Scarcity and Health Inequality: Evidence from Liver Transplantation *

Kevin Callison
Tulane University

Michael E. Darden
Johns Hopkins University and NBER

Keith F. Teltser
Georgia State University

November 20, 2025

Abstract

We study how reduced scarcity affects racial disparities in liver transplantation. When direct-acting antivirals dramatically reduced liver demand from Hepatitis C (HCV^+) end-stage liver disease patients, we show that transplants increased by 56.6% among White patients *without HCV* versus only 11.9% for Black patients. The transplant rate rose (19.5pp) and waiting times fell (31.1%) exclusively for White HCV^- patients. These patterns are surprising because transplant priority depends on disease severity, and Black patients join the waiting list in worse liver health. A decomposition suggests that differences in age, payer, blood type, and geography explain only 19.5% of the differential gains.

Keywords: Health Disparities; Scarcity, Liver Transplantation

JEL Classification: I10; I11; I14; O3

*We thank Betsy Cliff, Fabian Siuda, Jonathan Zhang, and seminar participants at the American Society of Health Economics Annual Conference, Fife Applied Microeconomics Conference, Southeastern Health Economics Study Group, Carolina Region Empirical Economics Day Workshop, MPI Bonn, University of Cologne, Johns Hopkins University, University of Iowa, University of North Carolina Charlotte, University of Bologna, Tecnológico de Monterrey, and Tinbergen Institute for comments. We gratefully acknowledge financial support from Georgia State University via the Pre-Tenure Scholarly Support Grant Program. The data reported here have been supplied by the Hennepin Healthcare Research Institute (HHRI) as the contractor for the Scientific Registry of Transplant Recipients (SRTR). The interpretation and reporting of these data are the responsibility of the author(s) and in no way should be seen as an official policy of, or interpretation by, the SRTR or the U.S. government. More information on how to obtain the SRTR Standard Analysis Files can be found at the following website: https://www.srtr.org/requesting-srtr-data/data-requests/.

1 Introduction

Resource scarcity has been shown to worsen health (Aguilar-Gomez et al., 2025; Francetic et al., 2024; Hackmann et al., 2024; Hoe, 2022), and there is growing evidence that scarcity can exacerbate racial disparities (Singh & Venkataramani, 2022; Freedman, 2016). However, the processes through which changes in resource availability affect disparities remains unclear. Organ transplantation offers a useful setting to examine these dynamics, as the supply of donor organs is inherently scarce and non-price allocation mechanisms generate significant waiting lists. Furthermore, while the allocation of deceased donor organs is intended to be based solely on medical need, in practice, unequal access to referrals, specialty care, and evaluation resources can affect *who* is added to the waiting list, and differences in patient resources may drive differences in transplant outcomes (Park et al., 2022).

We study racial disparities in liver transplantation during a period when medical innovation dramatically *lessened* the scarcity of donor livers. Specifically, we frame the 2013 introduction of direct-acting antiviral (DAA) therapeutics for the treatment of chronic hepatitis C infection (HCV) as an exogenous shock to the availability of donor livers for patients with non-HCV (henceforth HCV^-) forms of end-stage liver disease (ESLD). Prior to 2013, HCV was both the leading cause of infectious disease death in the United States and the leading cause of referral to the liver transplant waiting list. By raising HCV viral clearance rates to over 90%, DAAs reduced the HCV^+ ESLD demand for liver transplants by 40% (Callison et al., 2024). The result was a significant increase in the number of donor livers available to HCV^- patients, which both increased the likelihood of an HCV^- waiting list enrollee receiving a transplant and increased the incentive for marginal HCV^- ESLD patients to enroll in the liver transplant waiting list. Therefore, the stylized research question we ask is: when scarcity is lessened through innovation, are the resulting gains equitably distributed between Black and White patients?

Using data on the universe of liver transplant waiting list registrations and transplants from 2005 to 2019, we find that White HCV^- patients disproportionately benefited from the increase in donor liver availability that followed the introduction of DAAs for HCV. We find a 56.6% average annual increase in the count of liver transplants for White HCV^- patients, but only an 11.9% increase for Black HCV^- patients. Furthermore, for White HCV^- patients, we estimate an average annual increase of 19.5 percentage points in the transplant rate (i.e., transplants conditional on listing) and a 31.1% reduction in the time from listing to transplant; we find no economically or statistically meaningful changes in these measures for Black patients. To put these results in context, prior to DAAs, 75% of HCV^- liver transplants went to White patients, but our results imply that 85% of transplants that can be causally attributed to DAA-driven reallocation went to White HCV^- patients.

Importantly, these results run counter to the medical need of the marginal patient. While we document larger flows of HCV^- White patients onto the waiting list (46.3% increase from baseline) than HCV^- Black patients

(22.4% increase from baseline) following the introduction of DAAs, Black patients had Model for End-Stage Liver Disease (MELD) scores, the principal measure of medical urgency used to prioritize transplant candidates, that were 17% higher (worse) than White patients at the time of listing. To explore alternative mechanisms for our results, we decompose the differential (Black/White) gains from innovation and find that age, education, blood type, insurance type, and place of residence explain only 19.5% of the racial gap.[1]

Our results are evident in trends from raw data, however, we focus on a research design that studies behavior (i.e., listing decisions) and outcomes (i.e., transplants) among HCV^- ESLD patients relative to similar trends for end-stage renal disease (ESRD) patients before and after the introduction of DAAs. Since DAAs are not an effective treatment for ESRD, this group serves as a plausibly unaffected counterfactual, allowing us to net out concurrent shocks such as the Affordable Care Act's Medicaid expansions or the opioid crisis, which have both been shown to influence the demand and supply of transplantable organs (Lemont, 2023; Dickert-Conlin et al., 2024). We show robustness of our main findings through a triple differences design in which we compare outcomes before and after DAA availability, across organs, and across markets with above and below median baseline HCV^+ transplant rates. The argument for the third difference is that markets with high HCV^+ transplant rates prior to the introduction of DAAs should, all else equal, see larger reductions in the demand for liver transplant from HCV^+ patients. Additionally, this strategy nets out race-group specific differences in the proportional contribution in each organ market. Results from these triple-difference models are consistent with our main difference-in-differences findings that DAAs disproportionately benefited White patients.

We contribute to the large economics literature on scarcity and health care. One strand of this literature emphasizes how scarcity causes a psychology of inefficiency, where otherwise rational actors are less efficient in managing resources (Mullainathan & Shafir, 2013). Recent evidence from Singh & Venkataramani (2022) suggests that this "capacity strain" causes physicians to rely on potentially racially biased heuristics that exacerbate existing racial disparities precisely when capacity strain is binding (Arogyaswamy et al., 2022). In our context, because both the listing and transplant decisions are made jointly between patient and physician, we have the opportunity to test the symmetry of this finding. In doing so, we also contribute to a large economic literature on Black/White gaps in health care access and health outcomes (Hollingsworth et al., 2024; Zewde, 2024; Arias et al., 2022; Kuziemko et al., 2018; Wherry et al., 2018) and recent work on the economics of organ transplantation (Elías et al., 2019; Dickert-Conlin et al., 2024; Callison et al., 2024).

Our work is closely related to the economic literature that has found medical innovation to both be overwhelmingly

[1]We also rule out racial concordance, the idea that waiting list registrants are more likely to be offered an organ from a donor of the same race. Black HCV^+ transplants fell by a similar percentage relative to White HCV^+ transplants (-33.0% vs. -32.2%). Furthermore, we show no effects on waiting list mortality, which rules out the idea that the composition of the list changed along other health dimensions.

welfare improving in the long-run (Ho & Pakes, 2024; Dranove et al., 2022; Hall & Jones, 2007; Murphy & Topel, 2006; Cutler & McClellan, 2001; Newhouse, 1992) and produced and diffused unequally across groups in the short-run (Cutler et al., 2012; Koning et al., 2021; Alsan et al., 2023; Glied & Lleras-Muney, 2008; Hoagland, 2024). Disadvantaged groups may lack access to innovations or face constraints that prevent adoption, such as travel costs or labor market frictions (Papageorge, 2016; Hamilton et al., 2021). A large literature recognizes that, even when product and procedure innovations pass benefit-cost tests overall, these new technologies can increase inequality, especially in the short-run (Aghion et al., 2018; Jaravel, 2018). In our case, conditional on listing and prior to DAAs, Black HCV^- patients were more likely to receive a transplant because of worse liver health, but the downstream effect of innovation was to disproportionately benefit White HCV^- patients, equalizing transplant rates even though marginal Black patients remained in greater medical need.

Finally, our work speaks to the growing literature on algorithmic decision-making that may, or may not, exacerbate health disparities (Obermeyer et al., 2019; Rambachan et al., 2020; Arnold et al., 2021; Hurtado & Sakong, 2024). The MELD score quantifies a patient's liver function by predicting their short-term mortality risk and, conditional on biological compatibility, is the primary metric used to allocate donor livers based on medical need. We show that before and after DAAs, the mean MELD score of Black registrants at listing remained roughly 15% above that of White registrants, reflecting greater illness severity among Black patients. Prior to DAAs, this translated into a higher transplant rate for Black HCV^- ESLD patients relative to White patients. However, despite Black patients continuing to present with more advanced liver disease at listing, the Black-White gap in transplant rates *narrowed* following the introduction of DAAs, as White patients saw disproportionate gains.[2] Our results suggest that complementary policies may be needed to ensure equitable distribution of organs (Fleurence & Collins, 2023; Auty et al., 2022), including adjustments to the MELD score. This has implications for organ allocation policy, as future medical innovations that reduce demand for organs in other therapeutic areas could create similar distributional challenges.

2 Background

When a patient's liver disease has progressed to liver failure (i.e., end-stage liver disease) the only viable treatment option is transplant. The liver transplant process includes three distinct phases, each with opportunities for disparities. At the evaluation phase, patients are referred to a transplant center by their primary care provider or medical specialist to complete a series of clinical and psychosocial workups that may include assessing the degree of social support available to the candidate, psychiatric illness, and whether the candidate uses alcohol, tobacco,

[2]Recent reporting suggests that organ allocation is increasingly separate from medical necessity. https://www.nytimes.com/interactive/2025/02/26/us/organ-transplants-waiting-list-skipped-patients.html

or other substances (Wahid et al., 2021). Conditional on passing the evaluation, a patient may be listed on the liver transplant waiting list. Overall, rates of listing among those who have been evaluated for transplant range between 30% and 50%, however several studies have documented variation in listing rates across various subgroups (Rosenblatt et al., 2021; Jesse et al., 2019; Bryce et al., 2010, 2009). Conditional on listing, a patient may receive an organ offer and undergo a liver transplant.

Following most of the medical literature cited above, we focus on disparities in the allocation of organs conditional on listing. Prior to 2002, transplant priority among those listing was determined by time accrued on the waiting list, hospitalization status, and an index comprised of five clinical measures (Cholongitas et al., 2005). This allocation mechanism disadvantaged people who tended to list later in their disease progression (i.e., racial and ethnic minorities) and, as a result, prior research concluded that Black patients were less likely to receive a transplant conditional on listing (Reid et al., 2004). Due to these perceived inequities, the Organ Procurement and Transplantation Network (OPTN) issued a final rule in October 1999 calling for revisions to the liver allocation criteria (OPTN, 1999). Those revisions resulted in the adoption of the Model for End-Stage Liver Disease (MELD) score in 2002 as the mechanism to determine deceased donor liver allocation among waiting list registrants (Trivedi, 2022). The MELD score is intended to quantify the 3-month mortality risk for individuals with ESLD, where a higher score corresponds to a higher mortality risk. In its current iteration, the MELD score is comprised of clinical measures (i.e., serum bilirubin, serum creatinine, serum sodium, and prothrombin time) along with an indicator for whether the individual received 2 or more dialysis treatments within the past week, and does not consider time spent on the waiting list or hospitalization status (Kim et al., 2021). In practice, the MELD score determines priority among candidates who are otherwise compatible, but organ offers also depend on other clinical and logistical factors including blood type, donor–recipient size match, geographic proximity under OPTN allocation rules, and the availability of surgical teams (Darden et al., 2021; Goldberg et al., 2016).

There is conflicting evidence on the degree to which disparities in transplant outcomes conditional on listing persist in the post-MELD era. Moylan et al. (2008) concluded that while Black race was associated with a lower probability of liver transplant within three years of listing and a higher probability of becoming too sick to transplant or dying before the introduction of the MELD score, these associations were no longer present after the MELD score had been introduced. However, several other studies have contradicted this finding and continue to report evidence of transplant disparities by race in the post-MELD period (Nephew & Serper, 2021). In our data, between 2005 and 2013, Black HCV^- waiting list registrants were 40% *more* likely to receive a transplant than White registrants, but Black registrants also had MELD scores that were worse than White registrants at the time of listing. Our data allow us to model both transplant outcomes and flows onto the waiting list when DAAs made livers more abundant for HCV^- patients.

3 Data

We use data from the Scientific Registry of Transplant Recipients (SRTR) from 2005 through 2019.[3] The SRTR data include comprehensive individual-level information on organ transplant waiting list registrants, donors, and recipients, collected from the Organ Procurement and Transplantation Network (OPTN) through the United Network for Organ Sharing (UNOS) (Wright, 2022). The data include measures of health that enter the MELD score both at the time of registration and at the time of transplant. Registrants are recorded as leaving the waiting list in the event of transplant or attrition through death or becoming too sick for transplant. Rarely, a patient's health will improve causing them to leave the list.

The SRTR data collect HCV antibody test results for transplant recipients, but do not directly measure HCV status at the time of wait-listing. Therefore, to determine whether a registrant was HCV^+ at listing, we examined the frequency at which different primary diagnosis codes commonly occurred among liver transplant recipients with and without HCV. For example, 59% of HCV^+ transplant recipients have a diagnosis of "cirrhosis: type C" (SRTR code 4204) compared to only 2.2% of HCV^- recipients. Similarly, "alcoholic cirrhosis with hepatitis C" (SRTR code 4216) is observed in 13.3% of HCV^+ transplant recipients and only 0.6% of HCV^- recipients. Conversely, "cirrhosis: fatty liver (NASH)" (SRTR code 4214) is found among 14.3% of HCV^- transplant recipients compared to only 0.6% of HCV^+ recipients. Likewise, "alcoholic cirrhosis" (SRTR code 4215) is present in 26.7% of HCV^- transplant recipients and only 3.5% of HCV^+ recipients. We then classify a code as indicative of HCV status only if its frequency in one group (either HCV^+ or HCV^- transplant recipients) exceeded that of the other group by a factor of at least four (Callison et al., 2024). Additionally, the SRTR data include an optional text field containing supplementary diagnostic information that we use to further refine our HCV classifications. Examples of text in this field include terms such as "HCV," "Hepatitis C," "Hep C," and variations that may include periods, dashes, slashes, or minor typos.[4]

While we have data on the confirmed HCV status of transplant recipients, for consistency across outcomes, we use inferred status in all analyses. To the extent that inferred HCV status leads to misclassification, as some HCV^+ individuals are categorized as HCV^- (and vice versa), any bias introduced will likely attenuate our estimated effects, and we would not expect differential attenuation by race. Since HCV antibodies are detectable even after viral clearance, we use antibody status at the time of transplant to evaluate whether individuals we classify as HCV^- might include those who had cleared the infection, which could overstate the impacts of DAAs on HCV^- wait-

[3]The SRTR data system includes data on all donor, wait-listed candidates, and transplant recipients in the United States, 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.

[4]Including information from this text field yielded an additional 1,804 HCV^+ registrants (roughly 120 per year) to the 93,547 registrants (roughly 6,236 per year) who we identified as HCV^+ or HCV^- through diagnosis codes alone.

listing. Our findings indicate this is unlikely. For instance, in 2014, 99 (3.2%) of the 3,128 liver transplant recipients categorized as HCV^- based on diagnostic codes tested positive for HCV antibodies at transplant, compared to 206 (3.3%) of the 6,180 categorized as HCV^- in 2019. Finally, the available diagnostic codes and text descriptions do not allow us to determine HCV status in approximately 15% of registrants, so we exclude these individuals from our analyses.

Table 1 provides counts, means, and proportions of the endogenous variables by time period (before and after DAAs), HCV status, and, as a source of comparison that we utilize below, for kidneys. We present these statistics in two panels representing White and Black patients and include data on the average annual count of waiting list additions, the average annual count of ESLD/ESRD deaths, and their ratio, which serves as a proxy listing rate as discussed above, time to transplant in days, the mean annual count of transplants, and the transplant rate, defined as the total number of transplants divided by average number of registrations on the waiting list throughout the year.[5] Table 1 also shows the mean initial MELD score at the time of wait listing and at transplant for ESLD patients only, as there is not a comparable summary health measure for ESRD patients.

Statistics on HCV^+ waiting list registrations and transplant counts convey the magnitude of the direct impact of DAAs on liver allocation. For example, for White HCV^+ patients, average annual waiting list additions fell from 2,701 to 1,580 between the period prior to DAAs (2005-2013) and after DAAs (2014-2019). Similarly, White HCV^+ average annual transplants fell from 1,473 to 1,049. Table 1 shows similar declines for Black patients. The HCV^+ liver columns demonstrate how DAAs obviated the need for a transplant for many HCV^+ patients and created an increase in the availability of deceased donor organs for HCV^- patients.

For HCV^- White patients, average annual additions to the waiting list (i.e., the flow onto the list) increased from 3,832 to 5,682, and the average count of annual ESLD deaths fell from 65,837 to 60,245 following DAAs.[6] The ratio of additions to deaths, which proxies for the accessibility of the waiting list, increased from 0.064 to 0.077. For White patients, both the MELD score at wait listing (WL) and at transplant (TX) increased (18.8 to 19.7 and 23.0 to 24.1, respectively), suggesting that marginal White patients were of worse liver health following DAAs. However, conditional on receiving a transplant, the time to transplant fell from 239 days to 216 days. Ultimately, the average annual count of liver transplants for White HCV^- patients increased from 2,058 to 3,385, and the transplant rate increased from 0.322 to 0.503.

For Black patients, the average annual count of HCV^- waiting list registrations also increased after DAAs became available (from 365 to 499). However, unlike White HCV^- patients, Black patients also experienced an

[5] While we focus on these two groups, our sample also includes individuals identifying as Hispanic, Asian, Pacific Islander and Native American. Because our focus is on gaps between Black and White patients, we control for differences in these groups.

[6] Greater HCV^- waiting list enrollment could be due to behavioral factors (e.g., improved transplant odds resulting from lower HCV^+ demand) or increasing disease prevalence. However, Callison et al. (2024) shows that the majority of the post-DAA increase in HCV^- listing is associated with alcoholic liver disease (ALD) and that the prevalence of ALD is flat during this period.

increase in average annual ESLD deaths, from 9,368 to 10,914. Although the ratio of waiting list additions to deaths improved slightly for Black HCV^- patients (0.039 to 0.046), the gap between the Black and White ratios actually widened over this period. As with White HCV^- patients, newly listed Black HCV^- registrants presented in worse liver health as measured by the MELD score (22.7 to 23.1), as did newly transplanted Black patients (26.4 to 27.0). Black HCV^- patients saw other improvements with the introduction of DAAs: average time to transplant fell from 201 to 192 days, average annual transplants increased from 220 to 317, and the observed transplant rate increased from 0.452 to 0.601. However, these improvements were modest in size compared to the gains experienced by White HCV^- patients.

The presentation of statistics for HCV^- liver patients and kidney patients hints at our research design. Changes in trends in HCV^- liver behaviors and outcomes following the introduction of DAAs may be due to DAAs, but could also be influenced by unrelated, concurrent shocks. The kidney comparison allows us to formulate a counterfactual trend in these behaviors and outcomes that should not be affected by DAAs. For example, kidney waiting list registrations increased marginally following DAAs from 15,830 to 16,049, which is smaller than the White HCV^- liver waiting list addition change, but which would suggest an attenuated effect of DAAs on the flow onto the waiting list. For White patients, similar changes occurred for the annual count of transplants. Kidney transplant counts increased from 8,323 to 8,743, which again would attenuate the effect of DAAs on HCV^- transplants. For Black HCV^- patients, waiting list additions, transplants, and the transplant rate all increased, but in each case, relative to the changes in kidneys, the increases are attenuated.

Figures 1a-1d present the log counts of waiting list additions and transplants by race, HCV status among liver patients, and organ over time. These figures show a clear inflection point in 2014, with sharp declines in HCV^+ liver waiting list additions and transplants across both racial groups coinciding with the introduction of DAAs. For White HCV^- patients, there is a marked and sustained increase in liver waiting list additions and transplants, while the increases for Black HCV^- patients are more muted. Kidney trends are more stable by comparison, though we do observe some post-2014 increases in kidney waitlisting, particularly for Black patients around 2017, and transplant counts for both Black and White patients. These changes likely reflect concurrent shocks such as the opioid crisis or Medicaid expansion, reinforcing the importance of including a comparison group to net out the influence of these potential confounders. Appendix Figure 1 plots liver transplant rates for HCV^- waiting list registrants by race over the sample period. After declining for several years prior to the introduction of DAAs, transplant rates increased for both Black and White HCV^- patients after 2014. However, where the Black transplant rate was substantially higher than the White rate in the pre-DAA period, by 2019 the rates had converged.

4 Research Design and Results

To formalize the trends depicted in Figures 1a-1d, we estimate the following difference-in-differences (DD) specification separately for each racial group:

$$Y_{dlt} = \beta[\mathbb{1}(l = liver) \times DAA_t] + \gamma_{dl} + \eta_t + \epsilon_{dlt}, \tag{1}$$

where Y_{dlt} represents a dependent variable for donor-service area (DSA) d, organ l, and year t. Since most dependent variables are measured as counts, we generally estimate Equation 1 via Poisson regression. Our coefficient of interest is β, which measures deviations for livers (relative to kidneys) following DAAs. We also include DSA-by-organ, γ, and time, η, fixed effects.

Table 2 reports race-specific estimates of β, DSA-clustered standard errors, and the baseline means of each dependent variable. The first column of Table 2 presents our estimates of changes in liver transplants for HCV^+ ESLD patients associated with the introduction of DAAs, conveying the magnitude of the direct impact of DAAs on the targeted patient group. Relative to baseline means, estimates in Column 1 suggest that HCV^+ transplants fell by 32.2% and 33.0% for White and Black patients, respectively.[7]

Turning to HCV^- patients, Column 2 of Table 2 includes estimates of the effect of DAAs on the average annual count of liver transplants to HCV^- recipients by race. Relative to their respective baseline means, DAAs increased average annual liver transplants by 56.6% for White HCV^- recipients and 11.7% for Black HCV^- recipients. Column 3 of Table 2 includes estimates of the effect of DAAs on the average number of days from joining the waiting list to receiving a transplant for HCV^- recipients by race.[8] The results indicate that the introduction of DAAs led to a reduction in the waiting time for liver transplants for White (31.1%) recipients, but show no evidence of reduced times from listing to transplant for Black liver transplant recipients. Finally, Column 4 of Table 2 provides estimates of the effect of DAAs on the liver transplant rate by race. Unlike in Table 1, in which we present national transplant rates per year, in our regressions, we define the transplant rate as the number of transplants in a given DSA-year divided by the number of DSA waiting list registrants, and we calculate separate rates for each racial group. The purpose of examining transplant rates in addition to transplant counts is that conditioning on the size of the waiting list effectively removes the influence of DAA-induced changes to waiting list inflows and outflows, allowing us to assess how DAAs affected HCV^- transplants independent of changes in the waiting list. Notably we find that DAAs only improved HCV^- transplant rates for White recipients (19.53 percentage points).[9] Overall, results in Table

[7] All coefficients except for the final column in Table 2 represent log point changes, which can be transformed into percentages using the formula $100 \times (e^{\hat{\beta}} - 1)$.

[8] The sample for the time-to-transplant analysis is restricted to those who received a liver or kidney transplant.

[9] Appendix Table 1 shows how estimates of β change with the inclusion of year and dsa-by-organ fixed effects. The inclusion of year

2 show that transplant gains associated with DAAs disproportionately favored White HCV^- ESLD patients over Black patients. Indeed, while 75% of transplants went to White patients prior to 2013, estimates in Table 2 imply that 85% of transplants that are causally attributed to DAAs went to White patients.

To demonstrate parallel pre-trends in these outcomes relative to our kidney comparison, we also estimate a time-disaggregated (i.e., event study) version of our DD specification separately by race,

$$Y_{dlt} = \sum_{k=2005}^{2019} \beta_k [\mathbb{1}(l = liver) \times \mathbb{1}(t = k)] + \gamma_{dl} + \eta_t + \epsilon_{dlt}, \tag{2}$$

where the effect of DAAs is allowed to vary over time relative to the baseline normalization in year 2012.[10] All other elements of the model presented in Equation 2 are defined as in Equation 1. Figure 2 presents event study estimates for log transplant counts and transplant rates for White and Black patients. For both outcomes, we find little evidence of systematic differential pre-trends for either racial group, supporting the validity of the research design. Consistent with our results in Table 2, we see large gains in transplant counts in Figure 2a for White patients but considerably noisier effects on log transplant counts for Black patients (Figure 2b). Similarly, we see a considerable increase in the transplant rate for White patients (Figure 2c) but no measurable effect for Black patients (Figure 2d). Appendix Figure 2 presents event study estimates for time from listing to transplant for White and Black patients, and shows similar effects to those in Table 2.

Our primary concern with the research design of comparing trends in liver transplant outcomes to kidney transplant outcomes is that the effects of DAAs may spillover to kidney patients. For example, the willingness of ESRD patients to accept an HCV^+ kidney may increase with DAA availability, causing an increase in kidney transplants. As another example, the supply of kidneys may increase if newly cured HCV^+ patients are thus eligible for kidney donation. Callison et al. (2024) document robust evidence that such spillovers are unlikely to affect the qualitative conclusion that DAAs caused a significant externality to HCV^- patients, but in our setting, concern remains that these spillovers would have differential effects by race. To address this concern, we consider a triple differences strategy that exploits variation in the HCV^+ transplant rate prior to DAAs, which prior work has shown to be an economically important determinant of larger reductions in donor liver scarcity following DAA availability (Callison et al., 2024). This triple-differences design also nets out race-group specific differences in the proportional contribution in each organ market. These results are presented in Appendix Table 2 for transplant count, time to transplant, and the transplant rate by race. In all cases, the triple-difference terms (i.e., the interaction between

fixed effects significantly attenuates the estimate for the Black transplant rate, which suggests that averaging over post-DAA years (as in Table 1) masks important trends in the transplant rate. The year fixed effects are important in explaining the difference between the unadjusted rates in Table 1 and our difference-in-differences estimates in Table 2.

[10] We chose 2012 as the baseline year because DAAs were approved by FDA in December, 2013.

the post period, race, and being in an above-median HCV^+ DSA) point in the direction of our results in Table 2, though the triple-difference estimates are less precise than our main findings.

We present two additional robustness exercises. First, we show robustness to our transplant rate definition. In Appendix Table 3, alongside estimates of our preferred transplant rate, we also present results on the total number of transplants divided by number of unique registrations that were on the list and waiting at any point during the year. Here, the baseline rates and effects are attenuated for both Black and White patients, but the White effect remains roughly four times larger. Second, because our interest is in differences in outcomes across races, changes in the racial composition of the liver transplant waiting list as a result of the introduction of DAAs is a concern. Indeed, the percentage flow effects onto the waiting list differ markedly by race (we discuss this in the next section). However, Appendix Table 4, which shows difference-in-differences estimates of the share of each racial group comprising the liver transplant waiting list, indicate no statistical changes in waiting list racial composition as a result of DAAs.

5 Mechanisms

We explore three potential classes of mechanisms to explain the differential gains in transplants. First, we conduct a series of sub-group analyses that show how the differential transplant gains from DAAs vary across education, age, insurance coverage, blood type, rurality, and the racial composition of the DSA. At the allocation stage, MELD-based match runs determine the priority order for compatible organs, but transplant centers retain discretion over whether to accept an offered organ, and center practices can vary in ways that interact with patient resources and local demographics (Goldberg et al., 2016). Table 3 presents results from these subgroup analyses. While the magnitude of the Black/White gap in transplant gains varies across subgroups, results consistently indicate that White HCV^- patients saw larger gains than Black patients. For example, in our baseline specification, transplants to White HCV^- patients increased by 56.6% compared to 11.9% for Black HCV^- patients, a gap of 44.7 percentage points. When restricting our sample to those with at least some college education (Panel A, Column 1), the size of the gap in transplant gains remained similar at 48.0 percentage points. Restricting the sample to those with private insurance (Panel A, Columns 3 and 4) or those with blood types O or B (Panel A, Columns 5 and 6), yield very similar gaps. Only by restricting the sample to those ages 55 and older do we observe a reduction in the racial gap in transplant gains (Panel A, Column 2). Among this group, White HCV^- patients experienced a 37.8% increase in the number of transplants compared to an 18.8% increase for Black HCV^- patients, a gap of 19 percentage points.

In Panel B of Table 3, we investigate heterogeneity in our main effects by geography. This analysis is motivated by research showing that racial representation in health care settings can influence disparities in access and outcomes (Alsan et al., 2019). We find similarly large gaps in the gains from DAAs in more rural DSAs (Panel B, Column 1),

and DSAs with above median Black (Panel B, Column 2) and above median White (Panel B, Column 3) HCV^- populations. Appendix Tables 5 and 6 present results on all outcomes for above median Black and above Median White DSAs, respectively.

Our third mechanism deals with the health of the marginal waiting list registrant. A straightforward explanation for the disproportionate gains for White HCV^- patients would be that marginal White patients (i.e., those induced to join the waiting list because of the increased donor liver availability due to DAAs) were in worse liver health. Indeed, in Panel B, Column 4 of Table 3, we show a 46.34% increase in waiting list additions for White HCV^- patients relative to kidney patients before and after DAAs. For Black patients, this effect was only 22.40%.[11] For two reasons, we argue that differential flows to the waiting list do not explain our transplant results. First, because the racial flow gap was similar in magnitude to the racial transplant gap, the racial composition of the waiting list did not significantly change. Second, Appendix Figure 4a shows that the MELD scores at listing are flat through the introduction of DAAs and consistently higher (i.e., worse) for Black patients (≈ 23) than for White (≈ 20) patients. We observe a similar pattern in MELD scores at the time of transplant. In Appendix Figure 4b, the Black/White gap in MELD at transplant remains approximately 3 MELD points before and after DAAs became available. While we cannot estimate an event study for either MELD measure because a similar summary measure does not exist for kidneys, evidence in Appendix Figures 4a and 4b suggests that Black patients remain in worse health both at listing and at transplant following the introduction of DAAs. [12] Our conclusion is that White patients did not experience disproportionate gains due to medical need relative to Black patients.

Our final potential explanation deals with racial concordance. While prior research has not identified improved outcomes for same race donor/recipient pairs relative to mixed donor/recipient pairs, the higher likelihood of biological compatibility within race groups may still affect organ matching. For instance, if the HCV^+ patients who benefited from DAAs were disproportionately White and would have received livers from White donors in the absence of DAAs, then the organs effectively freed up by DAAs would more often come from White donors. As a result, those livers may have been easier to match with other White recipients, contributing to the larger gains we observe among White HCV^- ESLD patients. Instead, in Appendix Table 7, we show no effect of DAAs on the shares of White or Black deceased donors, even in areas with above median numbers of Black patients. As a result, we rule out racial concordance as a mechanism driving our results.

In the final two columns of Panel B of Table 3, we return to our transplant analysis controlling for private insurance share within the DSA (Column 5) and all covariates considered in Table 3 including waiting list flows (Column 6).

[11] Appendix Figure 3 shows event study results on the log of waiting list additions for White (3a) and Black (3b) HCV^- patients.

[12] For both Black and White patients, Appendix Figure 5 shows null effects in event studies of waiting list mortality. This rules out a mechanism in which Black patients in worse non-liver health gain access to the waiting list because of DAA-induced scarcity reductions, but Black patients realize lower transplant gains because these marginal Black patients leave the waiting list because of their poor health and/or mortality.

In both cases, the gap in transplant gains remains large and relatively unchanged in magnitude. An Oaxaca-Blinder decomposition using the Column 6 regression specification suggests that all of the covariates in Table 3 together explain just 19.5% of the racial gap in transplant gains from DAAs (see Appendix Table 8 for decomposition results).

6 Conclusion

This research addresses the broad question of how easing resource scarcity affects disparities in health outcomes. In the context of a curative technology for the leading cause of infectious disease death in the U.S., we study the racial incidence of the benefits of this technology among HCV^- patients in need of liver transplantation. We have three main conclusions. First, DAAs caused a disproportionate increase in transplants for White HCV^- ESLD patients. Second, despite a fairly algorithmic allocation mechanism for donor livers based on medical need, we show that the liver health of Black registrants was significantly worse, and the relative liver health composition of White and Black registrants did not change following DAAs, implying that transplant gains to White patients were not driven by greater clinical urgency. Finally, while patient characteristics (e.g., age) and resources (e.g., payer) may explain some differences in allocation net of liver health, we find a large proportion of the gap in transplant gains to be unexplained by these covariates.

Our results imply that achieving equity in the liver transplant market requires more than addressing disparities in evaluation and listing that cause Black patients to list in worse health. In fact, the allocation process of organs for those already listed generates differences in transplants that are not explained by important measures of patient resources.

References

Aghion, Philippe, Akcigit, Ufuk, Bergeaud, Antonin, Blundell, Richard, & Hemous, David. 2018. Innovation and Top Income Inequality. The Review of Economic Studies, **86**(1), 1–45.

Aguilar-Gomez, Sandra, Graff Zivin, Joshua S, & Neidell, Matthew J. 2025. Killer Congestion: Temperature, Healthcare Utilization and Patient Outcomes. Working Paper 33491. National Bureau of Economic Research.

Alsan, Marcella, Garrick, Owen, & Graziani, Grant. 2019. Does Diversity Matter for Health? Experimental Evidence from Oakland. American Economic Review, **109**(12), 4071–4111.

Alsan, Marcella, Durvasula, Maya, Gupta, Harsh, Schwartzstein, Joshua, & Williams, Heidi. 2023. Representation and Extrapolation: Evidence from Clinical Trials*. The Quarterly Journal of Economics, **139**(1), 575–635.

Arias, Elizabeth, Kochanek, Kenneth D., Xu, Jiaquan, & Tejada-Vera, Betzaida. 2022. Provisional Life Expectancy Estimates for 2022. https://stacks.cdc.gov/view/cdc/135467.

Arnold, David, Dobbie, Will, & Hull, Peter. 2021. Measuring Racial Discrimination in Algorithms. AEA Papers and Proceedings, **111**(May), 49–54.

Arogyaswamy, Sagarika, Vukovic, Nemanja, Keniston, Angela, Apgar, Sarah, Bowden, Kasey, Kantor, Molly A., Diaz, Manuel, McBeth, Lauren, & Burden, Marisha. 2022. The Impact of Hospital Capacity Strain: a Qualitative Analysis of Experience and Solutions at 13 Academic Medical Centers. Journal of General Internal Medicine, **37**(6), 1463–1474.

Auty, S.G., Griffith, K.N., Shafer, P.R., Gee, R.E., & Conti, R.M. 2022. Improving Access to High-Value, High-Cost Medicines: The Use of Subscription Models to Treat Hepatitis C Using Direct-Acting Antivirals in the United States. Journal of health politics, policy and law, **47**(6), 691–708.

Bryce, C.L., Angus, D.C., Arnold, R.M., C., Chang., Farrell, M.H., Manzarbeitia, C., Marino, I.R., & Roberts, M.S. 2009. Sociodemographic Differences in Early Access to Liver Transplantation Services. American Journal of Transplantation, **9**(9), 2092–2101.

Bryce, C.L., Chang, C.H., Angus, D.C., Arnold, R.M., Farrell, M., & Roberts, M.S. 2010. The Effect of Race, Sex, and Insurance Status on Time-to-Listing Decisions for Liver Transplantation. Journal of Transplantation.

Callison, Kevin, Darden, Michael E, & Teltser, Keith F. 2024. Externalities from Medical Innovation: Evidence from Organ Transplantation. Journal of Political Economy Microeconomics. Forthcoming.

Cholongitas, E, Papatheodoridis, GV, Vangeli, M, Terreni, N, Patch, D, & Burroughs, AK. 2005. Systematic review: the model for end-stage liver disease–should it replace Child-Pugh's classification for assessing prognosis in cirrhosis? Alimentary pharmacology & therapeutics, **22**(11-12), 1079–1089.

Cutler, David M, & McClellan, Mark. 2001. Is technological change in medicine worth it? Health affairs, **20**(5), 11–29.

Cutler, David M, Meara, Ellen, & Richards-Shubik, Seth. 2012. Induced Innovation and Social Inequality: Evidence from Infant Medical Care. Journal of Human Resources, **47**(2), 456–492.

Darden, Michael, Parker, Geoff, Anderson, Edward, & Buell, Joseph F. 2021. Persistent sex disparity in liver transplantation rates. Surgery, **169**(3), 694–699.

Dickert-Conlin, Stacy, Elder, Todd, Lemont, Bethany, & Teltser, Keith. 2024. Opioids and Organs: How Overdoses Affect the Supply and Demand for Organ Transplants. American Journal of Health Economics, **10**(4), 505–538.

Dranove, David, Garthwaite, Craig, Heard, Christopher, & Wu, Bingxiao. 2022. The economics of medical procedure innovation. Journal of Health Economics, **81**, 102549.

Elías, Julio J., Lacetera, Nicola, & Macis, Mario. 2019. Paying for Kidneys? A Randomized Survey and Choice Experiment. American Economic Review, **109**(8), 2855–88.

Fleurence, R.L., & Collins, F.S. 2023. A National Hepatitis C Elimination Program in the United States. JAMA, **329**(15), 1251–1252.

Francetic, Igor, Meacock, Rachel, & Sutton, Matt. 2024. Free-for-all: Does crowding impact outcomes because hospital emergency departments do not prioritise effectively? Journal of Health Economics, **95**, 102881.

Freedman, Seth. 2016. Capacity and Utilization in Health Care: The Effect of Empty Beds on Neonatal Intensive Care Admission. American Economic Journal: Economic Policy, **8**(2), 154–85.

Glied, Sherry, & Lleras-Muney, Adriana. 2008. Technological innovation and inequality in health. Demography, **45**(3), 741–761.

Goldberg, D.S., French, B., Sahota, G., Wallace, A.E., Lewis, J.D., & Halpern, S.D. 2016. Use of population-based data to demonstrate how waitlist-based metrics overestimate geographic disparities in access to liver transplant care. American Journal of Transplantation, **16**(10), 2903–2911.

Hackmann, Martin B., Pohl, R. Vincent, & Ziebarth, Nicolas R. 2024. Patient versus Provider Incentives in Long-Term Care. American Economic Journal: Applied Economics, **16**(3), 178–218.

Hall, R.E., & Jones, C.I. 2007. The value of life and the rise in health spending. The Quarterly Journal of Economics, **122**(1), 39–72.

Hamilton, Barton, Hincapié, Andrés, Kalish, Emma C, & Papageorge, Nicholas W. 2021 (May). Medical Innovation and Health Disparities. Working Paper 28864. National Bureau of Economic Research.

Ho, Kate, & Pakes, Ariel. 2024 (June). Evaluating Pharmaceutical Policy Options. Working Paper 32606. National Bureau of Economic Research.

Hoagland, Alex. 2024. Innovations and Inequities in Access to Medical Services. Working Paper. University of Toronto.

Hoe, Thomas P. 2022. Does Hospital Crowding Matter? Evidence from Trauma and Orthopedics in England. American Economic Journal: Economic Policy, **14**(2), 231–62.

Hollingsworth, Alex, Karbownik, Krzysztof, Thomasson, Melissa A., & Wray, Anthony. 2024. The Gift of a Lifetime: The Hospital, Modern Medicine, and Mortality. American Economic Review, **114**(7), 2201–38.

Hurtado, Agustin, & Sakong, Jung. 2024. Racial Disparities in the US Mortgage Market. AEA Papers and Proceedings, **114**(May), 201–04.

Jaravel, Xavier. 2018. The Unequal Gains from Product Innovations: Evidence from the U.S. Retail Sector*. The Quarterly Journal of Economics, **134**(2), 715–783.

Jesse, M.T., Abouljoud, M., Goldstein, E.D., Rebhan, N., Ho, C., Macaulay, T., Bebanic, M., Shkokani, L., Moonka, D., & Yoshida, A. 2019. Racial Disparities in Patient Selection for Liver Transplantation: An Ongoing Challenge. Clinical transplantation, **33**(11), e13714.

Kim, W Ray, Mannalithara, Ajitha, Heimbach, Julie K, Kamath, Patrick S, Asrani, Sumeet K, Biggins, Scott W, Wood, Nicholas L, Gentry, Sommer E, & Kwong, Allison J. 2021. MELD 3.0: the model for end-stage liver disease updated for the modern era. Gastroenterology, **161**(6), 1887–1895.

Koning, Rembrand, Samila, Sampsa, & Ferguson, John-Paul. 2021. Who do we invent for? Patents by women focus more on women's health, but few women get to invent. Science, **372**(6548), 1345–1348.

Kuziemko, Ilyana, Meckel, Katherine, & Rossin-Slater, Maya. 2018. Does Managed Care Widen Infant Health Disparities? Evidence from Texas Medicaid. American Economic Journal: Economic Policy, **10**(3), 255–83.

Lemont, B. 2023. The Effect of Distance on Use of Care: Evidence from Low-Income Organ Transplant Candidates. Working Paper.

Moylan, C.A., Brady, C.W., Johnson, J.L., Smith, A.D., Tuttle-Newhall, J.E., & Muir, A.J. 2008. Disparities in liver transplantation before and after introduction of the MELD score. Jama, **300**(20), 2371–2378.

Mullainathan, Sendhil, & Shafir, Eldar. 2013. Scarcity: Why Having Too Little Means So Much. New York: Times Books.

Murphy, K.M., & Topel, R.H. 2006. The Value of Health and Longevity. Journal of Political Economy, **114**(5), 871–904.

Nephew, L.D., & Serper, M. 2021. Racial, gender, and socioeconomic disparities in liver transplantation. Liver Transplantation, **27**(6), 900–912.

Newhouse, J.P. 1992. Medical Care Costs: How Much Welfare Loss? Journal of Economic Perspectives, **6**(3), 3–21.

Obermeyer, Ziad, Powers, Brian, Vogeli, Christine, & Mullainathan, Sendhil. 2019. Dissecting racial bias in an algorithm used to manage the health of populations. Science, **366**(6464), 447–453.

Organ Procurement and Transplantation Network (OPTN). 1999. Health resources and services administration, HHS. Final rule. Fed Regist, **64**(202), 56650–56661.

Papageorge, Nicholas W. 2016. Why medical innovation is valuable: Health, human capital, and the labor market. Quantitative Economics, **7**(3), 671–725.

Park, Christine, Jones, Mandisa-Maia, Kaplan, Samantha, Koller, Felicitas L, Wilder, Julius M, Boulware, L Ebony, & McElroy, Lisa M. 2022. A scoping review of inequities in access to organ transplant in the United States. International journal for equity in health, **21**(1), 22.

Rambachan, Ashesh, Kleinberg, Jon, Ludwig, Jens, & Mullainathan, Sendhil. 2020. An Economic Perspective on Algorithmic Fairness. AEA Papers and Proceedings, **110**(May), 91–95.

Reid, Andrea E, Resnick, Maria, Chang, YuChiao, Buerstatte, Nathan, & Weissman, Joel S. 2004. Disparity in use of orthotopic liver transplantation among blacks and whites. Liver transplantation, **10**(7), 834–841.

Rosenblatt, R., Wahid, N., Halazun, K.J., Kaplan, A., Jesudian, A., Lucero, C., Lee, J., Dove, L., Fox, A., Verna, E., Samstein, B., Fortune, B.E., & Brown Jr., R.S. 2021. Black patients have unequal access to listing for liver transplantation in the United States. Hepatology, **74**(3), 1523–1532.

Singh, Manasvini, & Venkataramani, Atheendar. 2022 (August). Rationing by Race. Working Paper 30380. National Bureau of Economic Research.

Trivedi, Hirsh D. 2022. The evolution of the MELD score and its implications in liver transplant allocation: a beginner's guide for trainees. ACG Case Reports Journal, **9**(5), e00763.

Wahid, N.A., Rosenblatt, R., & Brown Jr, R.S. 2021. A review of the current state of liver transplantation disparities. Liver Transplantation, **27**(3), 434–443.

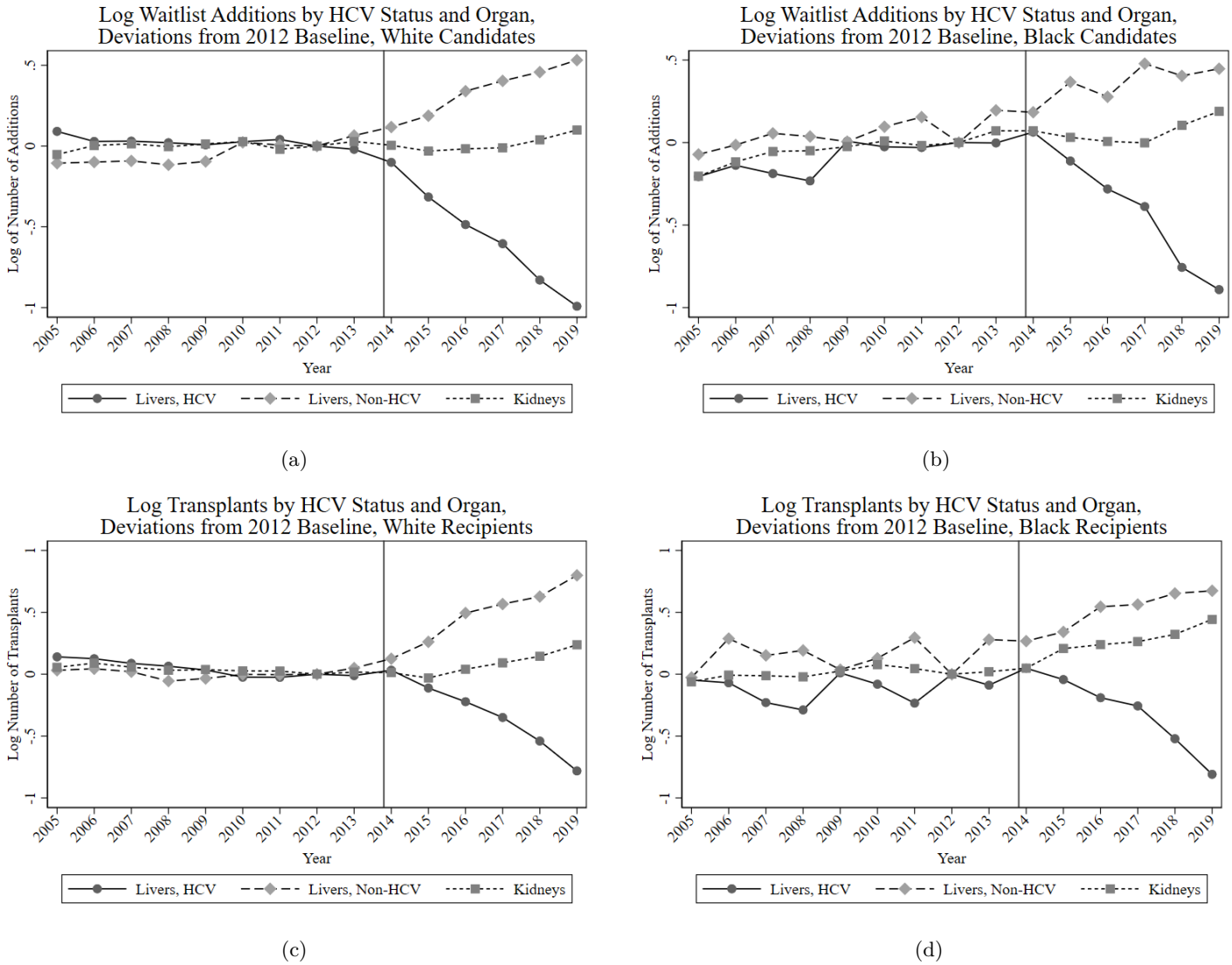
Wherry, Laura R., Miller, Sarah, Kaestner, Robert, & Meyer, Bruce D. 2018. Childhood Medicaid Coverage and Later-Life Health Care Utilization. The Review of Economics and Statistics, **100**(2), 287–302.

Wright, L.S. 2022. Transplant Programs: An Overview of the Scientific Registry of Transplant Recipients. Nephrology Nursing Journal, **49**(6), 505–508.

Zewde, Naomi. 2024. Racial Wealth Inequality and Access to Care with High-Deductible Health Insurance. AEA Papers and Proceedings, **114**(May), 180–85.

Figures and Tables

Figure 1: Log Waiting List Additions and Transplants by HCV, Organ, and Race

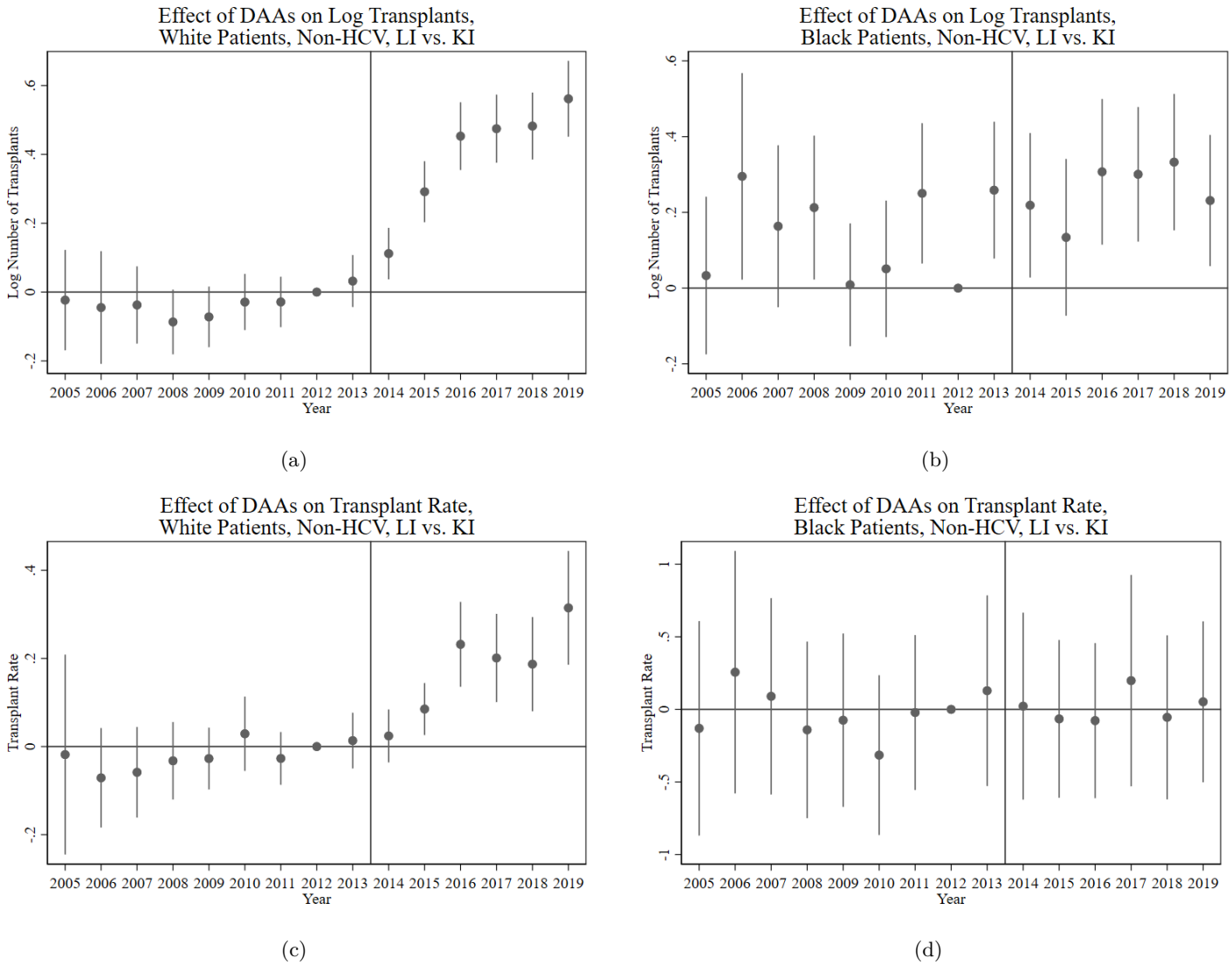


(a) (b)

(c) (d)

Notes: Authors' calculations of yearly national log counts using SRTR data. This figure adds the kidney registrant comparison group and recalculates the trends in terms of deviations from 2012. We exclude the 0.13% of kidney registrants who are known to have an HCV-related diagnosis using the optional diagnosis text field in the data.

Figure 2: Transplant and Transplant Rate Event Studies by Race



Notes: Event studies of the count of transplants and the transplant rate by race relative to the normalization of 2012. Figures a. and b. are generated from Poisson regressions. The transplant rate is defined as the total number of transplants in a DSA-year divided by average number of registrations on the waiting list throughout that DSA-year. Vertical bars represent 95% confidence intervals based on standard errors clustered at the DSA-by-organ level.

Table 1: Liver Waiting List and Transplant Summary Statistics

	HCV+ Liver		HCV- Liver		Kidney	
	2005-13	2014-19	2005-13	2014-19	2005-13	2014-19
White						
WL Additions, Yearly	2,701	1,580	3,832	5,682	15,830	16,049
ESLD or ESRD Deaths, Yearly	10,511	10,204	65,837	60,245	34,953	36,016
WL Adds / Deaths	0.265	0.144	0.064	0.077	0.453	0.446
MELD at WL	16.2	15.6	18.8	19.7	-	-
MELD at TX	20.8	18.5	23.0	24.1	-	-
Days to TX	303	341	239	216	514	608
Transplants, Yearly	1,473	1,049	2,058	3,385	8,323	8,743
TX Rate	0.315	0.388	0.322	0.503	0.256	0.227
Black						
WL Additions, Yearly	433	336	365	499	9,623	10,736
ESLD or ESRD Deaths, Yearly	2,886	3,230	9,368	10,914	8,382	9,365
WL Adds / Deaths	0.150	0.104	0.039	0.046	1.148	1.146
MELD at WL	18.7	17.1	22.7	23.1	-	-
MELD at TX	22.5	19.8	26.4	27.0	-	-
Days to TX	220	269	201	192	864	879
Transplants, Yearly	253	218	220	317	3,973	5,118
TX Rate	0.487	0.491	0.452	0.601	0.137	0.145

Notes: Authors' calculations of endogenous variables by HCV^+ status and time period. Each statistic represents the annual average mean/count within the corresponding time period. Those for whom HCV status cannot be inferred are excluded from the calculations in this table. This amounts to roughly 15% of liver registrants, or 24,847 of 167,888 total liver registrants who listed between 2005 to 2019. Higher MELD scores reflects higher mortality risk. The transplant rate reflects the total number of transplants divided by average number of registrations on the waiting list throughout a given year.

Table 2: Difference-in-Differences Estimates

	HCV^+	HCV^-		
	TX	TX	Days to TX	TX Rate
	Poisson	Poisson	Poisson	Fraction, OLS
DAA x White	-0.3886***	0.4486***	-0.2697***	0.1953***
	(0.0495)	(0.0469)	(0.0513)	(0.0435)
	32.74	45.72	250.34	0.496
DAA x Black	-0.4003***	0.1106**	0.0323	0.0360
	(0.0831)	(0.0558)	(0.1507)	(0.0763)
	5.62	4.89	212.26	0.809
Observations	5,655	5,700	5,190	5,567
N of Clusters	95	95	95	95

Notes: Each column of coefficients comes from a poisson regression of the outcome of interest on the DAA treatment indicator interacted with racial group, comparing group-specific liver counts to group-specific kidney counts. Note that all coefficients in this table except for the final column represent log point changes, which can be transformed into percentages using the formula $100 \times (e^{\hat{\beta}} - 1)$. Group-specific baseline means of the dependent variable reflect the pre-treatment period (2005–2013) DSA-year means in levels for HCV^- liver candidates only. While there are 57 DSAs in the U.S., we use modified DSA identifiers due to changes in DSA existence and services over time, which yields 50 kidney-serving DSA and 45 liver-serving DSA identifiers. Standard errors are in parentheses and are clustered at the DSA-by-organ level. *** p<0.01, ** p<0.05, * p<0.1

Table 3: Factors that May Contribute to the White-Black Transplant Gap

Panel A: Education, Age, Insurance, Blood Type

	Some College or More TX, Poisson	Age 55 or Older at Listing TX, Poisson	Any Private Insurance TX, Poisson	Any Private Insurance, Under 65 TX, Poisson	Blood Type O TX, Poisson	Blood Type B TX, Poisson
DAA x White	0.4988***	0.3209***	0.4965***	0.4926***	0.4632***	0.4730***
	(0.0571)	(0.0550)	(0.0483)	(0.0460)	(0.0479)	(0.0604)
	21.71	24.04	34.04	29.96	19.59	5.33
DAA x Black	0.1543**	0.1719**	0.2483***	0.2345***	0.1120*	0.1605
	(0.0737)	(0.0791)	(0.0591)	(0.0593)	(0.0591)	(0.0997)
	2.15	1.37	3.00	2.84	2.31	1.19
Observations	5,670	5,655	5,685	5,685	5,625	5,565
N of Clusters	95	95	95	95	95	95

Panel B: Geography, Waitlist Additions, Including Covariates

	Not in Large Metro TX, Poisson	Above Median Black DSAs TX, Poisson	Above Median White DSAs TX, Poisson	All Groups WL Adds, Poisson	All Groups, Control for % with Private Ins. TX, Poisson	All Groups, Control for Multiple Covariates TX, Poisson
DAA x White	0.4692***	0.5109***	0.3725***	0.3803***	0.4477***	0.4345***
	(0.0526)	(0.0581)	(0.0645)	(0.0487)	(0.0465)	(0.0441)
	12.79	53.54	41.36	85.15	45.72	45.72
DAA x Black	0.0106	0.1628**	-0.1020	0.2021***	0.1041*	0.0914*
	(0.1054)	(0.0644)	(0.1210)	(0.0683)	(0.0551)	(0.0538)
	0.81	7.94	2.23	8.12	5.01	5.01
Observations	5,340	2,820	2,880	5,700	5,630	5,628
N of Clusters	95	47	48	95	95	95

Notes: Each column of coefficients comes from a poisson regression of the outcome of interest on the DAA treatment indicator interacted with racial/ethnic group, comparing group-specific liver counts to group-specific kidney counts. Note that all coefficients in this table represent log point changes, which can be transformed into percentages using the formula $100 \times (e^{\hat{\beta}} - 1)$. Group-specific baseline means of the dependent variable reflect the pre-treatment period (2005–2013) DSA-year means in levels for HCV^- liver candidates only. Above-median Black/White DSAs are designated based on the racial composition of HCV^- candidates removed from the waiting list between 2005-13. "Not in Large Metro" refers to candidates residing in counties that are *not* located within metropolitan areas with population of 250,000 or more, based on the 2013 USDA Rural-Urban Continuum Codes (i.e., groups 3-9). In the final column of Panel B, covariates include the percent of waitlisted candidates within each DSA-organ-year with educational attainment beyond high school, age 55 or older at time of joining the waitlist, blood type O, blood type B, any private insurance (primary or secondary), residence outside of a large metro. While there are 57 DSAs in the U.S., we use modified DSA identifiers due to changes in DSA existence and services over time, which yields 50 kidney-serving DSA and 45 liver-serving DSA identifiers. Standard errors are in parentheses and are clustered at the DSA-by-organ level. *** p<0.01, ** p<0.05, * p<0.1