Can Redrawing Boundaries Save Lives? Evidence from a Reform of the Kidney Allocation System*

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Abstract

Determining eligibility for publicly regulated goods and services based on geographic boundaries faces tradeoffs between equity in access and administrative costs. A 2021 reform re-drew the geographic areas for matching donated kidneys to patients, shifting from arbitrary county-based boundaries to 250 nautical miles from the place of organ recovery. The reform lowered the kidney discard rate by 17 percent and reduced pre-transplant mortality. The estimated increase in additional transplants per year implies substantial improvements in life expectancy and quality of life, even after accounting for organ quality and baseline health characteristics of marginal transplant recipients.

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1 Introduction

Kidney transplant serves as an important treatment strategy for severe chronic kidney disease, widely recognized for extending life expectancy and enhancing quality of life for patients relative to dialysis (Wolfe et al. 1999; Held et al. 2016). Demand for donated kidneys is substantial. In recent years, over 100,000 Americans are on the waiting list for deceased donor kidney transplants.[1] Despite this high demand, more than 4,000 kidneys recovered for transplant are discarded each year, and a similar number of candidates die before a transplant, indicating scope for improving the allocation of donated kidneys.[2]

Similar to other publicly provided goods and services (Olson 1969), donated organs in the U.S. are distributed through a system that uses catchment areas.[3] Traditionally, donated organs have been distributed through a system that prioritizes transplant candidates registered at transplant centers within the same county group ("service area") as the donor hospital where these organs are recovered, with some minor exceptions. The system may contribute to substantial geographical variation in organ usage and transplant access, possibly because service areas were not designed to balance the availability and demand for donated organs across regions (Adler et al. 2016; King, Husain, and Mohan 2019).

In light of these concerns, discussions about modifying the boundaries have been ongoing since kidneys began to be allocated using Donor Service Areas (DSAs), which were originally established to facilitate organ recovery and emphasized procurement logistics over equalizing transplant access across locations (U.S. Congress 1984; National Kidney Foundation 2019). Using broader service areas can draw a larger pool of potential recipients, especially for hard-to-place organs, and can reduce geographic disparities in waiting time. Smaller service areas, by contrast, reduce transportation costs and shorten organ preservation time (cold ischemia

1. Deceased donor kidneys account for 77 percent of all kidney transplants in 2021 (Lentine et al. 2023).

2. In 2019, 4,163 donated kidneys intended for transplant were discarded, and 46 percent were not used due to unviability before they could be successfully matched to a recipient. In the same year, 7,703 candidates either died or became too sick for a transplant while waiting for an offer.

3. Local catchment areas are used to decide which households are eligible in the context of school assignment in public education (Cullen, Jacob, and Levitt 2005), vaccines (Pathak et al. 2024), and food assistance programs (Marcus and Yewell 2022), for instance.

time), which is associated with better post-transplant outcomes (Morris et al. 1999; Debout et al. 2015). While adopting broader service areas may improve kidney access by redistributing organs from high-access to low-access areas, such improvements could be undermined by behavioral changes such as reductions in organ donation, shifts in waitlist enrollment, and increased kidney discard rates in areas benefiting from improved access. Further, the distributional effects of such changes are unclear ex-ante.

With this in mind, this paper examines these trade-offs by exploiting a reform that removed county-group service areas for the first time since the deceased donor kidney allocation system was established in the U.S. Starting on March 15, 2021, county-group service areas were replaced by a 250 nautical mile radius around each donor hospital, expanding service areas by 289 percent. To study this, I create a novel dataset consisting of detailed administrative information on the universe of donated organs, transplant candidates, and hospitals involved in the organ allocation process.

I employ two empirical specifications to investigate the causal effects of the policy on the use of donated kidneys and the composition of transplant recipients. I deploy a regression discontinuity (RD) design comparing kidneys entering the allocation system on or after March 15, 2021, to those entering shortly before. My RD design leverages the fact that donated kidneys that entered the allocation system on or after March 15, 2021, were allocated based on the new service areas. Using data on organ offers made to potential kidney recipients, I identify the exact date each kidney enters the allocation system and use this as the running variable. Since donated kidneys remain viable for only a limited period (up to three days), each kidney enters the allocation system *only once* before being either transplanted or discarded. The identifying assumption is that factors other than the policy change evolve smoothly through the cut-off when donated kidneys enter the allocation system. I provide evidence against confounding changes in organ supply and composition and demonstrate that the reform redistributed access to kidneys.

The reform has an immediate effect on where donated kidneys are allocated and how they are utilized nationally. The likelihood that a kidney is matched to a transplant recipient within the original county-based service areas falls dramatically by 23.5 percentage points (43 percent). The reform improves the use of donated kidneys. The likelihood a donated kidney is discarded decreases by 3.8 percentage points (17 percent), driven by a 3.3 percentage point (27 percent) reduction in discards due to waiting too long.

My estimates remain closely aligned across various alternative specifications, including removing control variables, excluding weighting schemes, employing a local linear specification, using bias-corrected methods, and varying bandwidth choices. To examine potential threats to the identifying assumption, I conduct placebo tests using other donated organs, which are allocated through systems independent of kidney allocation policy. Reassuringly, I find no effects on allocation or use of non-kidney organs. Furthermore, a complementary analysis indicates that the drop in discard rates at the discontinuity persists throughout the study period. Taken together, the decline in discards likely translates into more kidney transplants after the reform.

To investigate potential mechanisms, I conduct various heterogeneity analyses using the main RD specification. The additional kidneys transplanted after the reform tend to be of lower quality and harder to place, yet they remain viable and offer a survival benefit relative to dialysis. These kidneys also tend to be recovered from areas where nearby transplant centers are predicted to have tighter kidney access after the reform.

Furthermore, the reform changes the composition of transplant recipients. The findings suggest that the reform increased equity. Marginal recipients after the reform are more likely to come from counties with socioeconomically marginalized populations and to have longer dialysis histories, groups that would otherwise face higher health risks from longer waiting times. These gains were accompanied by greater distances between donor hospitals and recipients, lengthening transport times and potentially raising the risk of graft failure.

I turn next to the health consequences of the reform for transplant candidates. Using the pre-reform data, I calculate predicted changes in access to kidneys by transplant center and use this as a proxy for treatment intensity to examine the effects on mortality of transplant candidates. I develop a difference-in-differences (DD) design that combines the timing of the reform with variation across transplant centers in predicted changes in kidney availability before and after the reform. Importantly, the administrative data include the exact locations of all transplant centers and donor hospitals, allowing me to assign each to their pre- and post-reform service areas.

For each additional kidney predicted to become available at a transplant center, the monthly number of pre-transplant deaths among transplant candidates decreases by 1.2 percent after the reform. The impact on pre-transplant deaths is not driven by changes in living donor kidney transplants or new waitlist registration, but by an increase in transplant recipients. In addition, there are no changes in the number of transplant candidates experiencing graft failure, returning to dialysis, or dying within 3 to 12 months after a kidney transplant. It is of note that the additional kidneys transplanted following the reform tend to be of lower quality and are stored for longer periods prior to transplantation, both of which are associated with a higher risk of graft failure.

Taken together, the findings indicate that the reform generated nontrivial gains. Based on the RD estimates, a back-of-the-envelope calculation suggests that the reform led to 807 additional transplants in the first year of implementation. This implies 4,035–5,649 additional life-years relative to dialysis, corresponding to $0.8–$1.1 billion in aggregate lifetime value. In addition to saving lives, increased use of donated kidneys generated $118 million in Medicare savings, given that the 1 percent of enrollees eligible due to permanent kidney failure account for 6 percent of Medicare spending. These savings reflect reduced dialysis use and the fact that Medicare eligibility under end-stage kidney disease ends three years after a transplant (USRDS 2023).

This paper makes several contributions to the literature. First, it builds on the literature examining how place-based determinants shape patient health, healthcare utilization, and the healthcare sector (Song et al. 2010; Doyle 2011; Chetty, Hendren, and Katz 2016; Finkelstein, Gentzkow, and Williams 2016; Deryugina and Molitor 2020; Finkelstein, Gentzkow, and Williams 2021; Agha, Ericson, and Zhao 2023; Molitor 2018; Dingel et al. 2023; Cutler et al. 2019; Frakes 2013). I provide causal evidence that geographic allocation boundaries generate inefficiencies in the use of healthcare resources and show that redesigning local catchment areas can mitigate them. By providing the first causal evidence on geographic boundaries in organ allocation, this paper extends prior work documenting disparities in transplant access under county-based service areas (Adler et al. 2016; Goldberg et al. 2015; Dickert-Conlin, Elder, and Teltser 2019).[4]

This paper is also the first to demonstrate that reallocating organ transplant access through service area redesign affects *both* the use of donated organs and waitlisted candidates, complementing studies examining how changes in allocation priorities tied to candidate characteristics affect health outcomes (Choi 2021; Lemont 2025).[5]

Second, this paper contributes to the literature on the design of organ allocation systems. Much of this literature lies within the market design tradition, including research on waitlist design for deceased donor transplants (Agarwal et al. 2021; Ashlagi, Monachou, and Nikzad 2024; Agarwal, Hodgson, and Somaini 2025; Sweat 2024) and kidney-exchange programs for living donor transplants (Roth, Sönmez, and Ünver 2004; Agarwal et al. 2019).[6] This paper provides empirical evidence that tighter access to deceased donor kidneys can increase organ utilization by improving matching within organs' limited viability window.

4. Complementary descriptive evidence from the medical literature includes analyses by Robinson, Booker, and Gauntt (2022) and Rausch, Niederhaus, and Forbes (2022), which compare donated kidneys recovered before and after the reform while applying different time spans to define the pre- and post-reform periods. These studies reach conflicting conclusions regarding changes in use of donated kidneys, underscoring the importance of accounting for time-varying confounding factors.

5. Subsequent work by McMichael (2025) examines related reforms across organ allocation systems by comparing transplant candidates before and after changes in service-area boundaries. In contrast, understanding the impacts of such reforms on candidates' health requires accounting for how they affect the use of donated organs, which in turn determines both the number and composition of transplant recipients. Furthermore, identifying health effects through cross-organ candidate comparisons is challenging because allocation systems differ substantially in patient populations, geographic coverage, and policy design.

6. Related papers examine determinants of organ supply in laboratory settings (Kessler and Roth 2012, 2014, 2025; Chan and Roth 2024; Chan, Gupta, and Xu 2025), in quasi-experimental contexts (Dickert-Conlin, Elder, and Moore 2011; Li, Hawley, and Schnier 2013; Schnier et al. 2018), as well as determinants of demand (Dickert-Conlin, Elder, and Teltser 2019; Dickert-Conlin et al. 2024; Ng 2024).

More broadly, this paper builds on prior research exploring policy alternatives that help individuals by effectively increasing service area boundaries. Examples include busing programs for students (Angrist et al. 2022; Setren 2024), expanding networks of health care providers in public health insurance (Rose et al. 2021; Russo 2023), and travel support for transplant candidates (Ata, Skaro, and Tayur 2017) and living organ donors (Fernandez, Howard, and Kroese 2013). This paper contributes to this literature by demonstrating that redistributing kidney access through service area redesign can improve both the efficiency and equity of the allocation system, with relatively low implementation costs.

2 Institutional Background

2.1 Deceased Donor Kidneys

Organs may be procured for transplant from either living or deceased individuals ("donors"). While those from living donors are generally given to relatives or spouses[7], deceased donor organs enter a centralized allocation system and are matched with an anonymous recipient. This study focuses exclusively on organs from deceased donors, which account for 77 percent of all transplants in the U.S. in 2021 (Lentine et al. 2023).

Individuals can elect to have their organs donated after death by registering on their state's donor registry via the Department of Motor Vehicles, enrolling on the national Donate Life registry online, and including organ donation preferences in their will.[8] A deceased patient can also be put into the donor registry if the next of kin agrees to donate the organs.

When an organ donor is declared deceased in a hospital (henceforth, "donor hospital"), physicians first conduct a medical evaluation to determine whether the donated organs are suitable for transplant.[9] Multiple organs can be recovered from a single deceased donor and

7. Between January 2010 and June 2015, 3.1 percent of all living kidney donations were contributed by "non-directed donors" who generously donated their kidneys to strangers (OPTN 2015).

8. Age and definition of eligible death may vary by state and local laws. For instance, individuals below 18 cannot be a registered organ donor upon death nor a living donor unless state or local law allows them to do so.

9. Appendix Figure A.1a is a map of the locations of donor hospitals recovered at least one deceased donor kidney for transplant between January 2019 to February 2021.

each organ type has its own allocation system. This study focuses on transplants using kidneys, which are the most common deceased donor organ transplant in U.S., accounting for 19,636 of 36,421 (54 percent) transplant cases in 2022 (OPTN 2023).

2.2 Transplant Candidates

In 2021, chronic kidney disease affected one in seven Americans, making it the ninth-leading cause of death (Curtin, Tejada-Vera, and Bastian 2024). Patients with serious renal disease may be recommended for a transplant by their physicians. End-stage renal disease (ESRD) is characterized by advanced-stage, chronic kidney failure that requires regular dialysis or a kidney transplant for patient survival (CDC 2023).

Compared with remaining on dialysis, receiving a kidney transplant generally improves survival and quality of life and can reduce overall healthcare costs.[10] Quality of life for dialysis patients increases 44 percent after a kidney transplant (Whiting 2000), while the annual cost of dialysis and related treatments is $121,000 per patient (Held et al. 2016). To address the high medical costs linked with ESRD treatment, Medicare eligibility is extended to ESRD patients under 65.[11]

To register their name on the waitlist for a kidney transplant, candidates must obtain a referral and then select a transplant center.[12] Since multiple organs can be recovered from a single deceased donor, transplant centers often participate in multiple organ waitlist programs. The types of organ transplant programs offered may differ across county-based

10. Transplant recipients can enjoy an extra 7 years of life and a better quality of life compared to those on dialysis, which translates to a lifetime value of $1.3 million per recipient (Held et al. 2016). Patients undergoing dialysis face heightened health risks, including a high rate of hospitalizations and a one-year mortality rate of 33.8% within the first year of treatment (Kolbrink et al. 2023).

11. Medicare coverage for individuals with ESRD who are under 65 starts either 1) after the third month of dialysis treatment or 2) upon admission to a Medicare-certified hospital for a kidney transplant or necessary pre-transplant healthcare, as long as the transplant occurs within the following two months. For ESRD patients with group health plans from their own or spouses' current employer, Medicare serves as a secondary payer that only covers costs that the group health plan does not cover due to coverage limits. After the 30th month of eligibility, Medicare becomes the primary payer of benefits.

12. Appendix Figure A.1b presents a map of 218 transplant centers that performed at least one deceased donor kidney transplant from January 2019 to February 2021.

service areas, but kidney is the only organ program available in *every* service area.[13] Once a potential transplant candidate submits their application to a transplant center, a patient assessment is conducted. This assessment involves gathering relevant information for the transplant process. For instance, the estimated post transplant survival (EPTS) score is a measure of the expected post-transplant survival of candidates calculated based on the following four factors: candidate's age, duration on dialysis in years, current diabetes status, and prior organ transplant. Dialysis duration is a key factor for kidney transplant priority (Friedewald et al. 2013), as waiting time calculations have included dialysis initiation date prior to waitlist registration since December 2014 (OPTN 2014).[14]

Once a candidate is registered in the system, they may continue to receive dialysis or any other necessary treatments they received prior to joining the waitlist. Transplant candidates have the option to register their name at different transplant centers, a practice known as multi-listing, although this is uncommon.[15] However, it is important to note that registering for more than two transplant centers within the same service area is not permitted.

Patients will then wait for a suitable transplant offer to become available. Upon receiving a transplant, candidates are recommended to attend follow-up visits and adhere to the prescribed immunosuppressant medications to ensure transplant success.

2.3 Allocation System for Deceased Donor Kidneys

There are no other channels for obtaining deceased donor organs outside of the allocation system in the U.S. Two major pieces of legislation–the Uniform Anatomical Gift Act of 1968 (UAGA) and the National Organ Transplantation Act of 1984 (NOTA)–created much of the regulations governing the organ allocation system that exist in the country today. The UAGA specifies the circumstances through which an individual can become an organ donor,

13. Among centers providing deceased donor kidney transplants, 30% also offered lung transplants, 55% offered heart transplants, and 60% offered liver transplants in 2021.

14. As the life expectancy for transplant candidates on dialysis is 12.3 years (Held et al. 2016), those who undergo an extended period of dialysis face not only a shorter expected life span but an increased risk of being removed from the transplant waitlist because of factors such as mortality or other medical complications.

15. This occurs among 4 percent of candidates per transplant center (Ardekani and Orlowski 2010).

either through their own choices or post-mortem by their relatives. The NOTA prohibited commercial transactions of human organs nationwide and established the Organ Procurement and Transplantation Network (OPTN). OPTN administers organ recovery, maintains a national organ matching registry, and develops organ allocation policies.

In addition, the NOTA introduced the concept of a "service area," which is a geographical boundary within which donor hospitals are matched to transplant centers and later referred to as donor service area (DSA). DSAs consist of sets of counties defined to ensure an adequate supply of organs to transplant candidates (U.S. Congress 1984). There were 57 DSAs across the nation in 2021 (Figure 1).

If the donor's organ is eligible for transplant, the donor hospital notifies the local Organ Procurement Organization (OPO). The OPO oversees the allocation of the organs recovered within the DSA. Next, the donated kidney is evaluated for quality based on donor health and demographic information. KDPI is calculated using the following ten donor characteristics to evaluate the expected life span of kidneys: age, height, weight, ethnicity, hypertension history, diabetes, cerebrovascular accident death, serum creatinine, Hepatitis C virus status, and donation after circulatory death. A higher index means a kidney has a lower expected likelihood of graft failure compared to other kidneys recovered in the last year. The allocation system classifies them into four subgroups: (i) 0–20%, (ii) 21–34%, (iii) 35–85%, and (iv) 86–100%.

Finally, a computer system called DonorNet generates an ordered list of transplant candidates who are eligible for the offer, restricting the list to candidates with compatible blood types.[16] Candidates are also assessed on the similarity of tissue typing with a prospective donor based on HLA-ABDR typing. Fewer HLA mismatches are linked to a decreased likelihood of triggering an immune response and better post-transplant outcomes (Held et al. 1994;

16. Kidneys from donors with blood types of AB, B, and O are offered to transplant candidates with the same blood types. Exceptions include (i) kidneys with blood types O or B can be transplanted to candidates with different blood types for offers with zero HLA mismatch and (ii) kidneys with blood type A are offered to transplant candidates with blood type AB.

Opelz and Döhler 2012).[17] Priority is given to those who are registered at a transplant center within the same service area as the donor hospital, except for cases in which candidates have the same tissue typing as the donor.[18] That is, candidates in the same DSA as the donor hospital are prioritized for a kidney offer over those enrolled in transplant centers outside the DSA but within the same OPTN region and those who are outside the OPTN region (that is, elsewhere in the nation).[19]

After receiving an offer, candidates are given a specific amount of time to accept or reject the offer, given that kidneys lose viability within 72 hours after the donor's death. Using a deceased donor kidney recovered outside the recipient's DSA typically raises organ acquisition costs by about $4,376 per kidney, relative to one recovered within the same DSA (Held et al. 2021).

Two commonly used measures of allocation efficiency are the non-utilization rate and pre-transplant mortality. First, to evaluate the use of donated kidneys, non-utilization rate (henceforth, "discard rate") is the share of donated organs recovered for transplant but ultimately discarded (Israni et al. 2020; OPTN 2023). Second, pre-transplant mortality is the number of transplant candidates who pass away prior to getting a kidney transplant.

2.4 Donor Service Areas and the 2021 Reform

Although the DSA boundaries were originally defined to ensure equal access to kidney transplant candidates, in recent decades, supply and demand for deceased donor kidney trans-

17. The number of mismatches ranges from zero ("zero mismatch") to six, and a lower number indicates that donors and transplant recipients share a similar tissue type.

18. Candidates with "zero mismatch" with the donor are prioritized over candidates within the same DSA as the donor hospital, regardless of the location of their transplant centers.

19. Each OPTN region consists of a group of DSAs. There have been 11 OPTN regions in the U.S. since 1984. Appendix Figure A.2 presents the map of OPTN regions in the country. Appendix Table A.1 provides the kidney allocation point calculation used to rank each candidate within each candidate category. Table 1 of Israni et al. (2014) presents how candidates are ranked in the national waitlist based on their health and demographic characteristics when kidney(s) becomes available from a deceased donor. In Appendix Table A.2, calculation of the priority points considers the distance between donor hospital and transplant center (0-2 points) starting from March 15, 2021. If candidates have same points within the category, they are ranked based on the duration of registration. Consistent with prior studies demonstrating dialysis duration as a key determinant of transplant priority (e.g., Friedewald et al. 2013), and given an average distance of 139 nautical miles within a 250 nautical mile radius, the findings in Section 5.2.1 suggest that the points allocated for distance plays a limited role in transplant priority.

plants vary greatly across different geographical areas (Adler et al. 2016). Figure 2 illustrates geographical variation in the kidney discard rate (Panel A) and access to kidney transplants (Panel B) in the years prior to the reform.

A new policy, often referred to as KAS-250, was introduced on March 15, 2021, to address concerns regarding efficiency and geographic equity in kidney transplant access. Under this reform, the allocation of deceased donor kidneys is based on the proximity between donor hospitals and transplant candidates rather than county-based service areas.[20] Candidates listed at transplant centers located within 250 nautical miles (i.e., 287.695 miles) from the donor hospital are prioritized for kidney offers, regardless of whether they are located within the same DSA as the donor hospital.[21] The average size of a proximity-based service area for a donor hospital is 260,024.6 square miles, which is 3.9 times larger than the average county-based service area of 66,809.6 square miles.[22]

The timing of implementation was hard to predict because the policy was originally scheduled to take effect on December 15, 2020, but was pushed back due to concerns about the increased role of socioeconomic factors on transplant access and the COVID-19 pandemic. The OPTN announced in late February that the policy would be implemented on March 15, 2021 barring any further court intervention. The OPTN website posted an announcement on March 6, 2021, that the policy would go into effect on March 15, 2021.

While the change in geographic boundaries was the main policy change, three additional policy measures were introduced on March 15, 2021. These policies change the priority ranking of three rare types of candidates that comprise a small share of transplant recipients

20. Note that the county-based service area is still used even after KAS-250 to define which counties each OPO oversees. The reform also took place in the pancreas allocation system. However, the size of the system is considerably smaller in scale compared to that of kidneys, with 19,762 kidney transplants in contrast to just 964 pancreas transplants in 2021.

21. The only exception was kidneys recovered from donor hospitals in Alaska (which account for less than 0.3% of kidneys recovered for transplant from 2021–2022) for which the circle is centered around Seattle-Tacoma International Airport. This measure ensures that kidneys recovered in Alaska can find suitable recipients promptly, given that there are no transplant centers located within the state.

22. 2021 Census U.S. Gazetteer Files is used to calculate total area in square miles for each county. I merge this to a list of counties with their OPO affiliation information to calculate the total area size in square miles for each donor service area that existed as of February 2021. After implementation of the reform, the average service area size increased to 260,024.6 square miles ($= \pi \times (287.695 \text{ miles})^2$ or $\pi \times (250 \text{ nm})^2$).

(<2% in both pre- and post-policy period) and they that had been prioritized over most other candidates prior to the reform (Israni et al. 2014). These categories are: (1) candidates with exhausted and imminent failure of access to dialysis ("medical urgency")[23]; (2) candidates who are prior living donors; and (3) pediatric candidates with kidney offers with non-zero HLA mismatch and KDPI below 35%. In robustness exercises, I show that my results are highly similar in a subsample of candidates whose ranking would not have been affected.[24]

3 Data

I employ the restricted Scientific Registry of Transplant Recipients (SRTR) for the analysis. The SRTR dataset contains information on the universe of deceased and living transplant donors, transplant candidates, and transplant recipients in the U.S. I combine detailed donor and candidate demographics and clinical characteristics, comprehensive organ offer histories for each kidney, precise geographic identifiers for donor hospitals and transplant centers, and candidate mortality from Social Security records. Using these data, I construct two analysis samples: (i) a kidney level sample of all donated kidneys spanning January 2019–May 2023 and (ii) a monthly transplant center panel covering the same period.

3.1 Deceased Donor Kidney Sample

I construct a dataset covering all kidneys offered to transplant recipients from January 2019 to May 2023. Each observation is a donated kidney. To create these data, I first link together four datasets on donated kidneys using a unique ID for the donor. The first includes donor health measures, which are used to assess kidney quality. The second, called the Potential Transplant Recipient (PTR) dataset, is offer-level data for kidneys recovered for transplant. The PTR data provide the date each organ offer was generated, which I use to identify when each kidney first entered the allocation system. The data also include information on any

23. Transplant candidates ever reported with medical urgency are rare — only 14 registrations were ever waiting in medical urgency status and 4 received a deceased donor transplant between the policy implementation date and June 30, 2021 (Robinson, Booker, and Gauntt 2022).

24. This aligns with Rausch, Niederhaus, and Forbes (2022), which discusses that the reform is unlikely associated with changes in access to kidney transplants for pediatric candidates.

subsequent offers and the results of each offer (i.e., whether it was accepted or refused and the reasons for any refusals).

Third, I use data on the outcome ("disposition") for each kidney, including whether it was ultimately transplanted or discarded and the reasons for these outcomes. In particular, kidneys may be discarded for three reasons: (a) waited too long on the waitlist, (b) low quality, or (c) other factors.[25]

Fourth, I link the donor hospital that oversaw organ recovery with detailed geographic information (GPS coordinates and OPO affiliation). As the distance between donor hospital and transplant center determines allocation after the reform, I calculate the distance for all possible pairs of donor hospitals and transplant centers using their GPS coordinates.

Finally, for the subset of kidneys that are transplanted, I merge in detailed information on each transplant recipient. I use this information to shed light on changes in access to kidney transplants across subgroups in response to the policy change. Specifically, the information includes demographics (age, race, ethnicity, insurance coverage, county of residence at transplant) and health conditions (history of dialysis, diabetes, prior organ transplant).

To examine whether the reform changes access to kidneys among sociodemographic groups, I merge recipients' county of residence with the CDC Social Vulnerability Index (SVI) (CDC 2020). SVI is a composite measure of social determinants of health that ranks counties based on 15 sociodemographic factors.[26] It is used to assess the area's relative vulnerability to public health emergencies and is known to be associated with disparities in access to health care and health outcomes among residents (Khazanchi et al. 2020; Phelos, Deeb, and Brown 2021; Bauer et al. 2022). I use the 2020 SVI data as it provides the most recent information available prior to the 2021 reform.

25. Discard reasons classified as "waited too long on the waitlist" include being too old on the pump, too old on ice, warm ischemic time being too long, and no recipient located, resulting in the list being exhausted. Discard reason classified as "low quality" include donor medical history, positive CMV, positive HIV, positive Hepatitis, biopsy findings, diseased organ, poor organ function, organ trauma, anatomical abnormalities, and inadequate urine output.

26. These factors include poverty rate, unemployment rate, educational attainment, elderly and child population, disability status, single-parent households, ethnic diversity, English proficiency, housing type, and vehicle ownership. CDC obtains these variables from the American Community Survey.

My analytic sample includes adult deceased donors whose kidneys were recovered for transplant with non-missing information for donor characteristics, including information used to calculate KDPI score for each kidney.[27] The sample is further limited to deceased donor kidneys recovered from donor hospitals outside Alaska and recovered in DSAs with no change in OPO affiliation throughout the sample period.[28] The sample includes 23,528 kidneys recovered for transplant within 199 days of the policy change from 1,747 donor hospitals.

In Table 1, Panels A-B present descriptive statistics for the kidney-level data. In Panel A, 23 percent of kidneys recovered for transplant are ultimately discarded. Of kidneys that were discarded, 60.8 percent were not used for transplant as they waited too long on the waitlist, 28.4 percent of them were discarded due to organ or donor health concerns, and 10.3 percent were discarded due to other reasons. 16.3 percent of kidneys with KDPI above 85%, which are often considered marginal quality organs but remain suitable for transplant. Panel B provides descriptive statistics of transplant recipients. Average distance between donor hospital and transplant recipient is 200.3 nautical miles and the average wait-time per transplant recipient is 1408.5 days.

3.2 Transplant Center Sample

My second analysis dataset is a monthly panel of transplant centers that includes measures of health outcomes for candidates registered at a given center, including those that do not receive a transplant. To create this sample, I use microdata on candidates that include health conditions (e.g., history of dialysis, diabetes, previous transplant records), transplant registration records, and transplant records (e.g., date of transplant, type of donor, characteristics of transplanted kidney). In addition, the data provide the exact date of death of all transplant candidates from the Social Security Death Master File.

27. Categories of deceased donor organs not recovered are (a) authorization was not requested, (b) authorization not obtained, (c) not recovered, (d) recovered not for transplant (e.g., education/research purposes). Donated kidneys with one of these disposition decision codes rarely enter the allocation system– a total of 248 non-recovered kidneys appeared in the PTR dataset within 26 weeks of the policy implementation date.

28. Two OPOs, LifeChoice Donor Services and New England Donor Bank, merged on January 1, 2021 (Source: https://neds.org/neds-successfully-merged-opos/).

My sample consists of transplant centers with at least one active transplant candidate prior to the policy change. To proxy for the size of each center, I calculate the average monthly waitlist enrollment during the pre-period. I exclude transplant centers located in DSAs that experienced any change in OPO affiliation during the sample period. Panel C of Table 1 reports descriptive statistics for transplant centers. The sample covers 204 transplant centers, with an average of 450 waitlisted candidates prior to the reform.

I consider two measures of candidate mortality: deaths while waiting for a transplant and deaths within five years of waitlist registration, regardless of whether the candidate receives a transplant. The first captures deaths that may have been avoidable with a kidney transplant, while the second captures overall mortality over a five year horizon, including deaths after transplant. For each outcome, I calculate total death counts by transplant center and month. To examine whether the policy change affected candidates' choice of transplant centers, I calculate the monthly number of newly added transplant candidates per transplant center.

Finally, I consider a few outcomes that are observed only for the subset of candidates that receive a transplant. These include whether the candidate experienced death or graft failure, or went back to dialysis within 3, 6, 9, and 12 months after their transplant.

3.2.1 Treatment Intensity

While all transplant candidates are subject to the policy change, the extent of its impact varies across transplant centers depending on changes in the number of available kidneys. I develop a measure of the *predicted* change in available deceased donor kidneys at each transplant center, based on *pre-reform* data on kidney supply and demand at that center. This measure serves as a proxy for treatment intensity in the difference-in-differences approach described below.

Predicted changes depend on the number of donor hospitals serving a transplant center and the size of competing centers drawing from the same donor pool. For example, consider a pre-reform DSA containing one donor hospital and one transplant center. If several additional donor hospitals lie within 250 nautical miles of that center but outside its DSA, the reform would increase its predicted access to kidneys, holding fixed the set of centers competing for those organs.

In Eq. 1, $\Delta Access_h$ denotes the predicted change in deceased donor kidney availability for transplant center h:

$$\underbrace{\Delta Access_h}_{\substack{\text{predicted change}\\ \text{in kidney availability}\\ \text{at transplant center } h}} = \underbrace{\sum_{d \in circle(h)} k_d \times \frac{n_h}{n_{circle(d)}}}_{\substack{\textit{predicted} \text{ kidney availability}\\ \text{within } r \text{ nautical miles (post-reform)}}} - \underbrace{\sum_{d \in DSA(h)} k_d \times \frac{n_h}{n_{DSA(d)}}}_{\substack{\text{kidney availability}\\ \text{within DSA (pre-reform)}}} \tag{1}$$

where $DSA(h)$ denotes the set of donor hospitals located in the same DSA as transplant center h. $circle(h)$ denotes the set of donor hospitals located within r nautical miles of h, with r set to 250 following the reform. k_d denotes the average monthly number of kidneys recovered at donor hospital d during the pre-reform period. n_h is the average monthly waitlist enrollment at transplant center h prior to the reform. $n_{DSA(d)}$ and $n_{circle(d)}$ denote the total number of waitlisted candidates at transplant centers within donor hospital d's DSA and within r nautical miles of donor hospital d, respectively.[29] Intuitively, the measure reallocates pre-reform kidney supply across transplant centers according to their share of waitlisted candidates under the pre- and post-reform geographic rules. Appendix Figure A.3 provides a numerical illustration.

Of 204 transplant centers included in the sample, 48.5 percent are predicted to see higher kidney availability following the reform (Panel C of Table 1).[30] To examine whether the predicted treatment intensity is a strong proxy for observed changes in access to transplants,

29. Greater geographic overlap under the post-reform rules does not necessarily imply higher predicted access. Because allocation prioritizes waiting time, donor hospitals may reroute kidneys toward candidates with longer waiting times at nearby centers that were previously outside the DSA. Consistent with this mechanism, the RD estimates show that post-reform transplants disproportionately accrue to candidates with longer waiting times and to centers newly eligible under the 250 nautical mile rule.

30. Appendix Figure A.6 presents a histogram of $\Delta Access_h$, and Appendix Figure A.7 illustrates the average treatment intensity mapped by transplant center. Each dot represents a transplant center, with the size indicating the absolute value of treatment intensity to visualize changes in predicted kidney access as a response to the policy change.

I calculate the correlation between the predicted and actual changes in the monthly number of kidneys per transplant center before and after the reform. I provide suggestive evidence that the predicted treatment intensity is a good proxy for the actual changes: transplant centers expected to gain access subsequently exhibit increases in kidney supply, while those projected to face reduced access show declines in kidney availability (Appendix Figure A.4). In addition, centers with lower pre-reform kidney availability are those predicted to see improved access after the reform, indicating that the reform may mitigate disparities in access to kidneys by reallocating donated kidneys to places with lower access during the pre-reform period (Appendix Figure A.5).

Furthermore, I use Eq. 1 to examine how use of kidneys depends on overall changes in access to kidneys among nearby transplant centers. For instance, the decrease in the discard rate at the cut-off is likely to come from kidneys recovered from donor hospitals whose nearby transplant centers are predicted to experience lowered access to kidneys after the policy change. In Eq. 2, $\overline{\Delta Access}_d$ is calculated as the average treatment intensity measure across transplant centers located within donor hospital d's pre-reform service area, weighted by their relative size to all transplant centers in that service area. $H(d)$ denotes the set of transplant centers in donor hospital d's pre-reform DSA, and $n_{H(d)} = \sum_{h \in H(d)} n_h$ denotes total pre-reform waitlist enrollment across these centers.

$$\overline{\Delta Access}_d = \sum_{h \in H(d)} \Delta Access_h \times \frac{n_h}{n_{H(d)}} \tag{2}$$

4 Empirical Strategies

My empirical strategies are (1) a regression discontinuity (RD) design with the initial offer date as a running variable and (2) a difference-in-differences (DD) design exploiting variation in the timing of the reform and treatment intensity across transplant centers.[31] I use the kidney-level data to estimate the RD design and the transplant-center dataset for the DD design.

4.1 Regression Discontinuity Design

My RD design exploits the sharp timing of the reform with respect to donated kidneys first entering the allocation system. I develop this study design by leveraging the fact that donated kidneys have a limited viability window and can only enter the allocation system once before being either transplanted or discarded. Using this design, I investigate how the use of kidneys and the composition of transplant recipients respond when the service areas used for kidney allocation were changed from county-based geographical boundaries to broader circles. The sample includes deceased donor kidneys recovered for transplant and first offered to transplant candidates within 199 days of the policy implementation date, March 15, 2021.[32] Eq. 3 presents the estimating equation for my RD specification:

$$Y_i = \alpha + \beta \mathbf{1}[\mathrm{D}_i \geq c] + \mathbf{1}[\mathrm{D}_i \geq c] \cdot f(\mathrm{D}_i - c) + f(\mathrm{D}_i - c) + X_i \rho + \epsilon_i \tag{3}$$

where $f(\cdot)$ is a control function based on the initial offer date. D_i denotes the initial date on which deceased donor kidney i first appeared in the allocation system. $1[\mathrm{D}_i \geq c]$ is an indicator for donated kidneys offered to transplant candidates for the first time on or after March 15, 2021, which serves as the cut-off value c. X_i denotes control variables, which include a set of kidney characteristics (gender, race/ethnicity, blood type of deceased donors, and donation after cardiac death). Triangular kernels are used to linearly weight each observation based on distance from the cut-off. Standard errors are clustered at the level of initial offer date.

31. 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.

32. The data-driven optimal bandwidth for the main outcome variable an indicator of whether kidneys were discarded calculated following Calonico, Cattaneo, and Titiunik (2014) is 199 days.

The identifying assumption is that the assignment of kidneys into the allocation system on either side of the cut-off is as good as random so that outcomes would have evolved smoothly in the absence of the policy change (Lee 2008). Under this assumption, β captures the effects on the use of deceased donor kidneys and the composition of transplant recipients.

I employ two tests to assess the identifying assumption. First, I check the smoothness of the distribution of the initial offer date using the McCrary density test. This test helps examine possible manipulation or deliberate delay in registering certain kidneys in the allocation system under the new system. The McCrary density test does not reject the null hypothesis that the density of my running variable is smooth around the cut-off point (p-value=0.172).[33]

Second, I examine whether donated kidneys on either side of the cut-off have similar observable characteristics. Table 2 and Appendix Tables A.3-A.4 provide the RD estimates when Eq. 3 is estimated by setting each of the following kidney characteristics as the dependent variable: a) donor demographics, b) donor health conditions, c) donor consent mechanisms, and d) donor circumstances of death. There are no significant systematic differences in these observable characteristics around the cut-off, supporting the validity of my RD design.

I check the sensitivity of the findings by performing numerous robustness exercises. First, I estimate Eq. 3 using a number of alternatives to my baseline specification: (i) excluding triangular weights, (ii) excluding X_i, (iii) setting $f(\cdot)$ as a local linear functional form, (iv) using bias-corrected method from (Calonico et al. 2019), and (v) using alternative bandwidth choices. Second, I estimate Eq. 3 on placebo samples consisting of livers, lungs, and hearts, which are recovered from deceased donors whose kidneys are also included in the kidney level dataset. Because allocation systems operate separately by organ type, the reform should not affect the allocation of these non-kidney organs.

4.2 Difference-in-Differences Design

Next, I use the monthly panel of transplant centers to examine how the reform affected access to transplants and health outcomes of transplant candidates. With these data, I develop

33. Appendix Figure A.8 presents the density of deceased donor kidneys based on their initial offer date.

a DD design leveraging within-transplant center variation in predicted access to deceased donor kidney transplants over time. A fixed-effect Poisson model is used to estimate Eq. 4 to address the existence of zero pre-transplant deaths in certain transplant centers during specific months:

$$E[Y_{hm}|X] = \exp(\gamma Post_m \times \Delta Access_h + \theta_h + \lambda_m) \tag{4}$$

where Y_{hm} denotes an outcome for transplant center h in calendar month m. $Post_m$ is an indicator for calendar months on or after March 2021. $\Delta Access_h$ is the predicted change in the available deceased donor kidneys for h, as defined in Eq. 1. θ_h is a transplant center fixed effect to take unobserved time-invariant transplant center characteristics into account. λ_m is a calendar-month fixed effect to capture aggregate time trends affecting all transplant centers in the U.S. I control for the natural log of the average number of candidates on the waitlist during the pre-period for each transplant center and constrain the coefficient to be one. γ is the key parameter of interest, capturing the effect of changing the service area boundaries on transplant center outcomes. Standard errors are clustered by transplant center.

To interpret γ as the causal effect of the reform, transplant centers predicted with higher treatment intensity would have had to have otherwise evolved on the same trajectory as those with lower treatment intensity during the post-period (Callaway, Goodman-Bacon, and Sant'Anna 2021). I estimate the following event study specification to test for differential pre-trends in outcomes across transplant centers and to illustrate dynamic treatment effects:

$$E[Y_{hm}|X] = \exp\left(\sum_{\tau=-15(\neq-1)}^{14} \delta_\tau \, 1(t=\tau) \times \Delta Access_h + \theta_h + \lambda_t\right) \tag{5}$$

where event time τ is the difference in months between a given calendar month t and March 2021. For pre-transplant mortality, the event time is defined by date of death. For adverse post-transplant outcomes, the event time is measured from the transplant date to capture health events occurring within a specific follow-up period. Under the identifying assumption,

δ_τ captures changes in transplant center outcomes at τ, relative to February 2021 ($\tau = -1$).

5 Results

I estimate the RD specification using the kidney-level data to study the effect of the reform to service areas on the use of deceased donor kidneys and the characteristics of transplant recipients. Then, I conduct the DD analysis using the transplant-center-level data to examine the impact on transplant candidates' health outcomes.

5.1 Effects on Use of Donated Kidneys

I begin by assessing whether the reform shifts the geographic allocation of kidneys. In particular, I test whether kidneys become less likely to be transplanted at centers in the same county based service area as the donor hospital. Figure 3 plots the share of kidneys transplanted within the DSA by initial offer date. Table 3 reports estimates and standard errors corresponding to Y_i from Eq. 3. In Column (1), the likelihood that a kidney is transplanted within the DSA drops by 23.5 percentage points (43 percent) at the cut-off, suggesting that the reform has an immediate and important effect on where kidneys are allocated.[34]

Next, I explore how the policy change affects the use of these kidneys. Figure 4a plots the overall discard rate against the initial offer date. The likelihood of kidneys being discarded drops by 3.8 percentage points (17 percent; Column (2)) at the cut-off. In particular, the likelihood of kidneys being discarded because they remain on the waitlist too long discontinuously drops by 3.3 percentage points (27 percent; Column (3)). In contrast, there are no discontinuous changes in the likelihood of kidneys being discarded because of organ-quality issues and other reasons at the cut-off (Columns (4)–(5)). Thus, these results suggest that the reform increased the usage of donated kidneys and did so through an improvement in allocative efficiency, rather than a change in donor composition or other factors.

34. Similarly, the share of kidneys transplanted within the OPTN region drops by 11.95 percentage points (18 percent; Column (1) of Appendix Table A.5). Appendix Figure A.9 plots the share of kidneys transplanted within the OPTN region by initial offer date.

Robustness and Placebo Checks To assess the robustness of my findings, I estimate Eq. 3 using the dependent variables in Table 3 but with a number of different specifications: (i) dropping the control variables, (ii) excluding weights, (iii) setting f() as a local linear function form, (iv) using a bias-corrected method (Calonico et al. 2019), and (v) using different bandwidth choices. In Appendix Table A.6, the RD estimates remain very similar across different specifications, which suggests that my findings are not sensitive to alternative specification.

Moreover, I perform placebo tests using samples of donated livers, hearts, and lungs, as their allocation systems operate separately from the kidney allocation policy and should not be impacted by the reform. Appendix Figure A.10 plots the discard rates for each of these non-kidney organs. Reassuringly, all RD estimates obtained using placebo cut-offs are statistically indistinguishable from zero, supporting the validity of my RD design (Table 4).

5.1.1 Heterogeneity Analysis and Mechanisms

(a) Kidney Quality: To explore whether certain types of kidneys are more likely to be allocated after the reform, I examine how the effects on the discard rate vary by kidney quality.[35] In Panel A-(i) of Figure 5, the discard rate for kidneys with KDPI above 85% (or "marginal" kidneys) decreases by 8.7 percentage points (14 percent) at the cut-off. In contrast, the use of "non-marginal" kidneys remain similar around the cut-off.

Reassuringly, the findings are similar when an alternative measure of kidney quality is used to estimate Eq. 3 (Panel A-(ii) of Figure 5).[36] These findings indicate that the policy particularly increases the use of marginal kidneys, which remain viable for transplant and

35. As explained earlier, kidney quality decreases (equivalently, health risk increases) with KDPI and these four subgroups are (a) 0–20%, (b) 21–35%, (c) 35–85%, and (d) 86–100%. Appendix Figure A.11 plots the discard rate by four subgroups based on the KDPI score used by the allocation system.

36. Prior to 2014, kidneys were classified into one of two categories: expanded criteria donor (ECD) or standard criteria donor (SCD) kidneys, with the latter indicating higher quality than the former. ECD kidneys are those recovered from donors (1) aged 60 or older or (2) aged 50–59 with two or three of the following health conditions: high blood pressure, creatinine levels of 1.5 or higher, or death due to stroke (Ojo 2005). Similar to KDPI >85% kidneys, ECD kidneys were only offered to candidates who showed interest in them in advance. For further information about ECD and KDPI, see Bae (2024). In Columns (5)–(6) of Appendix Table A.7, ECD kidneys show a 8.7 percentage point (16 percent) decrease in the discard rate at the cut-off.

offer recipients a survival benefit and improved quality of life relative to remaining on dialysis (Dahmen et al. 2019; Axelrod et al. 2018).

(b) Market Tightness: Redistributing kidney access from high- to low-access regions through the reform has potential to enhance the use of donated kidneys recovered from areas in historically high-access. In Panel B-(i) of Figure 5, the discard rate drops by 5.9 percentage points (26 percent) for kidneys recovered from DSAs with above-median access to kidneys in the pre-period, compared to 2.1 percentage point (10 percent) decrease for those recovered in donor hospitals located in DSAs with below-median kidney access.

Next, I explore how use of donated kidneys changes in response to shifts in access to kidneys at nearby transplant centers. In Panel B-(ii) of Figure 5, the discard rate for kidneys recovered from donor hospitals where all nearby transplant centers are predicted to experience reduced kidney access after the reform drops by 5.7 percentage points (25 percent) at the cut-off. In comparison, the discard rate for kidneys recovered from donor hospitals whose nearby transplant centers are unlikely to experience reduced kidney access after the reform drops by 2.1 percentage points (10 percent).

Alternative approach–Difference-in-Differences Design: I conduct a complementary difference-in-differences (DD) design to further examine the dynamic treatment effects on the use of donated kidneys. An underlying increasing trend in the kidney discard rate (Figure 4a) could complicate the interpretation of RD estimates. Leveraging the fact that the reform affects only kidney allocation, the DD specification compares outcomes for donated kidneys to those for non-kidney organs recovered from the same donors. A detailed explanation is provided in Appendix Section A.1.

The event study estimates in Appendix Figure A.12 are consistent with the decline in kidney discard rates at the cut-off remaining stable throughout the post-reform period (28 weeks) in the RD analysis. This pattern is further supported by the DD results for the number of kidney transplant recipients presented in the next section. Mirroring the heterogeneity analysis by organ quality, the decline in discard rates is concentrated among marginal kidneys. Taken together, these findings suggest that the reform had an immediate effect on the use of donated kidneys, with effects that persisted over the study period.

5.2 Effects on Kidney Access and Transplant Recipients

While the RD analysis suggests that the reform increased the utilization of donated kidneys, it is important to examine the distributional effects to understand how these gains in allocative efficiency were achieved, especially since such effects were uncertain ex-ante. I examine whether the reform is expected to reduce nationwide geographic disparities in kidney access and assess how the reform changes who receives a kidney transplant. Appendix Figure A.13 provides the distribution of the monthly number of recovered kidneys per candidate across transplant centers before and after the reform.

Dispersion in kidney availability across centers is predicted to decline after the reform, indicating that the reform may have contributed to equalizing access across regions. To further examine how predicted kidney availability varies with the size of the donor service area, I calculate predicted kidney availability for each transplant center by varying the radius r in Eq. 1. The dispersion in kidney access is predicted to fall steadily as the donor service area radius widens from 50 to 550 nautical miles (Appendix Figure A.14).

5.2.1 Characteristics of Transplant Recipients

I turn to examine how the reform changes who receives a kidney transplant. To do so, I limit the kidney-level data to kidneys used for transplant. Figure 6 presents the RD estimates across subgroups to illustrate varying effects by transplant recipients' health and sociodemographic characteristics.[37]

(a) Travel Distance and Hours: Next, I examine how the policy change affects travel distance and transport time between donor hospitals and transplant centers. Because the average distance between donor hospitals and transplant centers within the relevant alloca-

37. I estimate the RD model in Eq. 3 using the dependent variable as an indicator of candidate subgroups to test whether the composition of transplant recipients changes at the cut-off. These RD estimates are reported in Appendix Tables A.9-A.12.

tion area is expected to rise from 74 to 139 nautical miles under the reform, kidneys travel farther after implementation. Cold storage time increases by 1.6 hours (9 percent; Column (1) of Appendix Table A.8), and travel distance increases by 22.0 nautical miles (11 percent; Column (2)).

I find the distributional effects for travel distance: the likelihood of kidneys transplanted to recipients within 250 nautical miles of donor hospitals increases by 4 percent (Column (5)), while the likelihood of finding recipients at shorter distances (within 50 and 150 nautical miles) decreases by 40 and 17 percent, respectively (Columns (3)–(4)). These findings suggest the reform helped donated kidneys reach recipients outside their county-based boundaries.

(b) Recipient Health Status: To examine whether the reform affects access to transplants for transplant candidates with higher health risks, I focus on three factors used to calculate the EPTS score: duration of dialysis, prior transplant history, and diabetes status at listing. Average duration of dialysis increases by 134.4 days (10 percent) at the cut-off, while I find no discontinuous changes in the likelihood of receiving a kidney transplant among candidates with a prior transplant history or diabetes at listing (Appendix Table A.9).

To assess any distributional effects, I estimate Eq. 3 using the dependent variable as an indicator of four subgroups categorized by dialysis duration of the transplant recipients: (i) $<$ 1 year, (ii) 1-2 years, (iii) 3-4 years, and (iv) 5 years or more. In Panel A of Figure 6, the likelihood of candidates with five or more years of dialysis history receiving a kidney transplant increases by 6.1 percentage points (20 percent) at the cut-off. Since dialysis duration is a key determinant of transplant priority and is associated with higher waitlist mortality (Friedewald et al. 2013), the findings suggest that the reform helped kidneys reach recipients with greater medical needs and longer waiting times.

(c) Recipient Sociodemographic Characteristics: Next, I examine whether the policy change has varying impacts on access to kidney transplants based on sociodemographic characteristics. I estimate Eq. 3 by setting dependent variables as indicators for quartile groups based on SVI of counties where candidates live at the time of the transplant. In

Panel B of Figure 6, the likelihood that a recipient lives in a higher SVI county increases discontinuously at the cutoff, rising by 3.7 percentage points (15 percent) for the fourth quartile and falling by 3.0 percentage points (12 percent) for the first quartile. Similarly, average SVI discontinuously increases by 4 percent at the cut-off (Appendix Table A.10).

Given that SVI is a composite measure of social determinants of health, I check the robustness of results by re-estimating Eq. 3 by setting dependent variables as county poverty rates and indicators for racial/ethnic subgroups. Panel C of Figure 6 shows that recipients from higher poverty counties become more likely to receive a kidney transplant at the cutoff. Panel D of Figure 6 reports results by race and ethnicity. The likelihood that the recipient is Hispanic or Latino increases by 2.3 percentage points (12 percent) at the cutoff, while changes for other groups are smaller.[38]

5.3 Effects on Pre-Transplant Mortality

Given that the RD analysis suggests that the use of deceased donor kidneys increased in response to the policy change, the policy change may have affected transplant candidates. In light of this, I turn to the transplant center-level identification strategy to examine the impact of the reform on transplant candidates' health outcomes. To further explore its potential channels, I examine the impact on monthly deceased kidney transplants, living donor kidney transplants, and candidates newly joining the waitlist.

I begin by estimating the event study specification in Eq. 5 to examine the effects on the deaths of transplant candidates. Figure 7a plots the event study coefficients on the number of transplant candidates who passed away before getting any transplants in a month for a given transplant center. Transplant centers predicted to have higher treatment intensity evolved along the same trajectory in the number of transplant candidate deaths during the pre-period as those predicted to have lower treatment intensity. Table 5 reports the estimated value for γ in Eq. 4, which captures the average effects of a one-unit increase in the number of kidneys

38. ESRD incidence rates are 3.8 times higher for Black individuals and twice as high for Hispanic individuals than for non Hispanic White individuals (USRDS 2023). Appendix Table A.12 presents the corresponding RD estimates.

available to transplant centers after the reform. Monthly pre-transplant deaths decrease by 1.2 percent when access to deceased donor kidneys increases by one unit (Column (1)).

Results are similar using an alternative death measure. Figure 7b plots the event study estimates for deaths within five years of waitlist registration. This measure includes all deaths of transplant candidates who passed away on the waitlist and those who received kidney transplants but died within five years of entering the waitlist. Monthly deaths within five years of listing decrease by 1.6 percent for a one-unit increase in kidney availability after the reform (Column (2) of Table 5).

Consistent with the RD findings that the reform *increases* the use of deceased donor kidneys, deceased donor kidney transplants increase by 1.7 percent when access to kidneys increases by one unit after the reform (Column (3) of Table 5). Appendix Figure A.15a plots the event study estimates on the monthly number of deceased donor kidney transplant recipients per center.

In contrast, living donor transplants do not change (Column (4) of Table 5; Appendix Figure A.15b). Because living donor transplantation requires identifying a compatible donor, these results suggest limited substitution across donor types. This is consistent with lower substitutability, particularly given that living donor graft survival exceeds that of deceased donor transplants and the post-reform increase is concentrated among lower-quality kidneys (Section 5.1.1).[39] Similarly, I find no evidence that changes in waitlist registration drive the decline in pre-transplant mortality (Column (5) of Table 5; Appendix Figure A.15c).

To check the robustness of the findings, I re-estimate Eq. 4 with OLS specification and provide the results on the transplant candidate outcomes in Appendix Table A.13. Reassuringly, the results are similar to those from the Poisson model in Table 5.[40]

39. As most living donors for kidney transplant are family members or relatives of the recipients, a living donor kidney transplant is expected to have greater compatibility for the recipient compared to a deceased donor kidney transplant. Living donor graft survival averages 19.2 years compared to 12.1 years for deceased donor grafts (Poggio et al. 2021).

40. For example, Column (1) of Appendix Table A.13 shows that pre-transplant deaths per 1,000 candidates decline by 1.2 percent under OLS for a one-unit increase in kidney availability, consistent with the 1.2 percent decline in the Poisson specification in Eq. 4.

5.4 Effects on Post-Transplant Health Outcomes

The RD analysis suggests that the decrease in the discard rate is largely driven by increased use of marginal kidneys and that kidneys are remaining in cold storage longer before being transplanted to recipients than they were prior to the reform. As these types of kidneys are expected to have higher graft failure, I examine whether the policy change affects the health outcomes of transplant recipients in the short run. I define post-transplant adverse health outcomes as (i) deaths, (ii) graft failure, and (iii) resuming maintenance dialysis.

Table 6 reports the estimates of γ in Eq. 4. Figure 8 plots the event study coefficients on monthly number of recipients who ever experience adverse post-transplant health outcomes within 3, 6, 9, and 12 months of transplant. In Figure 8, transplant centers predicted to have higher treatment intensity move on the same trajectory in terms of the number of transplant recipients experiencing adverse health outcomes during the pre-period compared to those predicted to have lower treatment intensity. All estimates in Table 6 remain very small and are statistically indistinguishable from zero, which aligns with the findings from the OLS model.[41] The findings indicate that increases in predicted kidney access does not cause adverse post-transplant health outcomes in the short run, although the additional kidneys transplanted after the reform are often of lower quality and have longer storage times prior to transplant.

6 Conclusion

This paper studies the impact of redefining boundaries to allocate perishable goods across local catchment areas and its implications for efficiency and equity. I examine these questions in the context of deceased donor kidney transplants where the stakes of preventing inefficient allocation are particularly high. To study this, I develop two empirical designs: a regression discontinuity design that exploits the sharp timing of the reform and a difference-in-differences design that leverages variation in treatment intensity across transplant centers

41. Appendix Table A.14 provides the results from the OLS model on the post-transplant health outcomes.

based on their precise location.

The reform had immediate effects on both kidney utilization and waitlisted candidates. First, it reduced the role of pre reform geographic boundaries in the allocation system and lowered the kidney discard rate by 17 percent, with the decline persisting throughout the study period. The additional kidneys transplanted were more likely to be lower quality but still transplantable, and they were disproportionately recovered in regions that previously had better access and are expected to face tighter markets after the reform.

Second, the reform improved access for patients who otherwise would have faced greater health risks due to longer waiting times. The marginal kidney recipients were more likely to have an extended dialysis history and lived in counties with more socioeconomically disadvantaged populations relative to pre-reform recipients. Third, the reform decreased monthly pre-transplant deaths by 1.2 percent but did not change the number of transplant candidates experiencing adverse health outcomes within 12 months after transplant.

Using the RD estimates, I conduct a back-of-the-envelope calculation to explore the extent of the reform's effects within the first year after implementation. First, the reform may have led to an additional 807 kidneys being used for transplant, which would otherwise have been discarded.[42]

Second, the additional transplants induced by the reform generated between 4,035 and 5,649 additional life-years, depending on whether one assumes survival gains consistent with ECD kidneys (five years) or the average survival gain from transplantation (seven years).[43] Valuing life-years using standard calibrations implies aggregate lifetime gains of \$0.8–\$1.1 bil-

42. As 23,528 kidneys were recovered for transplant within 199 days of the reform, 1,799 kidneys were recovered for transplant each month on average. With this in mind,

$$\text{807 additional transplants per year} \approx \underbrace{\text{1,799 kidneys}}_{\substack{\text{Recovered for transplant}\\ \text{per month nationwide}}} \times \underbrace{0.22}_{\substack{\text{Pre-reform}\\ \text{discard rate}}} \times \underbrace{0.17}_{\substack{\text{Reduction in}\\ \text{discard rate (RD analysis)}}} \times \underbrace{12}_{\text{Months}}$$

43. Kidney transplantation is estimated to generate roughly seven additional life-years relative to dialysis, implying a lifetime value of \$0.93–\$1.3 million per recipient under standard value-of-life-year calibrations (Held et al. 2016). Because the post-reform increase in transplants is driven largely by greater utilization of ECD and high-KDPI kidneys, I use five life-years as a lower-bound benchmark, consistent with survival estimates for ECD kidneys (Ojo et al. 2001).

lion. Lastly, the additional transplants may have saved Medicare $118 million (807 transplant recipients × $146,000) that would have otherwise been spent subsidizing dialysis treatment. These potential savings appear to outweigh the additional $25.8 million expected to be incurred from transporting kidneys to transplant centers outside the DSA in which they were recovered.[44]

The findings suggest that the reform improved both allocative efficiency and equity in the kidney allocation system in the short run. Redefining geographic allocation boundaries increased organ utilization and access for waitlisted patients, with no detectable adverse short run health effects, implying an estimated 807 additional transplants per year and a decline in discard rates. These gains were accompanied by longer transport times and greater use of marginal kidneys, but I find no evidence of changes in adverse post transplant outcomes within 12 months. The results highlight how geographic allocation rules shape both utilization and access in the distribution of scarce, lifesaving organs, and point to the possibility of longer run adjustments in donation practices, transplant center behavior, offer acceptance, and listing decisions as important margins for future work.

44. Using the RD estimate in Table 3, the number of kidneys transplanted outside the donor hospital's DSA increases by 492 per month after the reform. The implied annual increase in Medicare reimbursement for organ transport is:

$$\$25.8 \text{ million per year} \approx \underbrace{492 \text{ kidneys}}_{\substack{\text{Transplanted}\\ \text{outside DSA per month}\\ \text{nationwide}}} \times \underbrace{\$4{,}376}_{\substack{\text{Cost per imported kidney}\\ \text{outside the transplant center's DSA}\\ \text{(Held et al. 2021)}}} \times \underbrace{12}_{\text{Months}}$$

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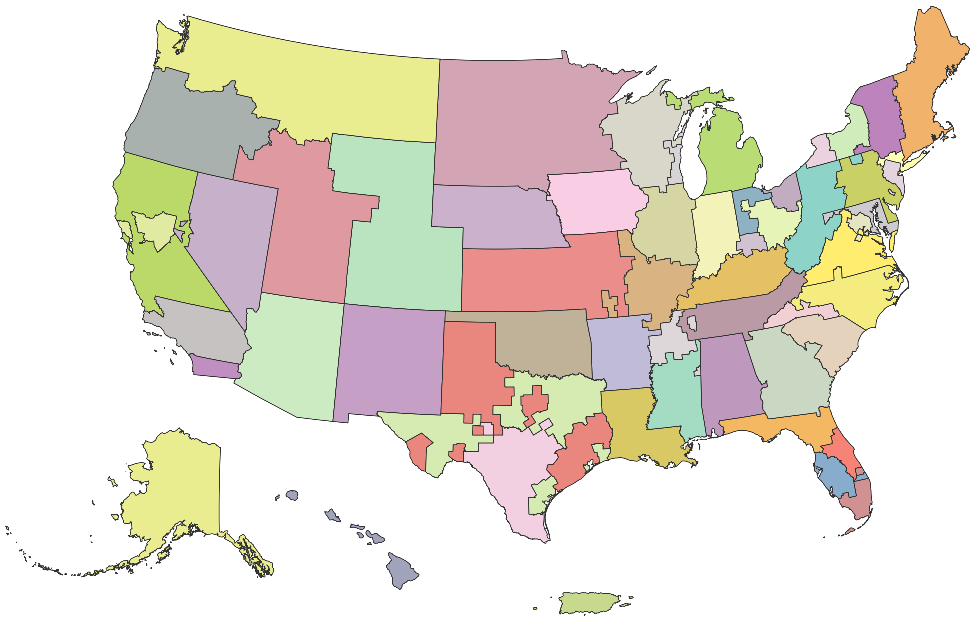
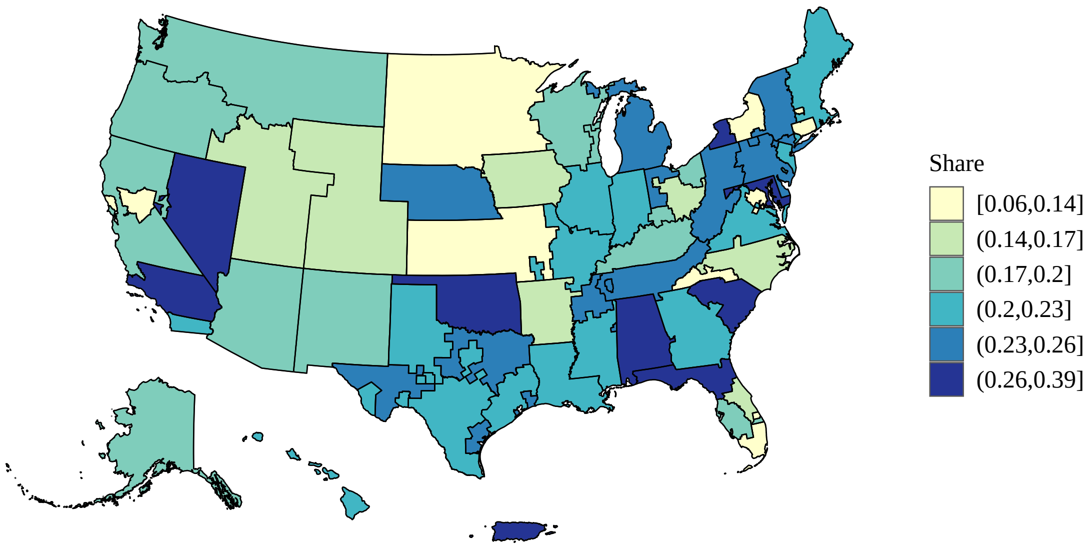
Figure 1: Map of Donor Service Area



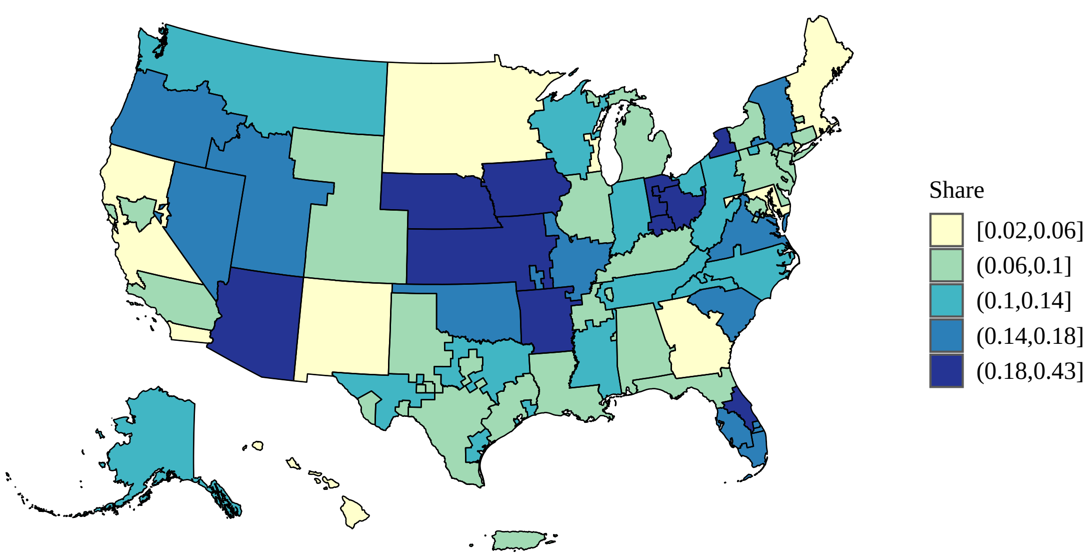
Notes: In 2021, there are 57 donor service areas (DSAs) in the United States (Panel A). Each DSA consists of a group of counties that defined the geographic boundaries for organ allocation prior to the reform. Under the 2021 reform, the allocation of deceased donor kidneys is based on the proximity between donor hospitals and transplant candidates rather than county-based service areas. See section 2 for details.

Figure 2: Geographic Disparities in Kidney Allocation Prior to the 2021 Reform

(a) Share by Kidneys Discarded by Donor Location



(b) Share of Candidates Receiving Kidney Transplants by Location



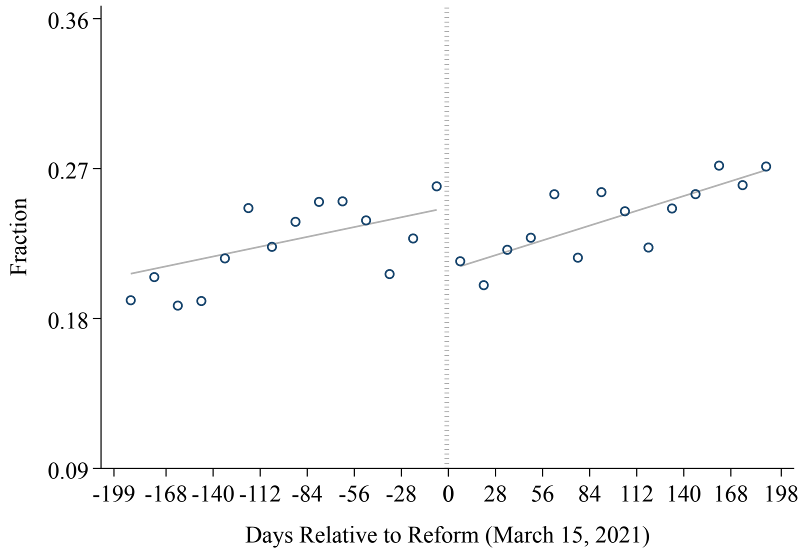
Notes: The figure presents geographic variation in the kidney discard ate (Panel A) and transplant access (Panel B) in the pre-reform period (January 2019–February 2021). Panel A maps the share of deceased donor kidneys recovered within each donor service area (DSA). Panel B maps the share of transplant candidates who received a deceased donor kidney recovered from a donor hospital within the same DSA. Source of data is the restricted Scientific Registry of Transplant Recipients (SRTR) datasets, which cover the universe of deceased donor kidneys and transplant candidates in the United States.

Figure 3: Impact on Kidneys Transplanted Within "Pre-Reform Service Areas"

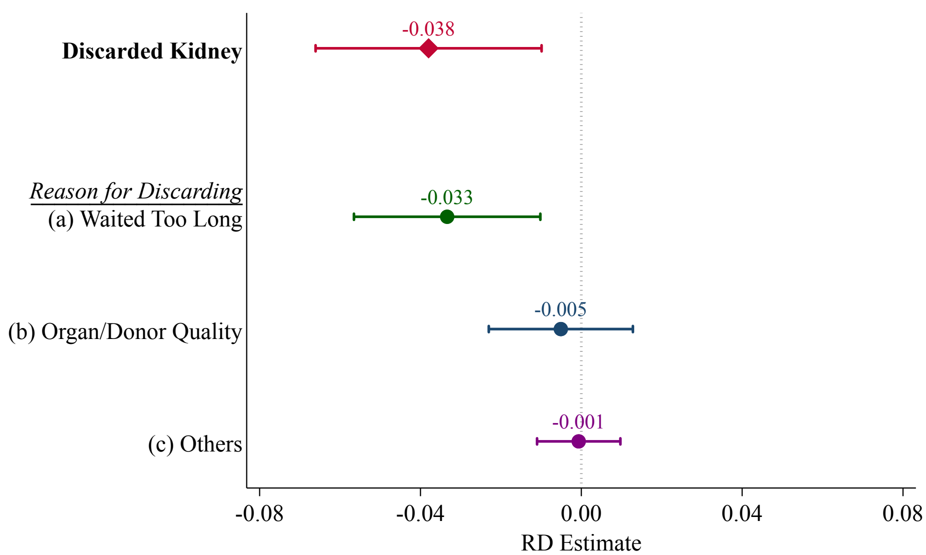
Notes: This figure plots the share of kidneys transplanted to candidates at transplant centers within the donor hospital's donor service area(DSAs), the allocation boundaries in use prior to March 15, 2021. The date on the x-axis is the initial offer date. Each point represents a two-week bin. The sample is limited to (i) adult donors (18 or above), (ii) initial offer was made $\pm$ 199 days from the cut-off, (iii) donors whose kidney biopsy information is complete, (iv) donor hospitals located outside Alaska, (v) donor hospitals that did not experience any change in OPO affiliation through the sample period. Sample is drawn from the restricted Scientific Registry of Transplant Recipients (SRTR) datasets, which include the universe of deceased donor kidneys in the U.S. Each observation represents a kidney recovered from a deceased donor for transplant. See Section 3 for details on sample construction.

Figure 4: Effects on Kidney Discard Rate

(a) Overall Discard Rate

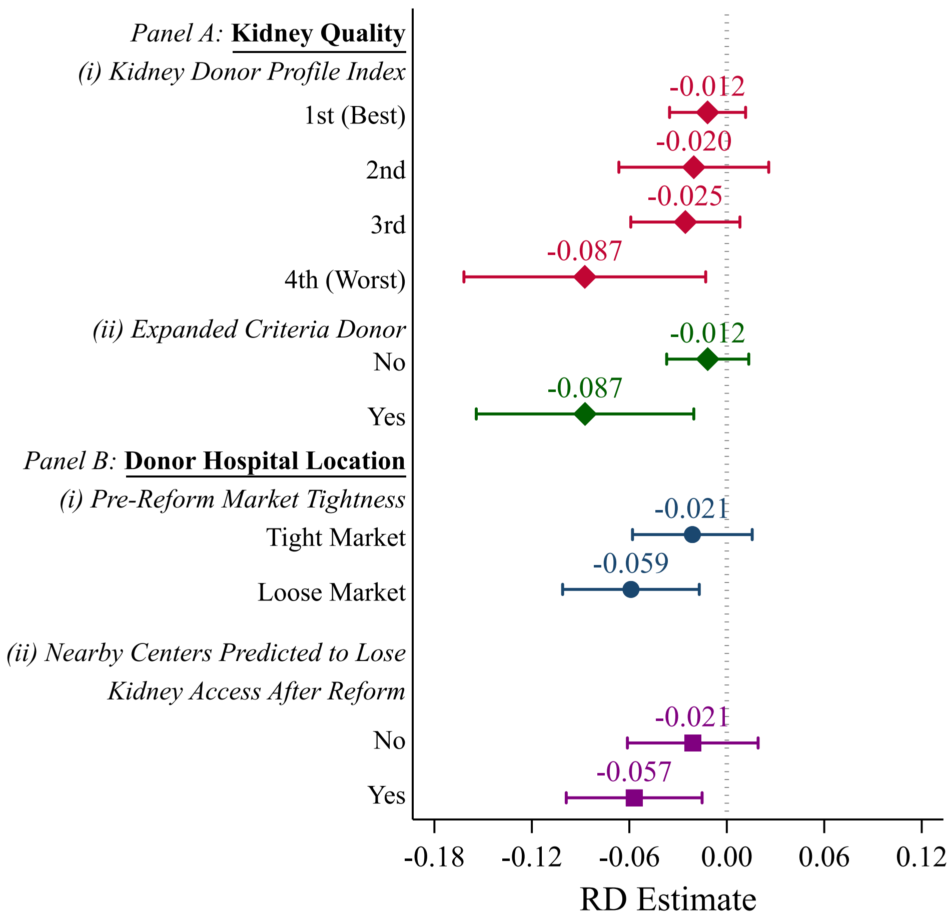


(b) By Reason for Discarding



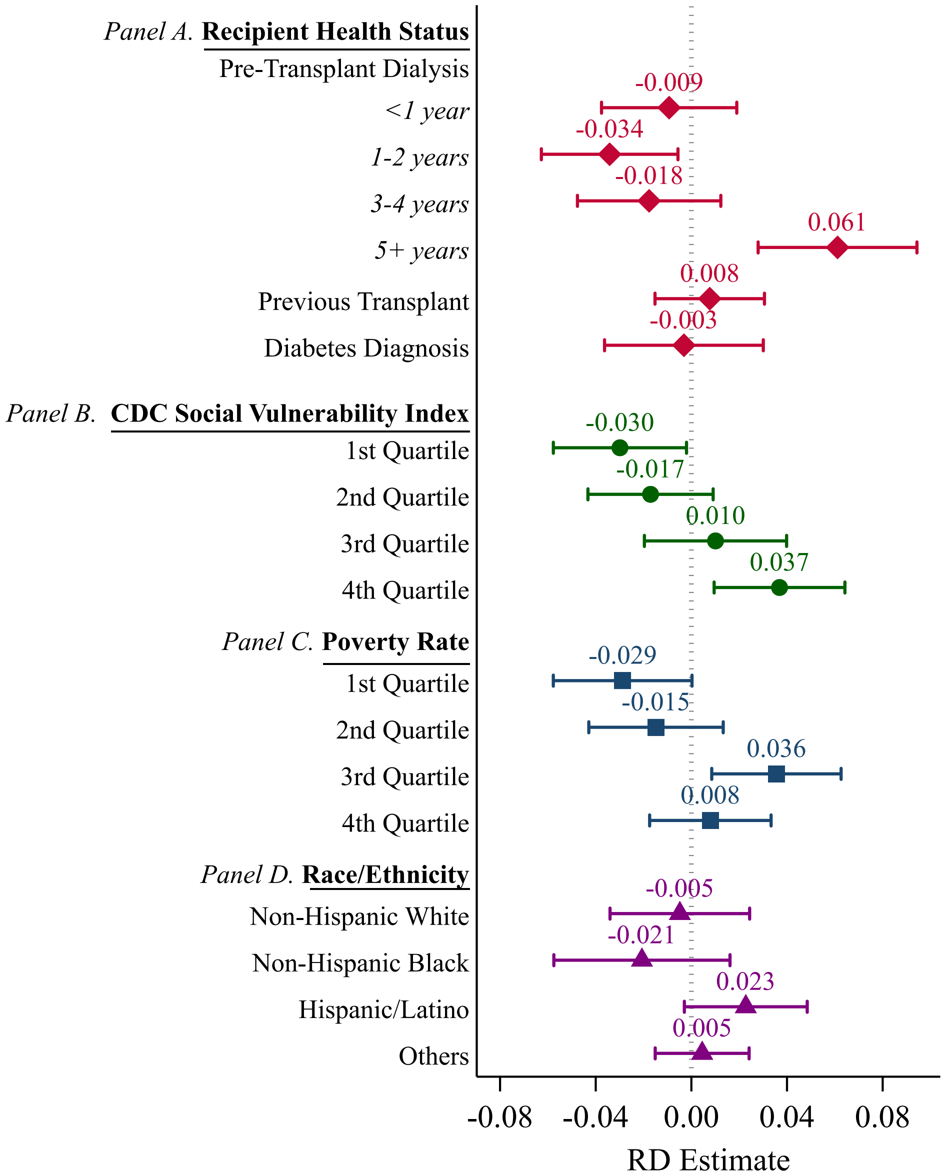
Notes: Figure 4a plots the share of deceased donor kidneys that are discarded by initial offer date relative to the allocation reform on March 15, 2021. Each point represents a two-week bin. Figure 4b plots the RD estimates (β from Eq. 3) with 95% confidence intervals. Outcomes include an indicator for discard and indicators for discard due to (i) list exhaustion (waited too long), (ii) donor quality concerns, and (iii) other reasons. The x axis is the initial offer date. Each observation in the analytic sample is a kidney recovered from a deceased donor for transplant. The sample is limited to (i) adult donors (18 or above), (ii) initial offer was made $\pm$ 199 days from the cut-off, (iii) donors whose kidney biopsy information is complete, (iv) donor hospitals located outside Alaska, (v) donor hospitals that did not experience any change in OPO affiliation through the sample period. Source of data is the restricted Scientific Registry of Transplant Recipients (SRTR) datasets, which include the universe of deceased donor kidneys in the U.S. See Section 3 for details on sample construction.

Figure 5: Heterogeneous Effects on the Likelihood a Kidney is Discarded



Notes: Notes: This figure plots RD estimates of β from Eq. 3 with 95% confidence intervals. Panel A reports heterogeneity in discard effects by kidney quality. Panel B reports heterogeneity by donor hospital location. Panel B(i) splits donor hospitals by whether pre reform kidney access in their DSA was above or below the median. Panel B(ii) relates discard effects to predicted changes in kidney access among nearby transplant centers from Eq. 2. Each observation in the analytic sample is a kidney recovered from a deceased donor for transplant. The sample is limited to (i) adult donors (18 or above), (ii) initial offer was made ± 199 days of the policy implementation date, (iii) donors whose kidney biopsy information is complete, (iv) donor hospitals located outside Alaska, (v) donor hospitals that did not experience any change in OPO affiliation through the sample period. Source of data is the restricted Scientific Registry of Transplant Recipients (SRTR) datasets, which include the universe of deceased donor kidneys in the U.S. See Section 3 for details on sample construction. Appendix Tables A.7-A.11 provide the corresponding RD estimates.

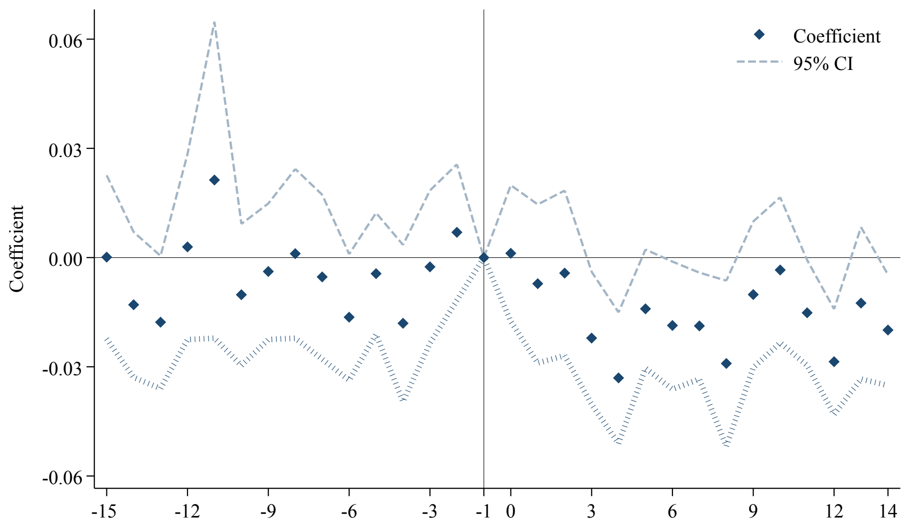
Figure 6: Effects on the Composition of Kidney Transplant Recipients



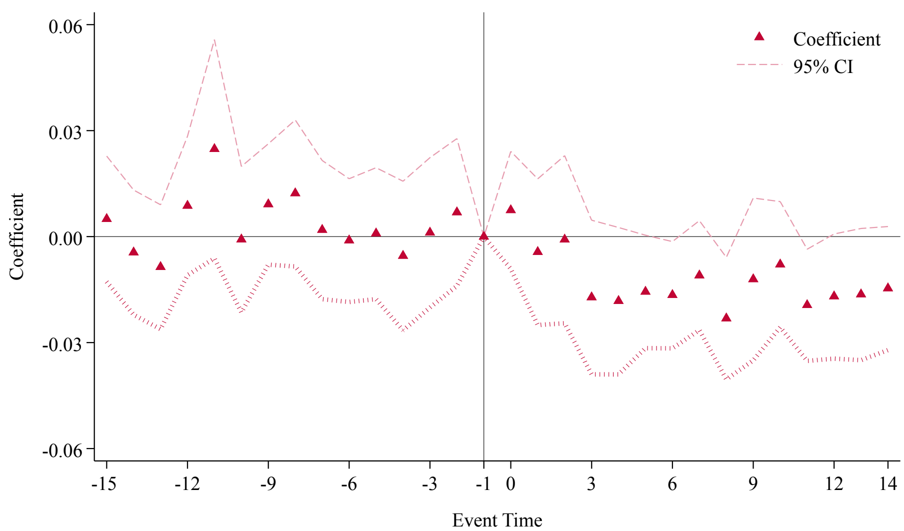
Notes: This figure plots RD estimates of β from Eq. 3 with 95% confidence intervals. Panel A uses indicators for four dialysis duration groups at transplant (0 years, 1–2 years, 3–4 years, and 5+ years) as outcomes. Panel B uses indicators for quartiles of the CDC Social Vulnerability Index of the recipient's county of residence at transplant. Panel C uses indicators for quartiles of the recipient county poverty rate at transplant. Panel D uses indicators for recipient race and ethnicity. The sample is restricted to kidneys recovered for transplant from (i) adult donors (age 18+), (ii) kidneys with an initial offer date within $\pm$ 199 days of the policy implementation date, (iii) donors whose kidney biopsy information is complete, (iv) donor hospitals located outside Alaska, (v) donor hospitals that did not experience any change in OPO affiliation through the sample period. Source of data is the restricted Scientific Registry of Transplant Recipients (SRTR) datasets, which include the universe of deceased donor kidneys in the U.S. See Section 3 for details on sample construction. Appendix Tables A.9-A.12 report the corresponding regression results.

Figure 7: Effects on Deaths Among Transplant Candidates

(a) Candidates Deaths Without Transplant



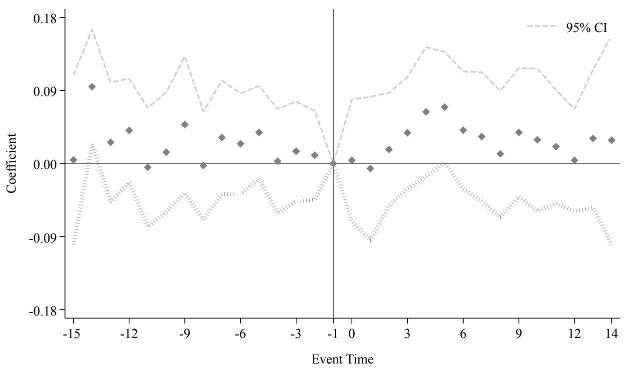
(b) All Candidate Deaths Within 5 Years of Entering Waitlist



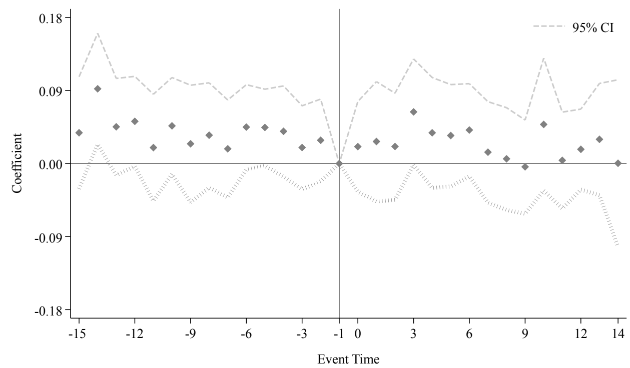
Notes: This figure plots event study coefficients and 95% confidence intervals from Eq. 5. Event time is defined as the number of months since February 2021, a month before the policy change. In Figure 7a, the dependent variable is the monthly number of candidates at a transplant center who die without receiving a deceased donor kidney transplant. In Figure 7b, the dependent variable is the monthly number of candidate deaths within five years of waitlist registration. The sample includes transplant centers with at least one candidate waitlisted for a deceased donor kidney transplant during the pre-reform period (January 2019–February 2021). The sample is further restricted to centers with at least one active candidate prior to the policy change and located in DSAs with no changes in OPO affiliation during the sample period. See Section 3 for details on sample construction.

Figure 8: Event Study Figures on Post-Transplant Adverse Health Outcomes

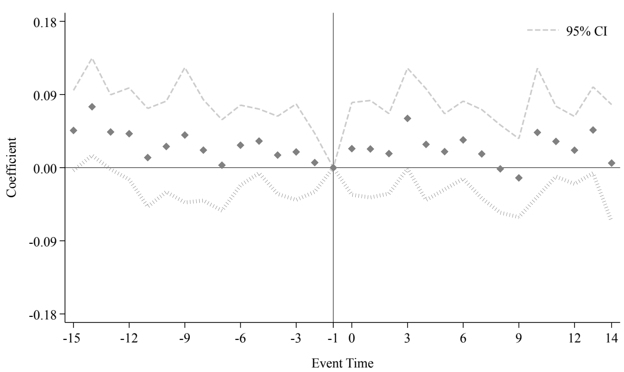
(a) Within 3 months of transplant



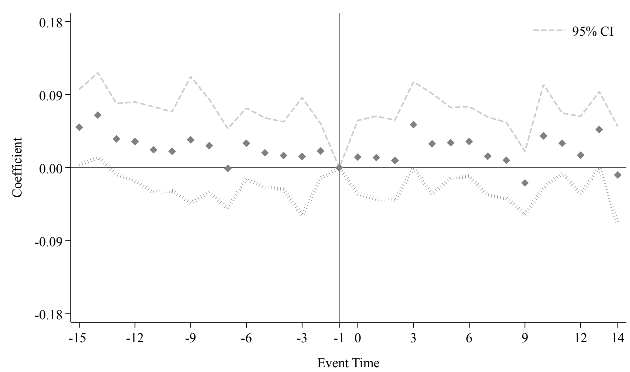
(b) Within 6 months of transplant



(c) Within 9 months of transplant



(d) Within 12 months of transplant



Notes: This figure plots event study coefficients and 95% confidence intervals from Eq. 5. Event time refers to the number of months between transplant date and February 2021, a month prior to the policy change. Adverse post transplant outcomes include (i) death, (ii) graft failure, and (iii) resumption of maintenance dialysis. Panels A–D use as the dependent variable the number of transplant recipients who experience an adverse outcome within 3, 6, 9, and 12 months of transplant, respectively. The sample includes transplant centers with at least one candidate waitlisted for a deceased donor kidney transplant during the pre-reform period (January 2019–February 2021). The sample is further restricted to centers with at least one active candidate prior to the policy change and located in DSAs with no changes in OPO affiliation during the sample period. Source of data is the restricted Scientific Registry of Transplant Recipients (SRTR) datasets, which include the universe of deceased donor kidneys and transplant candidates in the U.S. See Section 3 for details on sample construction.

Table 1: Descriptive Statistics

	(1) Mean
Panel A: Deceased Donor Kidneys *(N=23,528)*	
Discard rate	0.232
a) Discarded due to list exhaustion	0.141
b) Discarded due to kidney/donor quality	0.066
c) Others	0.024
Blood O Type	0.480
KDPI 86-100%	0.163
Donor hospital characteristics	
Located in metropolitan core	0.576
Predicted decrease in access to kidneys at nearby transplant centers	0.610
Panel B: Transplant Recipients *(N=17,628)*	
Non-Hispanic white	0.375
Non-Hispanic black	0.344
Hispanic/Latino	0.197
Wait time (in days)	1408.459
Distance (in nautical miles)	200.343
County of residence	
CDC Social vulnerability index	0.627
Poverty rate	14.159
Panel C: Transplant Centers *(N=204)*	
Average number of candidates	449.564
Centers with predicted increase in access to kidneys after the reform	0.480

Notes: The source of data is the restricted Scientific Registry of Transplant Recipients (SRTR) datasets, which include the universe of deceased donor kidneys in the U.S. In Panel A, each observation is a donated kidney from a deceased donor. The sample is limited to (i) adult donors (18 or above), (ii) initial offer was made ± 199 days from the cut-off, (iii) donors whose kidney biopsy information is complete, (iv) donor hospitals located outside Alaska, (v) donor hospitals that did not experience any change in OPO affiliation through the sample period. The discard rate is the number of kidneys not transplanted divided by the number of kidneys recovered for transplant. Discard reasons are based on the organ disposition code and are classified as (i) list exhaustion (waited too long), (ii) donor quality concerns, and (iii) other reasons. In Panel B, the sample covers 17,911 transplant recipients who (1) received transplants using kidneys included in the sample for Panel A (2) with non-missing candidate ID. In Panel C, descriptive statistics for transplant centers included in the transplant-center sample are provided. These transplant centers have at least one candidate waiting for a deceased donor kidney transplant prior to the policy change.

Table 2: Validity Test

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
	Kidney Quality Ranking (KDPI)				Donor Blood Type				Donor Hospital Characteristics	
	1st (Best)	2nd	3rd	4th (Worst)	A	B	AB	O	Metropolitan Core Area	Predicted Change in Kidney Access at Nearby Transplant Centers
1(InitialOffer≥ c)	0.0046	0.0019	0.0032	-0.0097	0.0018	0.0110	0.0153	-0.0281	0.0083	-0.0306
	(0.0171)	(0.0125)	(0.0178)	(0.0145)	(0.0177)	(0.0072)	(0.0124)	(0.0210)	(0.0208)	(0.0198)
Mean, Pre-policy	0.185	0.136	0.519	0.159	0.378	0.032	0.104	0.486	0.573	0.616
Observations	23,528	23,528	23,528	23,528	23,528	23,528	23,528	23,528	23,528	23,528
Controls	No	No	No	No	No	No	No	No	No	No
Bandwidth	± 199 days	± 199 days	± 199 days	± 199 days	± 199 days	± 199 days	± 199 days	± 199 days	± 199 days	± 199 days
Degree of polynomial	1	1	1	1	1	1	1	1	1	1
Weighting Scheme	Triangular	Triangular	Triangular	Triangular	Triangular	Triangular	Triangular	Triangular	Triangular	Triangular
Std error	Cluster	Cluster	Cluster	Cluster	Cluster	Cluster	Cluster	Cluster	Cluster	Cluster

Notes: This table provides the RD estimates of β from Eq. 3 estimated without control variables, X_i. Each column reports results from a separate regression, with the outcome listed in the column heading. Columns (1)–(4) use as outcomes indicators for KDPI categories based on the Kidney Donor Profile Index: 0–20% ("1st best"), 21–34%, 35–85%, and 86–100% ("4th worst"). Each observation is a donated kidney from a deceased donor. The sample is limited to (i) adult donors (18 or above), (ii) initial offer was made ± 199 days from the cut-off, March 15, 2021, (iii) donors whose kidney biopsy information is complete, (iv) donor hospitals located outside Alaska, (v) donor hospitals whose OPO affiliation does not change over the sample period. "Mean, Pre-policy" is the average of outcome variable between -1 and -199 days prior to the policy change. For more information on the sample, see the notes to Table 1. The source of data is the restricted Scientific Registry of Transplant Recipients (SRTR) datasets, which include the universe of deceased donor kidneys in the U.S. Standard errors are clustered by initial offer date and reported in parentheses. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Table 3: Impact on Use of Deceased Donor Kidney

	(1)	(2)	(3)	(4)	(5)
	1(Transplanted Within DSA)	1(Discarded Kidney)	Reason Code for Being Discarded		
			1(Waited Too Long)	1(Organ quality)	1(Others)
$1(D_i \geq c)$	-0.2354***	-0.0380***	-0.0334***	-0.0051	-0.0006
	(0.0158)	(0.0143)	(0.0118)	(0.0091)	(0.0053)
Mean, Pre-policy	0.549	0.223	0.126	0.070	0.025
Observations	23,528	23,528	23,528	23,528	23,528
Controls	Yes	Yes	Yes	Yes	Yes
Bandwidth	± 199 days	± 199 days	± 199 days	± 199 days	± 199 days
Degree of polynomial	1	1	1	1	1
Weighting Scheme	Triangular	Triangular	Triangular	Triangular	Triangular
Std error	Cluster	Cluster	Cluster	Cluster	Cluster

Notes: This table reports the RD estimates of β from Eq. 3. The running variable is the initial offer date of kidneys. Each column reports results from a separate regression, with the outcome listed in the column heading. Each observation is a deceased donor kidney recovered for transplant. "1(Transplanted Within DSA)" is an indicator of kidneys finding recipient within the donor service area of donor hospital. "1(Discarded Kidney)" is an indicator of discarded kidneys. "1(Waited Too Long)" is an indicator of kidneys discarded as they waited too long on the waitlist. "1(Organ Quality)" is an indicator of kidneys discarded due to organ quality concerns. "1(Others)" is an indicator of kidneys discarded due to factors other than waiting too long or organ quality concerns. Controls include donor gender, race and ethnicity, blood type, and an indicator for donation after circulatory death. The data is obtained from the restricted Scientific Registry of Transplant Recipients (SRTR) datasets, which include the universe of deceased donor kidneys in the U.S. The sample is limited to (i) adult donors (18 or above), (ii) initial offer was made ± 199 days from the cut-off, March 15, 2021, (iii) donors whose kidney biopsy information is complete, (iv) donor hospitals located outside Alaska, (v) donor hospitals that did not experience any change in OPO affiliation during the sample period. "Mean, Pre-policy" is the average of outcome variable between -1 and -199 days prior to the policy change. Standard errors are clustered by initial offer date and reported in parentheses. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Table 4: Placebo Test: Non-Kidney Samples

	(1)	(2)	(3)	(4)	(5)
	1(Transplanted Within DSA)	1(Discarded Organ)	Reason Code for Being Discarded		
			1(Waited Too Long)	1(Organ quality)	1(Others)
Panel A. Liver					
$1(D_i \geq c)$	0.0055	0.0120	-0.0071	0.0143	0.0012
	(0.0221)	(0.0133)	(0.0062)	(0.0108)	(0.0070)
Observations	8,282	8,282	8,282	8,282	8,282
Panel B. Heart					
$1(D_i \geq c)$	-0.0021	-0.0107	-0.0036	-0.0085	0.0010
	(0.0292)	(0.0101)	(0.0035)	(0.0059)	(0.0069)
Observations	3,363	3,363	3,363	3,363	3,363
Panel C. Lung					
$1(D_i \geq c)$	-0.0546	-0.1109	-0.0145	-0.0560	-0.0437
	(0.0832)	(0.0763)	(0.0403)	(0.0475)	(0.0533)
Observations	627	627	627	627	627

Notes: This table provides the RD estimates of β from Eq. 3 for placebo samples. The sample consists of livers, hearts, and lungs recovered for transplant from the same donors included in the kidney level data, restricted to single organ recoveries so that the unit of observation is an organ. Each column reports coefficients and standard errors obtained from separate regressions, with the outcome variable indicated in the column heading. The cut-off is March 15, 2021. "1(Transplanted Within DSA)" is an indicator of kidneys finding recipient within the donor service area of donor hospital. "1(Discarded Organ)" is an indicator of discarded kidneys. "1(Waited Too Long)" is an indicator of kidneys discarded as they waited too long on the waitlist. "1(Organ Quality)" is an indicator of kidneys discarded due to organ quality concerns. "1(Others)" is an indicator of kidneys discarded due to factors other than waiting too long or organ quality concerns. "Mean, Pre-policy" is the average of outcome variable between -1 and -199 days prior to the policy change. Source of data is the restricted Scientific Registry of Transplant Recipients (SRTR) datasets, which include the universe of deceased donor kidneys and transplant candidates in the U.S. Standard errors are clustered by initial offer date and reported in parentheses. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Table 5: Monthly Transplant Center Outcomes: Transplant Candidates

	(1)	(2)	(3)	(4)	(5)
	Monthly Counts of Candidate Outcomes				
	Deaths		Received Transplant		New Waitlist Registrations
	Without Transplant	All Deaths $\leq$ 5 years Listing	Deceased Donor Kidney	Living Donor Kidney	
$\Delta Access_h \times Post_{hm}$	-0.01224***	-0.01632***	0.01677***	0.00253	0.00330
	(0.00391)	(0.00319)	(0.00581)	(0.00478)	(0.00380)
Mean of Dep. Var (Pre)	3.254	3.088	6.770	2.039	12.576
Observation	6,120	6,120	6,120	6,120	6,120

Notes: This table reports the estimates of γ from Eq. 4. Pre-transplant deaths include candidates removed from the waitlist due to death as well as those removed for being too sick who subsequently die. The dependent variable in Column (1) is the number of candidates who die without receiving a deceased donor kidney transplant. The dependent variable in Column (2) is the number of candidate deaths within five years of waitlist registration, which includes deaths before transplant, after waitlist removal, and after transplant. Columns (3) and (4) use as outcomes the number of deceased donor and living donor kidney transplants, respectively. Column (5) uses as the outcome the monthly number of new waitlist registrations. Figures 7a and 7b plot the corresponding event study estimates for Columns (1) and (2). Appendix Figures A.15a–A.15c plot the corresponding event study estimates for Columns (3)–(5). The transplant center–month sample includes centers with active transplant candidates prior to the policy change and is restricted to centers located in DSAs whose OPO affiliation does not change over the sample period. "Mean of Dep-Var" is the average of outcome variable between -1 and -15 months prior to the policy change. Standard errors are clustered at the transplant center level and reported in parentheses. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Table 6: Monthly Transplant Center Outcomes: Transplant Recipients

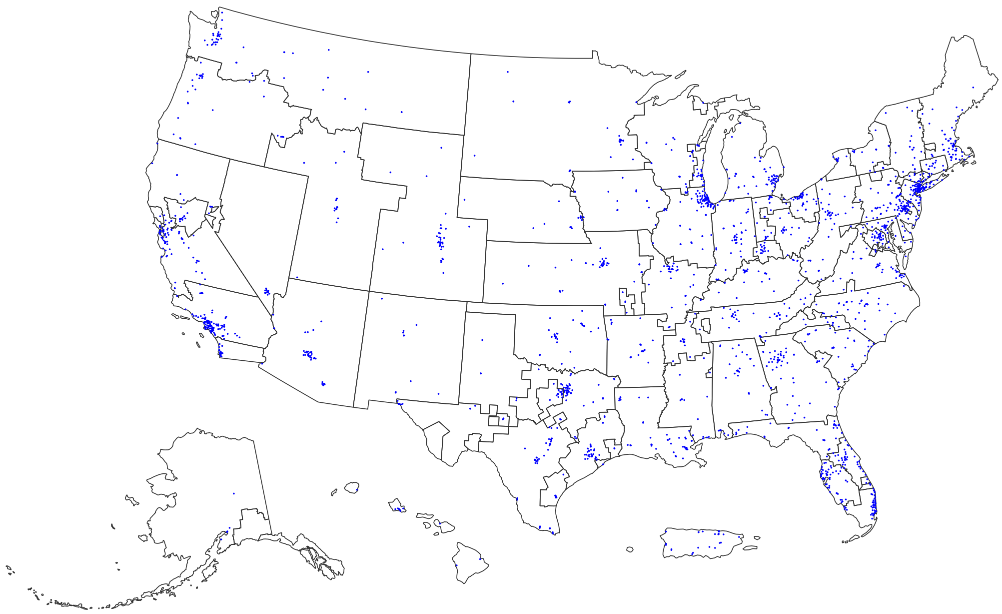
	(1)	(2)	(3)	(4)
	Monthly Counts of Kidney Transplant Recipients with Adverse Outcomes Within Months Since Transplant			
	$\leq$ 3 months	$\leq$ 6 months	$\leq$ 9 months	$\leq$ 12 months
$\Delta Access_h \times Post_{hm}$	0.00369	-0.01139	-0.00272	-0.00471
	(0.01357)	(0.01124)	(0.00942)	(0.00781)
Mean of Dep. Var (Pre)	0.196	0.298	0.385	0.467
Observation	6,120	6,120	6,120	6,120

Notes: This table reports the estimates of γ from Eq. 4. Post-transplant adverse outcomes are defined as (i) death, (ii) graft failure, and (iii) resumption of maintenance dialysis within 3, 6, 9, and 12 months of a deceased donor kidney transplant. Columns (1)–(4) use as the dependent variable the number of recipients who experience any of these adverse events within 3, 6, 9, and 12 months after transplant, respectively. The transplant center–month sample includes centers with active transplant candidates prior to the policy change and is restricted to centers located in DSAs whose OPO affiliation does not change over the sample period. "Mean of Dep-Var" is the average of outcome variable between -1 and -15 months prior to the policy change. Figure 8 plots the corresponding event study estimates from Eq. 5. Standard errors are clustered at the transplant center level and reported in parentheses. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

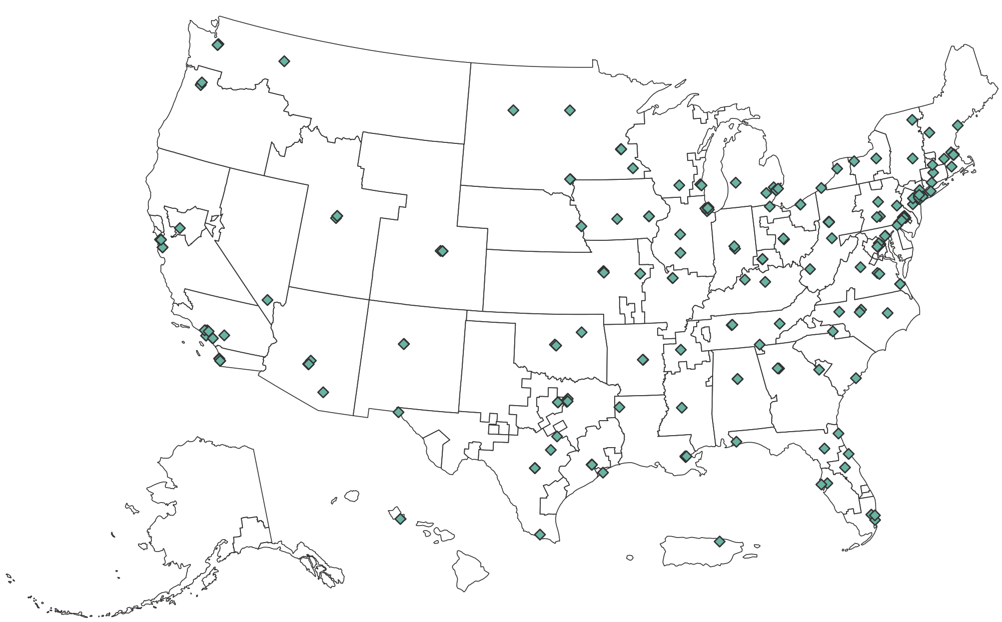
Appendix Figures and Tables

Figure A.1: Map of Donor Hospital and Transplant Center

(a) Donor Hospitals

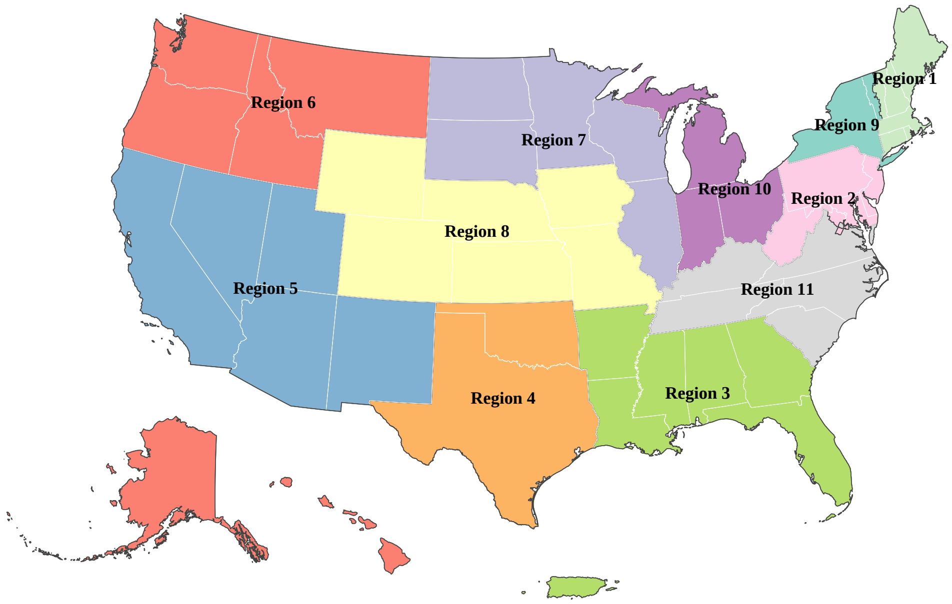


(b) Transplant Centers



Notes: This figure plots the locations of 2,048 donor hospitals (Panel A) and 218 transplant centers (Panel B). Each dot marks the geographic coordinates of a donor hospital or transplant center.

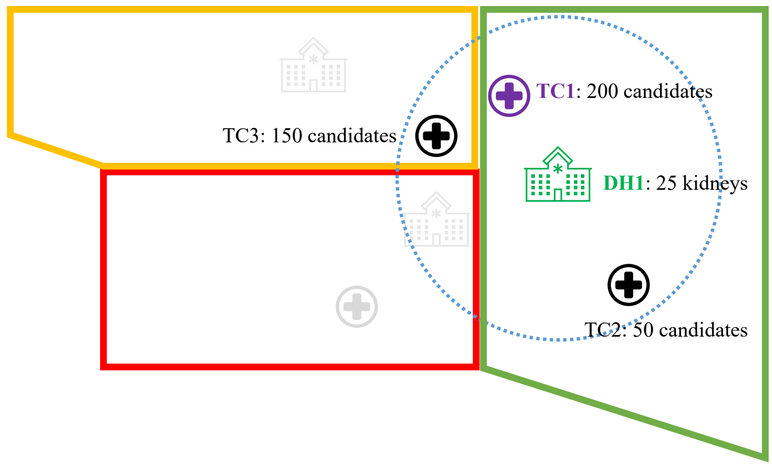
Figure A.2: Map of OPTN Region



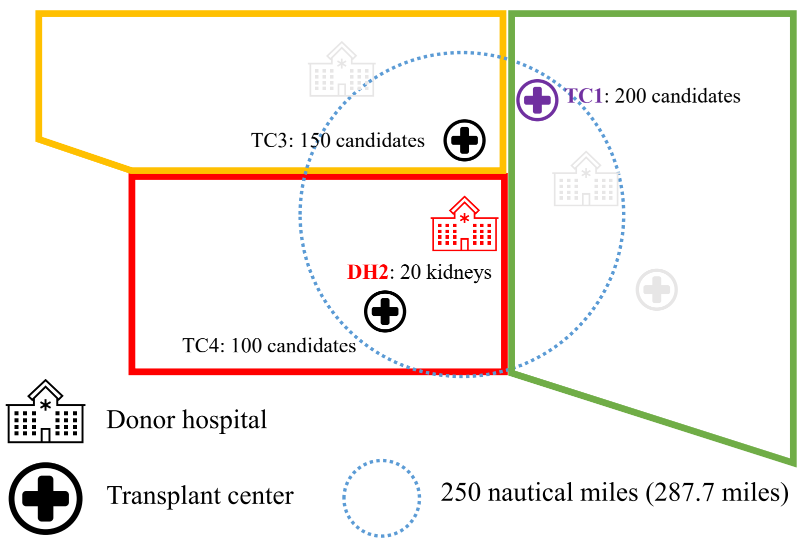
Notes: The 11 OPTN regions were established in 1986 and have remained unchanged since then (Source: https://optn.transplant.hrsa.gov/about/regions/). For more information about OPTN regions, see section 2.

Figure A.3: Numerical Example of Calculating Treatment Intensity

(a) Panel A: Donor Hospital in Green County-based Service Area

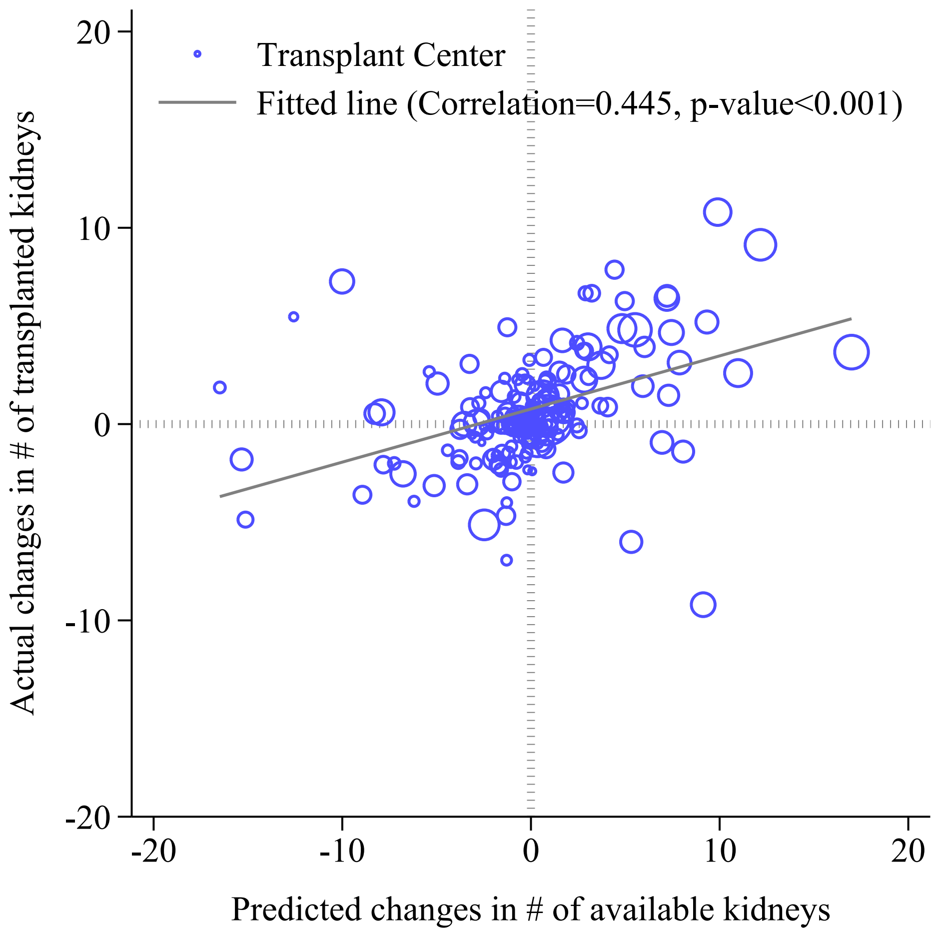


(b) Panel B: Donor Hospital in Red County-based Service Area



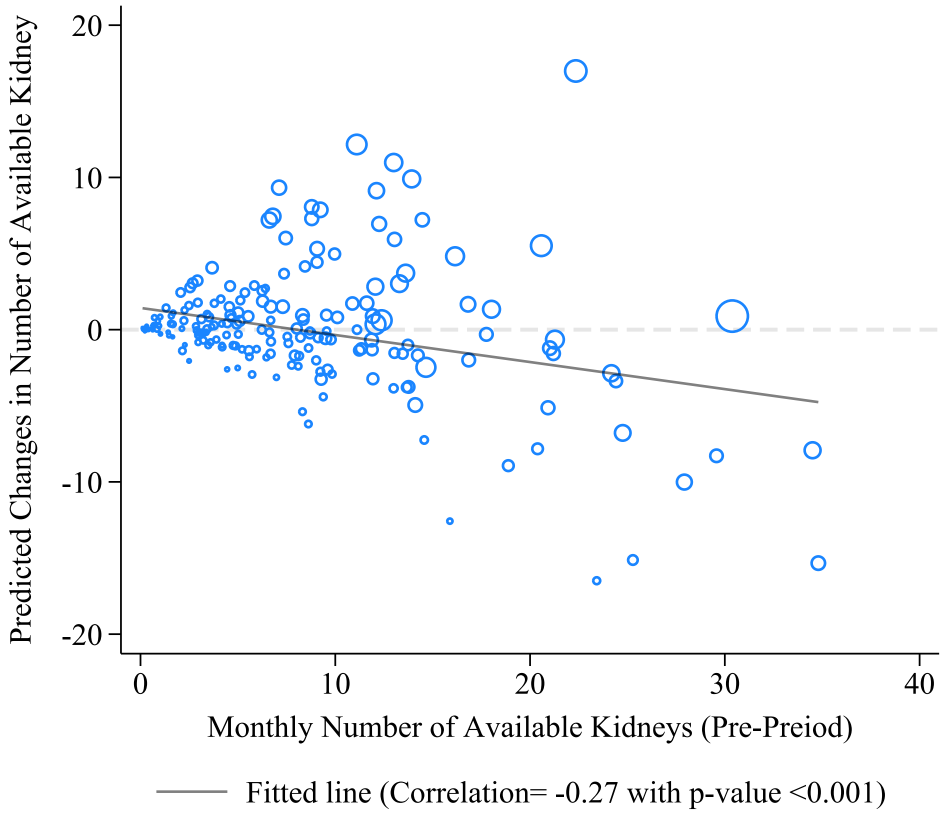
Notes: This figure provides a stylized example of the treatment intensity calculation. The region is divided into three county based service areas (green, yellow, and red). The green donor service area contains two transplant centers, TC1 and TC2, and one donor hospital, DH1, which recovers an average of 25 deceased donor kidneys per month. TC1 has 200 active transplant candidates and TC2 has 50. Since DH1 is the only donor hospital in the green area, candidates listed at TC1 or TC2 have priority access to DH1 kidneys relative to candidates listed outside the green area. Prior to the policy change, TC1's predicted access is $25 \times \frac{200}{200+50} = 20$ kidneys per month. In the post-period, TC1 now belongs to the initial offer group of two donor hospitals: DH1, located within the same county-based service area, and DH2, located in the red county-based service area, which recovers 20 kidneys monthly. In Panel A, DH1 is within 250 nm of three transplant centers (TC1, TC2, and TC3), with 400 candidates in total. In Panel B, DH2 is within 250 nm of three transplant centers (TC1, TC3, and TC4), with 450 candidates in total. TC1 is predicted to receive 12.5 ($=25 * (200/400)$) kidneys from DH1 and 8.9 ($\approx 20 * (200/450)$) kidneys from DH2 in the post-period. The implied change in predicted access for TC1 is $21.4 - 20 = 1.4$ kidneys per month.

Figure A.4: Correlation Between Predicted and Actual Changes in Kidney Access



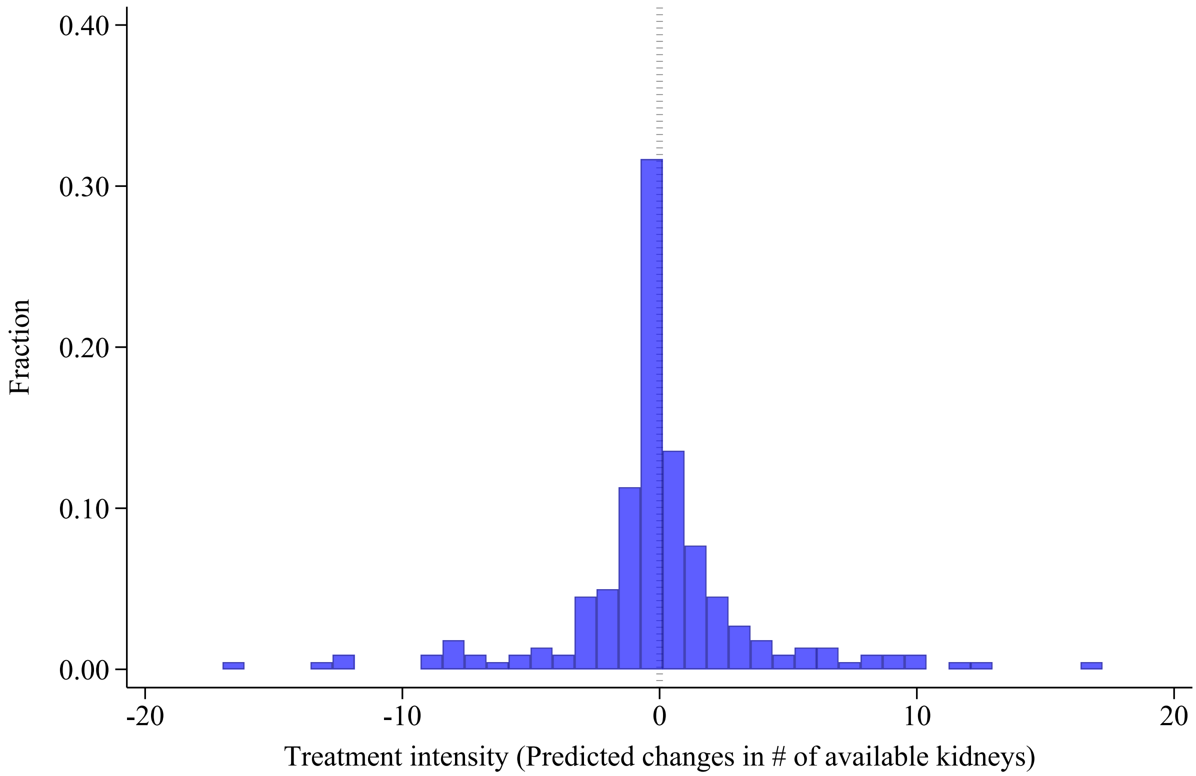
Notes: This scatterplot compares predicted changes in available kidneys ("treatment intensity") against the actual changes in average deceased donor kidney transplant recipients within 15 months of the policy change. Predicted changes in the number of available deceased donor kidneys for transplant center h is calculated based on Eq. 1. Appendix Figure A.3 presents a numerical example of calculating the predicted changes in available deceased donor kidneys for each transplant center. The correlation between the predicted and actual changes, weighted by the size of the transplant center, is 0.445 (p-value<0.001).

Figure A.5: Predicted Changes in Kidney Access and Pre-Reform Kidney Access



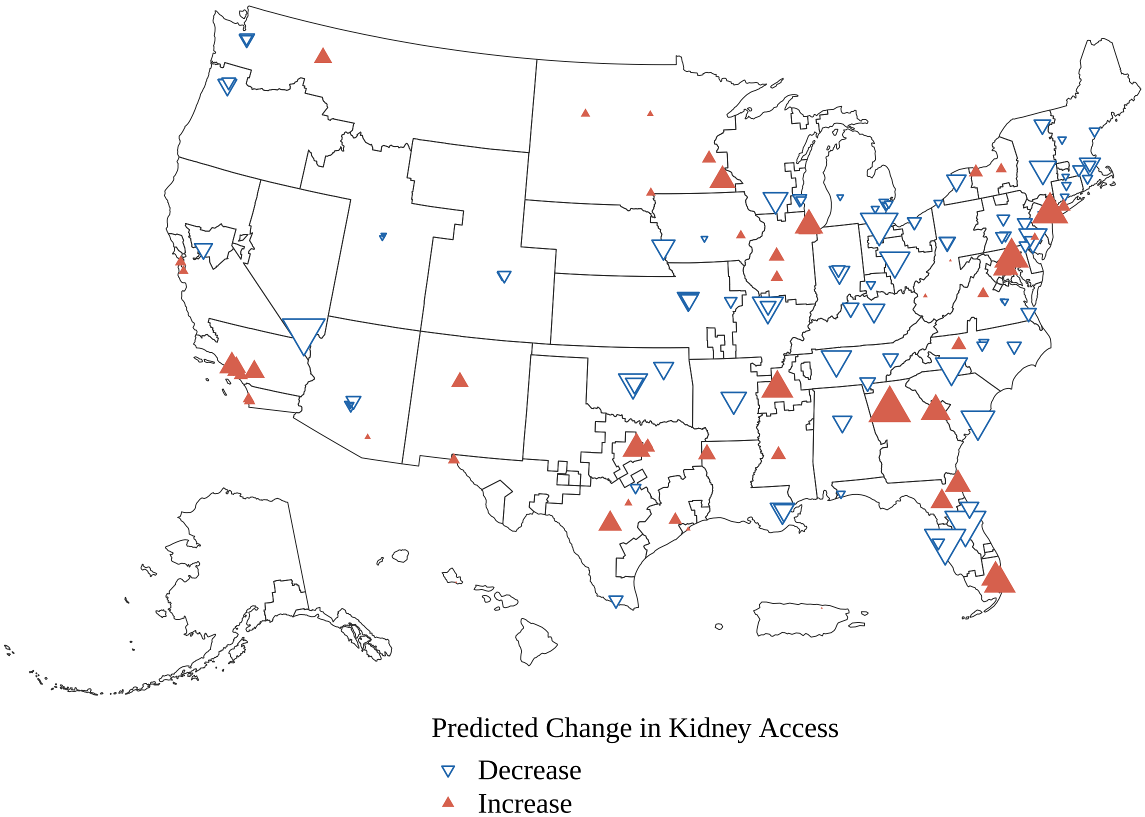
Notes: This figure displays a scatterplot illustrating the relationship between the monthly number of avaiable kidneys during pre-reform period and the predicted changes in kidney access by transplant center. Each data point on the scatterplot represents a transplant center. The correlation between these two measures, weighted by the size of the transplant center, is - 0.27 (p-value<0.001). Source of data is the restricted Scientific Registry of Transplant Recipients (SRTR) datasets, which include the universe of deceased donor kidneys and transplant candidates in the U.S.

Figure A.6: Histogram of Predicted Changes in Number of Kidneys by Transplant Center



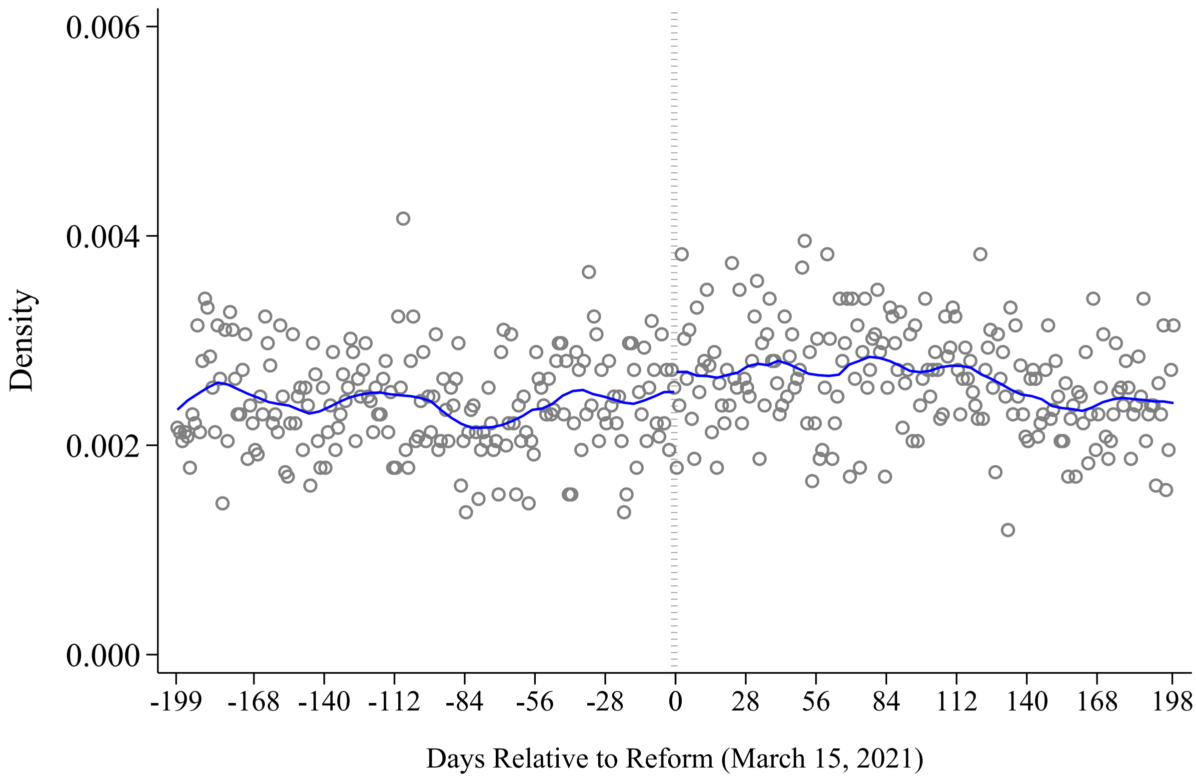
Notes: This figure plots a histogram of the treatment intensity measure using 40 equal-width bins. Treatment intensity is computed from Eq. 1. Appendix Figure A.3 provides a numerical example of calculating the predicted changes in available deceased donor kidneys for each transplant center. Source of data is the restricted Scientific Registry of Transplant Recipients (SRTR) datasets, which include the universe of deceased donor kidneys and transplant candidates in the U.S.

Figure A.7: Map of Treatment Intensity By Transplant Center



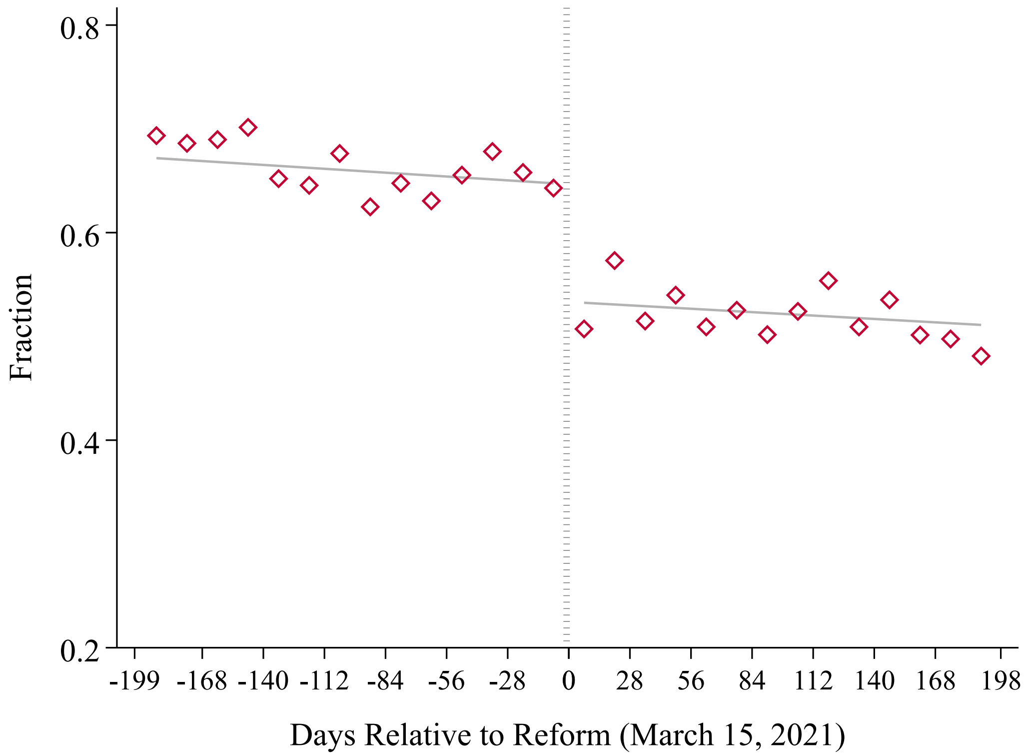
Notes: This figure maps treatment intensity by transplant center. Eq. 1 calculates the predicted change in the number of available deceased donor kidneys for each transplant center based on pre-reform data. Dot size is proportional to the absolute value of treatment intensity, which visualizes the magnitude of predicted changes in access. Source of data is the restricted Scientific Registry of Transplant Recipients (SRTR) datasets, which include the universe of deceased donor kidneys, transplant candidates, and transplant centers in the U.S.

Figure A.8: McCrary Density Test



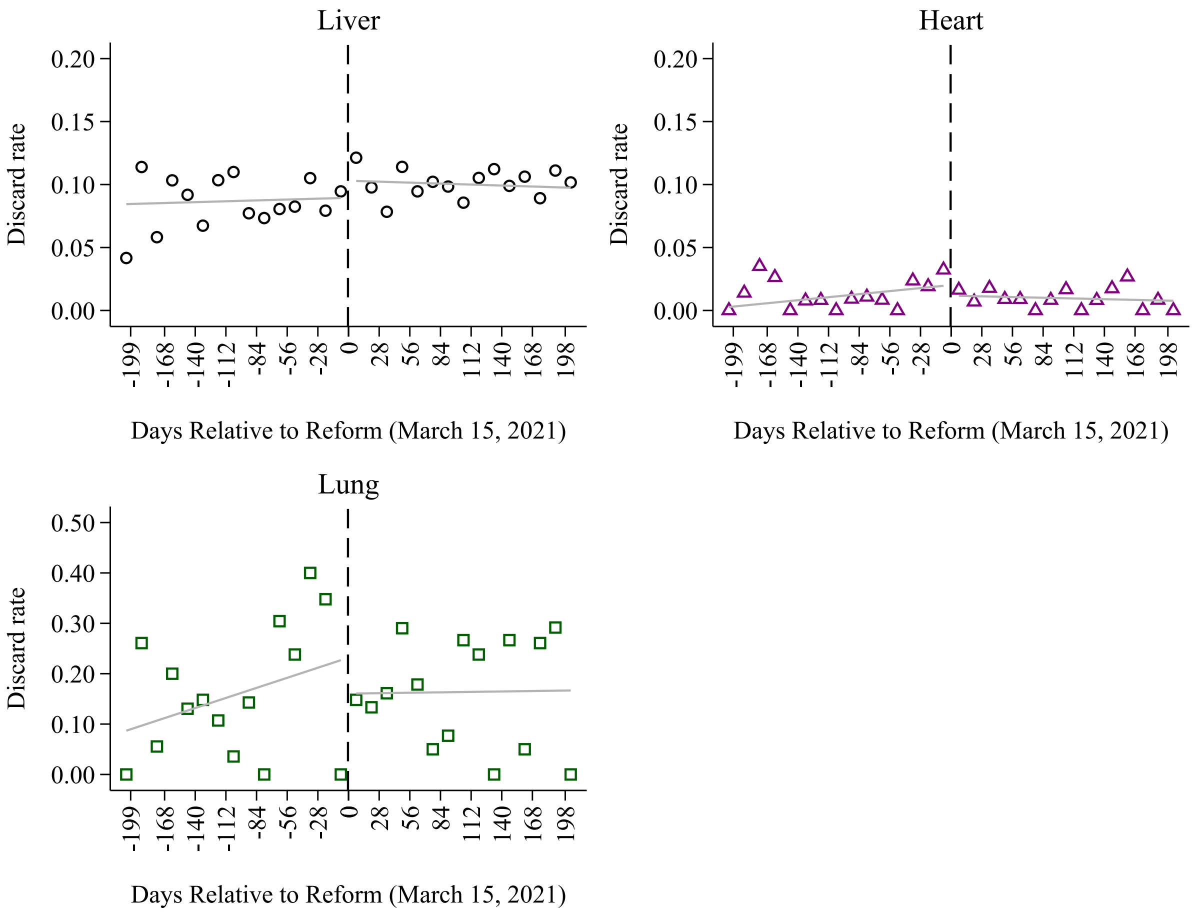
Notes: The figure presents the density of deceased donor kidneys by their initial offer date. Each dot represents a single day. I use DCDensity.ado, which was written by Justin McCrary and Brian Kovak, to estimate a McCrary density test in Stata. The McCrary density test discontinuity estimates are 0.0543 (standard error=0.0396, p-value=0.172). For more information on the sample, see the notes to Table 1.

Figure A.9: Share of kidneys finding the recipients within the same OPTN region



Notes: This figure shows the share of kidneys finding to the recipients within OPTN region by initial offer date relative to the allocation reform on March 15, 2021. Each point represents a two-week bin. Source of data is the restricted Scientific Registry of Transplant Recipients (SRTR) datasets, which include the universe of deceased donor kidneys in the U.S. For more information on sample, see the notes to Table 1.

Figure A.10: Placebo Test: Discard Rates for Livers, Lungs, and Hearts

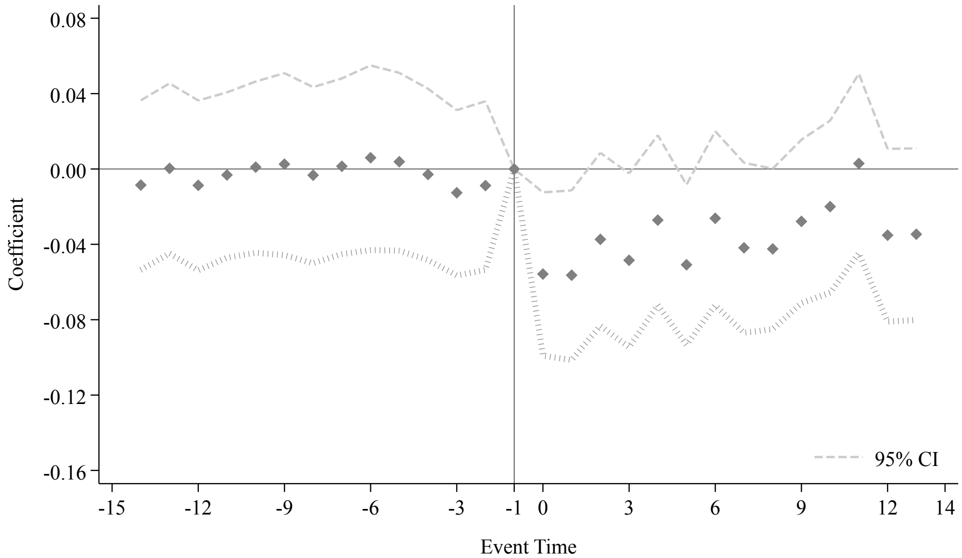


Notes: This figure plots the share of deceased-donor non-kidney organs (livers, lungs, and hearts) discarded, by initial offer date, relative to the kidney allocation reform implemented on March 15, 2021 (cutoff). The sample consists of livers, lungs, and hearts recovered for transplant from the donors included in the kidney-level data. The cut-off is March 15, 2021. “Mean, Pre-policy” is the average of outcome variable between -1 and - 199 days prior to the policy change. Source of data is the restricted Scientific Registry of Transplant Recipients (SRTR) datasets, which include the universe of deceased donor kidneys and transplant candidates in the U.S.

Figure A.11: Discard Rate by Kidney Donor Profile Index of Donated Kidney

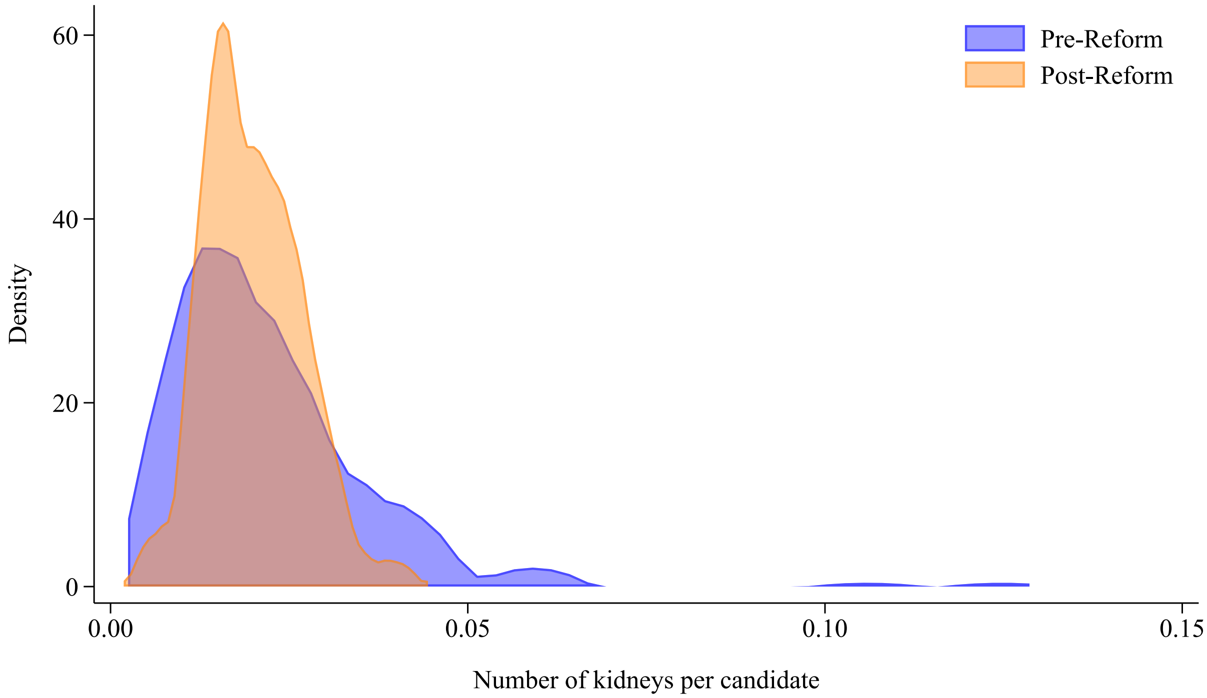
Notes: This figure plots the share of deceased donor kidneys discarded by initial offer date relative to the allocation reform on March 15, 2021. Each point represents a two week bin, and the x axis is the initial offer date. The sample is split into four Kidney Donor Profile Index (KDPI) categories used by the allocation system. KDPI is a kidney quality measure that summarizes the expected risk of graft failure for a deceased donor kidney relative to kidneys recovered in the prior year. Data come from the restricted Scientific Registry of Transplant Recipients (SRTR), which covers the universe of deceased donor kidneys in the United States. See the notes to Table 1 for additional sample details.

Figure A.12: Event Study Figures on Use of Donated Kidneys



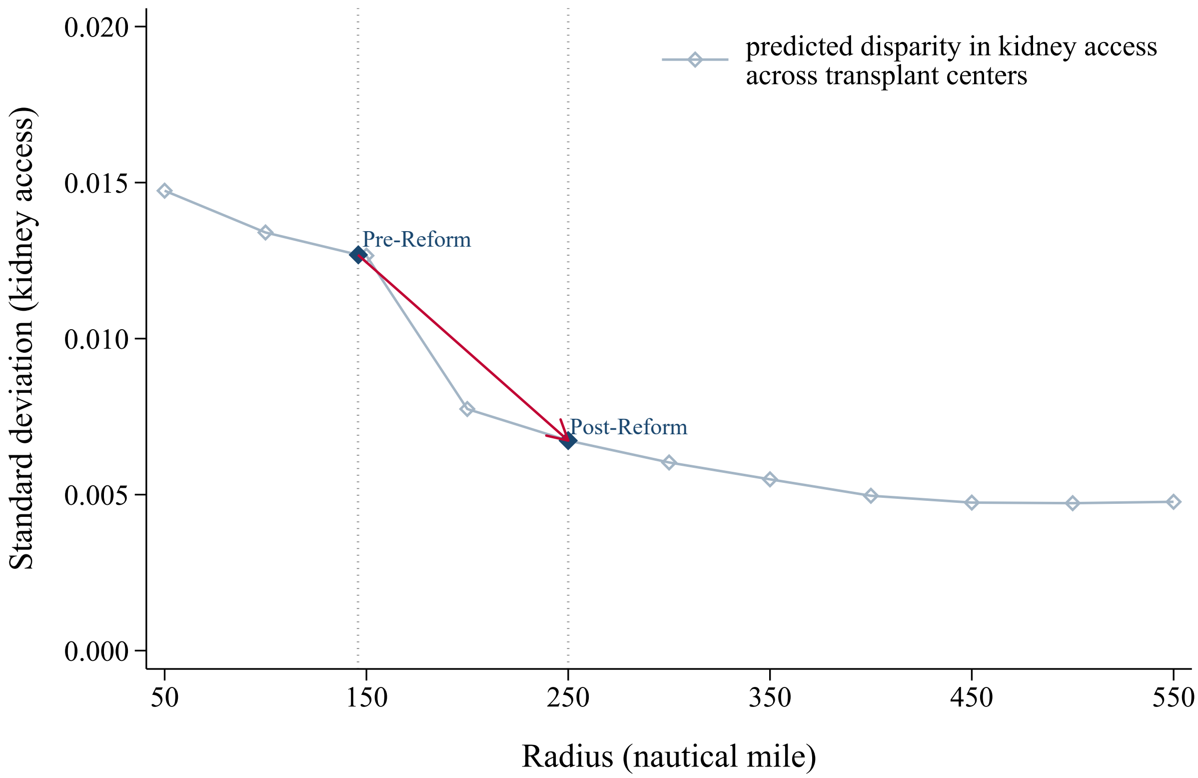
Notes: This figure plots the event study estimates and 95% confidence intervals from Equation 7. Event time is measured in two week intervals relative to the week of March 15, 2021. The sample includes kidneys from the main RD sample and the placebo sample of livers, hearts, and lungs recovered for transplant from the same donors. Because allocation systems operate independently by organ type, changes in kidney service area boundaries do not affect allocation of the placebo organs. The placebo sample is restricted to non kidney organs recovered from (i) adult donors (18 or above), (ii) initial offer was made ± 28 weeks from the policy implementation date, (iii) donors whose kidney biopsy information is complete, (iv) donor hospitals located outside Alaska, (v) donor hospitals that did not experience any change in OPO affiliation throughout the sample period. Data come from the restricted Scientific Registry of Transplant Recipients (SRTR), which includes the universe of deceased donor kidneys and transplant candidates in the United States. See Section 3 for details on sample construction.

Figure A.13: Distribution of Access to Kidneys Across Transplant Centers



Notes: The figure presents the kernel density of predicted access to kidneys across transplant centers before and after the reform. Predicted access to kidneys is defined as the quantity of available kidneys per candidate in a given transplant center during the pre-reform period (i.e., January 2019-February 2021). Source of data is the restricted Scientific Registry of Transplant Recipients (SRTR) datasets, which include the universe of deceased donor kidneys and transplant candidates in the U.S.

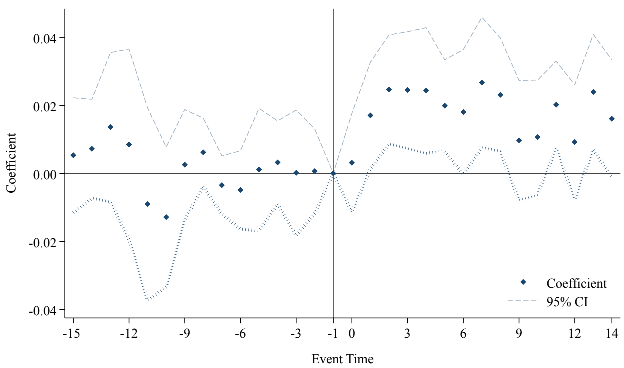
Figure A.14: Predicted Dispersion in Kidney Access by Service Area Size



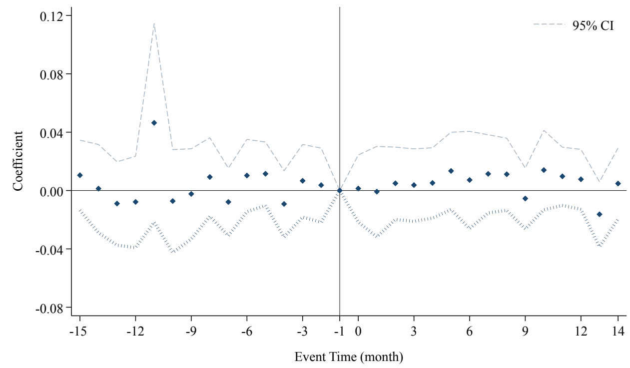
Notes: This figure shows how the dispersion of predicted kidney access across transplant centers varies with the radius of a circular service-area boundary. Using pre-reform data (January 2019–February 2021), predicted kidney availability is computed for each transplant center under counterfactual circles with radius r (nautical miles), where $r \in \{50, 100, 150, 200, 250, 300, 350, 400, 450, 500, 550\}$. The treatment-intensity measure $\Delta Access_h$ in Equation 1 is based on the reform's radius with r set to 250 and measures the predicted change in kidney access for center h. Source of data is the restricted Scientific Registry of Transplant Recipients (SRTR) datasets, which include the universe of deceased donor kidneys and transplant candidates in the U.S.

Figure A.15: Event Study Figures on Outcomes of Transplant Candidates

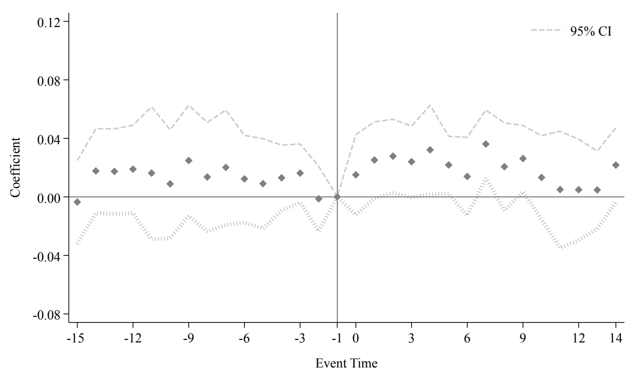
(a) Deceased Donor Kidney Transplant



(b) Living Donor Transplant



(c) Newly Joined to Waitlist



Notes: Figures A.15a–A.15c plot event study coefficients and 95% confidence intervals from Eq. 5. Event time refers to the number of months between transplant date and February 2021, a month prior to the policy change. Figure A.15a uses the monthly number of deceased donor kidney transplant recipients as the outcome. Figure A.15b uses the monthly number of living donor kidney transplant recipients. Figure A.15c uses the monthly number of newly waitlisted candidates. The sample includes transplant centers with at least one candidate waitlisted for a deceased donor kidney transplant during the pre-reform period (January 2019–February 2021). The sample is further restricted to centers with at least one active candidate prior to the policy change and located in DSAs with no changes in OPO affiliation during the sample period. Source of data is the restricted Scientific Registry of Transplant Recipients (SRTR) datasets, which include the universe of deceased donor kidneys and transplant candidates in the U.S. See Section 3 for details on sample construction.

Table A.1: Kidney Allocation Point Calculation

(a) Before March 15, 2021

Transplant Candidate	Points Awarded
1) Waiting Time (in days)	$\frac{1}{365}$ points
2) Age 0-10, zero-HLA mismatch	4 points
3) Age 11-17, zero-HLA mismatch	3 points
4) Age 0-10, KDPI 0-35% kidney	1 point
5) Prior living donor	4 points
6) CPRA 20-100%	Table A.2
7) Single HLA-DR mismatch	1 point
8) Zero HLA-DR mismatch	2 points

(b) On/After March 15, 2021

Transplant Candidate	Points Awarded
1) Waiting Time (in days)	$\frac{1}{365}$ points
2) Age 0-10, zero-HLA mismatch	4 points
3) Age 11-17, zero-HLA mismatch	3 points
4) Age 0-10, KDPI 0-35% kidney	1 point
5) Prior living donor	4 points
6) CPRA 20-100%	Table A.2
7) Single HLA-DR mismatch	1 point
8) Zero HLA-DR mismatch	2 points
9) Distance between donor hospital and transplant center	
(i) < 250nm	$2 - \left(\frac{2}{250} \times \text{distance}\right)$
(ii) 250nm -2499 nm	$4 - \left(\frac{4}{2500 - 250} \times (\text{distance} - 250)\right)$

Table A.2: Kidney Points Based on Transplant Candidate's CPRA Score

CPRA Score of Transplant Candidate	Points Awarded
0-19	0
20-29	0.08
30-39	0.21
40-49	0.34
50-59	0.48
60-69	0.81
70-74	1.09
75-79	1.58
80-84	2.46
85-89	4.05
90-94	6.71
95	10.82
96	12.17
97	17.3
98	24.4
99	50.09
100	202.1

Notes: This table describes the kidney allocation point system used to rank candidates within each category before and after the policy change. Appendix Table A.2 shows that starting March 15, 2021, the point system incorporates distance between the donor hospital and transplant center (0-2 points).

Table A.3: Validity Test: (1) Donor Demographics and Consent Mechanism

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
	Donor Demographics							Donor Consent Mechanism		
	Female	Age	Non-Hispanic White	Non-Hispanic Black	Hispanic /Latino	Body Mass Index	Recovered in Different State	Written Consent	Driver license	Donor Registry
$1(D_i \geq c)$	0.0127	-0.7795	0.0083	-0.0074	0.0005	-0.2402	-0.0059	-0.0089	0.0037	-0.0093
	(0.0207)	(0.6279)	(0.0158)	(0.0142)	(0.0140)	(0.3005)	(0.0099)	(0.0208)	(0.0162)	(0.0210)
Mean, Pre-policy	0.390	43.387	0.726	0.143	0.132	28.880	0.081	0.601	0.191	0.498
Observations	23,528	23,528	23,528	23,528	23,528	23,528	23,528	23,528	23,528	23,528
Controls	No	No	No	No	No	No	No	No	No	No
Bandwidth	± 199 days	± 199 days	± 199 days	± 199 days	± 199 days	± 199 days	± 199 days	± 199 days	± 199 days	± 199 days
Degree of polynomial	1	1	1	1	1	1	1	1	1	1
Weighting Scheme	Triangular	Triangular	Triangular	Triangular	Triangular	Triangular	Triangular	Triangular	Triangular	Triangular
Std error	Cluster	Cluster	Cluster	Cluster	Cluster	Cluster	Cluster	Cluster	Cluster	Cluster

Notes: This table reports the RD estimates of β from Eq. 3. Each column reports results from a separate regression, with the donor characteristic in the column heading as the outcome. The sample includes deceased donor kidneys for which the initial offer was made ± 199 days from the cut-off, March 15, 2021. The cut-off is March 15, 2021. "Mean, Pre-policy" is the average of outcome variable between -1 and -199 days prior to the policy change. Source of data is the restricted Scientific Registry of Transplant Recipients (SRTR) datasets, which include the universe of deceased donor kidneys and transplant candidates in the U.S. For more information on sample, see the notes to Table 1. Standard errors are clustered by initial offer date and reported in parentheses. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Table A.4: Validity Test: (2) Donor's Cause of Death and Health Status

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
	Kidney Donor	Expanded Criteria	Cancer	HCV	Donation after	Brain	Circumstances of Death			
	Risk Index	Donor Kidney	History	Positive	Circulatory Death	Death	Natural Causes	MVA	Suicide/Homicide	Non-MVA/Others
$1(D_i \geq c)$	-0.0200	-0.0215	0.0105	0.0055	-0.0049	0.0044	-0.0271	0.0183	-0.0121	0.0209
	(0.0165)	(0.0166)	(0.0075)	(0.0129)	(0.0155)	(0.0154)	(0.0211)	(0.0120)	(0.0131)	(0.0171)
Mean, Pre-policy	1.090	0.235	0.033	0.114	0.287	0.715	0.463	0.115	0.136	0.286
Observations	23,528	23,528	23,528	23,528	23,528	23,528	23,528	23,528	23,528	23,528
Controls	No	No	No	No	No	No	No	No	No	No
Bandwidth	± 199 days	± 199 days	± 199 days	± 199 days	± 199 days	± 199 days	± 199 days	± 199 days	± 199 days	± 199 days
Degree of polynomial	1	1	1	1	1	1	1	1	1	1
Weighting Scheme	Triangular	Triangular	Triangular	Triangular	Triangular	Triangular	Triangular	Triangular	Triangular	Triangular
Std error	Cluster	Cluster	Cluster	Cluster	Cluster	Cluster	Cluster	Cluster	Cluster	Cluster

Notes: This table reports the RD estimates of β from Eq. 3. Each column reports results from a separate regression, with the donor characteristic in the column heading as the outcome. The sample includes deceased donor kidneys for which the initial offer was made ± 199 days from the cut-off, March 15, 2021. The cut-off is March 15, 2021. "Mean, Pre-policy" is the average of outcome variable between -1 and -199 days prior to the policy change. Source of data is the restricted Scientific Registry of Transplant Recipients (SRTR) datasets, which include the universe of deceased donor kidneys and transplant candidates in the U.S. For more information on sample, see the notes to Table 1. Standard errors are clustered by initial offer date and reported in parentheses. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Table A.5: Results on the Likelihood a Kidney finds a Recipient within OPTN Region and State

	(1)	(2)
	Kidney Found Transplant Recipient	
	Within OPTN Region	Within State
$1(D_i \geq$c)	-0.1169***	-0.1376***
	(0.0152)	(0.0153)
Mean, Pre-policy	0.664	0.515
Observations	23,528	23,528
Controls	Yes	Yes
Bandwidth	± 199 days	± 199 days
Degree of polynomial	1	1
Weighting Scheme	Triangular	Triangular
Std error	Cluster	Cluster

Notes: This table reports the RD estimates of β from Eq. 3. Column (1) uses as the dependent variable an indicator for whether the kidney is transplanted within the donor hospital's OPTN region. Column (2) uses as the dependent variable an indicator for whether the kidney is transplanted within the donor hospital's state. The running variable is the initial offer date of kidneys. Source of data is the restricted Scientific Registry of Transplant Recipients (SRTR) datasets, which include the universe of deceased donor kidneys and transplant candidates in the U.S. The cut-off is March 15, 2021. For more information on sample, see the notes to Table 1. "Mean, Pre-policy" is the average of outcome variable between -1 and -199 days prior to the policy change. Standard errors are clustered by initial offer date and reported in parentheses. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Table A.6: Robustness Check

	(1)	(2)	(3)	(4)	(5)
	1(Transplanted Within DSA)	1(Discarded Kidney)	Reason Code for Being Discarded		
			1(Waited Too Long)	1(Organ quality)	1(Others)
Panel A. Main Specification					
$1(D_i \geq c)$	-0.2354***	-0.0380***	-0.0334***	-0.0051	-0.0006
	(0.0158)	(0.0143)	(0.0118)	(0.0091)	(0.0053)
Panel B. No Covariates					
$1(D_i \geq c)$	-0.2358***	-0.0372**	-0.0324***	-0.0052	-0.0007
	(0.0156)	(0.0144)	(0.0119)	(0.0091)	(0.0053)
Panel C. No Weighting					
$1(D_i \geq c)$	-0.2260***	-0.0413***	-0.0293***	-0.0120	-0.0008
	(0.0148)	(0.0134)	(0.0111)	(0.0083)	(0.0050)
Panel D. Local Linear Specification					
RD_Estimate	-0.2381***	-0.0374**	-0.0378***	-0.0012	0.0003
	(0.0173)	(0.0157)	(0.0129)	(0.0100)	(0.0057)
Panel E. Bias-corrected method (Calonico et al. 2019)					
$1(D_i \geq c)$	-0.2381***	-0.0414**	-0.0555***	0.0085	0.0039
	(0.0214)	(0.0188)	(0.0153)	(0.0112)	(0.0074)
Panel F. Bandwith ± 22 weeks					
$1(D_i \geq c)$	-0.2398***	-0.0348**	-0.0358***	-0.0009	0.0003
	(0.0177)	(0.0162)	(0.0133)	(0.0103)	(0.0059)
Panel G. Bandwith ± 24 weeks					
$1(D_i \geq c)$	-0.2388***	-0.0362**	-0.0350***	-0.0024	-0.0003
	(0.0171)	(0.0155)	(0.0128)	(0.0099)	(0.0056)
Panel H. Bandwith ± 26 weeks					
$1(D_i \geq c)$	-0.2379***	-0.0373**	-0.0346***	-0.0036	-0.0004
	(0.0165)	(0.0149)	(0.0123)	(0.0095)	(0.0055)
Panel I. Bandwith ± 30 weeks					
$1(D_i \geq c)$	-0.2339***	-0.0384***	-0.0327***	-0.0060	-0.0007
	(0.0154)	(0.0139)	(0.0115)	(0.0089)	(0.0052)
Panel J. Bandwith ± 32 weeks					
$1(D_i \geq c)$	-0.2317***	-0.0390***	-0.0323***	-0.0067	-0.0009
	(0.0150)	(0.0135)	(0.0111)	(0.0086)	(0.0050)
Panel K. Bandwith ± 34 weeks					
$1(D_i \geq c)$	-0.2309***	-0.0390***	-0.0312***	-0.0074	-0.0012
	(0.0146)	(0.0131)	(0.0108)	(0.0083)	(0.0049)

Notes: This table reports the RD estimates of β from Eq. 3under alternative specifications to the baseline in Panel A. Panel B excludes X_i. anel C drops triangular weights. Panel D uses a local linear control function. Panel E reports bias corrected estimates following (Calonico et al. 2019). Panels F–K use alternative bandwidth choices. The sample consists of deceased donor kidneys recovered for transplant. The cut-off is March 15, 2021. Source of data is the restricted Scientific Registry of Transplant Recipients (SRTR) datasets. See the notes to Table 1 for additional sample details. * p < 0.1, ** p < 0.05, *** p < 0.01.

Table A.7: Results on the Likelihood a Kidney is Discarded by Kidney Quality

	(1)	(2)	(3)	(4)	(5)	(6)
	Kidney Donor Profile Index (KDPI)				Expanded Criteria Donor	
	0-20	21-34	35-85	86-100	No (SCD)	Yes (ECD)
$1(D_i \geq$c)	-0.0118	-0.0203	-0.0255	-0.0874**	-0.0117	-0.0873**
	(0.0119)	(0.0235)	(0.0171)	(0.0379)	(0.0129)	(0.0341)
Mean, Pre-policy	0.030	0.060	0.205	0.647	0.128	0.530
Observations	4,210	3,170	12,321	3,827	18,055	5,473
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Bandwidth	± 199 days	± 199 days	± 199 days	± 199 days	± 199 days	± 199 days
Degree of polynomial	1	1	1	1	1	1
Weighting Scheme	Triangular	Triangular	Triangular	Triangular	Triangular	Triangular
Std error	Cluster	Cluster	Cluster	Cluster	Cluster	Cluster

Notes: This table provides the RD estimates of β from Eq. 3 with an indicator for discarded deceased donor kidneys as the dependent variable. The cut-off is March 15, 2021. Columns (1)-(4) use the sample of kidneys with the Kidney Donor Profile Index (KDPI) 2020 of (1) 0-20%, (2) 21-34%, (3) 35-85%, and (4) 86-100%, respectively. Columns (5)-(6) use the sample of kidneys classified as "standard criteria donor" (SCD) and "expanded criteria donor" (ECD), respectively. Prior to 2014, the kidney allocation system classified kidneys into two types: ECD or SCD kidneys. ECD kidneys are those recovered from donors (1) 60 or older or (2) aged 50–59 with two or three of the following conditions: high blood pressure, creatinine levels of 1.5 or higher, or death due to stroke. SCD kidneys refer to kidneys that are not categorized as ECD kidneys. The running variable is the initial offer date of kidneys. Source of data is the restricted Scientific Registry of Transplant Recipients (SRTR) datasets, which include the universe of deceased donor kidneys and transplant candidates in the U.S. For more information on sample, see the notes to Table 1. "Mean, Pre-policy" is the average of outcome variable between -1 and -199 days prior to the policy change. Standard errors are clustered by initial offer date and reported in parentheses. * p < 0.1, ** p < 0.05, *** p < 0.01.

Table A.8: Average Transplanted Kidney Characteristics – Travel Hours and Distance

	(1)	(2)	(3)	(4)	(5)	(6)
	Cold Ischemia	Distance from Donor Hospital to Transplant Center				
	Time (hours)	Nautical Mile (nm)	1(≤50 nm)	1(≤150 nm)	1(≤250 nm)	1(≤350 nm)
1(D_i ≥c)	1.6112***	21.9815*	-0.1858***	-0.1226***	0.0314**	0.0188
	(0.2827)	(12.7978)	(0.0189)	(0.0164)	(0.0126)	(0.0118)
Mean, Pre-policy	17.628	194.453	0.470	0.719	0.819	0.864
Observations	17,628	17,628	17,628	17,628	17,628	17,628
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Bandwidth	± 199 days	± 199 days	± 199 days	± 199 days	± 199 days	± 199 days
Degree of polynomial	1	1	1	1	1	1
Weighting Scheme	Triangular	Triangular	Triangular	Triangular	Triangular	Triangular
Std error	Cluster	Cluster	Cluster	Cluster	Cluster	Cluster

Notes: This table provides the RD estimates of β from Eq. 3. The running variable is the initial offer date of kidneys. Column (1) reports the impact on cold ischemic hours, which measures the number of hours the kidney was in cold or chilled status (i.e., between being removed from the donor and the cold storage solution). Column (2) reports the effect on travel distance in nautical miles (nm; 1 nm = 1.15078 miles) between donor hospital and transplant center. Columns (3)-(6) present the effects on whether the transplant center is located within 50, 150, 250 nm, and 350 nm of the donor hospital, respectively. The sample consists of deceased donor kidneys in Table 3 used for transplant. Source of data is the restricted Scientific Registry of Transplant Recipients (SRTR) datasets, which include the universe of deceased donor kidneys in the U.S. "Mean, Pre-policy" is the average of outcome variable between -1 and -199 days prior to the policy change. Standard errors are clustered by initial offer date and reported in parentheses. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Table A.9: Average Transplant Recipient Characteristics – Recipient Health Status

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	Dialysis Duration	Dialysis Duration Indicators				Previous	Diabetes
	(in Days)	< 1 year	1-2 years	3-4 years	5+ years	Transplant	Diagnosis
$1(D_i \geq$c)	134.3507***	-0.0093	-0.0342**	-0.0177	0.0611***	0.0077	-0.0031
	(46.6409)	(0.0144)	(0.0145)	(0.0153)	(0.0169)	(0.0116)	(0.0169)
Mean, Pre-policy	1353.224	0.251	0.238	0.207	0.304	0.125	0.413
Observations	17,628	17,628	17,628	17,628	17,628	17,628	17,628
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Bandwidth	± 199 days	± 199 days	± 199 days	± 199 days	± 199 days	± 199 days	± 199 days
Degree of polynomial	1	1	1	1	1	1	1
Weighting Scheme	Triangular	Triangular	Triangular	Triangular	Triangular	Triangular	Triangular
Std error	Cluster	Cluster	Cluster	Cluster	Cluster	Cluster	Cluster

Notes: This table provides the RD estimates of β from Eq. 3. The sample consists of deceased donor kidneys in Table 3 used for transplant. The cut-off is March 15, 2021. Source of data is the restricted Scientific Registry of Transplant Recipients (SRTR) datasets, which include the universe of deceased donor kidneys in the U.S. "Mean, Pre-policy" is the average of outcome variable between -1 and -199 days prior to the policy change.Standard errors are clustered at the running variable and in parentheses. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Table A.10: Average Transplant Recipient Characteristics – SVI and Poverty Rate

	(1)	(2)	(3)	(4)	(5)
	All	By Quartile			
	(Raw value)	1st	2nd	3rd	4th
Panel A. CDC Social Vulnerability Index					
$1(D_i \geq$c)	0.0260***	-0.0299**	-0.0171	0.0101	0.0369***
	(0.0084)	(0.0142)	(0.0133)	(0.0151)	(0.0139)
Mean, Pre-policy	0.621	0.257	0.255	0.244	0.243
Panel B. Poverty Rate					
$1(D_i \geq$c)	0.1639	-0.0287*	-0.0147	0.0357***	0.0078
	(0.1793)	(0.0148)	(0.0143)	(0.0138)	(0.0129)
Mean, Pre-policy	14.047	0.253	0.257	0.239	0.250
Observations	17,616	17,616	17,616	17,616	17,616
Controls	Yes	Yes	Yes	Yes	Yes
Bandwidth	± 199 days	± 199 days	± 199 days	± 199 days	± 199 days
Degree of polynomial	1	1	1	1	1
Weighting Scheme	Triangular	Triangular	Triangular	Triangular	Triangular
Std error	Cluster	Cluster	Cluster	Cluster	Cluster

Notes: This table provides the RD estimates of β from Eq. 3. The sample consists of deceased donor kidneys in Table 3 used for transplant. Source of data is the restricted Scientific Registry of Transplant Recipients (SRTR) datasets, which include the universe of deceased donor kidneys in the U.S. Poverty rate refers to the percentage of county residents living under the federal poverty line in 2019. Column (1) reports the impact on average county characteristics that recipient lived at the time of transplant. Columns (2)-(5) report the RD estimates when the dependent variable is an indicator of transplant recipient living in counties with in the first, second, third, or forth quartile group, respectively. "Mean, Pre-policy" is the average of outcome variable between -1 and -199 days prior to the policy change. Standard errors are clustered at the running variable and in parentheses. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Table A.11: Results on the Likelihood a Kidney is Discarded by Donor Hospital Location

	(1)	(2)	(3)	(4)
	Donor Hospital Location			
	Pre-Reform Market Tightness		Nearby Centers Predicted to Lose Kidney Access *After Reform*	
	Tighter Market	Loose Market	No	Yes
$1(D_i \geq$c)	-0.0212	-0.0590***	-0.0209	-0.0570***
	(0.0187)	(0.0214)	(0.0205)	(0.0213)
Mean, Pre-policy	0.223	0.223	0.220	0.226
Observations	13,094	10,434	12,312	11,216
Controls	Yes	Yes	Yes	Yes
Bandwidth	± 199 days	± 199 days	± 199 days	± 199 days
Degree of polynomial	1	1	1	1
Weighting Scheme	Triangular	Triangular	Triangular	Triangular
Std error	Cluster	Cluster	Cluster	Cluster

Notes: This table provides the RD estimates of β from Eq. 3 with an indicator of discarded deceased donor kidneys as the dependent variable. Pre-reform market tightness is calculated as the average monthly number of transplant candidates per kidney recovered within the donor hospital's DSA. A donor hospital is classified as located in a negatively affected DSA if all transplant centers in that DSA have negative predicted treatment intensity (Eq. 1), indicating lower kidney access after the reform. "Mean, Pre-policy" is the average of outcome variable between -1 and -199 days prior to the policy change. Source of data is the restricted Scientific Registry of Transplant Recipients (SRTR) datasets, which include the universe of deceased donor kidneys and transplant candidates in the U.S. Donor hospital location is defined by its pre-reform Donor Service Area (DSA). For more information on sample, see the notes to Table 1. Standard errors are clustered by initial offer date and reported in parentheses. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Table A.12: Average Transplant Recipient Characteristics – Race/Ethnicity

	(1)	(2)	(3)	(4)
	Transplant Recipient			
	Non-Hispanic White	Non-Hispanic Black	Hispanic /Latino	Others
$1(D_i \geq$c)	-0.0048	-0.0207	0.0228*	0.0045
	(0.0148)	(0.0187)	(0.0131)	(0.0100)
Mean, Pre-policy	0.390	0.343	0.186	0.084
Observations	17,628	17,628	17,628	17,628
Controls	Yes	Yes	Yes	Yes
Bandwidth	± 199 days	± 199 days	± 199 days	± 199 days
Degree of polynomial	1	1	1	1
Weighting Scheme	Triangular	Triangular	Triangular	Triangular
Std error	Cluster	Cluster	Cluster	Cluster

Notes: This table provides the RD estimates of β from Eq. 3 using the sample that consists of deceased donor kidneys used for transplant. The cut-off is March 15, 2021. "Mean, Pre-policy" is the average of outcome variable between -1 and -199 days prior to the policy change. Source of data is the restricted Scientific Registry of Transplant Recipients (SRTR) datasets, which include the universe of deceased donor kidneys and transplant candidates in the U.S. Standard errors are clustered at the running variable and in parentheses. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Table A.13: Robustness Check – Monthly Transplant Center Outcomes: Impact on Candidate Health Outcomes (OLS)

	(1)	(2)	(3)	(4)	(5)
	Monthly Outcomes per 1,000 Candidates				
	Deaths		Received Transplant		New Waitlist Registrations
	Without Transplant	All Deaths $\leq$ 5 years Listing	Deceased Donor Kidney	Living Donor Kidney	
$\Delta Access_h \times Post_{hm}$	-0.08600***	-0.12697***	0.24150***	0.00520	-0.02910
	(0.02907)	(0.02561)	(0.09267)	(0.02126)	(0.12389)
Mean of Dep. Var (Pre)	7.239	6.869	15.060	4.536	27.973
Observation	6,120	6,120	6,120	6,120	6,120

Notes: This table reports the estimates of γ in Eq. 4 but with the OLS specification. Columns (1) and (2) report the impact on the number of transplant candidates died on the waitlist per 1,000 candidate and transplant candidates died within 5 years of entering the waitlist per 1,000 candidates, respectively. Column (3) presents the impact on the number of deceased kidney transplants per 1,000 candidate. Column (4) reports the impact on the number of living donor transplants per 1,000 candidate. Column (5) reports the impact on the number of newly added candidates per 1,000 candidate. Results in Columns (1)–(5) are weighted by the monthly average waitlist enrollment during the pre-preiod. The transplant center–month sample includes centers with active transplant candidates prior to the policy change and is restricted to centers located in DSAs whose OPO affiliation does not change over the sample period. "Mean of Dep-Var" is the average of outcome variable between -1 and -15 months prior to the policy change, weighted by the average number of transplant candidates on the waitlist. Standard errors clustered at transplant center level are in parentheses. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Table A.14: Robustness Check – Monthly Transplant Center Outcomes: Recipients

	(1)	(2)	(3)	(4)
	Monthly Number of Recipients with Adverse Post-Transplant Health Outcomes (per 1,000 Candidates)			
	$\leq$ 3 months	$\leq$ 6 months	$\leq$ 9 months	$\leq$ 12 months
$\Delta Access_h \times Post_{hm}$	0.00114	-0.00880	-0.00294	-0.00490
	(0.00637)	(0.00853)	(0.00909)	(0.00911)
Mean of Dep. Var (Pre)	0.436	0.662	0.856	1.039
Observation	6,120	6,120	6,120	6,120

Notes: This table reports the estimates of γ in Eq. 4 but with the OLS specification. Post-transplant adverse outcomes are defined as (i) death, (ii) graft failure, and (iii) resumption of maintenance dialysis within 3, 6, 9, and 12 months of a deceased donor kidney transplant. Columns (1)–(4) use as the dependent variable the number of recipients per 1,000 waitlisted candidates at the transplant center who experience any of these adverse events within 3, 6, 9, and 12 months after transplant, respectively. Results in Columns (1)–(4) are weighted by the average number of transplant candidates on the waitlist per transplant center during the pre-preiod. The transplant center–month sample includes centers with active transplant candidates prior to the policy change and is restricted to centers located in DSAs whose OPO affiliation does not change over the sample period. "Mean of Dep-Var" is the average of outcome variable between -1 and -15 months prior to the policy change, weighted by the average number of transplant candidates on the waitlist. Standard errors clustered at transplant center level are in parentheses. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

A.1 Appendix: Difference-in-Differences Design as an Alternative Strategy for Evaluating the Impact on Use of Kidneys

I conduct a complementary difference-in-differences (DD) analysis to examine dynamic treatment effects on the use of donated kidneys. Because the policy change applies to kidney allocation but not to non-kidney allocation systems, the DD model treats donated kidneys in the main RD sample as the treatment group and non-kidney organs in the placebo sample as the control group (Section 5.1).

I implement a two-stage event study design following Gardner (2022), using specifications similar to those used in prior literature (e.g., Dobkin et al. 2018; Fadlon et al. 2024). This approach is relevant because the donor pool has expanded continuously over time, including increased use of older donors and donors after circulatory death, which are associated with declines in average organ quality (e.g., Marrero et al. 2017; Bradbrook et al. 2025). Because kidney allocation uniquely provides transplant centers with a formal organ quality metric, kidney discard rates may respond differently to these shifts in donor quality than discard rates for other organs.

In the first stage, I estimate the following specification using observations not affected by the kidney allocation reform. Specifically, I use all non kidney organs recovered within a 28 week window around the reform together with kidneys recovered before the policy change

$$Y_{io} = X_{io}\theta + \lambda_{w(i)} + \eta_o + \epsilon_{io} \tag{6}$$

where Y_{io} denotes an outcome for organ $o \in$ {kidney, heart, liver, lung} recovered from deceased donor i. $\lambda_{w(i)}$ denotes fixed effects for the organ offer date (in weeks). η_o denotes organ type fixed effects. X_{io} includes a linear time trend interacted with organ type and four Kidney Donor Profile Index (KDPI) subgroups (Section 2.3).

Using the estimated coefficients from Eq. 6, I construct a residualized outcome $\tilde{Y}_{io}$ defined as the difference between the observed and predicted values. I then estimate the event study specification in Eq. 7:

$$\tilde{Y}_{io} = \sum_{\tau=-15(\neq -1)}^{14} \delta_\tau 1(t=\tau) \times \underbrace{1(Kidney)_o}_{\text{Eligible organ type}} + \kappa_o + \varepsilon_{io} \tag{7}$$

where event time τ is measured in weeks relative to the reform, with $\tau = -1$ omitted. Standard errors are clustered at the donor hospital level. Appendix Figure A.12 reports the corresponding event study estimates.