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Implications of Censoring Methods for Survival Estimates in Transplantation

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Complete List of Authors:	Yu, Miko; Columbia University Vagelos College of Physicians and Surgeons; Columbia University Renal Epidemiology Group Husain, Syed; Columbia University Vagelos College of Physicians and Surgeons; Columbia University Renal Epidemiology Group King, Kristen; Columbia University Vagelos College of Physicians and Surgeons; Columbia University Renal Epidemiology Group Maclay, Lindsey M.; Columbia University Vagelos College of Physicians and Surgeons; Columbia University Renal Epidemiology Group Schold, Jesse D.; University of Colorado Anschutz Medical Campus Department of Surgery; Colorado School of Public Health Department of Epidemiology Mohan, Sumit; Columbia University Vagelos College of Physicians and Surgeons; Columbia University Renal Epidemiology Group; Columbia University Mailman School of Public Health
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	failure or last follow-up date. Results: Censoring follow-up time at the file end date for individuals without death events was the more non-informative censoring method, compared to censoring at graft failure or last reported date. Comparison of methods yielded ≥5% differences by year 8 of follow-up. Larger differences appeared in recent cohorts where the follow-up period coincided with COVID-19. Conclusion: Differences in results highlight the impact of analytic choices on reported results of kidney transplant registry studies. Each approach has a different set of advantages and disadvantages, underscoring the need for clear documentation of methodology.

Implications of Censoring Methods for Survival Estimates in Transplantation

Authors:

Miko E. Yu[1,2], S. Ali Husain[1,2], Kristen L. King[1,2], Lindsey M. Maclay[1,2], Jesse D. Schold[3,4]*, Sumit Mohan[1,2,5]*

Affiliations

[1]Division of Nephrology, Department of Medicine, Vagelos College of Physicians and Surgeons, Columbia University, New York, NY
[2]Columbia University Renal Epidemiology Group, New York, NY
[3]Department of Surgery, University of Colorado – Anschutz Medical Campus, Aurora, CO
[4]Department of Epidemiology, School of Public Health, University of Colorado – Anschutz Medical Campus, Aurora, CO
[5]Department of Epidemiology, Mailman School of Public Health, Columbia University, New York, NY
*Co-senior authors

ORCIDs

Corresponding Author

Sumit Mohan, MD, MPH
Professor of Medicine & Epidemiology
Division of Nephrology, Department of Medicine
Columbia University Irving Medical Center
622 W 168th St, PH4-124, New York, NY 10032
sm2206@cumc.columbia.edu

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Authors: Miko Yu, S. Ali Husain, Kristen L. King, Lindsey M. Maclay, Jesse D. Schold, Sumit Mohan

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Abbreviations: CMS – Centers for Medicare & Medicaid Services; HRSA – Health Resources and Services Administration; OPTN – Organ Procurement and Transplantation Network; SRTR – Scientific Registry of Transplant Recipients; US – United States

Abstract

Introduction: Censoring methods chosen for performing patient mortality and graft survival analyses in kidney transplant can impact the duration of follow-up available and which events are counted.

Methods: This retrospective cohort study examined differences in overall patient survival using four methods of censoring patient follow-up time and death ascertainment using 2023 SRTR files. Method 1 used all reported death events and censored administratively using the file end date. Method 2 only considered death events up until a center-reported graft failure date; time was censored at patients' reported graft failure date, or file end date if graft failure was not documented. Method 3 counted death events only up until graft failure; follow-up time was censored at this date. If graft failure was not documented, time was censored at patients' last center-reported follow-up date. Method 4 used all reported death events, regardless of its timing in relation to a patient's graft failure or follow-up date. If death was not documented, time was censored at patients' graft failure or last follow-up date.

Results: Censoring follow-up time at the file end date for individuals without death events was the more non-informative censoring method, compared to censoring at graft failure or last reported date. Comparison of methods yielded ≥5% differences by year 8 of follow-up. Larger differences appeared in recent cohorts where the follow-up period coincided with COVID-19.

Conclusion: Differences in results highlight the impact of analytic choices on reported results of kidney transplant registry studies. Each approach has a different set of advantages and disadvantages, underscoring the need for clear documentation of methodology.

Introduction

In the United States, kidney transplant registries containing data on all transplant donors and recipients are used to perform outcomes studies, to guide policy changes, and to regulate program performance.[1-3] Although the Organ Procurement and Transplantation Network (OPTN) coordinates a national registry to include data on all transplant events in the United States, long-term follow-up of patients is dependent on transplant centers to submit data annually with external data verification being variable.[1,4] In addition, graft failure and patient death endpoints are often supplemented or validated from external sources.[1,4] The need for supplementation of endpoints is related to the fact that patients often receive their follow-up care outside of their transplant centers and because of OPTN policies that do not require patient follow-up after graft loss.[1]

The hierarchy of data prioritization from the different sources can have important implications when there is discordance. When not adequately considered, policy choices that impact data collection may also unintentionally influence outcomes analyses.[1,2,4] For example, some patients may have reported death dates identified from an external source that occur much later than the patient's last reported date of follow-up reported by the transplant center.[1] For these patients, the analytical approach chosen for censoring time to event studies can impact the duration of follow-up available and which events are counted. This has the potential to create differences in results, with real-world implications when used to inform policy discussions. Given variations in data capture methods and completeness over time, there are also potential differences between recent cohorts and more distant patient cohorts.[1,4]

We compare some commonly used approaches for performing graft failure and patient mortality analyses in the transplant literature and describe the different calculations of the benefits and challenges that result from these choices.

Methods

This study used data from the Scientific Registry of Transplant Recipients (SRTR). The SRTR data system includes data on all donor, wait-listed candidates, and transplant recipients in the US, submitted by the members of the Organ Procurement and Transplantation Network (OPTN). The Health Resources and Services Administration (HRSA), U.S. Department of Health and Human Services provides oversight to the activities of the OPTN and SRTR contractors.

This study was approved by the institutional review board at Columbia University Medical Center. Informed consent was not required. Analyses were performed using STATA/MP 17.0 (StataCorp, College Station, TX). Patient and graft survival models were assessed using Kaplan-Meier methods, using Greenwood's formula to obtain 95% confidence intervals.[5] Study eras were constructed based on the year of transplantation: 2005-2009, 2010-2015, 2015-2019, and 2020-2023.

Censoring follow-up for patient survival outcomes

For each study era, we calculated patient survival following kidney-only transplantation using four different methods for censoring patient follow-up and ascertaining death events using the SRTR Standard Analysis Files from March 2023. Since survival estimates are dependent on the number of patients at risk and the follow-up duration for a given event, methods of censoring (i.e. limiting the follow-up time at a specific interval) are important to consider particularly when the systematic capture of events changes.

Method 1 used reported death dates from any source (reported directly by the transplant center or ascertained through an external source such as CMS data, the Social Security Death Master File, public obituaries, or family member contact).[1] All patients without a death event were censored administratively at the end of the file date regardless of the their graft status or last follow-up status with their transplant center. This method is used by the SRTR for their patient mortality analyses and

assumes every patient is alive as of the file end date unless a death date is documented, thereby maximizing analysis follow-up time for all patients (**Table 1**).[6] For a deceased patient whose death was not identified, follow-up time under this method would falsely extend past their death until the file end date (**Figure 1: Patient 2B, 3B**).

Since transplant centers are not required to follow and submit data for patients after they have experienced graft failure, there may be differential access to death data for these patients. Thus, Method 2 only considered death events up until a center-reported graft failure date. Any documented deaths reported after the graft failure date (presumably reported more frequently from external sources) would not be counted, and follow-up time would be censored at this date. When graft failure and death were reported to occur on the same date, these were counted as death events. All remaining patients who did not experience graft failure or death with a functioning graft were censored administratively at the file end date (**Figure 1: Patient 3B**).

Method 3 also counted death events only up until a center-reported graft failure date; follow-up time was censored at this date (**Figure 1: Patient 1, 2**). Then, since transplant centers are required to submit follow-up forms for each transplanted patient at 6 months and 1-year post-transplant, and annually thereafter, follow-up time was censored at each individual patient's last reported center follow-up date if no graft failure occurred (**Figure 1: Patient 3B**). In these cases, estimates for survival analyses are limited to only data reported during the periods that patients were known to be actively followed by their transplant center, but are also highly dependent on the timing of center-reported form submission (**Table 1, Supplemental Figure 1**). Deaths reported from other sources after the patient's last documented follow-up date would not be counted as events (**Figure 1: Patient 3A**). This method is similar to what the SRTR uses for censoring follow-up time for their all-cause graft failure analyses, except both graft failures and deaths would be counted as events in those analyses, whereas we consider only death as the event of interest.[6]

Method 4 counted any reported death date as an event, regardless of its timing in relation to a patient's graft failure date or last reported center follow-up date (**Figure 1: Patient 2A, 3A**). The remaining patients with no death event had their follow-up time censored at graft failure date or last center follow-up date (**Figure 1: Patient 2B, 3B**). This method identifies a maximum number of deaths but may be biased given different probability of identifying a death event (**Table 1**).

Plotting figures using time restrictions

For each study era, we plotted Kaplan-Meier curves with and without time restrictions on the x-axis. Time restrictions were based on the maximum follow-up time that could be expected for each era. For example, among patients transplanted 2015-2019, our cohort would only be expected to have a maximum follow-up time of 8 years, based on files current as of early 2023.

Censoring follow-up for graft survival outcomes

We also calculated graft survival following kidney-only transplantation using four different methods for censoring patient follow-up and ascertaining graft failure events. Method A used the reported graft failure date and only censored administratively at the end of the file date. Method B used the reported graft failure date and only censored at patient follow-up. Method C censored first at reported death date from any source, and then at administrative date if no death occurred. Similarly, the Method D censored first at death date, but then at patient last follow-up if no death occurred.

Results

There were significant differences in patient survival estimates among the four methods among cohorts of patients in all four study eras, with the most dramatic differences between Methods 2 and 4 (**Figure 2, Table 2**). Method 2 was the most optimistic estimate with the highest survival probabilities. When compared to Method 4, small differences were present by year 5, leading to at least a 5%

difference by year 8 in all study eras with the exception of 2020-2023, which only included 4 years of follow-up data.

While the survival probabilities for Method 4 were similar to the other methods for the first 5 years, differences in these estimates increased with longer follow-up. The notable exception where large differences were seen earlier by year 3 was in the 2020-2023 cohort, likely reflecting the higher incidence of deaths during the COVID pandemic. Similarly at the 8-year mark in the 2015-2019 cohort, reflecting the same maximum follow-up time, Method 4 resulted in markedly lower estimates as well. Moreover, the choice of a follow-up time restriction based on the cohort of study also resulted in differences in depicting survival probabilities over time (**Figure 3**).

In contrast to patient survival, rates of graft failure (i.e., graft losses) were much more concordant across the four methods, with a 5% difference only appearing after 10 years of follow-up, with the exception of more recent cohorts that coincided with the COVID pandemic (**Figure 4, Table 3**). Method A produced the most optimistic graft survival rates of the four methods and there was less concordance in graft survival between Methods B and C than that seen in patient survival.

Discussion

Our results demonstrate meaningful differences in post-transplant survival estimates resulting from the use of different methods of censoring. They highlight the impact of analytic choices, such as the cohort of interest and the duration of the follow-up period, on reported results of kidney transplant registry studies. Differences between the approaches are presented in each of the four cohorts that we examined, although the time point of divergence in the results between methods varies considerably. We noted large differences appearing earlier in the follow-up period within the latest patient cohort. This is likely a function of how events are recorded in the early post-transplant period as well as the high mortality rates noted in the early COVID pandemic, suggesting that methodology is particularly

important when looking at more recent cohorts. In addition, our results demonstrate the importance of ensuring sufficient follow-up time is possible within the cohort, such that the study time interval (particularly for longer-term analyses) is restricted to a period when a greater number of recipients are expected to have follow-up data submitted.

While differences are notable when examining the entire cohort of kidney transplant recipients in the OPTN registry, they may be even larger within smaller subsets of the population. For example, prior SRTR analyses have demonstrated differences in death ascertainment accuracy across age, race and geographic groups.[7] Other groups, such as highly sensitized or more complex patients, may be more likely to continue receiving care at their transplant center, resulting in reporting differences, including duration and likelihood of being lost to follow-up and completeness of outcome reporting. Recent OPTN analyses have also suggested considerable variation in transplant center data reporting practices. Consequently, differences in reporting of long-term follow-up for transplant recipients may have an exaggerated impact on survival estimates, especially if centers increasingly report patients as lost to follow-up. Analyses that censor follow-up on the date of the last follow-up, as reported by the transplant center, could result in a significant underestimation of mortality risk due to the potential undercounting of graft failures and subsequent deaths. This could be the case if the reasons for loss to follow-up are informative events and not randomly distributed. For example, it is likely that graft failure and mortality rates are potentially higher in patients who are less adherent to appointments and more likely to be lost to follow up. Similarly, mortality rates for patients with a graft failure are probably different than mortality rates for those with functioning grafts and thus censoring at graft failure may not be truly non-informative. In short, informative censoring can lead to selection bias and needs to be considered. Therefore, additional sensitivity analyses may be necessary to support the robustness of conclusions made under the assumptions of the chosen censoring method.

Investigators and regulators using transplant registry data for clinical research, program evaluations, or to guide transplant policies should be methodical about choosing an appropriate censoring approach. Given recent concerns about discordance between datasets and the challenges associated with the use of external sources to supplement these data (or the inability to do as is the case with graft failure data for kidney transplant recipients), understanding the implications of using a given analytic method is key to ensuring that results are robust.[1,4] For example, OPTN policy does not require transplant centers to report recipient deaths that occur after graft failure, so analyses focused on patient survival would need to censor patient follow-up time at graft failure in order to avoid overestimating patient survival rates.

Censoring follow-up time at the administrative date of the file for individuals who do not have a death date reported may be the more non-informative approach for patient survival analyses, compared to censoring at last follow-up date. However, rates of death are still subject to differences in how externally identified deaths are recorded in different datasets, affecting the ability to identify a true death event and biasing outcomes of deceased patients with unverified deaths. It is also important to recognize that this method may not be as robust for graft survival analyses in kidney transplantation. Given the current absence of secondary sources for evidence of graft failure, center-reported vital status may be unverified or incomplete in the dataset. Another impact of not having secondary verification (which is available with the Centers for the Medicare and Medicaid Services but not shared with the OPTN or the SRTR) is that centers with more vigilant self-reporting of graft failure will have lower estimated graft survival than centers with less comprehensive reporting. Thus, graft survival estimates are further challenged by center practice. Similar concerns arise in multivariable survival models, such as the Cox proportional hazards model, in which the hazard ratio may be influenced by significant deviations in estimates in later follow-up, given the assumption of proportional hazards. It is also important to recognize that there are several options for the visual presentation of time-to-event

analyses that include whether to display levels of uncertainty and how far to extend the plots – all of which can influence how results are interpreted by readers independent of the methods being discussed.[8]

This study examined four common approaches but is not a comprehensive list of censoring methods that may be used in transplant analyses for patient and graft survival. As noted, there may be inherent limitations based on the choice of dataset or real-world practices to take into consideration. Our analysis is limited to the Kaplan-Meier method, however we encourage investigators to take these factors into account in any time-to-event analysis and recognize that, particularly in post-transplant follow-up analyses, competing risk models may be more appropriate.[9-14]

Each of these methods has a different set of limitations and some censoring approaches are better for certain questions. It is imperative for authors to precisely report which approach was used for a given analysis and to ensure that the censoring is truly random and non-informative. These results further underscore the need for the sources of research files to provide clear documentation, including how these events are recorded or updated and how their methods should inform analyses for researchers, clinicians and policymakers to ensure that results are correctly interpreted.

Author Contributions

SM and JDS conceptualized the study; MEY and KLK were responsible for data curation and methodology; SM was responsible for funding acquisition, resources and supervision; KLK, MY and LMM were responsible for writing the original draft; and all authors reviewed and edited the manuscript.

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Table 1. Advantages and disadvantages of four different methods for censoring follow-up and ascertaining events for overall survival following kidney transplantation.

	Identifying Events for Overall Survival	Censoring Follow-up	Advantages	Disadvantages
1	All deaths reported from any source, regardless of timing	Only administrative censoring at the end of the file date	• Uses all available death data from all sources • Maximizes analysis follow-up time for all patients	• High risk of bias from differential reporting and restrictions in access to external sources of death data such as the Social Security Death Master File
2	Only deaths occurring prior to graft failure, reported from any source	Censored at graft failure date; if no graft failure reported, administrative censoring at end of file date	• Reduces potential bias due to differential/restricted access to death data for some patients whose grafts failed and are no longer expected to be followed by their transplant center • Maximizes analysis follow-up time for patients without graft failure to capture all death events that have occurred	• Ignores data on deaths occurring after graft failure which could lead to under-estimates of mortality risk • Potential over-counting of "alive" time for patients who were known to be lost to follow-up by their transplant center and less likely to have deaths identified
3	Only deaths occurring prior to graft failure or loss to follow-up by the transplant center	Censored at graft failure date; if no graft failure reported, censored at patient's last center-reported follow-up date	• Reduces potential bias due to differential/restricted access to death data from external sources for all patients by only counting deaths during the period when they were known to be actively followed by their transplant center	• Ignores data on deaths occurring after graft failure and loss to follow-up by the transplant center which could lead to under-estimates of mortality risk • Potential bias if some patients are more likely to be reported as lost to follow-up than others and their deaths from other sources are not counted • Annual timing of follow-up form submission by transplant centers could lead to censoring of up to a year for many patients, with the data lag impacting estimates for shorter-term outcomes
4	All deaths from any source, regardless of timing	For patients without a death reported, censor at patient's graft failure date or last center-reported follow-up date	• Uses all available death data from all sources • Partially reduces potential bias due to differential/restricted access to death data from external sources by censoring follow-up for patients with no death reported at the last known time they were followed by their transplant center	• May overestimate mortality risk by counting all death events and censoring only the "alive" time • Annual timing of follow-up form submission by transplant centers could lead to censoring of up to a year for many patients, with the data lag impacting estimates for shorter-term outcomes

Table 2. Kaplan-Meier patient survival estimates as calculated using four different methods for censoring follow-up time and ascertaining death events, overall and by transplant cohort.

Transplant Year	Method 1		Method 2		Method 3		Method 4	
Years since transplant	SF	95% CI	SF	95% CI	SF	95% CI	SF	95% CI
2005-2009								
1	0.97	(0.97 - 0.97)	0.97	(0.97 - 0.97)	0.97	(0.97 - 0.97)	0.97	(0.96 - 0.97)
3	0.92	(0.92 - 0.93)	0.94	(0.94 - 0.94)	0.94	(0.94 - 0.94)	0.92	(0.92 - 0.92)
5	0.87	(0.87 - 0.87)	0.89	(0.89 - 0.90)	0.89	(0.89 - 0.90)	0.86	(0.86 - 0.87)
8	0.78	(0.77 - 0.78)	0.81	(0.81 - 0.82)	0.82	(0.81 - 0.82)	0.75	(0.75 - 0.75)
10	0.71	(0.70 - 0.71)	0.75	(0.75 - 0.76)	0.76	(0.75 - 0.76)	0.66	(0.66 - 0.67)
15	0.54	(0.54 - 0.54)	0.59	(0.58 - 0.59)	0.58	(0.58 - 0.59)	0.39	(0.39 - 0.40)
18	0.46	(0.46 - 0.47)	0.51	(0.50 - 0.51)	0.38	(0.35 - 0.41)	0.09	(0.08 - 0.11)
2010-2014								
1	0.97	(0.97 - 0.97)	0.98	(0.98 - 0.98)	0.98	(0.98 - 0.98)	0.97	(0.97 - 0.97)
3	0.94	(0.93 - 0.94)	0.95	(0.94 - 0.95)	0.95	(0.94- 0.95)	0.93	(0.93 - 0.94)
5	0.89	(0.88 - 0.89)	0.90	(0.90 - 0.91)	0.90	(0.90 - 0.91)	0.88	(0.88 - 0.88)
8	0.78	(0.78 - 0.78)	0.81	(0.81 - 0.81)	0.81	(0.81 - 0.81)	0.75	(0.74 - 0.75)
10	0.70	(0.70 - 0.70)	0.73	(0.73 - 0.74)	0.72	(0.72 - 0.73)	0.61	(0.61 - 0.62)
2015-2019								
1	0.98	(0.97 - 0.98)	0.98	(0.98 - 0.98)	0.98	(0.98 - 0.98)	0.98	(0.97 - 0.98)
3	0.93	(0.93 - 0.93)	0.94	(0.94 - 0.94)	0.94	(0.94 - 0.94)	0.93	(0.92 - 0.93)
5	0.87	(0.87 - 0.87)	0.88	(0.88 - 0.88)	0.87	(0.87 - 0.88)	0.84	(0.83 - 0.84)
8	0.77	(0.76 - 0.77)	0.79	(0.78 - 0.79)	0.62	(0.59 - 0.65)	0.42	(0.40 - 0.45)
2020-2023								
1	0.96	(0.96 - 0.97)	0.97	(0.97 - 0.97)	0.96	(0.96 - 0.96)	0.96	(0.96 - 0.96)
3	0.91	(0.91 - 0.92)	0.92	(0.92 - 0.92)	0.80	(0.78 - 0.82)	0.73	(0.71 - 0.75)
All (2005-2023)								
1	0.97	(0.97 - 0.97)	0.97	(0.97 - 0.98)	0.97	(0.97 - 0.97)	0.97	(0.97 - 0.97)
3	0.93	(0.93 - 0.93)	0.94	(0.94 - 0.94)	0.94	(0.93 - 0.94)	0.92	(0.92 - 0.92)
5	0.87	(0.87 - 0.87)	0.89	(0.89 - 0.89)	0.89	(0.89 - 0.89)	0.86	(0.85 - 0.86)
8	0.77	(0.77 - 0.77)	0.80	(0.80 - 0.80)	0.80	(0.79 - 0.80)	0.73	(0.72 - 0.73)
10	0.70	(0.70 - 0.70)	0.73	(0.73 - 0.74)	0.73	(0.72 - 0.73)	0.62	(0.62 – 0.63)
15	0.53	(0.53 - 0.53)	0.57	(0.57 - 0.57)	0.55	(0.54 - 0.55)	0.35	(0.35 - 0.36)
18	0.45	(0.45 - 0.46)	0.49	(0.49 - 0.50)	0.36	(0.33 - 0.39)	0.09	(0.07 - 0.10)

Abbreviations: SF, survivor function estimate; CI, confidence interval

Table 3. Kaplan-Meier graft survival estimates as calculated using four different methods for censoring follow-up time and ascertaining graft failure events, overall and by transplant cohort.

Transplant Year	Method A		Method B		Method C		Method D	
Years since transplant	SF	95% CI	SF	95% CI	SF	95% CI	SF	95% CI
2005-2009								
1	0.96	(0.95 - 0.96)	0.96	(0.95 - 0.96)	0.96	(0.95 - 0.96)	0.95	(0.95 - 0.96)
3	0.92	(0.91 - 0.91)	0.91	(0.91 - 0.91)	0.91	(0.91 - 0.91)	0.91	(0.91 - 0.91)
5	0.87	(0.87 - 0.87)	0.86	(0.85 - 0.86)	0.86	(0.86 - 0.86)	0.86	(0.86 - 0.86)
8	0.81	(0.81 - 0.81)	0.78	(0.77 - 0.78)	0.79	(0.79 - 0.80)	0.78	(0.78 - 0.79)
10	0.78	(0.77 - 0.78)	0.72	(0.72 - 0.73)	0.75	(0.75 - 0.75)	0.73	(0.73 - 0.74)
15	0.71	(0.71 - 0.72)	0.58	(0.58 - 0.59)	0.66	(0.66 - 0.66)	0.61	(0.61 - 0.62)
18	0.69	(0.69 - 0.70)	0.39	(0.35 - 0.42)	0.63	(0.62 - 0.63)	0.48	(0.48 - 0.54)
2010-2014								
1	0.97	(0.97 - 0.97)	0.97	(0.97 - 0.97)	0.97	(0.97 - 0.97)	0.97	(0.97 - 0.97)
3	0.93	(0.93 - 0.94)	0.93	(0.93 - 0.93)	0.93	(0.93 - 0.93)	0.93	(0.93 - 0.93)
5	0.90	(0.89 - 0.90)	0.89	(0.88 - 0.89)	0.89	(0.89 - 0.89)	0.89	(0.89 - 0.89)
8	0.84	(0.84 - 0.85)	0.82	(0.81 - 0.82)	0.83	(0.83 - 0.83)	0.82	(0.82 - 0.82)
10	0.82	(0.81 - 0.82)	0.76	(0.76 - 0.76)	0.80	(0.79 – 0.80)	0.77	(0.77 - 0.77)
2015-2019								
1	0.98	(0.98 - 0.98)	0.97	(0.97 - 0.98)	0.98	(0.98 - 0.98)	0.98	(0.97 - 0.98)
3	0.95	(0.95 - 0.95)	0.94	(0.94 - 0.95)	0.95	(0.95 - 0.95)	0.95	(0.94 - 0.95)
5	0.92	(0.92 - 0.92)	0.90	(0.90 - 0.90)	0.91	(0.91 - 0.92)	0.90	(0.90 - 0.90)
8	0.89	(0.88 - 0.89)	0.73	(0.70 - 0.76)	0.88	(0.87 - 0.88)	0.76	(0.74 - 0.79)
2020-2023								
1	0.98	(0.98 - 0.98)	0.97	(0.97 - 0.97)	0.98	(0.97 - 0.98)	0.97	(0.97 - 0.97)
3	0.96	(0.96 - 0.96)	0.90	(0.89 - 0.92)	0.96	(0.96 - 0.96)	0.91	(0.89 - 0.92)
All (2005-2023)								
1	0.97	(0.97 - 0.97)	0.97	(0.97 - 0.97)	0.97	(0.97 - 0.97)	0.97	(0.97 - 0.97)
3	0.94	(0.93 - 0.94)	0.93	(0.93 - 0.93)	0.93	(0.93 - 0.93)	0.93	(0.93 - 0.93)
5	0.90	(0.90 - 0.90)	0.88	(0.88 - 0.88)	0.89	(0.89 - 0.89)	0.88	(0.88 - 0.88)
8	0.84	(0.84 - 0.85)	0.80	(0.80 - 0.81)	0.83	(0.83 - 0.83)	0.81	(0.81 - 0.81)
10	0.81	(0.81 - 0.82)	0.75	(0.75 - 0.75)	0.79	(0.79 - 0.79)	0.76	(0.76 – 0.76)
15	0.75	(0.75 - 0.75)	0.60	(0.60 - 0.61)	0.70	(0.70 - 0.70)	0.64	(0.63 - 0.64)
18	0.73	(0.73 - 0.73)	0.40	(0.36 - 0.44)	0.66	(0.66 - 0.67)	0.53	(0.50 - 0.56)

Abbreviations: SF, survivor function estimate; CI, confidence interval

Figure Legends

Figure 1. Follow-up duration for Methods 1 through 4 in three unique patient cases. Patient timelines to transplant and death are represented by the black arrow.

Figure 2. Kaplan-Meier curves for patient survival after transplantation comparing four different methods of censoring and event ascertainment for cohorts of patients receiving kidney-only transplants in **A)** 2005-2009, **B)** 2010-2014, **C)** 2015-2019, and **D)** 2020-2023

Figure 3. Comparison of Kaplan-Meier curves for overall survival among patients transplanted 2015-2019, with and without a follow-up time restriction. This study uses March 2023 data files and few patients would be expected to have follow-up data reported past 8 years.

Figure 4. Kaplan-Meier curves for graft survival after transplantation comparing four different methods of censoring and event ascertainment for cohorts of patients receiving kidney-only transplants in **A)** 2005-2009, **B)** 2010-2014, **C)** 2015-2019, and **D)** 2020-2023

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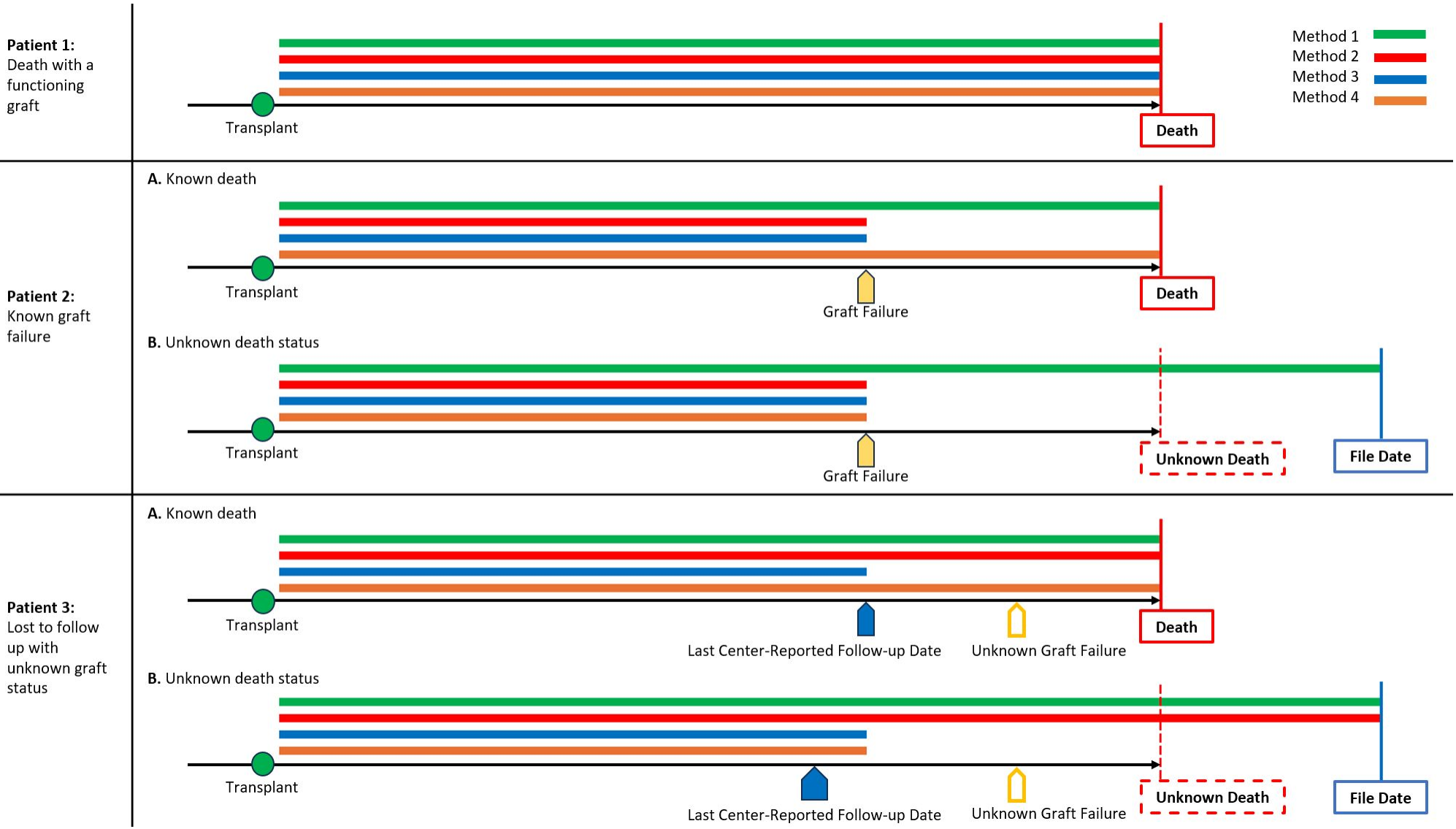

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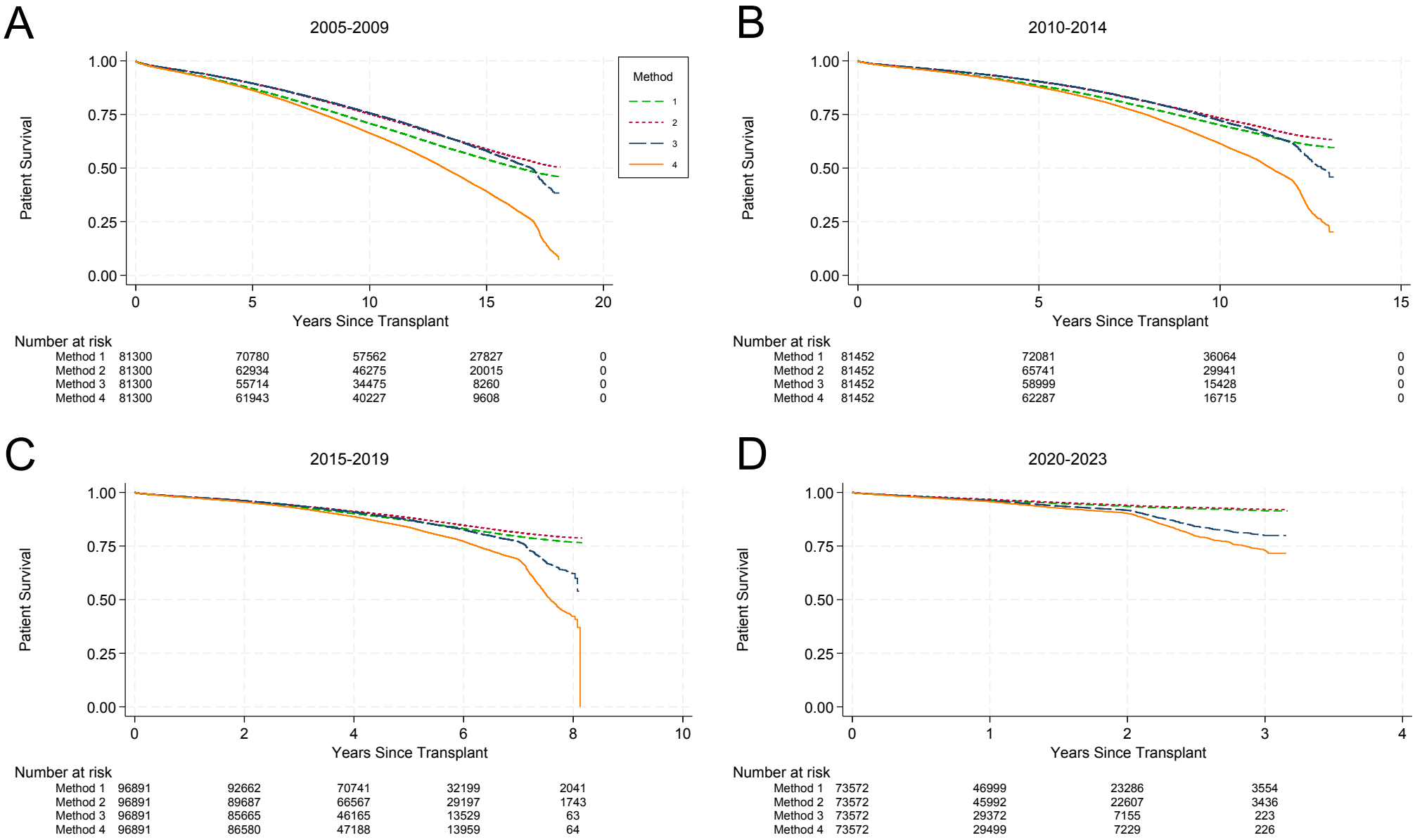

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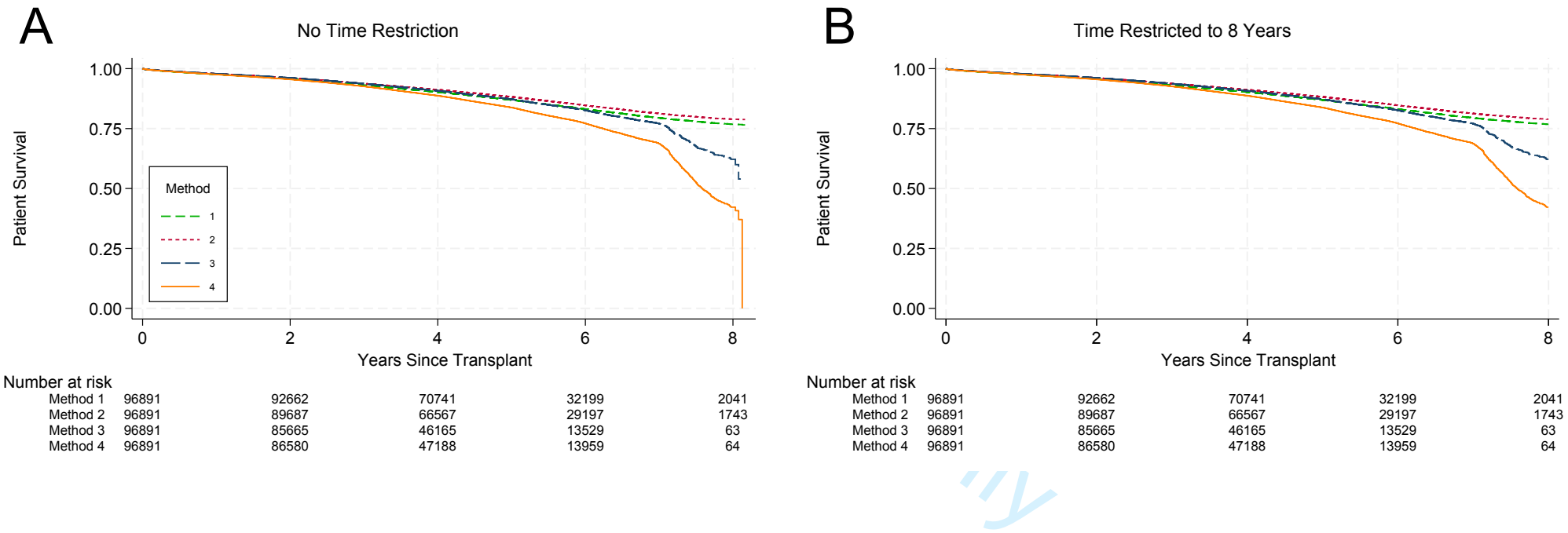

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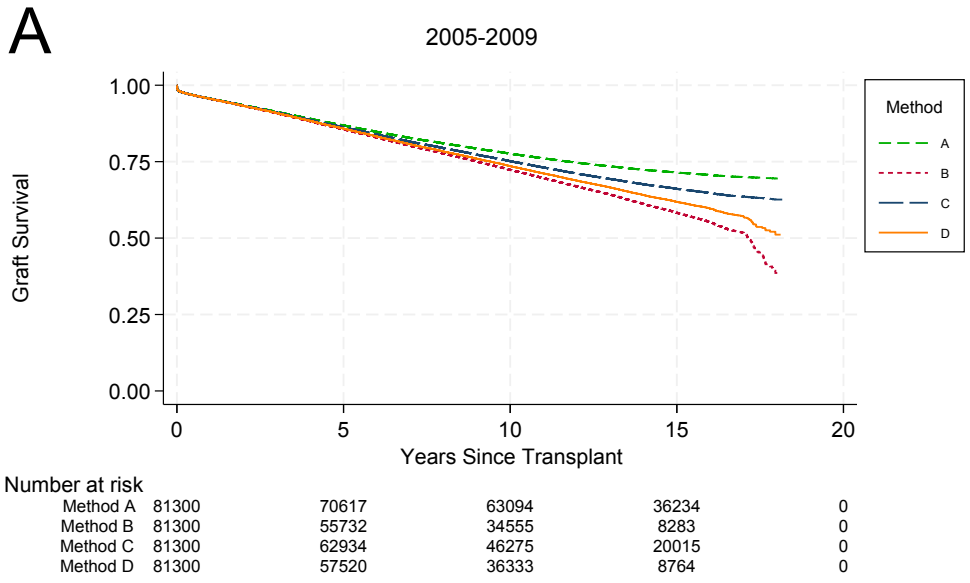

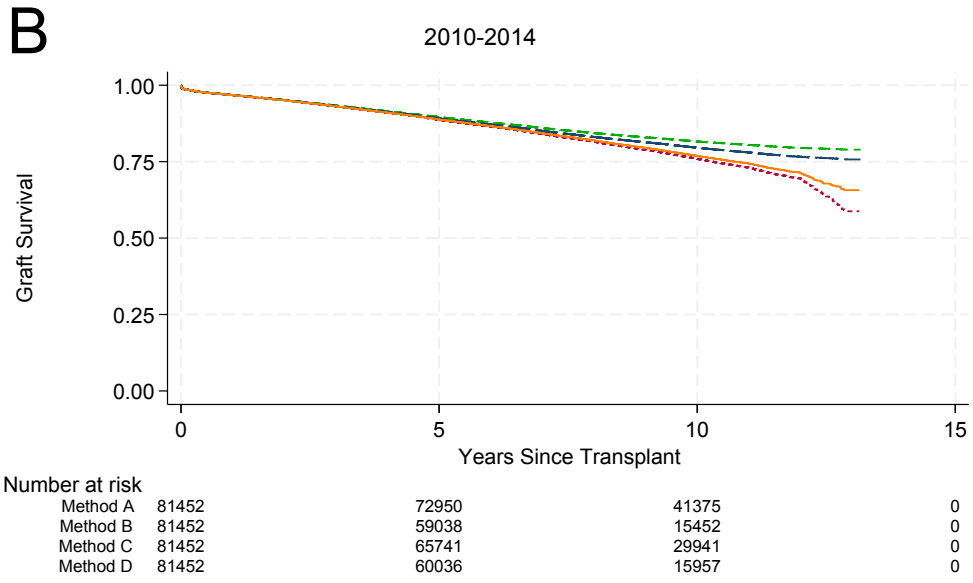

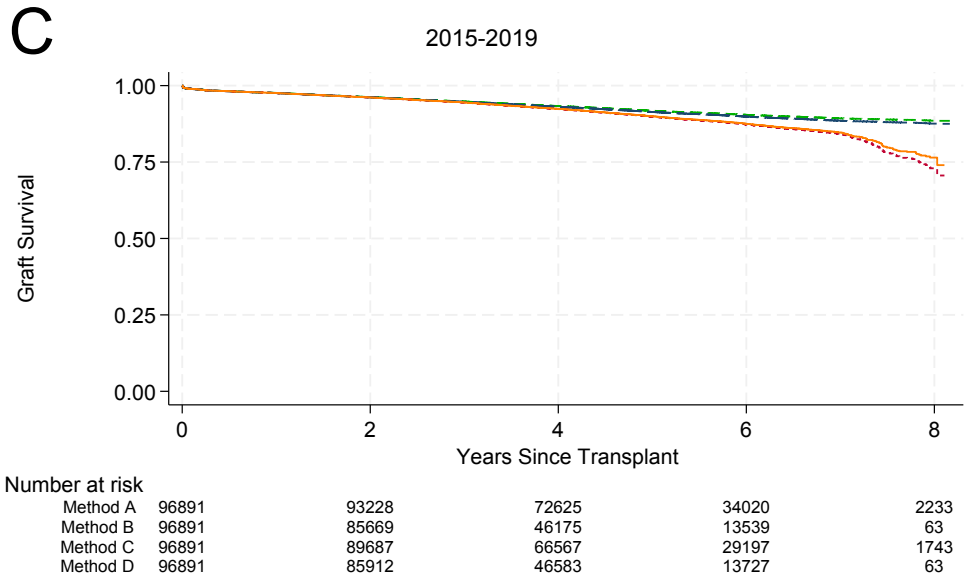

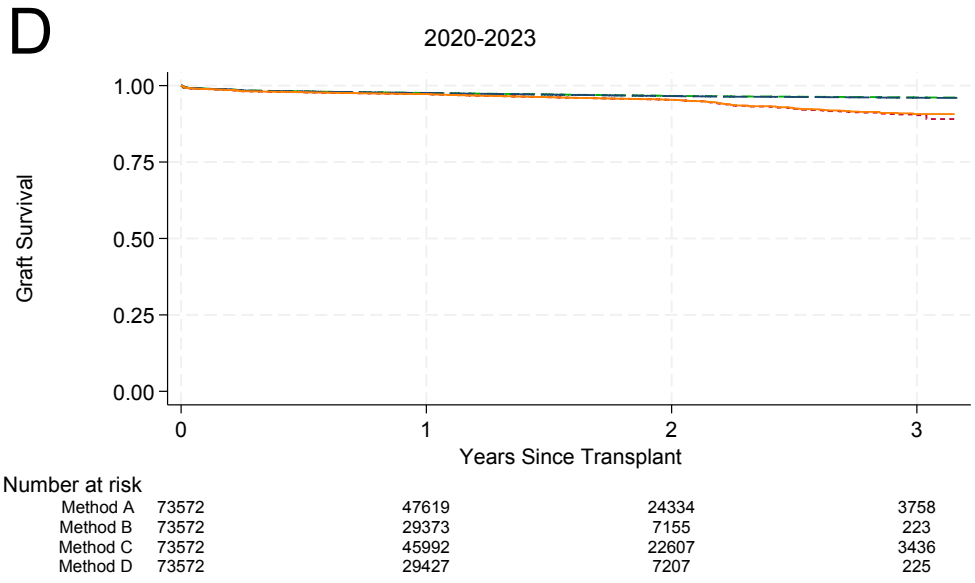

Supplemental Materials Table of Contents

Supplemental Figure 1. Differing distributions of calculated follow-up time using four different methods for counting events and censoring patient follow-up, for a cohort of patients receiving kidney transplants from 2015-2019 as documented in national registry data as of March 2023.

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