3,449)
Male gender (3,449)
Physical Examination
Weight (2,782)
Systolic Blood Pressure (3,153)
Diastolic Blood Pressure (3,153)
Comorbid Conditions
Diabetes (3,449)
Hypertension (3,449)
Immunologic Disease or SLE (3,449)
Current or Previous Smoking (3,449)
Urinary Tract Abnormality (3,449)
Vascular Disease (3,449)
Laboratory Data
Estimated GFR (3,449)
Hemoglobin (3,144)
Calcium (2,891)
Phosphate (2,629)
Albumin (2,906)
Alkaline Phosphatase (3,449)
Creatinine (3,449)
Sodium (3,265)
Potassium (3,265)
Chloride (3,265)
Bicarbonate (3,169)
Spot Urine Albumin-to-Creatinine Ratio (1,723)
24 Hour Urinary Protein Excretion (1,923)

n is the number of subjects for whom the variable is ascertained. Spot and timed urine collections were combined to provide an n of 2,506 for quantitative urinary protein excretion.

eTable 2. Model Discrimination at 3 Years Overall and in Subgroups of Interest

Model	All	Age (years)		Sex		CKD Stage		Albuminuria (mg/g)		Diabetes	
		≥65	<65	Males	Females	3	4	0-299	≥300	Yes	No
Development Cohort											
n	3449	2447	1002	1946	1503	2303	926	1938	1511	1278	2171
Model 2	0.89	0.90	0.88	0.90	0.89	0.72	0.76	0.91	0.86	0.88	0.90
Model 3	0.91	0.90	0.90	0.91	0.90	0.78	0.80	0.91	0.87	0.90	0.92
Model 6*	0.92	0.91	0.91	0.92	0.91	0.80	0.81	0.92	0.88	0.91	0.93
Model 7	0.92	0.92	0.92	0.92	0.92	0.81	0.83	0.93	0.88	0.92	0.93
Validation Cohort											
n	4942	3292	1650	2833	2109	2407	2095	2888	2054	1907	3035
Model 2	0.79	0.80	0.76	0.79	0.80	0.69	0.72	0.78	0.75	0.78	0.81
Model 3	0.83	0.84	0.81	0.83	0.83	0.79	0.77	0.79	0.78	0.83	0.84
Model 6*	0.84	0.84	0.82	0.84	0.84	0.81	0.78	0.80	0.78	0.83	0.85
Model 7	0.83	0.83	0.81	0.83	0.84	0.79	0.77	0.78	0.78	0.82	0.85

* Indicates best model. Albuminuria is defined as Albumin-to-Creatinine Ratio. C statistics are presented as measures of discrimination.

eTable 3. Model Discrimination and Integrated Discrimination Improvement in the Validation Dataset

Model	C Statistic			IDI (Relative)*		
	1 Year	3 Year	5 Year	1 Year	3 Year	5 Year
Model 2	0.83	0.79	0.79	--	--	--
Model 3	0.85	0.83	0.83	0.05 (33%)	0.09 (40%)	0.10 (42%)
Model 6	0.86	0.84	0.84	0.04 (19%)	0.03 (10%)	0.02 (6%)

*Comparisons are for successive models, $p < 0.001$ for all comparisons.

eTable 4. Net Reclassification Improvement Overall and in Relevant Subgroups in the Validation Cohort

Models	CKD Stage 3			CKD Stage 4		
	Net Reclassification (Events) n (%)	Net Reclassification (Non Events) n (%)	Net Reclassification Improvement n (%) (95% CI)	Net Reclassification (Events) n (%)	Net Reclassification (Non Events) n (%)	Net Reclassification Improvement n (%) (95% CI)
Overall	248 (100 %)	2159 (100 %)		400 (100 %)	1695 (100 %)	
Model 3 vs. 2	76 (30.6 %)	296 (13.7 %)	372 (44.4 %) (36.5, 52.2)	10 (2.5 %)	374 (22.1 %)	384 (24.6 %) (17.7, 31.4)
Model 6 vs. 2	91 (36.7 %)	296 (13.7 %)	387 (50.4 %) (42.7, 58.1)	5 (1.3 %)	432 (25.5 %)	437 (26.7 %) (20.1, 33.3)
Model 6 vs. 3	21 (8.5 %)	-11 (-0.5 %)	10 (8.0 %) (2.1, 13.9)	-2 (-0.5 %)	78 (4.6 %)	76 (4.1 %) (-0.5, 8.8)
Age > 65	94 (100 %)	1452 (100 %)		200 (100 %)	1256 (100 %)	
Model 3 vs. 2	35 (37.2 %)	233 (16.0 %)	268 (53.3 %) (40.6, 65.8)	8 (4.0 %)	264 (21.0 %)	272 (24.9 %) (14.5, 35.4)
Model 6 vs. 2	42 (44.7 %)	226 (15.6 %)	268 (60.2 %) (48.2, 72.3)	8 (4.0 %)	288 (22.9 %)	296 (26.9 %) (16.9, 37.0)
Model 6 vs. 3	7 (7.4 %)	-10 (-0.7 %)	-3 (6.8 %) (-2.9, 16.4)	5 (2.5 %)	31 (2.5 %)	36 (5.0 %) (-2.4, 12.5)
Age <65	154 (100 %)	707 (100 %)		200 (100 %)	439 (100 %)	
Model 3 vs. 2	41 (26.6 %)	63 (8.9 %)	104 (35.5 %) (25.1, 46.0)	2 (1.0 %)	111 (25.3 %)	113 (26.3 %) (17.0, 35.6)
Model 6 vs. 2	49 (31.8 %)	70 (9.9 %)	119 (41.7 %) (31.3, 52.2)	-3 (-1.5%)	144 (32.8%)	141 (31.3 %) (22.1, 40.5)
Model 6 vs. 3	14 (9.1 %)	-1 (-0.1 %)	13 (8.9 %) (1.2, 16.7)	-7 (-3.5%)	46 (10.5 %)	39 (7.0 %) (0.5, 13.5%)
Males	185 (100%)	1318 (100%)		242 (100 %)	860 (100 %)	
Model 3 vs. 2	63 (34.1 %)	188 (14.3%)	251 (48.3 %) (39.9, 56.7)	7 (2.9 %)	237 (27.6 %)	244 (30.5 %) (22.6, 43.6)
Model 6 vs. 2	67 (36.2 %)	225 (17.1 %)	292 (53.3 %) (44.8, 61.8)	-12 (-5.0 %)	286 (33.3 %)	274 (28.3%) (20.2, 36.4%)
Model 6 vs. 3	9 (4.9 %)	36 (2.7 %)	45 (7.6 %) (1.1, 14.1)	-16 (-6.6 %)	64 (7.4 %)	48 (0.8 %) (-5.2, 6.8%)
Females	63 (100%)	841 (100%)		158 (100 %)	835 (100 %)	

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Model 3 vs. 2	13 (20.6 %)	108 (12.8 %)	121 (33.5 %) (14.8, 52.1)	3 (1.9 %)	137 (16.4 %)	140 (18.4%) (6.4, 30.2)
Model 6 vs. 2	24 (38.1 %)	71 (8.4 %)	95 (46.5 %) (28.8, 64.3)	17 (10.8 %)	146 (17.5 %)	163 (28.2 %) (17.1, 39.4)
Model 6 vs. 3	12 (19.0 %)	-47 (-5.6 %)	-35 (13.5 %) (0.1, 26.8)	14 (8.9 %)	14 (1.7 %)	28 (10.5%) (3.0, 18.0)
ACR 30-299 mg/g	39 (100 %)	945 (100 %)		86 (100 %)	713 (100 %)	
Model 3 vs. 2	-10 (-25.6 %)	271 (28.7 %)	261 (3.0 %) (-11.0, 17.1)	54 (-62.8 %)	404 (56.7 %)	350 (-6.1 %) (-17.0, 6.7)
Model 6 vs. 2	-2 (-5.1 %)	245 (25.9 %)	243 (20.8 %) (4.7, 36.9)	-40 (-46.5%)	251 (49.6 %)	211 (3.1 %) (-9.8, 16.1)
Model 6 vs. 3	8 (20.5 %)	-20 (-2.1 %)	-12 (18.4 %) (3.6, 33.2)	12 (14.0 %)	-21 (-2.9 %)	-9 (11.0 %) (-1.6, 23.6)
ACR >300 mg/g	197 (100 %)	618 (100 %)		299 (100 %)	679 (100 %)	
Model 3 vs. 2	94 (47.7 %)	-265 (-42.9 %)	-171 (4.8%) (-3.1, 12.9)	78 (26.1 %)	-136 (-30.0 %)	-58 (-3.9%) (-10.5, 2.6%)
Model 6 vs. 2	100 (50.8 %)	-209 (-33.8 %)	-109 (16.9 %) (8.6, 25.3)	54 (18.1 %)	-92 (-13.6 %)	-38 (4.5 %) (-2.8, 11.8)
Model 6 vs. 3	13 (6.6 %)	38 (6.1 %)	51 (12.7 %) (5.3, 20.2)	-19 (-6.4 %)	110 (16.2 %)	91 (9.8 %) (4.4, 15.3)
Diabetes	156 (100 %)	762 (100 %)		230 (100 %)	579 (100 %)	
Model 3 vs. 2	55 (35.3 %)	66 (8.7 %)	121 (43.9 %) (33.5, 54.3)	19 (8.3 %)	99 (17.1 %)	118 (25.4 %) (15.6, 35.1)
Model 6 vs. 2	62 (39.7 %)	66 (8.7 %)	128 (48.4 %) (38.4, 58.4)	11 (4.8 %)	135 (23.3 %)	146 (28.1 %) (18.9, 37.6)
Model 6 vs. 3	12 (7.7 %)	-5 (-0.7 %)	7 (7.0 %) (-0.4, 14.5)	-4 (-1.7 %)	41 (7.1 %)	37 (5.3%) (-1.0, 11.7)
No Diabetes	92 (100 %)	1397 (100 %)		170 (100 %)	1116 (100 %)	
Model 3 vs. 2	21 (22.8 %)	231 (16.5 %)	252 (39.3 %) (26.8, 51.8)	-9 (-5.3 %)	275 (24.6 %)	266 (19.3 %) (9.4, 29.3)
Model 6 vs. 2	29 (31.5 %)	231 (16.5 %)	260 (48.0 %) (35.2, 60.8)	-6 (-3.5 %)	297 (26.6 %)	291 (23.1 %) (13.6, 36.6)
Model 6 vs. 3	9 (9.8 %)	-6 (-0.4 %)	3 (9.4 %) (-0.9, 19.6)	2 (1.2 %)	37 (3.3 %)	39 (4.5 %) (-3.1, 12.1)

Risk categories for CKD stage 3 are 0%-5%, 5%-15%, and >15% over 5 years, and for CKD stage 4 are 0%-10%, 10%-20%, and >20% over 2 years.

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eTable 5. Kidney Failure Risk Score

P (event) = Probability of kidney failure at 5 years

Risk Factor	Categories	Points	Risk Factor	Categories	Points	
eGFR	10-14	-35	Albumin	<= 2.5	-5	
	15-19	-30		2.6-3	0	
	20-24	-25		3.1-3.5	2	
	25-29	-20		>= 3.6	4	
	30-34	-15		Phosphorous	< 3.5	3
	35-39	-10			3.5-4.5	0
	40-44	-5			4.6-5.5	-3
	45-49	0			> 5.5	-5
	50-54	5			Bicarbonate	< 18
	55-59	10		18-22		-4
Male	No	0	23-25	-1		
	Yes	-2	>25	0		
ACR	<30	0	Calcium	<= 8.5	-3	
	30-300	-14		8.6-9.5	0	
	> 300	-22		>9.6	2	
Age	< 30	-4				
	30-39	-2				
	40-49	0				
	50-59	2				
	60-69	4				
	70-79	6				
	80-89	8				
	> 90	10				

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Interpretation

Score < -41 = P (Kidney Failure) > 90%

Score > -3 = P (Kidney Failure) < 5%

Between -3 and -41, please refer to the chart below

Score	P(event)	Score	P(event)
-41	89.0%	-21	26.4%
-40	86.9%	-20	24.2%
-39	84.1%	-19	22.2%
-38	81.0%	-18	20.3%
-37	77.8%	-17	18.6%
-36	74.4%	-16	17.0%
-35	70.9%	-15	15.5%
-34	67.3%	-14	14.1%
-33	63.6%	-13	12.9%
-32	59.9%	-12	11.7%
-31	56.3%	-11	10.7%
-30	52.8%	-10	9.7%
-29	49.3%	-9	8.8%
-28	45.9%	-8	8.0%
-27	42.7%	-7	7.3%
-26	39.6%	-6	6.6%
-25	36.6%	-5	6.0%
-24	33.8%	-4	5.5%
-23	31.2%		
-22	28.7%		

A smartphone app is available at <http://www.qxmd.com/Kidney-Failure-Risk-Equation>.

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