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Table S1: Study population selection

	People receiving a first transplant, N	Deaths, N	Deaths linked to NDI data, N
SRTR data used for selection of deaths for linkage to NDI, transplants during 1987-2019	711 276	291 385	138 664
Transplants and deaths included in October 2020 SRTR Standard Analytic File, with first transplant during 1987-2019	711 276	289 114	138 664
Exclusion of duplicate records	711 262	289 106	138 662
Exclusion of records with missing or conflicting data on gender or age	711 202	289 093	138 658
Exclusion of recipients who died on the day of transplantation	708 869	286 873	137 398
Exclusion of residents outside the continental United States, Hawaii, or Puerto Rico	706 039	286 264	137 241
Exclusion of first transplants and deaths from 2019	671 127	272 473	126 474
Final selection, by year of transplant			
1987-1994	103 417	77 556	15 002
1995-2004	201 625	115 733	44 966
2005-2009	122 583	45 514	33 378
2010-2018	243 502	33 670	33 128

Abbreviations: NDI National Death Index, SRTR Scientific Registry of Transplant Recipients

Table S2: Deaths in solid organ transplant recipients in the United States, according to age and calendar year of transplantation

Age group (years) and calendar year of transplantation		SOTR population N	Column %	Total deaths, N	Deaths matched to NDI N	Row %
All ages						
	1987-1994	103 417	15.4	77 556	15 002	19.3
	1995-2004	201 625	30.0	115 733	44 966	38.9
	2005-2009	122 583	18.3	45 514	33 378	73.3
	2010-2018	243 502	36.3	33 670	33 128	98.4
Birth-17						
	1987-1994	8715	1.3	4019	769	19.1
	1995-2004	14 213	2.1	4394	1643	37.4
	2005-2009	8128	1.2	1443	1045	72.4
	2010-2018	14 315	2.1	1104	1070	96.9
18-34						
	1987-1994	24 254	3.6	13 986	2,670	19.1
	1995-2004	30,540	4.6	10 688	4,162	38.9
	2005-2009	13 880	2.1	2728	1965	72.0
	2010-2018	24 641	3.7	1858	1821	98.0
35-49						
	1987-1994	36 644	5.5	28 513	5549	19.5
	1995-2004	65 019	9.7	33 559	12 937	38.6
	2005-2009	30 865	4.6	7890	5841	74.0
	2010-2018	53 032	7.9	4410	4333	98.3
50-64						
	1987-1994	30 136	4.5	27 520	5349	19.4
	1995-2004	75 514	11.3	53 098	20 772	39.1
	2005-2009	53 281	7.9	23 285	17 070	73.3
	2010-2018	105 519	15.7	16 139	15 904	98.5
65-96						
	1987-1994	3668	0.5	3518	665	18.9
	1995-2004	16 339	2.4	13 994	5452	39.0
	2005-2009	16 429	2.4	10 168	7457	73.3
	2010-2018	45 995	6.9	10 159	10 000	98.4

Abbreviations: NDI National Death Index, SOTR solid organ transplant recipient

Table S3: Mortality rates and multivariable mortality rate ratios for lung cancer among solid organ transplant recipients, 1987-2018 (expanded grouping of transplanted organs)

	Deaths^a	MR^b	MRR (95%CI)^c
Total	3796	131.5	
Gender			
Female	1139	98.3	Reference
Male	2657	153.0	1.37 (1.27-1.49)
Race/ethnicity			
Non-Hispanic White	3039	163.9	Reference
Non-Hispanic Black	501	95.7	0.82 (0.73-0.92)
Hispanic	157	42.3	0.37 (0.30-0.44)
Non-Hispanic API	73	52.2	0.39 (0.30-0.51)
Other	26	101.6	0.79 (0.50-1.25)
Age at transplantation, years			
0-17	2	0.7	0.01 (0.00-0.04)
18-34	26	7.6	0.09 (0.06-0.14)
35-49	573	82.4	Reference
50-64	2277	242.3	2.96 (2.66-3.28)
65+	918	325.3	4.86 (4.31-5.47)
Calendar year of transplantation			
1987-1994	367	127.9	Reference
1995-2004	1352	140.4	0.80 (0.72-0.90)
2005-2009	1167	143.3	0.69 (0.61-0.78)
2010-2018	910	99.7	0.53 (0.46-0.60)
Transplanted organ			
Kidney only	1793	99.3	0.58 (0.52-0.65)
Liver only	803	137.7	0.64 (0.56-0.72)
Heart only	570	273.3	Reference
Lung only	511	465.1	2.18 (1.90-2.50)
Other/multiple	119	66.9	0.52 (0.41-0.65)
Years since transplantation			
0 to 0.99	176	44.5	Reference
1 to 1.99	319	90.4	2.08 (1.68-2.58)
2 to 4.99	1090	131.2	3.12 (2.59-3.75)
5 to 9.99	1432	173.5	4.43 (3.68-5.33)
10+	779	136.3	4.57 (3.76-5.55)

Abbreviations: API Asian/Pacific Islander, CI confidence interval, MR mortality rate, MRR mortality rate ratio

^a Deaths are the number of deaths that were linked to National Death Index.

^b Mortality rates are deaths per 100 000 person-years.

^c Multivariable mortality rate ratios are mutually adjusted for the variables shown in the table.

Table S4: Mortality rates and multivariable mortality rate ratios for liver cancer among liver recipients, 1987-2018

	Deaths^a	MR^b	MRR (95%CI)^c
Total	2811	377.8	--
Gender			
Female	600	214.9	Reference
Male	2211	483.7	1.96 (1.77-2.18)
Race/ethnicity			
Non-Hispanic White	1997	372.1	Reference
Non-Hispanic Black	244	374.3	1.21 (1.04-1.42)
Hispanic	355	340.8	0.98 (0.86-1.11)
Non-Hispanic API	192	604.0	1.55 (1.31-1.83)
Other	23	335.3	1.02 (0.65-1.60)
Age at transplantation, years			
0-17	96	104.0	0.55 (0.42-0.71)
18-34	70	159.0	0.77 (0.57-1.05)
35-49	369	226.5	Reference
50-64	1747	517.8	1.83 (1.61-2.08)
65+	529	870.6	2.80 (2.41-3.26)
Calendar year of transplantation			
1987-1994	81	188.6	Reference
1995-2004	491	260.2	0.98 (0.77-1.24)
2005-2009	937	557.1	1.40 (1.11-1.77)
2010-2018	1302	672.3	1.10 (0.87-1.38)
Years since transplantation			
0 to 0.99	788	927.7	Reference
1 to 1.99	632	794.8	0.87 (0.77-0.98)
2 to 4.99	894	481.2	0.54 (0.48-0.60)
5 to 9.99	399	218.2	0.26 (0.22-0.30)
10+	98	77.0	0.12 (0.09-0.15)

Abbreviations: API Asian/Pacific Islander, CI confidence interval, MR mortality rate, MRR mortality rate ratio

^a Deaths are the number of deaths that were linked to National Death Index.

^b Mortality rates are deaths per 100 000 person-years.

^c Multivariable mortality rate ratios are mutually adjusted for the variables shown in the table.

Table S5: Standardized mortality ratios stratified by transplanted organ (any liver and any lung)¹ for cancer deaths among solid organ transplant recipients, 1992-2018 (N=608 306)

Cancer site ^a	Any Liver Recipient ¹			Any Lung Recipient ¹		
	Deaths ^b	MR ^c	SMR (95%CI)	Deaths ^b	MR ^c	SMR (95%CI)
Overall cancer	6145	961.2	3.45 (3.35-3.54)	1,479	1,314.3	4.56 (4.31-4.82)
Head and neck	114	19.9	3.28 (2.68-4.02)	30	23.9	4.07 (2.77-5.98)
Esophagus	102	21.1	2.03 (1.62-2.54)	29	31.6	3.11 (2.07-4.67)
Stomach	46	8.2	1.22 (0.88-1.69)	15	11.0	1.96 (1.15-3.32)
Colorectum	188	37.8	1.52 (1.30-1.79)	80	75.3	3.19 (2.49-4.10)
Liver/IHBD	2809	388.2	26.0 (25.0-27.1)	35	26.7	2.10 (1.47-3.00)
Pancreas	232	41.0	1.84 (1.59-2.13)	48	39.6	1.82 (1.30-2.53)
Lung	821	149.4	1.94 (1.80-2.10)	514	470.3	5.92 (5.37-6.52)
Soft tissue/Heart	57	10.3	4.56 (3.38-6.16)	16	12.7	5.36 (3.20-8.98)
Melanoma	58	10.3	2.02 (1.52-2.70)	25	23.8	4.44 (2.83-6.97)
Nonmelanoma skin cancer	95	17.9	13.2 (10.6-16.5)	132	109.6	84.0 (70.2-100.6)
Breast (Female only)	65	38.1	0.92 (0.69-1.21)	19	36.7	0.93 (0.58-1.52)
Ovary (Female only)	21	11.0	0.70 (0.43-1.12)	9	12.9	0.86 (0.45-1.67)
Prostate (Male only)	62	18.5	0.78 (0.59-1.04)	6	9.5	0.36 (0.15-0.84)
Bladder	42	7.6	1.05 (0.75-1.46)	37	35.3	4.97 (3.47-7.12)
Kidney	50	10.7	1.43 (1.03-1.99)	7	5.5	0.74 (0.34-1.63)
Brain	48	9.2	1.00 (0.72-1.37)	11	9.5	0.97 (0.51-1.85)
NHL/CLL	340	61.9	5.36 (4.75-6.05)	114	112.8	9.93 (8.05-12.24)
Myeloma	32	6.4	1.00 (0.69-1.44)	3	1.9	0.30 (0.10-0.92)
Leukemia	139	23.1	2.81 (2.32-3.39)	75	67.3	8.03 (6.17-10.7)
Other/Miscellaneous Malignancies	820	132.5	3.89 (3.60-4.20)	273	253.9	7.16 (6.28-8.16)

Abbreviations: CI confidence interval, MR mortality rate, SMR standardized mortality ratio

¹ These columns include results for all recipients of the indicated organ, either as a single organ transplant or part of a multiorgan transplant

^a Deaths from liver cancer include those due to intrahepatic cholangiocarcinoma. Deaths from non-Hodgkin lymphoma include those due to chronic lymphocytic leukemia.

^b Deaths are the number of deaths that were linked to National Death Index.

^c Mortality rates are deaths per 100 000 person-years.

Table S6: Standardized mortality ratios stratified by transplanted organ (any heart and any kidney)¹ for cancer deaths among solid organ transplant recipients, 1992-2018 (N=608 306)

Cancer site ^a	Any Heart Recipient ¹			Any Kidney Recipient ¹		
	Deaths ^b	MR ^c	SMR (95%CI)	Deaths ^b	MR ^c	SMR (95%CI)
Overall cancer	1,671	791.6	2.31 (2.20-2.43)	7876	445.0	1.81 (1.77-1.86)
Head and neck	25	11.4	1.51 (0.96-2.36)	167	9.5	1.91 (1.60-2.27)
Esophagus	47	29.2	2.01 (1.45-2.78)	179	10.5	1.36 (1.15-1.61)
Stomach	30	15.3	1.85 (1.24-2.77)	183	10.3	1.62 (1.37-1.91)
Colorectum	78	41.0	1.33 (1.04-1.70)	451	27.8	1.25 (1.13-1.39)
Liver/IHBD	32	16.3	1.04 (0.70-1.55)	332	16.8	1.32 (1.17-1.49)
Pancreas	66	30.4	1.15 (0.88-1.51)	466	24.1	1.35 (1.22-1.49)
Lung	519	267.9	2.58 (2.34-2.83)	1786	101.5	1.56 (1.49-1.65)
Soft tissue/Heart	23	10.8	4.23 (2.60-6.89)	91	5.7	2.78 (2.19-3.53)
Melanoma	74	35.4	5.44 (4.21-7.02)	200	11.3	3.20 (2.74-3.74)
Non-melanoma skin cancer	90	48.6	26.2 (20.8-32.9)	358	23.3	22.7 (20.2-25.6)
Breast (Female only)	35	62.6	1.57 (1.08-2.28)	208	33.0	0.92 (0.79-1.06)
Ovary (Female only)	8	17.6	1.28 (0.60-2.74)	85	12.7	1.03 (0.81-1.32)
Prostate (Male only)	30	20.7	0.59 (0.39-0.91)	128	13.0	0.52 (0.43-0.63)
Bladder	53	27.7	2.57 (1.91-3.45)	221	13.1	2.29 (1.97-2.66)
Kidney	37	19.0	1.99 (1.39-2.84)	498	27.8	4.58 (4.15-5.06)
Brain	18	6.8	0.65 (0.40-1.07)	125	6.9	0.99 (0.81-1.20)
NHL/CLL	173	85.7	5.63 (4.75-6.68)	764	45.3	4.72 (4.35-5.12)
Myeloma	20	11.2	1.27 (0.78-2.07)	164	9.6	1.62 (1.36-1.92)
Leukemia	75	36.4	3.44 (2.64-4.48)	214	11.4	1.63 (1.40-1.90)
Other/Miscellaneous Malignancies	237	105.3	2.71 (2.35-3.13)	1249	71.6	2.34 (2.20-2.49)

Abbreviations: CI confidence interval, MR mortality rate, SMR standardized mortality ratio

¹ These columns include results for all recipients of the indicated organ, either as a single organ transplant or part of a multiorgan transplant

^a Deaths from liver cancer include those due to intrahepatic cholangiocarcinoma. Deaths from non-Hodgkin lymphoma include those due to chronic lymphocytic leukemia.

^b Deaths are the number of deaths that were linked to National Death Index.

^c Mortality rates are deaths per 100 000 person-years.

Table S7: Standardized mortality ratios stratified by recipient gender for cancer deaths among solid organ transplant recipients, 1992-2018 (N=608 306)

Cancer site ^a	Males			Females		
	Deaths ^b	MR ^c	SMR (95%CI)	Deaths ^b	MR ^c	SMR (95%CI)
Overall cancer	11 989	702.0	2.38 (2.33-2.43)	4941	466.2	2.22 (2.15-2.29)
All cancer (excluding liver cancer among Liver SOTRs)	9766	598.8	2.06 (2.02-2.10)	4355	422.8	2.02 (1.96-2.09)
Head and neck	269	16.2	2.19 (1.91-2.51)	55	5.2	2.27 (1.69-3.03)
Esophagus	294	20.2	1.59 (1.40-1.82)	60	6.2	2.38 (1.78-3.18)
Stomach	195	12.2	1.49 (1.26-1.74)	80	7.7	1.93 (1.50-2.49)
Colorectum	462	31.0	1.14 (1.03-1.26)	327	34.8	2.00 (1.76-2.26)
Liver/IHBD	2471	117.9	6.56 (6.28-6.85)	673	52.5	8.67 (7.95-9.44)
Among any Liver Recipients ^d	2223	494.3	24.9 (23.9-26.1)	586	215.6	31.2 (28.4-34.1)
Among any non-Liver Recipient	248	17.9	1.02 (0.89-1.18)	87	10.9	1.87 (1.47-2.38)
Pancreas	569	32.7	1.47 (1.34-1.61)	230	21.6	1.41 (1.22-1.64)
Lung	2,509	158.7	1.93 (1.84-2.01)	1087	106.7	2.01 (1.88-2.14)
Among any Lung Recipient ^d	350	583.6	6.00 (5.34-6.75)	164	339.2	5.76 (4.86-6.82)
Among any non-Liver Recipient	2159	145.3	1.77 (1.69-1.86)	923	96.5	1.82 (1.70-1.96)
Soft tissue/Heart	123	8.1	3.51 (2.85-4.32)	58	5.8	3.08 (2.29-4.15)
Among any Heart Recipient ^d	17	10.4	3.69 (2.07-6.56)	6	12.0	6.67 (2.67-16.7)
Among any non-Heart Recipient	106	7.8	3.49 (2.79-4.35)	52	5.4	2.85 (2.08-3.91)
Melanoma	273	17.4	3.18 (2.78-3.64)	79	7.6	3.62 (2.83-4.64)
Non-melanoma skin cancer	571	36.6	22.7 (20.7-24.9)	97	11.6	28.5 (22.7-35.9)
Breast (Female only)	--	--	--	323	35.6	0.95 (0.84-1.08)
Ovary (Female only)	--	--	--	122	12.6	0.96 (0.79-1.18)
Prostate (Male only)	224	14.9	0.58 (0.50-0.67)	--	--	--
Bladder	259	16.7	1.87 (1.63-2.15)	89	9.5	3.63 (2.87-4.59)
Kidney	457	28.9	3.27 (2.95-3.64)	132	12.9	3.92 (3.24-4.75)
Among any Kidney Recipient ^d	385	36.0	4.47 (3.99-5.00)	113	15.6	4.99 (4.06-6.14)
Among any non-Kidney Recipient	72	15.6	1.51 (1.16-1.98)	19	6.7	1.83 (1.11-3.01)
Brain	141	8.5	0.91 (0.75-1.10)	60	5.9	1.08 (0.81-1.44)
NHL/CLL	947	61.0	4.69 (4.36-5.05)	429	44.3	6.65 (5.97-7.41)
Myeloma	146	9.5	1.31 (1.09-1.57)	70	7.5	1.61 (1.24-2.10)

Leukemia	356	21.3	2.34 (2.07-2.64)	142	12.9	2.46 (2.04-2.96)
Other/Miscellaneous Malignancies	1710	102.6	3.24 (3.07-3.42)	828	78.1	2.37 (2.20-2.56)

Abbreviations: CI confidence interval, MR mortality rate, SMR standardized mortality ratio

^a Deaths from liver cancer include those due to intrahepatic cholangiocarcinoma. Deaths from non-Hodgkin lymphoma include those due to chronic lymphocytic leukemia.

^b Deaths are the number of deaths that were linked to National Death Index.

^c Mortality rates are deaths per 100 000 person-years.

^d These rows include results for all recipients of the indicated organ, either as a single organ transplant or part of a multiorgan transplant

Table S8: Histologic subtypes of skin cancers corresponding to validated non-melanoma skin cancer deaths among solid organ transplant recipients

ICD-O3 code and histologic subtype	N^a	%
8247 Merkel cell carcinoma	68	82.9
8830 Fibrous histiocyoma, malignant	4	4.9
8560 Adenosquamous carcinoma	2	2.4
8400 Sweat gland adenocarcinoma	1	1.2
8409 Eccrine poroma, malignant	1	1.2
8410 Sebaceous adenocarcinoma	1	1.2
8413 Eccrine adenocarcinoma	1	1.2
8430 Mucoepidermoid carcinoma	1	1.2
8801 Spindle cell sarcoma	1	1.2
8980 Carcinosarcoma, not otherwise specified	1	1.2
8982 Malignant myoepithelioma	1	1.2

Abbreviations: ICD-O3 International Classification of Diseases for Oncology (third edition)

^a There were 81 deaths from non-melanoma skin cancer that were validated with linked cancer registry data. Eighty-two diagnoses are shown in the table, because one death was linked to two cancer registry diagnoses.

Table S9: Comparison of cancer mortality rates in solid organ transplant recipients, based on National Death Index data (present study) and cancer-attributable mortality estimates (Noone et al)¹

	Cancer-attributable mortality rate^a	Mortality Rate^b	Mortality rate, excluding liver cancer in liver recipients^c
Overall	516	603.1	531.7
Cancer site			
Esophagus	9	13.5	--
Stomach	14	10.4	--
Colorectum	29	33.4	--
Liver	10	85.0	13.7
Pancreas	19	26.9	--
Lung	121	131.5	--
Melanoma	11	13.6	--
Breast ^d	10	14.0	--
Prostate ^d	-1	8.4	--
Bladder	12	12.4	--
Kidney	18	23.2	--
Non-Hodgkin lymphoma	75	56.5	--
Myeloma	8	8.4	--
Gender			
Female	404	458.3	417.5
Male	590	696.3	605.2
Race/ethnicity			
Non-Hispanic White	600	712.2	631.7
Non-Hispanic Black	423	423.5	390.8
Hispanic	303	351.9	284.1
Asian/Pacific Islander	350	441.2	332.4
Other	506	502.2	443.9
Age at transplantation, years			
0-17	107	103.9	73.0
18-34	151	163.1	151.7
35-49	329	422.8	384.3
50-64	818	978.6	850.6
65+	1229	1437.9	1273.5
Transplanted organ			
Kidney only	410	449.3	449.3
Liver only	531	949.8	572.0
Heart only	891	856.9	856.9
Lung only	1241	1329.6	1329.6
Other/multiple	342	373.9	373.9

^a Cancer-attributable mortality rates are deaths per 100 000 person-years, calculated using population-attributable fractions from Noone et al., Cancer-attributable mortality among solid organ transplant recipients in the United States: 1987 through 2014. *Cancer*. 2019;125(15):2647-55. The cohort in Noone et al. excluded recipients who had a pretransplant cancer diagnosis.¹

^b Mortality rates are deaths per 100 000 person-years calculated using data from the National Death Index (present study). The cohort included recipients who had a pretransplant cancer diagnosis.

^c Mortality rates are deaths per 100 000 person-years calculated using data from the National Death Index in this study. The results in this column exclude deaths due to liver cancer among liver recipients (N=2811 deaths).

^d Mortality rates for breast and prostate cancers were calculated using cases and follow-up time among all transplant recipients (not restricted to females and males, respectively), to mirror the methodology in Noone et al.¹

References

1. Noone A-M, Pfeiffer RM, Dorgan JF, et al. Cancer-attributable mortality among solid organ transplant recipients in the United States: 1987 through 2014. *Cancer*. 2019;125(15):2647-2655.