Figure S1 The optimal cut-off of patient age and tumor size for patients based on X-tile software. The histograms showed distribution of patients while Kaplan-Meier plot showed overall survival in groups stratified using the optimal cutoff value, where turquois, grey and purple represents low-, middle- and high-level respectively. (A), (B), (C), and (D) represents breast cancer, bladder cancer, lung cancer, and renal carcinoma, respectively.
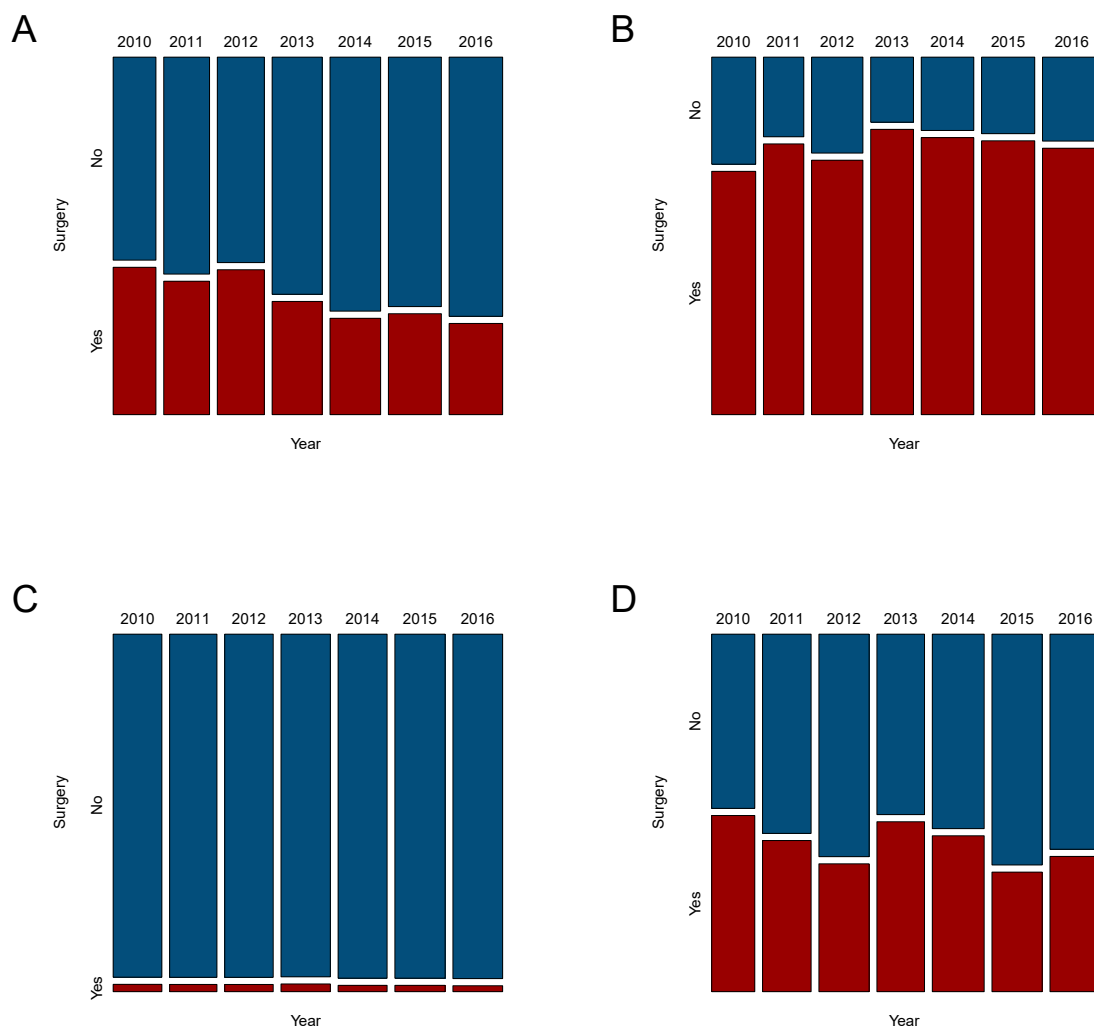
Figure S2 Receipt of surgical therapy over time in individual cancer type. The bar width is proportional to the number of cases. (A), (B), (C), and (D) represents breast cancer, bladder cancer, lung cancer, and renal carcinoma, respectively.
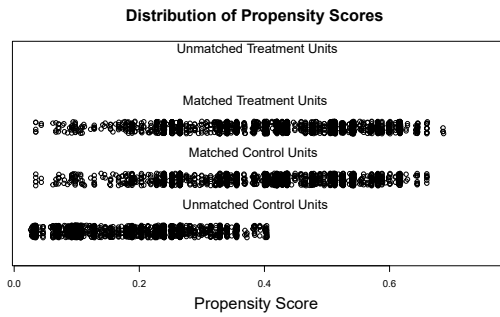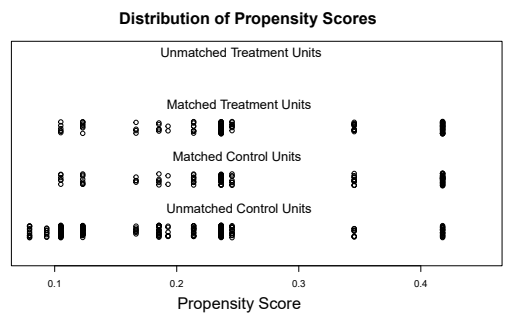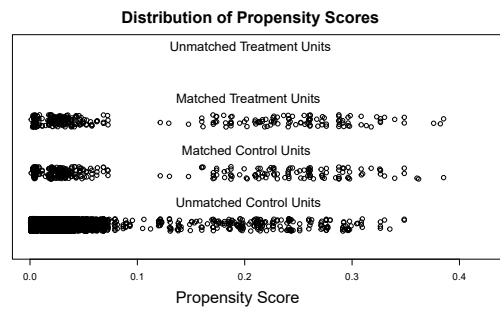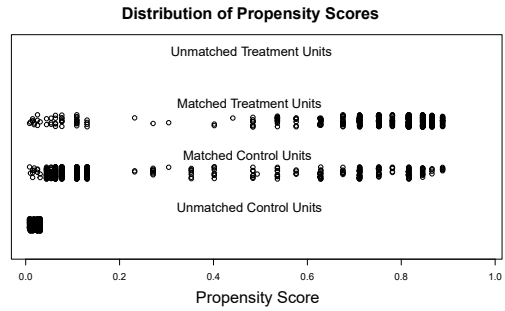
Figure S3 Distribution of propensity score before and after propensity matching procedure. (A), (B), (C) and (D) represents breast cancer, bladder cancer, lung cancer, and renal carcinoma, respectively.
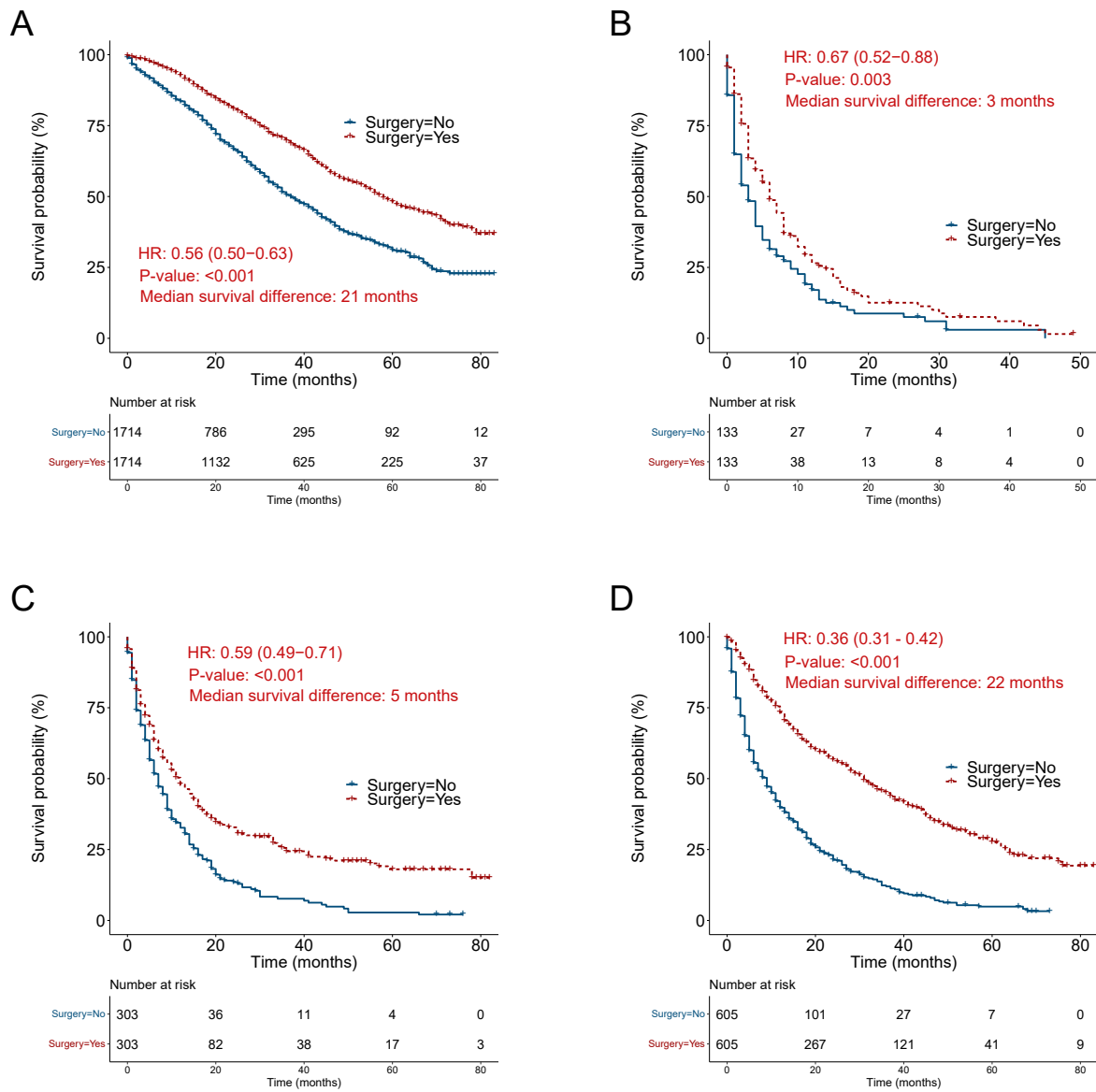
Figure S4 Kaplan-Meier curve showing cancer-specific survival by primary tumor surgery after propensity score matching. (A), (B), (C), and (D) represents breast cancer, bladder cancer, lung cancer, and renal carcinoma, respectively.
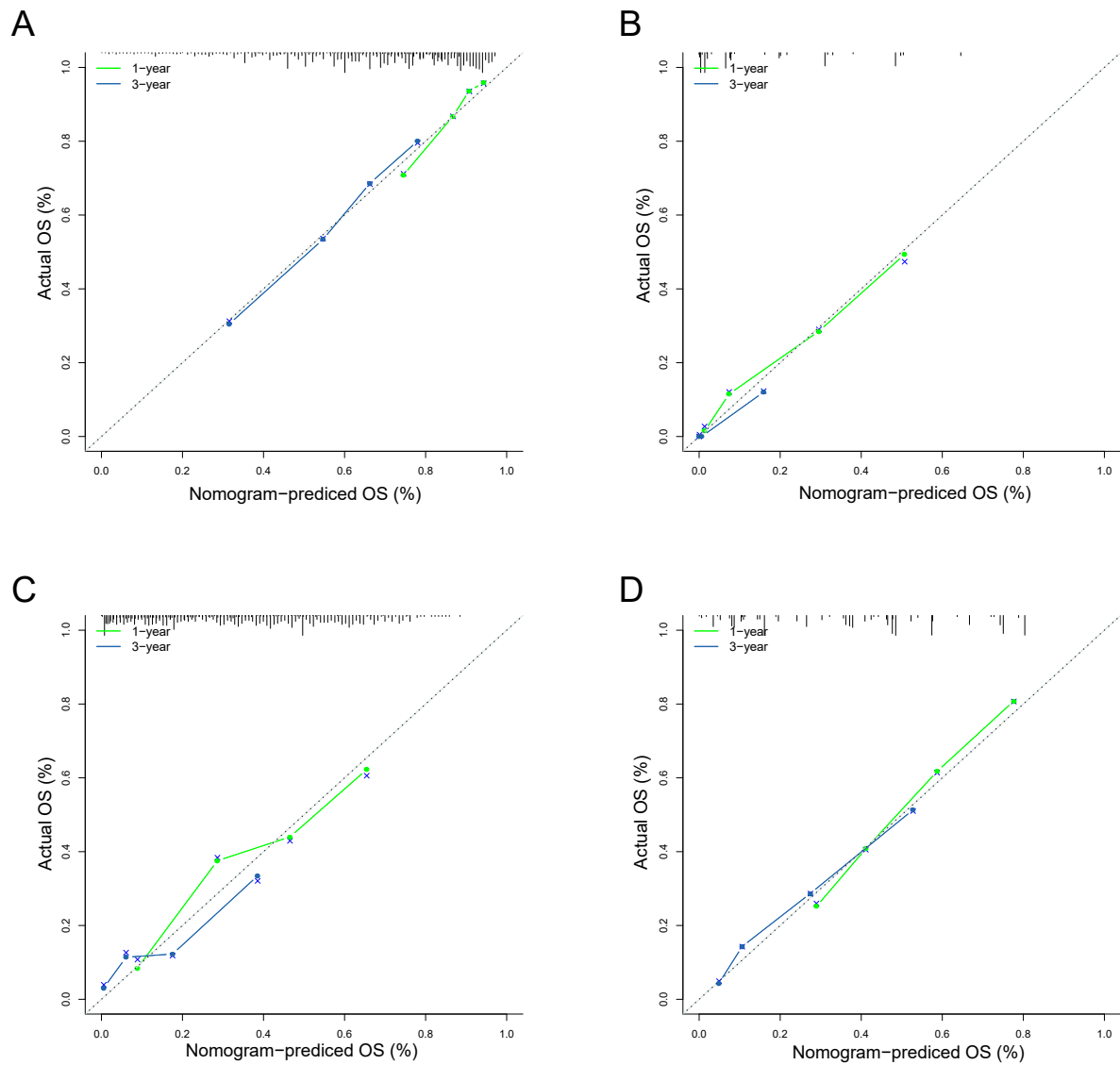
Figure S5 Calibration curve for predicting patient survival at 1- and 3-year overall survival. X-axis is nomogram-predicted survival probability, and y-axis is actual survival probability. Dashed line indicates the reference line on which an ideal nomogram would lie. (A), (B), (C), and (D) represents breast cancer, bladder cancer, lung cancer, and renal carcinoma, respectively.

**Figure S6** Net decision curve analyses demonstrate the comparison of benefit for predicting survival for overall survival. The y-axis indicates the net benefit, and x-axis indicates threshold probability. The blue line represents net benefit of the nomogram; red line represents net benefit of surgery-only; green line represents the hypothesis that all patients die within 3 years; black line represents the hypothesis that no patient dies within 3 years. (A), (B), (C), and (D) represents breast cancer, bladder cancer, lung cancer, and renal carcinoma, respectively.

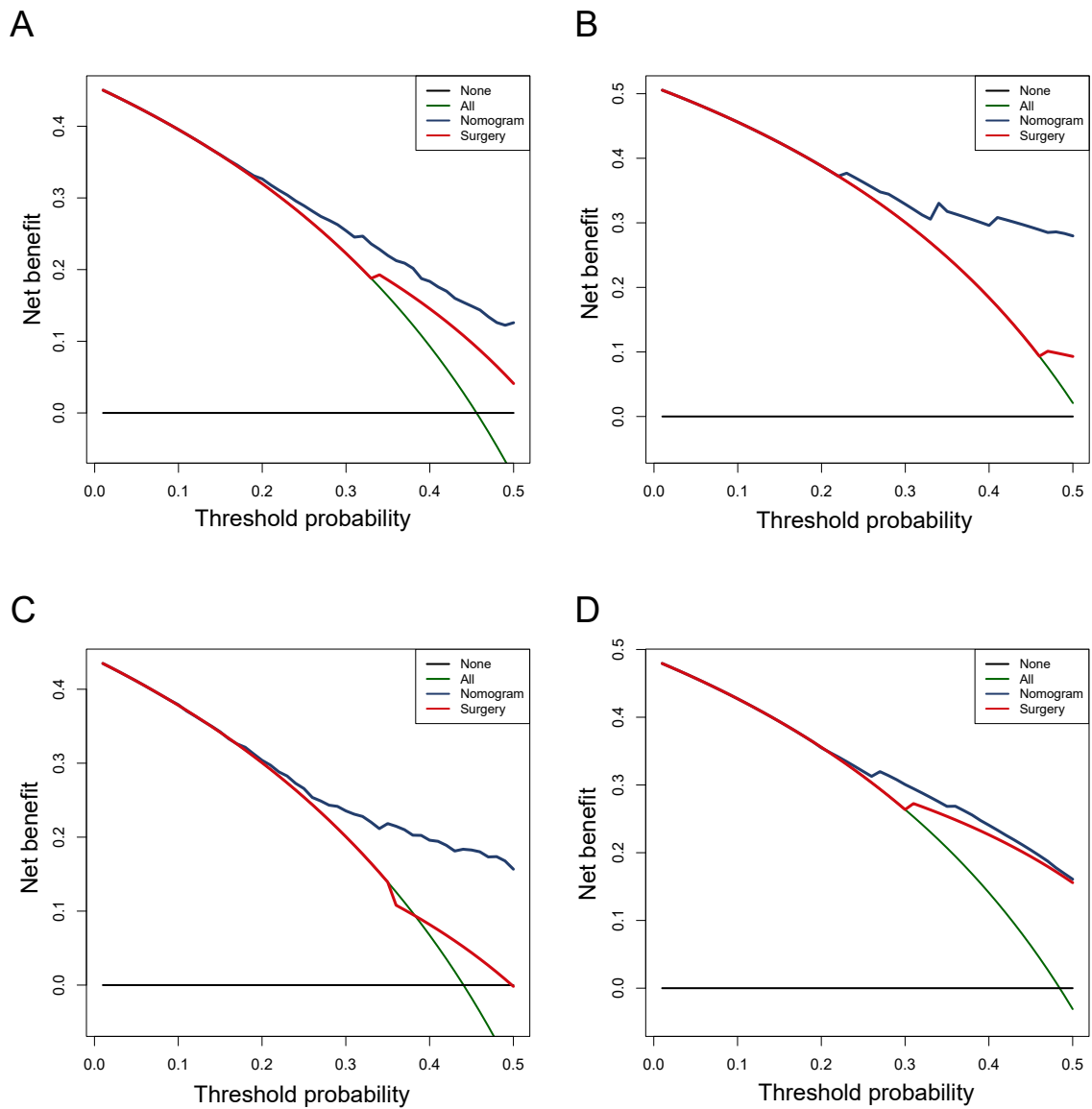**Table S1** Patient and tumor characteristics of bladder cancer patients grouped by surgery before and after propensity score matching (N=561)

Characteristics	Pre-Matching			Post-Matching	
	Non-Surgery	Surgery	P	Surgery	P
	N = 133	N=428		N = 133	
Age			0.596		1
<75y	110 (82.7%)	343 (80.1%)		110 (82.7%)	
>75y	23 (17.3%)	85 (19.9%)		23 (17.3%)	
Race			0.896		0.829
Black	17 (12.8%)	49 (11.4%)		15 (11.3%)	
White	109 (82%)	354 (82.7%)		109 (82%)	
Other	7 (5.3%)	25 (5.8%)		9 (6.8%)	
Sex			0.792		1
Female	31 (23.3%)	93 (21.7%)		31 (23.3%)	
Male	102 (76.7%)	335 (78.3%)		102 (76.7%)	
Grade			<0.001*		<0.001*
I	0 (0%)	5 (1.2%)		3 (2.3%)	
II	3 (2.3%)	12 (2.8%)		5 (3.8%)	
III	26 (19.5%)	88 (20.6%)		25 (18.8%)	
IV	41 (30.8%)	265 (61.9%)		85 (63.9%)	
Unknown	63 (47.4%)	58 (13.6%)		15 (11.3%)	
Tumor size			<0.001*		1
<5 cm	18 (13.5%)	93 (21.7%)		18 (13.5%)	
>5 cm	20 (15%)	120 (28%)		20 (15%)	
Unknown	95 (71.4%)	215 (50.2%)		95 (71.4%)	
Radiation			<0.001*		<0.001*
No	129 (97%)	283 (66.1%)		93 (69.9%)	
Yes	4 (3%)	145 (33.9%)		40 (30.1%)	
Chemotherapy			<0.001*		1
No	78 (58.6%)	163 (38.1%)		78 (58.6%)	
Yes	55 (41.4%)	265 (61.9%)		55 (41.4%)	

Values are expressed as n (%) unless otherwise indicated. *, Two-sided P values <0.05.

Table S2 Patient and tumor characteristics of lung cancer patients grouped by surgery before and after propensity score matching (N=15,484)

Characteristics	Pre-Matching			Post-Matching	
	Non-Surgery	Surgery	P	Non-Surgery	P
	N = 15,181	N = 303		N = 303	
Age			<0.001*		0.994
<60 y	4075 (26.8%)	104 (34.3%)		104 (34.3%)	
60-70 y	6252 (41.2%)	132 (43.6%)		133 (43.9%)	
>70 y	4854 (32%)	67 (22.1%)		66 (21.8%)	
Race			0.444		0.918
Black	1926 (12.7%)	31 (10.2%)		28 (9.2%)	
White	12093 (79.7%)	248 (81.8%)		251 (82.8%)	
Other	1162 (7.7%)	24 (7.9%)		24 (7.9%)	
Sex			0.271		0.742
Female	6063 (39.9%)	131 (43.2%)		126 (41.6%)	
Male	9118 (60.1%)	172 (56.8%)		177 (58.4%)	
Grade			<0.001*		0.891
I	222 (1.5%)	10 (3.3%)		6 (2%)	
II	1363 (9%)	64 (21.1%)		63 (20.8%)	
III	3274 (21.6%)	136 (44.9%)		139 (45.9%)	
IV	431 (2.8%)	13 (4.3%)		13 (4.3%)	
Unknown	9891 (65.2%)	80 (26.4%)		82 (27.1%)	
Tumor size			0.001*		0.903
<6 cm	8279 (54.5%)	197 (65%)		199 (65.7%)	
>6 cm	3294 (21.7%)	53 (17.5%)		49 (16.2%)	
Unknown	3608 (23.8%)	53 (17.5%)		55 (18.2%)	
Subtype			<0.001*		0.998
Adenocarcinoma	8438 (55.6%)	184 (60.7%)		185 (61.1%)	
Small cell	1953 (12.9%)	12 (4%)		12 (4%)	
Squamous	2528 (16.7%)	60 (19.8%)		59 (19.5%)	
Other	2262 (14.9%)	47 (15.5%)		47 (15.5%)	
Radiation			<0.001*		0.935
No	13814 (91%)	155 (51.2%)		153 (50.5%)	
Yes	1367 (9%)	148 (48.8%)		150 (49.5%)	
Chemotherapy			0.187		0.548
No	5954 (39.2%)	107 (35.3%)		99 (32.7%)	
Yes	9227 (60.8%)	196 (64.7%)		204 (67.3%)	

Values are expressed as n (%) unless otherwise indicated. *, Two-sided P values <0.05.

Table S3 Patient and tumor characteristics of kidney cancer patients grouped by surgery before and after propensity score matching (N = 1,440)

Characteristics	Pre-Matching			Post-Matching	
	Non-Surgery	Surgery	P	Non-Surgery	P
	N = 835	N = 605		N = 605	
Age			<0.001*		0.005*
<65y	399 (47.8%)	391 (64.6%)		342 (56.5%)	
>65y	436 (52.2%)	214 (35.4%)		263 (43.5%)	
Race			0.387		0.432
Black	87 (10.4%)	60 (9.9%)		67 (11.1%)	
White	702 (84.1%)	501 (82.8%)		504 (83.3%)	
Other	46 (5.5%)	44 (7.3%)		34 (5.6%)	
Sex			0.456		0.488
Female	239 (28.6%)	185 (30.6%)		173 (28.6%)	
Male	596 (71.4%)	420 (69.4%)		432 (71.4%)	
Grade			<0.001*		<0.001*
I	16 (1.9%)	10 (1.7%)		13 (2.1%)	
II	39 (4.7%)	127 (21%)		36 (6%)	
III	64 (7.7%)	223 (36.9%)		51 (8.4%)	
IV	20 (2.4%)	140 (23.1%)		18 (3%)	
Unknown	696 (83.4%)	105 (17.4%)		487 (80.5%)	
Tumor size			<0.001*		<0.001*
<4.5cm	223 (26.7%)	79 (13.1%)		124 (20.5%)	
>4.5cm	447 (53.5%)	513 (84.8%)		447 (73.9%)	
Unknown	165 (19.8%)	13 (2.1%)		34 (5.6%)	
Sarcomatoid			<0.001*		<0.001*
No	155 (18.6%)	441 (72.9%)		155 (25.6%)	
Yes	31 (3.7%)	121 (20%)		31 (5.1%)	
Unknown	649 (77.7%)	43 (7.1%)		419 (69.3%)	
Radiation			<0.001*		<0.001*
No	753 (90.2%)	228 (37.7%)		541 (89.4%)	
Yes	82 (9.8%)	377 (62.3%)		64 (10.6%)	
Chemotherapy			0.955		0.272
No	384 (46%)	280 (46.3%)		260 (43%)	
Yes	451 (54%)	325 (53.7%)		345 (57%)	

Values are expressed as n (%) unless otherwise indicated. *, Two-sided P values <0.05.

Table S4 Prognostic factors for overall survival in bladder cancer patients (N=561)

Characteristics	Univariate		Multivariate	
	HR (95% CI)	P	HR (95% CI)	P
Age				
<75y	Reference		Reference	
>75y	1.31 (1.05-1.65)	0.019*	1.25 (0.99-1.58)	0.062
Race				
Black	Reference			
White	0.77 (0.58-1.01)	0.06		
Other	0.66 (0.41-1.07)	0.092		
Sex				
Female	Reference			
Male	0.83 (0.66-1.03)	0.086		
Tumor size				
<5 cm	Reference		Reference	
>5 cm	1.51 (1.13-2)	0.005*	1.61 (1.21-2.14)	0.001*
Unknown	1.59 (1.24-2.04)	<0.001*	1.58 (1.23-2.04)	<0.001*
Grade				
I	Reference		Reference	
II	0.43 (0.15-1.24)	0.12	0.77 (0.26-2.27)	0.631
III	0.37 (0.15-0.92)	0.033*	0.77 (0.31-1.96)	0.586
IV	0.34 (0.14-0.82)	0.017*	0.79 (0.32-1.96)	0.613
Unknown	0.39 (0.16-0.96)	0.041*	0.79 (0.31-1.99)	0.61
Surgery				
No	Reference		Reference	
Yes	0.57 (0.46-0.7)	<0.001*	0.64 (0.51-0.8)	<0.001*
Radiation				
No	Reference			
Yes	0.91 (0.74-1.13)	0.39		
Chemotherapy				
No	Reference		Reference	
Yes	0.29 (0.24-0.34)	<0.001*	0.29 (0.24-0.36)	<0.001*

Values are expressed as hazard ratios (HR) with 95% confidence intervals (CI) unless otherwise indicated. *, Two-sided P values <0.05.

Table S5 Prognostic factors for overall survival in lung cancer patients (N = 15,484)

Characteristics	Univariate		Multivariate	
	HR (95%CI)	P	HR (95%CI)	P
Age				
<60y	Reference		Reference	
60-70y	1.16 (1.11-1.21)	<0.001*	1.12 (1.07-1.17)	<0.001*
>70y	1.4 (1.34-1.46)	<0.001*	1.24 (1.18-1.29)	<0.001*
Race				
Black	Reference		Reference	
White	0.93 (0.88-0.98)	0.004*	1 (0.95-1.05)	0.996
Other	0.58 (0.54-0.63)	<0.001*	0.68 (0.62-0.73)	<0.001*
Sex				
Female	Reference		Reference	
Male	1.24 (1.19-1.28)	<0.001*	1.18 (1.14-1.23)	<0.001*
Tumor size				
<6cm	Reference		Reference	
>6cm	1.31 (1.25-1.36)	<0.001*	1.28 (1.23-1.34)	<0.001*
Unknown	1.39 (1.34-1.45)	<0.001*	1.3 (1.25-1.35)	<0.001*
Grade				
I	Reference		Reference	
II	1.2 (1.03-1.4)	0.022*	1.24 (1.07-1.45)	0.006*
III	1.54 (1.33-1.79)	<0.001*	1.47 (1.27-1.71)	<0.001*
IV	1.69 (1.42-2.02)	<0.001*	1.64 (1.37-1.96)	<0.001*
Unknown	1.47 (1.27-1.7)	<0.001*	1.47 (1.27-1.7)	<0.001*
Subtype				
Adenocarcinoma	Reference		Reference	
Small cell	1.14 (1.08-1.2)	<0.001*	1.2 (1.14-1.27)	<0.001*
Squamous	1.48 (1.41-1.55)	<0.001*	1.27 (1.21-1.33)	<0.001*
Other	1.32 (1.26-1.39)	<0.001*	1.18 (1.12-1.24)	<0.001*
Surgery				
No	Reference		Reference	
Yes	0.54 (0.48-0.62)	<0.001*	0.55 (0.48-0.63)	<0.001*
Radiation				
No	Reference		Reference	
Yes	0.79 (0.75-0.84)	<0.001*	0.93 (0.88-0.99)	0.018*
Chemotherapy				
No	Reference		Reference	
Yes	0.32 (0.31-0.33)	<0.001*	0.32 (0.31-0.34)	<0.001*

Values are expressed as hazard ratios (HR) with 95% confidence intervals unless otherwise indicated. *, Two-sided P values <0.05.

Table S6 Prognostic factors for overall survival in kidney cancer patients (N=1,440)

Characteristics	Univariate		Multivariate	
	HR (95%CI)	P	HR (95%CI)	P
Age				
<65y	Reference		Reference	
>65y	1.58 (1.39-1.78)	<0.001*	1.39 (1.23-1.58)	<0.001*
Race				
Black	Reference			
White	0.85 (0.7-1.04)	0.115		
Other	0.82 (0.6-1.12)	0.208		
Sex				
Female	Reference			
Male	1.02 (0.89-1.17)	0.788		
Tumor size				
<4.5 cm	Reference		Reference	
>4.5 cm	0.87 (0.74-1.02)	0.079	1.11 (0.95-1.31)	0.188
Unknown	1.55 (1.25-1.92)	<0.001*	1.22 (0.98-1.51)	0.069
Grade				
I	Reference			
II	0.78 (0.45-1.36)	0.388		
III	1.18 (0.7-2.01)	0.529		
IV	1.66 (0.97-2.84)	0.066		
Unknown	2.08 (1.25-3.48)	0.005*		
Sarcomatoid				
No	Reference		Reference	
Yes	2.22 (1.79-2.74)	<0.001*	2.53 (2.04-3.14)	<0.001*
Unknown	2.32 (2.02-2.66)	<0.001*	1.1 (0.92-1.32)	0.284
Surgery				
No	Reference		Reference	
Yes	0.37 (0.32-0.42)	<0.001*	0.34 (0.27-0.41)	<0.001*
Radiation				
No	Reference		Reference	
Yes	0.56 (0.49-0.64)	<0.001*	1.02 (0.87-1.2)	0.811
Chemotherapy				
No	Reference		Reference	
Yes	0.81 (0.71-0.91)	0.001*	0.7 (0.61-0.79)	<0.001*

Values are expressed as hazard ratios (HR) with 95% confidence intervals unless otherwise indicated. *, Two-sided P values <0.05.