Supplementary Online Content

James MT, Neesh P, Hemmelgarn BR, et al. Derivation and external validation of prediction models for advanced chronic kidney disease following acute kidney injury. *JAMA*. doi:10.1001/jama.2017.16326

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

eTable 1 - Diagnostic and procedure codes used to identify candidate comorbidity and procedure variables in the derivation, internal validation (AKDN) and external validation (ICES) cohorts

	Coding Definition
Comorbidities	
Diabetes mellitus	*One hospitalization* with an ICD-9-CM code of 250.x, or ICD-10 codes E10-14, excluding codes for gestational diabetes or *Two physician claims* with an ICD-9 code of 250 *within two years*.
Hypertension	*One hospitalization* with an ICD-9-CM code of 401-405, or ICD-10 I10-I15, excluding codes for gestational hypertension or *Two physician claims with an* ICD-9 code (401-405) *within two years,* excluding codes for gestational hypertension.
Myocardial infarction	ICD-9-CM 410.x, 412.x, or ICD-10 I21.x, I22.x, I25.2
Congestive heart failure	ICD-9-CM 428.x, or ICD-10 I09.9, I11.0, I13.0, I13.2, I25.5, I42.0, I42.5–I42.9, I43.x, I50.x, P29.0
Peripheral vascular disease	ICD-9-CM 443.9, 441.x, 785.4, V43.4, or Procedure 38.48, or ICD-10 I70.x, I71.x, I73.1, I73.8, I73.9, I77.1, I79.0, I79.2, K55.1, K55.8, K55.9, Z95.8, Z95.9
Rheumatic disease	ICD-9-CM 710.0, 710.1, 710.4,714.0–714.2, 714.81, 725.x, or ICD-10 M05.x, M06.x, M31.5, M32.x–M34.x, M35.1, M35.3, M36.0
Mild liver disease	ICD-9-CM 571.2, 571.4–571.6, or ICD-10 B18.x, K70.0–K70.3, K70.9, K71.3–K71.5, K71.7, K73.x, K74.x, K76.0, K76.2–K76.4, K76.8, K76.9, Z94.4
Moderate or severe liver disease	ICD-9-CM 456.0–456.21, 572.2–572.8, or ICD-10 I85.0, I85.9, I86.4, I98.2, K70.4, K71.1, K72.1, K72.9, K76.5, K76.6, K76.7
Hemiplegia or paraplegia	ICD9-CM 344.1, 342.x, or ICD-10 G04.1, G11.4, G80.1, G80.2, G81.x, G82.x, G83.0–G83.4, G83.9
Metastatic solid tumor	ICD-9-CM196.x–199.1, or ICD-10 C77.x–C80.x

Comorbidities were identified from hospital discharge records and physician claims using validated ICD-9-CM and ICD-10 coding algorithms, based on the presence of codes recorded from hospitalizations, outpatient encounters, and physician claims up to 3 years prior to the index hospital admission. Procedures during the index hospitalization were identified using previously described approaches. A comorbidity or procedure was considered absent if no representative codes were identified for a participant.

Abbreviations: AKDN = Alberta Kidney Disease Network, ICES = Institute for Clinical Evaluative Sciences, ICD = International Classification of Diseases, CCI = Canadian Classification of Health Interventions

eTable 1 (Continued) - Diagnostic and procedure codes used to identify comorbidities and procedures in the derivation, internal validation (AKDN) and external validation (ICES) cohorts

	Coding Definition
Procedures in hospital	
Mechanical ventilation	ICD-9-CM Procedure codes 93.90, 93.92, 96.01, 96.04, 96.05, 96.70, 96.71, 96.72, or CCI procedure codes 1.GZ.31, or AH Physician claims 13.62A, or OHIP Physician claims G557, G558, G559, G405, G406, G407,
Cardiac catheterization	ICD-9-CM procedure codes 36.01, 36.02. 36.05, 36.06, or ICD-10 CA/CCI 31P10, 1IJ50, 1IJ5GQ,1IJ57GQ-AZ, or AH Physician claims 49.96 51.59D, 51.59E, 51.59F, or OHIP Physician claims G296, G297, G299, G300, G301, G304, G305, G306.
Cardiac surgery	ICD-9-CM Procedure codes 36.1x, 36.2x, or ICD-10 CA/CCI 1IJ76,1HU90, 1HU80, 1HV90, 1HV80, 1HT90, 1HT80, 1HS90, 1HS80, 1HW, or AH Physician claims 47.1, 47.2, 47.3, 47.4, 47.5, 47.7, 47.8, 47.9, 48.0, 48.1, 48.15, 48.19, 48.9, 49.1, 49.2, 49.3, 49.4, 49.5, or OHIP Physician claims Z434, R742, R743, R724, R725, R726, R727, R728, R729, R730, R733, R734, R735, R736, R737, R738, R772, R773, R774, R863, R876, R930.
Abdominal aortic aneurysm repair	ICD-9-CM Procedure codes 38.34, 38.64, 38.44, 39.71ICD-10 CA diagnostic code I71.4 plus CCI code 1.KA.80.LA-XXN or 1.KA.80.GQ-NRN, or CCI codes 1.KA.76.MZ-XXN or 1.KA.76.NB-XXN or 1.KA.50.GQ-OA (GQ-BD/GS-BD) or 1.KE.50.GQ-OA (GQ-BD/GS-BD) (note for these 4 CCI codes do not require the ICD-10 diagnostic code)
Acute dialysis	ICD-9-CM Diagnosis codes 584, 584.5, 584.6, 584.7, 584.8, 584.9 plus one of the following Procedure codes 39.95, V45.1, V56.0, V56.1, or ICD-10 Diagnosis codes N17, N17.0, N17.1, N17.2, 17.8, N17.9 plus one of the following ICD-10 CA/CCI Procedure codes 1.PZ.21.HQ-BR, 1.PZ.21.HPD4, 1.PZ.21.HQ-BS, 1.JQ.53.^^, 1.JT.53.^^ or ICD-10 diagnosis code: Z99.2, Z49.1, Z49.0, or AH Physician claims 1399A and 1399B, or OHIP Physician claims R849, G323, G866, G330, G331, G093, G095, G294, G295..

Comorbidities were identified from hospital discharge records and physician claims using validated ICD-9-CM and ICD-10 coding algorithms, based on the presence of codes recorded from hospitalizations, outpatient encounters, and physician claims up to 3 years prior to the index hospital admission. Procedures during the index hospitalization were identified using previously described approaches. A comorbidity or procedure was considered absent if no representative codes were identified for a participant.

Abbreviations: AKDN = Alberta Kidney Disease Network, ICES = Institute for Clinical Evaluative Sciences, ICD = International Classification of Diseases, CCI = Canadian Classification of Health Interventions

eTable 2 – Predictors of advanced CKD and their frequency in the derivation, internal validation (AKDN) and external validation (ICES) cohorts

Predictors	Derivation (AKDN) Cohort		Internal Validation (AKDN) Cohort		External Validation (ICES) Cohort	
	Full cohort (N=9973)	Advanced CKD (n=272)	Full cohort (N=4985)	Advanced CKD (n=136)	Full cohort (N=2761)	Advanced CKD (n=62)
Age (years), n (%)						
< 65	4266 (42.8)	94 (34.6)	2094 (42.0)	45 (33.1)	938 (34.0)	16 (25.8)
≥ 65	5707 (57.2)	178 (65.4)	2891 (58.0)	91 (66.9)	1823 (66.0)	46 (74.2)
Sex, n (%)						
male	5715 (57.3)	145 (53.3)	2091 (42.0)	74 (54.4)	1654 (59.9)	32 (51.6)
female	4258 (42.7)	127 (46.7)	2894 (58.0)	62 (45.6)	1107 (40.1)	30 (48.4)
AKI‡, n (%)						
Stage1	7686 (77.1)	136 (50.0)	3806 (76.4)	63 (46.3)	2165 (78.4)	32 (51.6)
Stage2	1357 (13.6)	45 (16.5)	699 (14.0)	26 (19.1)	356 (12.9)	13 (21.0)
Stage3	930 (9.3)	91 (33.4)	480 (9.6)	47 (34.6)	240 (8.7)	17 (27.4)
Baseline Scr, n (%)						
< 1.0 mg/dL	5906 (59.2)	97(35.7)	2985 (59.9)	43 (31.6)	1555 (56.3)	20 (32.3)
≥ 1.0 mg/dL	4067 (40.8)	175 (64.3)	2000 (40.1)	93 (68.4)	1206 (43.7)	42 (67.7)
Discharge Scr (mg/dL), n (%)						
<1.0	3394 (34.0)	13 (4.8)	1721 (34.5)	8 (5.9)	1057 (38.3)	7 (11.3)
1.0-<1.3	3207 (32.2)	37 (13.6)	1542 (30.9)	22 (16.2)	912 (33.0)	13 (21.0)
1.3-<1.6	1963 (19.7)	63 (23.2)	1012 (20.3)	21 (15.4)	532 (19.3)	14 (22.6)
1.6-<1.9	799 (8.0)	41 (15.1)	383 (7.7)	25 (18.4)	153 (5.5)	7 (11.3)
≥ 1.9	610 (6.1)	118 (43.4)	327 (6.6)	60 (44.1)	107 (3.9)	21 (33.9)
Albuminuria§, n (%)						
Normal	3775 (37.8)	63 (23.2)	1881 (37.7)	21 (15.4)	798 (28.9)	49 (18.1)
Mild	1373 (13.8)	38 (14.0)	662 (13.3)	22 (16.2)	137 (5.0)	6 (9.7)
Heavy	494 (5.0)	39 (14.3)	243 (4.9)	20 (14.7)	56 (2.0)	≤5 (<8)
Unmeasured	4331 (43.4)	132 (48.5)	2199 (44.1)	73 (53.7)	1770 (64.1)	≤5 (<8)

‡ AKI Stage: Stage 1 = Scr increase ≥0.3mg/dL or 1.5-1.9 times baseline within index hospitalization, Stage 2 = Scr increase 2.0-2.9 times baseline within index hospitalization, Stage 3 = SCr increase ≥3.0 times baseline or ≥4.0mg/dL or acute dialysis within index hospitalization.

§ Albuminuria: Normal = Albumin/Creatinine Ratio (ACR) < 30 mg/g or Dipstick urinalysis protein negative, Mild= ACR 30-300 mg/g or Dipstick urinalysis protein trace or 1+, Heavy=ACR > 300 mg/g or Dipstick urinalysis protein ≥ 2+. To convert urine ACR to mg/mmol, multiply by 0.113.

Abbreviations: AKDN = Alberta Kidney Disease Network, ICES = Institute for Clinical Evaluative Sciences, Scr = Serum creatinine, AKI = Acute Kidney Injury

The mean (SD) baseline Scr was 1.0 (0.2) mg/dL for all cohorts. The mean (SD) discharge eGFR was 62 (22) mL/min/1.73m^2 in the derivation and internal validation (AKDN) cohorts and 59 (22) mL/min/1.73m^2 in the external validation (ICES) cohort.

To convert serum creatinine to µmol/L, multiply by 88.4.

eTable 3 - Frequency, and observed risk of risk categories for 5 prediction models for advanced CKD in the derivation (AKDN) cohort

Model	Independent Variables	Predicted Risk Category	Sample Size (%) in Each Predicted Risk Category (%)	Advanced CKD, N (%)
Model 1	Age, Sex, AKI stage, Baseline Scr, Discharge Scr, Albuminuria	<1%	5228 (52.4)	23 (0.4)
		1-<5%	3512 (35.2)	70 (2.0)
		5-<10%	626 (6.2)	51 (8.2)
		10-<20%	360 (3.6)	70 (19.4)
		≥20	247 (2.5)	58 (23.5)
Model 2	Age, Sex, AKI stage, Baseline Scr, Discharge Scr	<1%	5116 (51.3)	23 (0.4)
		1-<5%	3569 (35.8)	67 (1.9)
		5-<10%	689 (6.9)	61 (8.8)
		10-<20%	363 (3.6)	68 (18.7)
		≥20	236 (2.3)	53 (22.5)
Model 3	Age, Sex, AKI stage, Baseline Scr	<1%	3124 (31.3)	11 (0.4)
		1-<5%	5617 (57.3)	133 (2.4)
		5-<10%	860 (8.6)	81 (9.4)
		10-<20%	267 (2.6)	30 (11.2)
		≥20	105 (1.0)	17 (16.2)
Model 4	Age, Sex, Discharge Scr	<1%	5260 (52.7)	26 (0.49)
		1-<5%	3532 (35.4)	78 (2.2)
		5-<10%	531 (5.3)	45 (8.5)
		10-<20%	477 (4.8)	87 (18.2)
		≥20	173 (1.7)	36 (20.8)
Model 5	Age, Sex, AKI stage	<1%	176 (1.8)	0 (0)
		1-<5%	8857 (88.8)	181 (2.0)
		5-<10%	516 (5.2)	49 (9.5)
		10-<20%	424 (4.2)	42 (9.9)
		≥20	0 (0)	0 (0)

There was a total of N=9973 patients in the derivation (AKDN) cohort, with 272 advanced CKD events in the derivation cohort (AKDN)

Abbreviations: CKD = Chronic Kidney Disease, AKDN = Alberta Kidney Disease Network, ICES = Institute for Clinical Evaluative Sciences, Scr = Serum creatinine

eTable 4 - Distribution of model predicted risk of advanced CKD (%) estimated in the derivation, internal validation (AKDN), and external validation (ICES) cohorts

Cohort	Model	Percentile of Predicted Risk						
		minimum	5th	25th	50th	75th	95th	maximum
Derivation (AKDN)	1	0.03	0.13	0.39	0.92	2.47	11.70	63.58
Internal validation (AKDN)		0.04	0.13	0.39	0.92	2.54	11.86	50.36
External validation (ICES)		0.07	0.16	0.44	0.93	2.58	9.76	61.71
Derivation (AKDN)	2	0.04	0.15	0.42	0.95	2.54	12.11	49.16
Internal validation (AKDN)		0.05	0.15	0.42	0.96	2.59	12.49	47.46
External validation (ICES)		0.05	0.14	0.40	0.81	2.33	8.54	48.40
Derivation (AKDN)	3	0.07	0.37	0.84	1.59	3.16	8.58	49.56
Internal validation (AKDN)		0.09	0.36	0.83	1.61	3.26	8.54	33.66
External validation (ICES)		0.09	0.42	0.92	1.64	3.29	8.33	39.69
Derivation (AKDN)	4	0.11	0.20	0.50	0.90	2.54	14.05	38.87
Internal validation (AKDN)		0.11	0.11	0.50	0.91	2.56	14.15	37.14
External validation (ICES)		0.16	0.19	0.49	0.80	2.29	6.89	36.13
Derivation (AKDN)	5	0.76	1.15	1.56	1.91	2.50	9.55	16.75
Internal validation (AKDN)		0.77	1.16	1.56	1.93	2.54	9.66	15.40
External validation (ICES)		1.08	1.33	1.65	1.97	2.48	9.78	15.08

Independent variables included in models: Model 1 = Age, Sex, AKI stage, Baseline Scr, Discharge Scr, Albuminuria; Model 2 = Age, Sex, AKI stage, Baseline Scr, Discharge Scr; Model 3 = Age, Sex, AKI stage, Baseline Scr, Model 4 = Age, Sex, Discharge Scr, Model 5 = Age, sex, AKI stage.

There was a total of N=9973 patients in the derivation (AKDN) cohort, with 272 advanced CKD events in the derivation cohort (AKDN), N=4985 patients with 136 advanced CKD events in the internal validation (AKDN) cohort, and N=2761 patients with 62 advanced CKD events in the external validation (ICES) cohort. The predicted risk of patients excluded from the cohorts due to no follow-up eGFR values was a median 0.87 (IQR 0.31-2.06) using model 1 in the derivation (AKDN) cohort.

Abbreviations: CKD = Chronic Kidney Disease, AKDN = Alberta Kidney Disease Network, ICES = Institute for Clinical Evaluative Sciences, Scr = Serum creatinine

eTable 5 – Discrimination and calibration of a six-variable model for advanced CKD in the internal validation (AKDN) cohort, stratified by timing of baseline Scr measurement and level of baseline eGFR

Strata	Advanced CKD, n (%)	Calibration intercept (p-value)	Calibration slope (p-value)	C statistic (95%CI)
Timing of baseline Scr				
≤ 3 months prior to admission (N=2918)	63 (2.1)	-0.36 (0.22)	0.90 (0.28)	0.83 (0.77, 0.89)
> 3 months prior to admission (N=2067)	73 (3.5)	0.48 (0.073)	1.19 (0.063)	0.89 (0.86, 0.93)
Level of baseline eGFR				
≥ 60 mL/min/1.73m^2 (N=3765)	57 (1.5)	-0.53 (0.052)	0.89 (0.18)	0.85 (0.80, 0.90)
45-59 mL/min/1.73m^2 (N=1221)	79 (6.5)	0.44 (0.15)	1.15 (0.24)	0.82 (0.77, 0.86)

Six-variable model for advanced CKD: Independent variables included in the model were Age, Sex, AKI stage, Baseline Scr, Discharge Scr, and Albuminuria
There was a total of N=4985 patients with 136 advanced CKD events in the internal validation (AKDN) cohort

Abbreviations: AKDN = Alberta Kidney Disease Network, CKD = Chronic Kidney Disease, AKDN = Alberta Kidney Disease Network, eGFR = estimated Glomerular Filtration Rate, Scr = Serum creatinine

eTable 6 - Predictive performance of models for advanced CKD in the patients excluded from original (AKDN) cohorts due to lack of pre-hospitalization Scr measurements between 7-365 days prior to hospital admission

	Models				
	Model 1	**Model 2**	**Model 3**	**Model 4**	**Model 5**
	Age, sex, AKI stage, Baseline Scr*, Discharge Scr, Albuminuria	Age, sex, AKI stage, Baseline Scr*, Discharge Scr	Age, sex, AKI stage, Baseline Scr*	Age, sex, Discharge Scr	Age, sex, AKI stage
Calibration intercept (p-value)	-0.48 (0.17)	-0.472 (0.18)	-1.06 (0.09)	-0.46 (0.21)	-1.5 (0.03)
Calibration slope (p-value)	0.92 (0.42)	0.888 (0.27)	0.80 (0.08)	0.89 (0.28)	0.67 (0.09)
C statistic (95%CI)	0.85 (0.79, 0.90)	0.84 (0.79, 0.89)	0.79 (0.74, 0.84)	0.84 (0.78, 0.89)	0.66 (0.60, 0.72)
Difference in C statistics (95% CI), p-value	Reference ¥	0.01 (-0.01, 0.01), 0.44	0.06 (0.03, 0.09), <0.001	0.007 (-0.01, 0.02), 0.357	0.19 (0.11, 0.26), <0.001
IDI (95%CI) %, p-value		0.3 (-0.3, 0.8), 0.31	3.5 (01.8, 0.052), <0.001	1.7 (0.6, 2.9), 0.003	6.1 (3.7, 8.5), <0.001
Continuous NRI (95% CI) %, p value		9.7 (-1.6, 21.0), 0.50	73.1 (45.9, 100.3), <0.001	57.0 (32.6, 81.4), <0.001	92.0 (66.0, 118.0), <0.001
Categorical NRI (95% CI) %§,		4.8 (-3.0, 12.4),	42.6 (24.3, 60.8),	11.8 (0.9, 22.8),	84.7 (63.3, 106.2),
p-value		0.25	<0.001	0.05	<0.001
NRI events‡ (%)		4 (8.2)	11 (22.4)	9 (18.3)	15 (30.6)
NRI non-events (%)		-99 (-3.4)	583 (20.1)	-189 (-6.5)	1568 (54.1)
Overall NRI (%)		-95 (4.8)	594 (42.6)	-180 (11.8)	1583 (84.7)

***Baseline Scr:** The closest value to the admission date, including values with 7 days prior to hospital admission were used

§ Risk categories: <1%, 1-<5%, 5-<10%, 10-<20% and ≥20%.

‡ NRI events refers to development of advanced CKD and NRI non-events refers to no development of advanced CKD.

¥ Reference: Each reduced model (model 2-5) was compared to the full model (model). For model comparisons differences in the C statistic, IDI, and NRI values greater than 0 indicate better performance for the full model (model 1) than the reduced model.

Abbreviations: Scr = Serum creatinine, AKDN = Alberta Kidney Disease Network, IDI = Integrated Discrimination Improvement, NRI = Net Reclassification Improvement

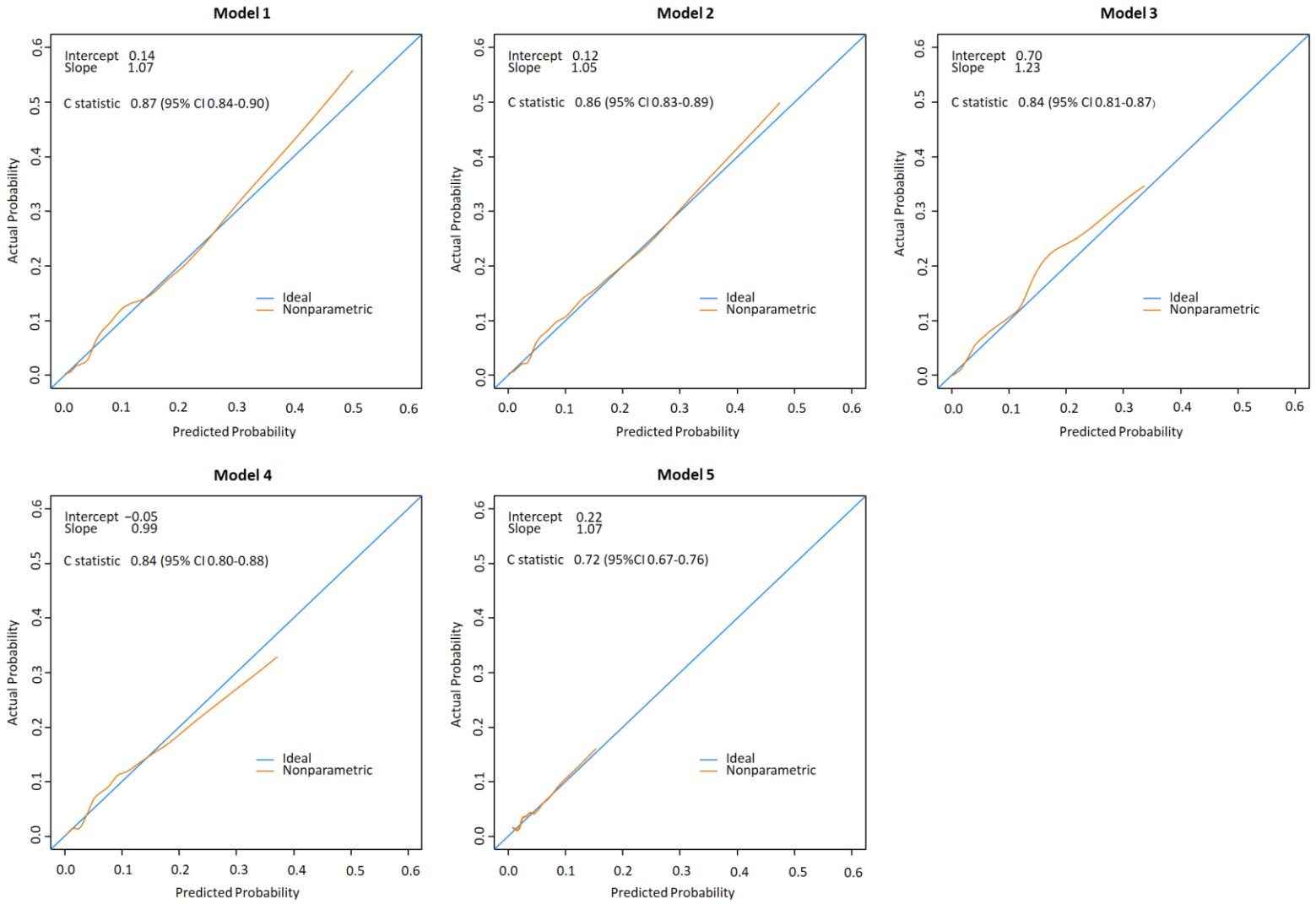
There was a total of N=2,946 patients included in this analysis**,** with 49 advanced CKD events.

eTable 7 - Varying thresholds of predicted risk based on the six-variable risk-index, proportion of patients who would be risk stratified for community CKD follow-up, and corresponding sensitivity, specificity, positive and negative predictive values for progression to advanced CKD during follow-up after a hospitalization with AKI

	Threshold for community CKD follow-up				
		Predicted risk			
	All patients	>1%	>5%	>10%	>20%
Risk score	Any	≥ 9	≥ 15	≥ 18	≥ 20
Patients risk stratified to community CKD follow-up, %	100	48.0	13.2	6.2	2.6
Sensitivity, % (95% CI)	NA	91.9 (86.0-95.9)	69.8 (61.4-77.4)	48.5 (39.9-57.2)	29.4 (21.9-37.8)
Specificity, % (95% CI)	NA	53.2 (51.8-54.6)	88.3 (87.4-89.2)	95.0 (94.2-95.5)	98.1 (97.7-98.5)
Positive Predictive Value, % 95% CI)	NA	5.2 (4.4-6.2)	14.4 (11.8-17.3)	21.2 (16.8-26.2)	30.5 (22.8-39.2)
Negative Predictive Value, % (95% CI)	NA	99.6 (99.2-99.8)	99.0 (98.7-99.3)	98.5 (98.1-98.8)	98.0 (97.6-98.4)

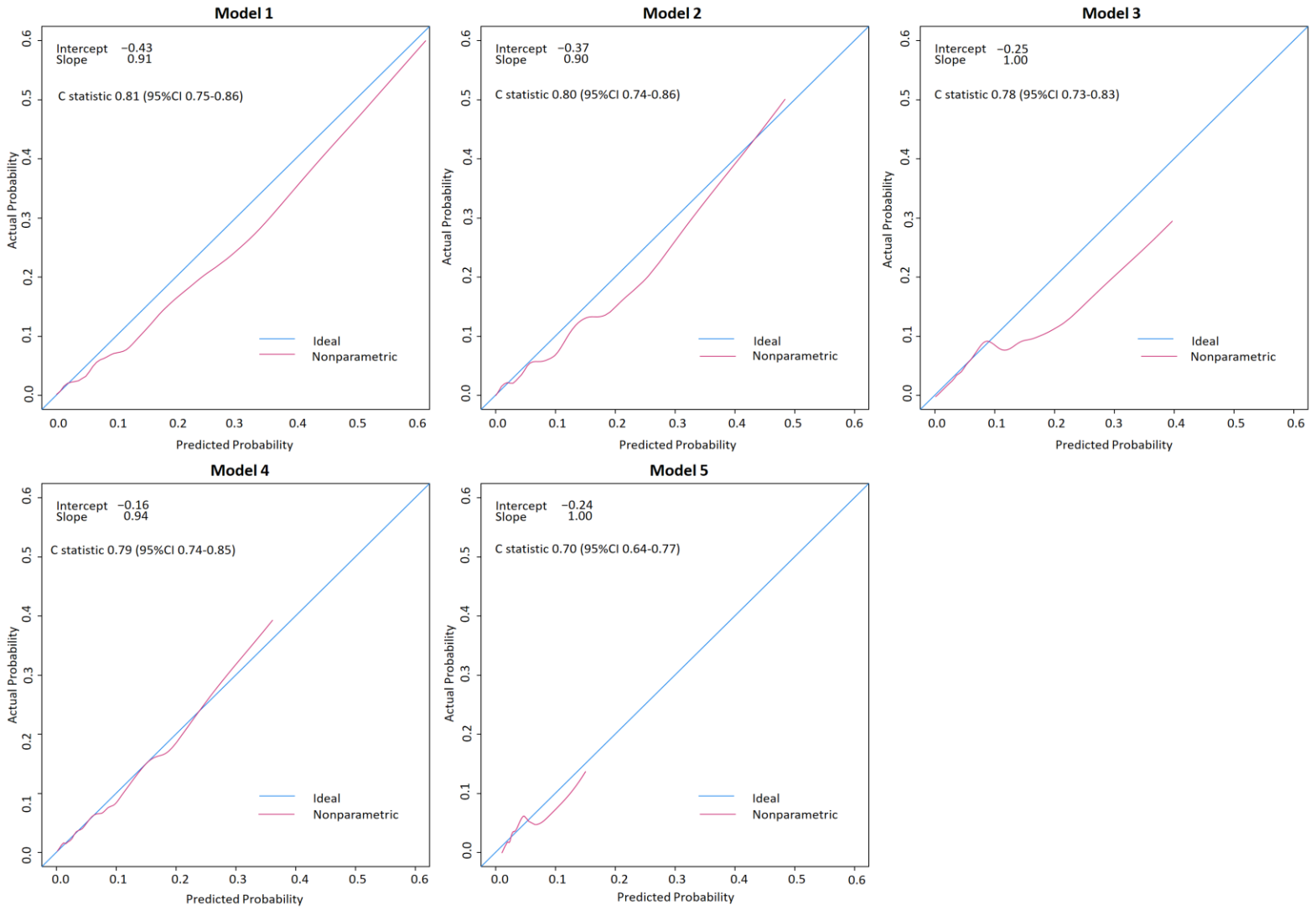
Abbreviations: CKD = Chronic kidney disease, AKI = Acute kidney injury, NA = Not applicable
Observed values obtained from the internal validation (AKDN) cohort

eFigure 1 – Calibration of the six-variable (Model 1) and reduced models (Models 2-5) in the internal validation (AKDN) cohort using locally weighted least squares regression smoother plots



Independent variables included in models: Model 1 = Age, Sex, AKI stage, Baseline Scr, Discharge Scr, Albuminuria; Model 2 = Age, Sex, AKI stage, Baseline Scr, Discharge Scr; Model 3 = Age, Sex, AKI stage, Baseline Scr, Model 4 = Age, Sex, Discharge Scr, Model 5 = Age, sex, AKI stage.
There was a total of N=4,985 patients in the internal validation (AKDN) cohort
Abbreviations: AKDN = Alberta Kidney Disease Network, CI = Confidence Interval

eFigure 2 – Calibration of the six-variable (Model 1) and reduced models (Models 2-5) in the external validation (ICES) cohort using locally weighted least squares regression smoother plots



Independent variables included in models: Model 1 = Age, Sex, AKI stage, Baseline Scr, Discharge Scr, Albuminuria; Model 2 = Age, Sex, AKI stage, Baseline Scr, Discharge Scr; Model 3 = Age, Sex, AKI stage, Baseline Scr, Model 4 = Age, Sex, Discharge Scr, Model 5 = Age, sex, AKI stage.
There was a total of N=2,761 patients in the external validation (ICES) cohort.
Abbreviations: ICES = Institute for Clinical Evaluative Sciences, CI = Confidence Interval