Relationship between Driving Time to Transplant Center and Socioeconomic Factors with Early Waitlisting among Transplant Referred End-Stage Kidney Disease Patients

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Introduction

- Kidney transplantation is considered the best long-term treatment for patients with end-stage kidney disease (ESKD). Transplantation requires referral to a transplant center, followed by an evaluation process and ultimately placement on a waitlist.
- However, there are barriers to transplant, most notably the limited supply of available kidneys and the associated long wait times (~5 years on average) to receive an organ.[1]
- Establishing and maintaining placement on a transplant list requires an abundance of office visits and medical tests occuring over an extended period of time and necessitating multiple trips.
- As the transplant process normally begins after the patient has ESKD, these office visits must be completed around the usual dialysis appointments, which often require 12+ hours/week to complete.
- The added travel burden required to establish transplant candidacy can be an important barrier for many patients; specifically those who are socioeconomically disadvantaged and rely on public transportation and fixed transportation schedules to reach their kidney-related appointments.

Objective

In this study, we sought to estimate the association of driving time to the transplant center and the probability of early waitlisting. We also sought a clearer understanding of the interaction of driving time with socioeconomic determinants on the probability of waitlisting.

Methods

- This was a retrospective cohort study of adult (age ≥18 years) incident ESKD dialysis patients at a dialysis organization from 01 Jan 2016 - 31 Dec 2019 who were referred for transplant.
- We excluded patients who had been referred to a transplant center prior to starting dialysis, patients who had been treated by another provider for >30 days prior to dialyzing at the dialysis organization, and patients for whom travel distance to nearest transplant facility could not be calculated.
- We adjusted for causally relevant socioeconomic factors including educational encounters documented by the dialysis organization and US Census Bureau tract median income and education data (Bachelor's degree or higher).
- Using the Hamiltonian Monte Carlo algorithm[2], we fit a Bayesian generalized linear model to model the relationship between driving time and the probability of early waitlisting, obtaining the posterior distribution.[2] We then sampled parameter values from this posterior distribution to simulate observations and perform estimation.
- Simulated observations based on relative levels of socioeconomic advantage (disadvantage and advantage comprising the 25th and 75th percentiles for listed variables, respectively).

Results

Table 1. Patient characteristics at time of referral

	N	(%)
Total Patients	33,158	100
Female	12,779	38.5
Race		
White	11,275	34.0
Black	11,181	33.7
Hispanic	6,912	20.8
Asian	1,565	4.7
Other, unknown, missing	2,225	6.7
Etiology		
Diabetes	14,204	42.8
Cystic/hereditary/congenital	780	2.4
Glomerlular Nephritis	1,423	4.3
Hypersensitive/large vessel disorder	7,833	23.6
Interstitial	631	1.9
Secondary GN/vasculitis	429	1.3
Neoplasm	253	0.8
Miscellaneous	7,605	22.9
Modality		
CAPD	759	2.3
CAPD and CCPD	4	0.01
CCPD	4,142	12.5
Home Hemodialysis	235	0.7
In-center Hemodialysis	27,890	84.1
IPD	6	0.02
NOC	118	0.4
Missing	4	0.01
Access		
CVC	14,884	44.9
Fistula	10,875	32.8
Graft/Shunt	2,484	7.5
PD Catheter	4,911	14.8
Missing	4	0.01
Primary Insurance		
Commercial	8,541	25.8
Government	100	0.3
Medicaid	6,172	18.6
Medicare	18,105	54.6
No Insurance	240	0.7
Diabetes	23,919	72.1

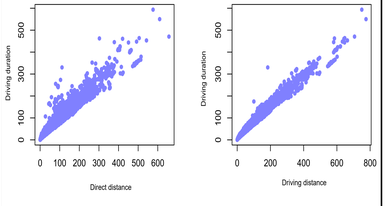
CAPD, Continuous ambulatory peritoneal dialysis; CCPD, Continuous cyclic peritoneal dialysis; CVC, central venous catheter; GN, glomerular nephritis; Hereditary, includes cystic disease, hereditary, and congenital kidney and ureteral diseases; IPD, intraperitoneal dialysis; NOC, noctural; PD, peritoneal dialysis.

	25th	50th	75th	Interquartile Range
Age	48.0	58.0	66.0	18.0
BMI	23.9	28.0	33.0	9.1
CCI	4.00	5.00	6.00	2.00
Census tract educational BA or above in those 25+ years (%)	12.7	20.4	32.3	19.6
All recorded transplant educational encounters	0.0	1.0	1.0	1.0
Census tract household median income, in thousands	39.4	52.6	70.7	31.3
Closest transplant center driving duration (min)	13.9	27.4	64.6	50.7

BA, Bachelor's degree; BMI, body mass index; CCI, Charlson comorbidity index

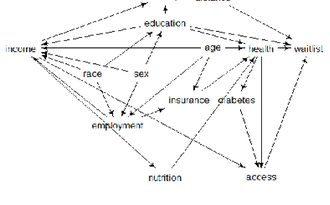
Half the population lived within 30 minutes of the nearest transplant center.

Figure 1. Comparing Potential Exposures: direct distance, driving distance, and driving time to the nearest transplant center



While the data clouds are mostly contained on the x-y axis, we can see points at which driving duration is longer than the direct distance ("as the crow flies") or driving distance, demonstrating that driving duration is likely a more valid measure of travel burden than the other potential exposures.

Figure 2. Directed Acyclic Graph (DAG)



We used this DAG as a guide for covariate adjustment to examining the causal effect of driving time on the probablity of 90-day waitlisting.

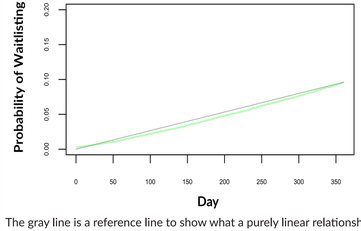
Table 2. Mean probability of waitlisting in 90 days from referral

Driving duration percentile (mins)	Unadjusted mean probability of waitlisting within 90 days from referral
0 (0)	0.023
25 (14)	0.017
50 (27)	0.026
75 (65)	0.016
100 (594)	0.022

Regardless of driving duration, the average transplant waitlisting 90 days after referral does not exceed 3%.

(Table 2, Figure 4A)

Figure 3. Probability of Waitlisting over 360 days from referral



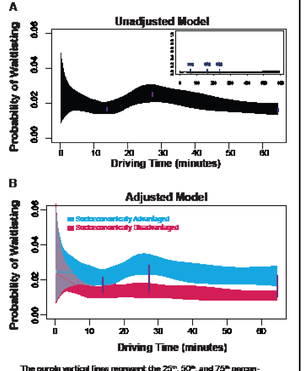
The gray line is a reference line to show what a purely linear relationship would look like given the beginning and end points. The green line shows the actual average probability of being waitlisted by that day.

- Overall probability of waitlisting within 90 days is 2.0%; within 180 days is 4.0%.
- The probability of being waitlisted over time was very similar to the linear gray line. Unfortunately, this did not seem to change over the course of 360 days, suggesting the probability of waitlisting does not improve with time.

Results

Figure 4. Travel Time and Waitlisting

- There was a non-linear relationship between driving time and probability of waitlisting (Figure 4A).
- This non-linear relationship interacts with the level of socioeconomic advantage to vary the slope (Figure 4B).
- Sensitivity analyses considering waitlisting by other benchmark dates (120, 150, and 180 days) did not alter the findings described here.



The purple vertical lines represent the 25th, 50th, and 75th percentiles of driving time. Probability of waitlisting was reliably higher among advantaged patients compared to disadvantaged patients at each of these percentiles.

Conclusions

- The probability of early waitlisting:
  - is currently rare for all dialysis patients and highlights an opportunity for overall improvement in the transplant process.
  - generally decreases with increased driving time, while mitigated by the "suburban bump" arising from the higher levels of socioeconomic advantage.
  - universally decreases with distance at greater levels of socioeconomic disadvantage
- While we look to improve the probability of early waitlisting, we need to do so in a manner that does not exacerbate existing inequities.

References

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2. Gelman A. et. al., Bayesian Workflow. arXiv. 2020. https://doi.org/10.48550/arXiv.2011.01808

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