

Supplementary Method 1. ICD-10 diagnostic codes to determine the variables

Body systems	Organs	ICD-10 codes
Oral cavity, lip, pharynx		C00-14
Digestive		C15-26
	Stomach	C16
	Colorectal	C18-19
	Liver or intrahepatic	C22
Respiratory and intrathoracic		C30-39
	Lung	C34
Female genital		C51-58
	Cervical cancer	C53
	Uterus & ovary	C54-56
Male genital		C60-63
	Testis	C62
	Prostate	C61
Urinary tract		C64-68
	Kidney	C64
	Urinary tract	C65-68
Hematopoietic		C81-96
	Non-Hodgkin lymphoma	C82-86
	Hodgkin lymphoma	C81
	Multiple myeloma	C92
	Leukemia	C91-95
Other		
	Thyroid	C73
	Breast	C50

Kidney disease codes: N03, N052, N053, N054, N055, N056, N072, N073, N074, N01, N18, N19, N25.

Cancer codes: Specific insurance codes that were issued by the National Health Insurance Service of Korea (V193) were reviewed to identify the confirmed malignancies. When the ICD-10 diagnostic codes were concomitantly applied for a patient multiple times, the patient was determined to have the corresponding site-specific cancer.

Supplementary Table 1. Baseline characteristics according to chronic kidney disease stages

Characteristic	Stage 1 (n = 41,108)	Stage 2 (n = 59,403)	Stage 3 (n = 359,224)	Stage 4 or 5 without RRT (n = 12,023)	P value
Matched variable					
Age (yr)	46 (37–55)	54 (44–62)	66 (60–72)	66 (56–72)	< 0.001
< 60	34,616 (84.2)	39,769 (66.9)	79,749 (22.2)	3,811 (31.7)	< 0.001
≥ 60	6,492 (15.8)	19,634 (33.1)	279,475 (77.8)	8,212 (68.3)	< 0.001
Sex, male	12,823 (31.2)	19,050 (32.1)	204,605 (57.0)	6,659 (55.4)	< 0.001
Smoking history					
Non-smoker	19,130 (46.5)	29,852 (50.3)	256,785 (71.5)	8,520 (70.9)	< 0.001
Ex-smoker	7,562 (18.4)	13,105 (22.1)	58,351 (16.2)	1,999 (16.6)	< 0.001
Current-smoker	14,416 (35.1)	16,446 (27.7)	44,088 (12.3)	1,504 (12.5)	< 0.001
Low income status	8,065 (19.6)	12,453 (21.0)	81,301 (22.6)	2,871 (23.9)	< 0.001
Unmatched variables					
Height (cm)	167 (160–173)	165 (159–171)	158 (152–165)	158 (151–165)	< 0.001
Weight (kg)	71 (61–81)	68 (60–76)	61 (54–68)	59 (51–67)	< 0.001
Body mass index (kg/m ²)	25.6 (22.9–28.4)	25.0 (22.8–27.3)	24.2 (22.3–26.3)	23.5 (21.3–25.8)	< 0.001
Serum Cr (mg/dL)	0.8 (0.7–0.9)	1.0 (0.9–1.1)	1.2 (1.0–1.4)	2.4 (1.9–3)	< 0.001
eGFR (mL/min/1.73 m ²)	104 (95–117)	75 (68–81)	52 (46–57)	24 (19–27)	< 0.001
Hypertension	20,668 (50.3)	35,853 (60.4)	238,053 (66.3)	10,359 (86.2)	< 0.001
Diabetes mellitus	14,584 (35.5)	22,204 (37.4)	102,121 (28.4)	4,792 (39.9)	< 0.001

Data are presented as median (interquartile range) or number (%).

Cr, creatinine; eGFR, estimated glomerular filtration rate; RRT, renal replacement therapy.

Supplementary Table 2. Cancer risk in the pre-dialysis chronic kidney disease population compared to that in the matched control group

Neoplasm	Univariable		Multivariable			
	HR (95% CI)	P	Model 1		Model 2	
			Adjusted HR (95% CI) ^a	P	Adjusted HR (95% CI) ^b	P
All neoplasms	1.031 (1.012–1.050)	0.001	1.033 (1.014–1.052)	< 0.001	1.009 (0.989–1.028)	0.3838
Oral cavity, lip, pharynx	0.980 (0.816–1.177)	0.829	0.983 (0.819–1.180)	0.852	0.964 (0.797–1.165)	0.704
Digestive	0.936 (0.911–0.961)	< 0.001	0.938 (0.912–0.963)	< 0.001	0.891 (0.866–0.917)	< 0.001
Stomach	0.856 (0.820–0.894)	< 0.001	0.858 (0.821–0.896)	< 0.001	0.834 (0.798–0.873)	< 0.001
Colorectal	0.988 (0.938–1.040)	0.641	0.989 (0.940–1.042)	0.686	0.931 (0.883–0.982)	0.009
Liver or intrahepatic	1.013 (0.941–1.091)	0.726	1.017 (0.944–1.095)	0.663	0.898 (0.831–0.971)	0.007
Respiratory and intrathoracic	1.014 (0.959–1.071)	0.634	1.016 (0.962–1.074)	0.566	0.969 (0.915–1.027)	0.289
Lung	1.021 (0.963–1.082)	0.491	1.023 (0.966–1.084)	0.437	0.972 (0.915–1.032)	0.351
Female genital	1.007 (0.905–1.121)	0.896	1.005 (0.902–1.118)	0.932	1.007 (0.902–1.125)	0.900
Cervical cancer	1.136 (0.965–1.336)	0.125	1.134 (0.964–1.334)	0.130	1.150 (0.974–1.359)	0.100
Uterus & ovary	0.919 (0.794–1.063)	0.256	0.916 (0.792–1.060)	0.239	0.910 (0.783–1.057)	0.218
Male genital	1.035 (0.976–1.097)	0.257	1.041 (0.982–1.104)	0.178	1.055 (0.993–1.121)	0.086
Testis	1.610 (0.731–3.548)	0.238	1.616 (0.733–3.561)	0.234	2.317 (1.028–5.227)	0.043
Prostate	1.039 (0.980–1.103)	0.198	1.046 (0.986–1.110)	0.134	1.058 (0.995–1.125)	0.072
Urinary system	2.037 (1.891–2.194)	< 0.001	2.042 (1.896–2.200)	< 0.001	1.969 (1.823–2.126)	< 0.001
Kidney	2.525 (2.217–2.876)	< 0.001	2.529 (2.221–2.881)	< 0.001	2.411 (2.108–2.757)	< 0.001
Other urinary tract	1.818 (1.661–1.990)	< 0.001	1.823 (1.665–1.996)	< 0.001	1.750 (1.593–1.922)	< 0.001
Hematopoietic	1.463 (1.331–1.608)	< 0.001	1.466 (1.333–1.611)	< 0.001	1.525 (1.383–1.681)	< 0.001
Non-Hodgkin lymphoma	1.075 (0.931–1.241)	0.324	1.077 (0.933–1.243)	0.311	1.110 (0.957–1.287)	0.169
Hodgkin lymphoma	2.128 (0.963–4.704)	0.062	2.135 (0.966–4.718)	0.061	1.961 (0.867–4.438)	0.106
Multiple myeloma	1.468 (1.149–1.875)	0.002	1.471 (1.151–1.879)	0.002	1.497 (1.162–1.928)	0.002
Leukemia	1.402 (1.159–1.695)	0.001	1.405 (1.162–1.700)	< 0.001	1.434 (1.179–1.746)	< 0.001
Thyroid	0.904 (0.850–0.962)	0.001	0.903 (0.849–0.960)	0.001	0.877 (0.823–0.934)	< 0.001
Breast	1.051 (0.966–1.143)	0.246	1.048 (0.964–1.140)	0.272	1.056 (0.968–1.151)	0.218

HR, hazard ratio; 95% CI, 95% confidence interval.

^aHRs and 95% CIs were obtained using a multivariable model that was adjusted for the matched variables (age, sex, low-income status and history of smoking).

^bHRs and 95% CIs were obtained using the fully-adjusted model that included the matched variables (age, sex, low-income status, and smoking history) and unmatched characteristics (history of hypertension, diabetes mellitus and body mass index).

Supplementary Table 3. Cancer incidences according to chronic kidney disease stage

Neoplasm	Stage 1 (n = 41,108)		Stage 2 (n = 59,403)		Stage 3 (n = 359,224)		Stage 4/5 without RRT (n = 12,023)	
	Event (n)	Incidence rate (/100,000 PY)	Event (n)	Incidence rate (/100,000 PY)	Event (n)	Incidence rate (/100,000 PY)	Event (n)	Incidence rate (/100,000 PY)
All neoplasms	1,120	641.64	2,248	898.48	19,099	1,079.86	504	851.66
Oral cavity, lip, pharynx	10	5.73	25	9.99	189	10.69	3	5.07
Digestive	497	284.73	1,049	419.26	8,256	466.80	226	381.90
Stomach	170	97.39	375	149.88	3,139	177.48	83	140.25
Colorectal	117	67.03	291	116.31	2,388	135.02	68	114.91
Liver or intrahepatic	87	49.84	198	79.14	1,082	61.18	30	50.69
Respiratory and intrathoracic	85	48.70	228	91.13	2,144	121.22	54	91.25
Lung	77	44.11	212	84.73	1,958	110.71	48	81.11
Female genital	30	17.19	48	19.19	574	32.45	16	27.04
Cervical cancer	15	8.59	20	7.99	268	15.15	7	11.83
Uterus & ovary	15	8.59	26	10.39	297	16.79	7	11.83
Male genital	58	33.23	176	70.34	1,983	112.12	43	72.66
Testis	1	0.57	2	0.80	12	0.68	1	1.69
Prostate	57	32.66	175	69.94	1,968	111.27	42	70.97
Urinary tract	84	48.12	198	79.14	1,781	100.70	45	76.04
Kidney	40	22.92	64	25.58	674	38.11	19	32.11
Other urinary tract	44	25.21	134	53.56	1,112	62.87	27	45.63
Hematopoietic	76	43.54	135	53.96	808	45.69	32	54.07
Non-Hodgkin lymphoma	22	12.60	41	16.39	318	17.98	5	8.45
Hodgkin lymphoma	2	1.15	1	0.40	16	0.90	0	0
Multiple myeloma	15	8.59	14	5.60	124	7.01	4	6.76
Leukemia	18	10.31	26	10.39	206	11.65	4	6.76
Thyroid	182	104.27	233	93.13	1,488	84.13	32	54.07
Breast	51	29.22	81	32.37	957	54.11	27	45.63

PY, person-year; RRT, renal replacement therapy.

Supplementary Table 4. Cancer risk according to chronic kidney disease stages compared to the matched control group

Neoplasm	Stage 1		Stage 2		Stage 3		Stage 4 or 5 without RRT	
	Adjusted HR (95% CI)	P	Adjusted HR (95% CI)	P	Adjusted HR (95% CI)	P	Adjusted HR (95% CI)	P
All neoplasms	0.997 (0.937–1.061)	0.930	1.081 (1.034–1.130)	< 0.001	1.008 (0.988–1.029)	0.418	0.788 (0.721–0.862)	< 0.001
Oral cavity, lip, pharynx	0.781 (0.407–1.501)	0.459	1.060 (0.692–1.623)	0.790	0.980 (0.804–1.195)	0.844	0.449 (0.143–1.407)	0.169
Digestive	0.908 (0.828–0.995)	0.040	0.997 (0.934–1.064)	0.931	0.885 (0.859–0.911)	< 0.001	0.708 (0.620–0.808)	< 0.001
Stomach	0.747 (0.639–0.874)	< 0.001	0.859 (0.771–0.957)	0.006	0.842 (0.803–0.883)	< 0.001	0.657 (0.528–0.817)	< 0.001
Colorectal	0.794 (0.657–0.959)	0.017	1.035 (0.915–1.172)	0.584	0.933 (0.882–0.986)	0.014	0.782 (0.614–0.995)	0.046
Liver or intrahepatic	1.041 (0.832–1.304)	0.724	1.257 (1.077–1.468)	0.004	0.856 (0.788–0.929)	< 0.001	0.659 (0.458–0.948)	0.025
Respiratory and intrathoracic	0.705 (0.566–0.878)	0.002	0.961 (0.837–1.105)	0.579	0.993 (0.935–1.054)	0.817	0.710 (0.541–0.931)	0.013
Lung	0.715 (0.567–0.900)	0.004	0.996 (0.862–1.150)	0.955	0.992 (0.932–1.056)	0.803	0.690 (0.517–0.919)	0.011
Female genital	1.020 (0.697–1.492)	0.921	1.038 (0.768–1.402)	0.808	1.008 (0.899–1.130)	0.895	0.886 (0.538–1.459)	0.634
Cervical cancer	1.387 (0.806–2.386)	0.238	1.126 (0.707–1.793)	0.001	1.147 (0.965–1.363)	0.120	0.951 (0.447–2.023)	0.895
Uterus & ovary	0.770 (0.451–1.317)	0.340	0.904 (0.601–1.361)	0.790	0.925 (0.791–1.082)	0.330	0.679 (0.320–1.440)	0.313
Male genital	0.705 (0.54–0.921)	0.010	0.880 (0.752–1.030)	0.110	1.098 (1.031–1.169)	0.003	0.699 (0.516–0.947)	0.021
Testis	1.336 (0.153–11.67)	0.794	2.084 (0.432–10.046)	0.360	2.376 (1.000–5.647)	0.050	8.560 (1.037–70.687)	0.046
Prostate	0.708 (0.541–0.926)	0.012	0.887 (0.758–1.039)	0.138	1.101 (1.034–1.172)	0.003	0.689 (0.507–0.936)	0.017
Urinary tract	1.366 (1.087–1.718)	0.008	1.766 (1.510–2.065)	< 0.001	2.046 (1.891–2.214)	< 0.001	1.538 (1.139–2.078)	0.005
Kidney	1.446 (1.021–2.049)	0.038	1.569 (1.188–2.072)	0.002	2.626 (2.289–3.013)	< 0.001	2.195 (1.376–3.501)	0.001
Other urinary tract	1.115 (0.817–1.520)	0.492	1.753 (1.450–2.119)	< 0.001	1.802 (1.637–1.985)	< 0.001	1.287 (0.874–1.894)	0.201
Hematopoietic	2.482 (1.933–3.186)	< 0.001	2.358 (1.947–2.856)	< 0.001	1.393 (1.257–1.544)	< 0.001	1.716 (1.201–2.454)	0.003
Non-Hodgkin lymphoma	1.293 (0.825–2.026)	0.262	1.337 (0.957–1.867)	0.088	1.093 (0.936–1.277)	0.262	0.535 (0.221–1.299)	0.167
Hodgkin lymphoma	4.477 (0.853–23.491)	0.076	1.136 (0.138–9.361)	0.906	1.974 (0.854–4.564)	0.112	NA	NA
Multiple myeloma	2.824 (1.569–5.084)	0.001	1.508 (0.848–2.682)	0.162	1.420 (1.089–1.851)	0.010	1.456 (0.532–3.980)	0.464
Leukemia	2.211 (1.324–3.692)	0.002	1.726 (1.128–2.641)	0.012	1.382 (1.126–1.696)	0.002	0.835 (0.309–2.259)	0.723
Thyroid	0.846 (0.720–0.993)	0.041	0.888 (0.772–1.022)	0.097	0.889 (0.830–0.952)	< 0.001	0.547 (0.385–0.777)	< 0.001
Breast	0.757 (0.565–1.014)	0.062	0.881 (0.699–1.111)	0.285	1.099 (1.004–1.202)	0.040	0.962 (0.655–1.414)	0.844

Hazard ratios (HR) and 95% confidence intervals (95% CI) were obtained from the fully-adjusted model that included the matched variables (age, sex, low-income status, and smoking history) and unmatched characteristics (history of hypertension, diabetes mellitus and body mass index). Reference group was the matched control group. NA, not analyzable due to limited number of events; RRT, renal replacement therapy.

Supplementary Table 5. The 3-year mortality risk after cancer diagnosis for each chronic kidney disease stage

Neoplasm	Stage 1		Stage 2		Stage 3		Stage 4 or 5 without RRT	
	Adjusted HR (95% CI)	P	Adjusted HR (95% CI)	P	Adjusted HR (95% CI)	P	Adjusted HR (95% CI)	P
All neoplasms	1.454 (1.210–1.748)	< 0.001	1.249 (1.112–1.403)	< 0.001	1.059 (1.008–1.113)	0.023	1.317 (1.087–1.595)	0.005
Oral cavity-lip-pharynx	1.693 (0.369–7.759)	0.498	2.205 (0.742–6.557)	0.155	1.512 (0.961–2.380)	0.074	3.564 (0.474–26.792)	0.217
Digestive	1.465 (1.140–1.883)	0.003	1.224 (1.042–1.438)	0.014	1.102 (1.028–1.181)	0.006	1.379 (1.048–1.815)	0.022
Stomach	1.323 (0.675–2.591)	0.415	1.175 (0.815–1.695)	0.388	1.196 (1.037–1.380)	0.014	1.549 (0.870–2.758)	0.137
Colorectal	1.533 (0.779–3.016)	0.216	0.842 (0.535–1.325)	0.457	1.103 (0.933–1.303)	0.251	2.245 (1.350–3.735)	0.002
Liver or intrahepatic	0.884 (0.538–1.453)	0.627	1.254 (0.960–1.639)	0.097	1.053 (0.918–1.209)	0.460	1.473 (0.862–2.517)	0.157
Respiratory and intrathoracic	1.344 (0.895–2.019)	0.154	1.133 (0.902–1.424)	0.283	1.011 (0.918–1.114)	0.826	1.176 (0.787–1.757)	0.428
Lung	1.226 (0.810–1.856)	0.336	1.058 (0.838–1.337)	0.634	1.018 (0.922–1.123)	0.726	1.150 (0.757–1.748)	0.512
Female genital	5.997 (2.075–17.338)	< 0.001	2.589 (1.021–6.562)	0.045	1.390 (0.977–1.979)	0.067	0.792 (0.109–5.734)	0.817
Cervical cancer	22.589 (3.976–128.338)	< 0.001	2.016 (0.263–15.436)	0.500	1.078 (0.577–2.013)	0.814	NA	NA
Uterus & ovary	3.604 (0.836–15.540)	0.086	3.649 (1.245–10.693)	0.018	1.688 (1.073–2.657)	0.024	NA	NA
Male genital	1.753 (0.643–4.778)	0.273	0.382 (0.121–1.208)	0.101	1.329 (1.066–1.659)	0.012	2.207 (1.148–4.243)	0.018
Testis	NA	NA	NA	NA	NA	NA	NA	NA
Prostate	1.788 (0.656–4.875)	0.256	0.390 (0.123–1.231)	0.108	1.344 (1.076–1.679)	0.009	2.227 (1.158–4.282)	0.016
Urinary system	1.654 (0.759–3.603)	0.206	1.295 (0.800–2.096)	0.292	0.995 (0.786–1.261)	0.969	1.895 (1.051–3.419)	0.034
Kidney	2.086 (0.718–6.057)	0.176	0.912 (0.316–2.632)	0.864	0.648 (0.426–0.985)	0.042	2.483 (1.096–5.625)	0.029
Other urinary tract	1.181 (0.367–3.797)	0.781	1.490 (0.863–2.573)	0.153	1.195 (0.897–1.591)	0.223	1.379 (0.590–3.221)	0.458
Hematopoietic	0.926 (0.510–1.680)	0.800	0.881 (0.585–1.327)	0.544	0.871 (0.713–1.065)	0.178	1.072 (0.593–1.936)	0.818
Non-Hodgkin lymphoma	0.909 (0.210–3.940)	0.898	1.062 (0.506–2.230)	0.874	1.022 (0.741–1.411)	0.893	1.013 (0.244–4.199)	0.986
Hodgkin lymphoma	0.910 (0.021–38.601)	0.961	NA	NA	0.278 (0.028–2.791)	0.277	NA	NA
Multiple myeloma	1.322 (0.479–3.652)	0.590	0.477 (0.114–1.993)	0.310	0.617 (0.411–0.927)	0.020	0.952 (0.227–4.001)	0.947
Leukemia	1.043 (0.398–2.739)	0.931	1.148 (0.542–2.433)	0.719	0.684 (0.496–0.943)	0.021	1.050 (0.254–4.340)	0.946
Thyroid	2.535 (0.323–19.904)	0.377	1.492 (0.341–6.526)	0.595	1.174 (0.677–2.036)	0.569	2.366 (0.316–17.707)	0.402
Breast	3.402 (0.437–26.463)	0.242	4.021 (1.165–13.877)	0.028	1.350 (0.771–2.363)	0.294	2.411 (0.540–10.774)	0.249

Hazard ratios (HR) and 95% confidence intervals (95% CI) are from the fully-adjusted model including the matched variables (age, sex, low-income status, and smoking history) and unmatched characteristics (history of hypertension, diabetes mellitus and body mass index). Reference group was the matched control group. NA, not analyzable due to limited number of events; RRT, renal replacement therapy.