Supplemental Materials:

Table S1: Characteristics of Hispanic and non-Hispanic whites initiating dialysis in the U.S., by age group

	Age <40 years				*Age 40-59 years*				*Age 60-75 years*			
	Non-Hispanics		***Hispanics***		***Non-Hispanics***		***Hispanics***		***Non-Hispanics***		***Hispanics***	
	N	*(%)*	*N*	*(%)*	*N*	*(%)*	*N*	*(%)*	*N*	*(%)*	*N*	*(%)*
Total	26030	(100.0)	9800	(100.0)	106989	(100.0)	33759	(100.0)	202704	(100.0)	38519	(100.0)
Male gender	15748	(60.5)	5716	(58.3)	63026	(58.9)	20456	(60.6)	112913	(55.7)	19719	(51.2)
Dialysis Modality												
Hemodialysis	21399	(82.2)	8529	(87.0)	92268	(86.2)	31012	(91.9)	184576	(91.1)	36365	(94.4)
Peritoneal Dialysis	4631	(17.8)	1271	(13.0)	14721	(13.8)	2747	(8.1)	18128	(8.9)	2154	(5.6)
Missing	74	(0.3)	14	(0.1)	146	(0.1)	18	(0.1)	187	(0.1)	15	(<0.1)
Comorbidities												
Diabetes	10069	(38.7)	2864	(29.2)	59616	(55.7)	22953	(68.0)	110055	(54.3)	27792	(72.2)
Hypertension	18685	(71.8)	7295	(74.4)	82725	(77.3)	27624	(81.8)	157915	(77.9)	31395	(81.5)
Heart failure	2724	(10.5)	886	(9.0)	27937	(26.1)	8304	(24.6)	80436	(39.7)	13456	(34.9)
Cerebrovascular disease	640	(2.5)	145	(1.5)	7913	(7.4)	1776	(5.3)	23207	(11.4)	3371	(8.8)
Atherosclerotic heart disease	1326	(5.1)	253	(2.6)	23776	(22.2)	5154	(15.3)	76953	(38.0)	10276	(26.7)
Peripheral vascular disease	1209	(4.6)	303	(3.1)	15282	(14.3)	3957	(11.7)	42140	(20.8)	6218	(16.1)
Chronic obstructive lung disease	338	(1.3)	53	(0.5)	7716	(7.2)	599	(1.8)	26922	(13.3)	1646	(4.3)
Cancer	394	(1.5)	68	(0.7)	4464	(4.2)	521	(1.5)	16969	(8.4)	1278	(3.3)

	Age <40 years				Age 40-59 years				Age 60-75 years			
	Non-Hispanics		Hispanics		Non-Hispanics		Hispanics		Non-Hispanics		Hispanics	
	N	(%)	N	(%)	N	(%)	N	(%)	N	(%)	N	(%)
Alcohol dependence	363	(1.4)	99	(1.0)	2198	(2.1)	559	(1.7)	1986	(1.0)	289	(0.8)
Drug dependence	516	(2.0)	161	(1.6)	1063	(1.0)	339	(1.0)	178	(0.1)	32	(0.1)
Tobacco use	2877	(11.1)	275	(2.8)	11808	(11.0)	1002	(3.0)	12117	(6.0)	758	(2.0)
Unable to transfer or ambulate	525	(2.0)	139	(1.4)	4232	(4.0)	911	(2.7)	10000	(4.9)	1748	(4.5)
Body Mass Index (kg/m^2)												
<18.5	1809	(6.9)	579	(5.9)	5078	(4.7)	1268	(3.8)	9795	(4.8)	1700	(4.4)
18.5-24.9	12030	(46.2)	4141	(42.3)	31166	(29.1)	10531	(31.2)	68134	(33.6)	14263	(37.0)
25.0-29.9	6094	(23.4)	2585	(26.4)	28015	(26.2)	10863	(32.2)	60748	(30.0)	12771	(33.2)
30.0-39.9	4572	(17.6)	1951	(19.9)	31217	(29.2)	8878	(26.3)	51840	(25.6)	8319	(21.6)
≥40.0	1525	(5.9)	544	(5.6)	11513	(10.8)	2219	(6.6)	12187	(6.0)	1466	(3.8)
Missing	2247	(7.9)	609	(5.8)	6500	(5.7)	1709	(4.8)	11124	(5.2)	22119	(5.4)
Blood Group[a]												
O	7077	(27.2)	3797	(38.7)	16242	(15.2)	7522	(22.3)	8681	(4.3)	2801	(7.3)
A	6304	(24.2)	1833	(18.7)	14960	(14.0)	3986	(11.8)	8075	(4.0)	1417	(3.7)
B	1532	(5.9)	638	(6.5)	3936	(3.7)	1293	(3.8)	2103	(1.0)	453	(1.2)
AB	591	(2.3)	150	(1.5)	1383	(1.3)	301	(0.9)	795	(0.4)	108	(0.3)
Payer of Health Care												
Medicare Primary, Part A and B	5860	(22.5)	1406	(14.3)	29042	(27.1)	7403	(21.9)	139273	(68.7)	21408	(55.6)
Medicare Primary, Other	413	(1.6)	136	(1.4)	1926	(1.8)	559	(1.7)	4303	(2.1)	2140	(5.6)
Medicare Secondary with EGHP	2425	(9.3)	415	(4.2)	11257	(10.5)	1328	(3.9)	10124	(5.0)	964	(2.5)

	Age <40 years				Age 40-59 years				Age 60-75 years			
	Non-Hispanics		Hispanics		Non-Hispanics		Hispanics		Non-Hispanics		Hispanics	
	N	*(%)*	*N*	*(%)*	*N*	*(%)*	*N*	*(%)*	*N*	*(%)*	*N*	*(%)*
Medicare Secondary, no EGHP	70	(0.3)	7	(0.1)	695	(0.6)	94	(0.3)	1916	(0.9)	181	(0.5)
Medicare 90 Day Waiting Period	14389	(55.3)	6096	(62.2)	51837	(48.5)	20276	(60.1)	21916	(10.8)	6515	(16.9)
Group Health Organization	201	(0.8)	62	(0.6)	2366	(2.2)	884	(2.6)	19795	(9.8)	5270	(13.7)
Other/Unknown	2672	(10.3)	1678	(17.1)	9866	(9.2)	3215	(9.5)	5377	(2.7)	2041	(5.3)

EGHP – employer group health plan. # - cell counts <10 are suppressed per federal research regulations.

[a] Blood type was available only among patients on the kidney transplant waitlist.

Table S2: Cumulative incidences of study events

	All Patients N=418,122 (100%)	Non-Hispanic N=336,039 (80.4%)	Hispanic N=82083 (19.6%)
Censoring Events			
Death	250889 (60.0)	210954 (62.8)	39935 (48.7)
Living Kidney Transplant	21512 (5.1)	17364(5.2)	4148 (5.1)
Administratively censored	71459 (17.1)	53286(15.9)	18173 (22.1)
Lost to Follow-up	39016 (9.3)	26654 (7.9)	12362 (15.1)
Deceased Donor Transplant without Waitlisting	78 (<1.0)	59 (<1.0)	19 (<1.0)

Table S3: Relative rates of transplant waitlisting and kidney transplantation in Hispanic *versus* non-Hispanic whites, by age group

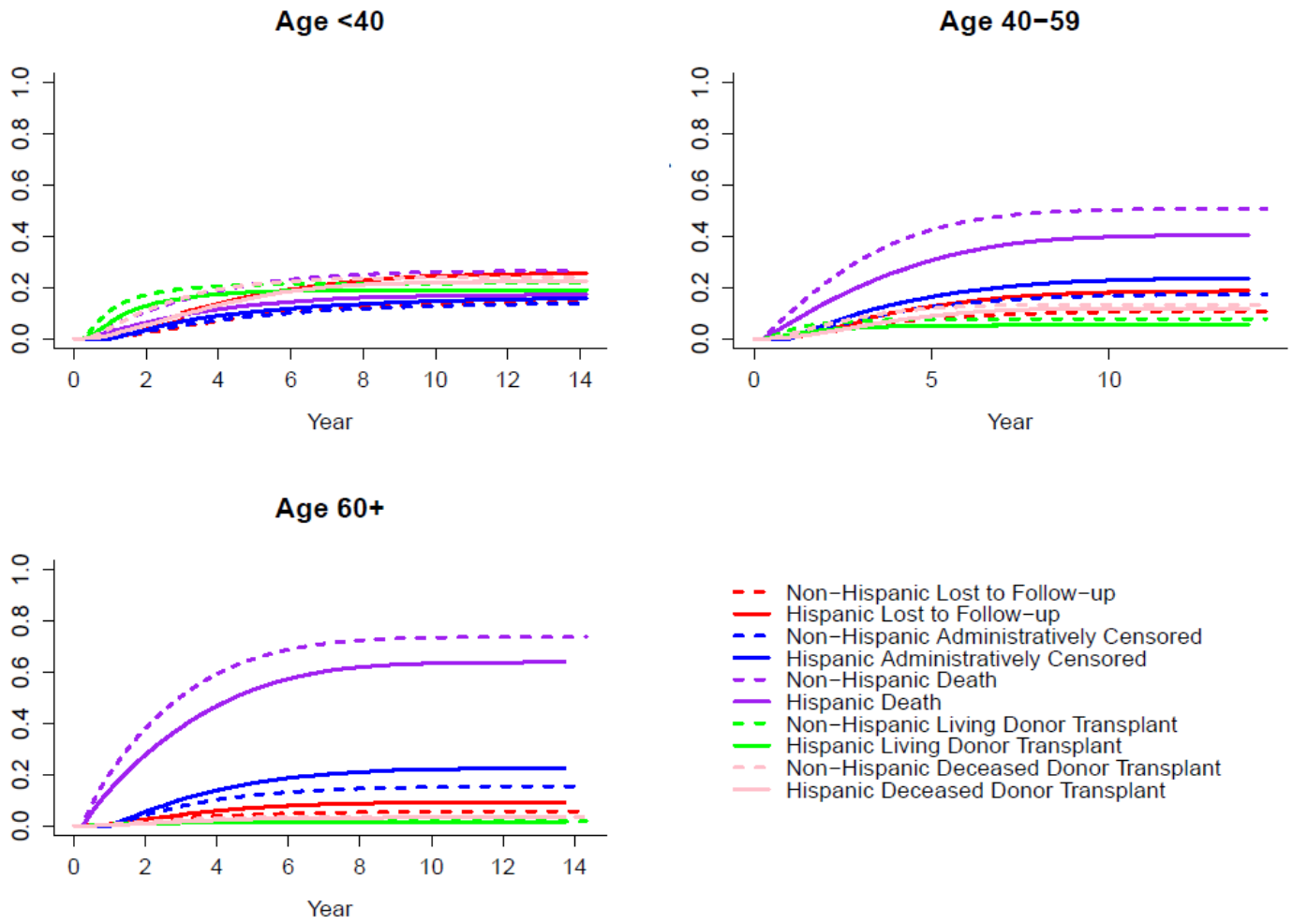
	Model 1 Unadjusted		Model 2 (Adjusted for age, sex, and year of dialysis initiation)		Model 3 (Further adjusted for all comorbidities, dialysis modality, payer status, BMI, and blood type)		Model 4 (Further adjusted for OPO)	
Age (yrs)	**HR_{CS} (95% CI)**	**HR_{SD} (95% CI)**	**HR_{CS} (95% CI)**	**HR_{SD} (95% CI)**	**HR_{CS} (95% CI)**	**HR_{SD} (95% CI)**	**HR_{CS} (95% CI)**	**HR_{SD} (95% CI)**
Time from ESRD to Transplant								
< 40	0.76 (0.72, 0.80)	0.92 (0.88, 0.97)	0.77 (0.74, 0.81)	0.95 (0.91,1.00)	0.74 (0.70, 0.77)	0.89 (0.85, 0.94)	0.79 (0.75, 0.84)	0.94 (0.89, 1.00)
40-59	0.71 (0.68, 0.73)	0.90 (0.87, 0.93)	0.71 (0.69, 0.74)	0.90 (0.87, 0.94)	0.68 (0.66, 0.91)	0.84 (0.81, 0.87)	0.82 (0.78, 0.85)	0.99 (0.94, 1.03)
60-75	0.77 (0.72, 0.82)	0.95 (0.90, 1.01)	0.66 (0.62, 0.70)	0.81 (0.76, 0.86)	0.64 (0.60, 0.68)	0.74 (0.69, 0.79)	0.75 (0.70, 0.81)	0.88 (0.82, 0.94)
Time from ESRD to Waitlisting								
< 40	1.06 (1.03, 1.10)	1.14 (1.11, 1.18)	1.04 (1.01, 1.08)	1.13 (1.09, 1.16)	0.95 (0.92, 0.98)	1.02 (0.99, 1.06)	0.90 (0.87, 0.94)	0.96 (0.92, 0.99)
40-59	1.05 (1.03, 1.08)	1.16 (1.13, 1.18)	1.05 (1.02, 1.07)	1.15 (1.12, 1.17)	0.98 (0.95, 1.00)	1.05 (1.03, 1.07)	0.96 (0.93, 0.98)	1.03 (1.00, 1.06)
60-75	1.19	1.31	1.01	1.11	0.95	1.01	0.93	0.99

	(1.15, 1.23)	(1.27, 1.35)	(0.98, 1.05)	(1.07, 1.14)	(0.91, 0.98)	(0.97, 1.04)	(0.90, 0.97)	(0.95, 1.04)
Time from Waitlisting to Transplantation[a]								
< 40	0.62	0.76	0.67	0.81	0.70	0.85	0.85	0.99
	(0.59, 0.65)	(0.72, 0.80)	(0.64, 0.70)	(0.77, 0.85)	(0.67, 0.74)	(0.80, 0.89)	(0.80, 0.91)	(0.93, 1.05)
40-59	0.60	0.73	0.63	0.76	0.67	0.80	0.89	1.02
	(0.58, 0.63)	(0.71, 0.76)	(0.61, 0.65)	(0.74, 0.79)	(0.64, 0.69)	(0.77, 0.83)	(0.85, 0.93)	(0.97, 1.06)
60-75	0.58	0.68	0.60	0.70	0.64	0.75	0.87	0.98
	(0.54, 0.62)	(0.64, 0.72)	(0.56, 0.63)	(0.66, 0.74)	(0.60, 0.69)	(0.70, 0.80)	(0.81, 0.93)	(0.91, 1.05)

Abbreviations: OPO, organ procurement organization; BMI – body mass index; HR_{CS} – cause-specific hazard ratio; HR_{SD} – sub-distribution hazard ratio.

[a] Blood type was available only among waitlisted patients and, therefore, incorporated in the model analyzing time from placement of the waitlist to transplantation

Supplemental Figure S1: Cumulative Incidence Plot



Supplemental Technical Appendix:

In time to event analyses, censoring occurs if an individual does not experience the event of interest before the end of the study or experiences another event (e.g. death before transplantation). One of the assumptions in such analyses is that censoring is independent of the outcome of interest. In the presence of competing events (an event whose occurrence either precludes or fundamentally alters the occurrence of another event), this important assumption is violated.[1] In the present analysis, we cannot assume that the probability of an individual experiencing a competing event (e.g., death) is independent of the outcome of interest as people who are very sick are unlikely to receive a transplant. In this situation, traditional methods for analyzing survival data are inappropriate, and a competing risk framework must be used.

Two modifications of survival analysis methodology—the cause-specific (HR_{CS}) and the subdistribution hazard ratio (HR_{SD})—are used in a competing risks analysis and have different interpretations. The HR_{CS} estimates the observed relative rate of the outcome of interest (i.e. transplantation) among those with an exposure (i.e. Hispanic ethnicity) compared to those without the exposure (i.e. non-Hispanic whites). Analytically, the individuals who experience a competing event (e.g. death) are removed from the risk set in the same manner as those censored due to loss to follow-up. Therefore, the HR_{CS} is interpreted as the relative hazard of observing the event of interest. Conversely, the subdistribution hazard ratio (HR_{SD}) estimates the association of the exposure with the event of interest in the hypothetical scenario where the competing event did not occur. While the HR_{CS} is the observed rate, the HR_{SD} is described as the epidemiological rate as it has a (potentially) causal interpretation. Analytically, in contrast

with the cause-specific hazard ratio, individuals experiencing the competing event are maintained in the risk set.

Both hazard functions may be used in conjunction or separately depending on the focus of the research question. The HR_{CS} is more appropriate to determine the relative rate of *observing* an event across different groups. On the other hand, the HR_{SD} provides more insight into the *relationship* between an exposure and an outcome, by taking into account the impact of competing events especially if the cohorts under analysis experience competing events at higher and/or differential rates.[2]

To explore the relationship between covariates and each possible event in the cause-specific hazard function, a traditional Cox proportional hazards model software can be used—only the interpretation of the coefficient changes. When estimating the subdistribution hazard function, several approaches have been described in the literature. Each approach handles the "missing" censoring times as a missing data problem. One approach is to observe individuals until the administrative censoring date[3] (as performed in our analysis) or to impute the missing censoring times using the Kaplan-Meier multiple imputation method.[4] Using this modified data set, Cox proportional hazards model software is used to estimate HR_{SD} for the covariates of interest. Another common approach, described by Fine and Gray, involves using a regression analysis that models the hazard that corresponds to the cumulative incidence function.[5]

By using a competing risks framework, we accounted for informative censoring and provided insight into potential mechanisms explaining the disparity in access to transplantation among Hispanics. The cause-specific hazard ratio describes what we observe in the "real world" by excluding patients who experience the competing events. In doing so, we observed that

Hispanics were transplanted at a lower rate compared to non-Hispanics, but this disparity attenuated substantially once accounting for patient blood type and OPO. When accounting for competing events (more specifically the Hispanic survival advantage) by using the subdistribution hazard function, the disparity in access to transplantation by ethnicity was further attenuated. One potential explanation for this shift is that non-Hispanics tend to be sicker compared to Hispanics. Therefore, non-Hispanics tend to die earlier (an observation described in previous work) leading to a sub-selected "healthier" cohort of non-Hispanics. Consequently, more transplant-eligible, non-Hispanic patients may be observed compared to Hispanics.

By treating death as a competing rather than a censored event, we were able to account for differences in patient survival by ethnicity and provide a better estimate of access to deceased donor kidney transplantation with use of the subdistribution hazard function. Although we are confident that our competing risks approach provides a better estimate of access to transplantation among the Hispanic population, the HR_{SD} is not generalizable to Hispanic subgroups that experience competing events (e.g. death, living kidney transplantation) at different rates. Future studies evaluating Hispanic subgroups are warranted to provide a better understanding of disparities in access to kidney transplantation in this growing, heterogeneous minority population.

References

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