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Featured Article

Left digit bias in selection and acceptance of deceased donor organs

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ABSTRACT

Background: Organs suitable for donation are a scarce resource and maximizing the use of available organs is a priority. We aimed to determine whether there is a supply restricting left digit bias in organs offered and accepted for donors entering a new decade of age.
Methods: Potential deceased organ donors (n = 105,387) who had any organs offered for transplantation from 2010 to 2019 Organ Procurement and Transplantation Network data were analyzed. Donors were identified 1 year before and after a decade altering birthday.
Results: At age 70 there was a 5.4% decrease in the probability of any organ placement compared to 69 (95% CI 1.1–9.7). There was a decrease of 0.25 organs (95% CI 0.13–0.37) after age 70.
Conclusions: There was a significant left digit bias in the acceptance of any organs for transplantation at ages 60 and 70 as well as in the acceptance of a kidney at age 70.

1. Introduction

Heuristics, subtle but ingrained patterns of thinking, pervade our everyday life and effect many of our choices from what to buy at the grocery store to who receives surgery.[1,2] These mental shortcuts can lead to bias when inappropriately applied.[3] Evaluation of donor organs, under time restrictions and with limited information, is a process that may be particularly vulnerable to cognitive biases.[4–6] Bias has been previously demonstrated in transplant surgeon evaluation of future graft failure, with a trend towards inaccurately low estimations.[5] In the surgical field broadly, surgical complication management, decision making, risk assessment, and shared decision making have all been shown to be susceptible to these types of unconscious bias and there is growing interest in understanding and mitigating these biases.[5,7–11]

Left digit bias is one of the most common numerical biases and is an individual's propensity to determine numerical value based on the leftmost digit of a continuous variable.[1,12,13] This type of bias in age has been shown in the evaluation process for coronary-artery bypass grafting (CABG) and cholecystectomy affecting physician perception of age.[2,14] Recently, left-digit bias has been described in kidney transplantation, impacting rates of discard for organs in age (69 vs 70 years old) and final creatinine (1.9 vs 2.0 mg/dl).[6] It is possible that these biases may be present in other organ types as well as other steps of organ evaluation, as they also require timely, high pressure decision making. To date, there has been no comprehensive investigation into whether this left-digit bias is present in evaluation of organ donor age across different organ types. If this cognitive bias is present in evaluation of donor organs, it is possible the donor organ supply is being restricted by this heuristic thinking.

Herein, we investigate the assessment of deceased donor organs for the presence of a left-digit bias based on age. Match-run data from the Organ Procurement and Transplantation Network (OPTN) from 2010 to 2019 was obtained on all offers made, regardless of organ outcomes, and was used to evaluate the selection of donors and surgeon acceptance of organ offers. Organ acceptance and donor selection was compared for donor organ offers with age at donation on either side of a milestone, left digit altering, birthday.

2. Methods

2.1. Study design, population, and data source

We performed a retrospective cohort study using data from two sources, specifically the United Network for Organ Sharing (UNOS) Standard Transplant Analysis and Research (STAR) file and the UNOS Potential Transplant Recipient (PTR) file.[15] The PTR file contains donor-identifier and center-identifier encrypted information for each and every organ offer made to a potential transplant recipient in the US

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separately for kidney, liver, lung, intestine, heart/lung combination, and kidney/pancreas combination. Specifically, the PTR dataset contains information regarding the exact date and time of the initial offer and center response as well as the exact date and time of the final offer and response. These files were requested from UNOS with data included from January 1, 2010 through December 31st, 2019. We requested additional data from the OPTN regarding donor's exact date of birth as this is not generally included in the standard files. We investigated all deceased potential organ donors, which include any potential donor with at least one organ for which an organ offer was made, but not necessarily ever accepted, including those deceased by brain death (DBD) as well as deceased by cardiac death (DCD). We excluded organ offers for intestines as well as heart/lung and kidney/pancreas combinations as these were an exceedingly small fraction of the total number of organ offers precluding a robust statistical analysis.

Given the use of retrospective data, this study was deemed exempt from approval and informed consent by the institutional review board at the University of Michigan, Ann Arbor. This report follows the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) reporting guideline for cohort studies.[16]

2.2. Study outcomes and covariates

Our primary outcome was whether a potential donor had any of their organs offered and accepted for transplantation, regardless of whether or not that organ was eventually transplanted into a recipient. As left digit bias may manifest at both the donor level as well as individual organ level, a secondary analysis was completed investigating the number of organs successfully placed per donor. Donor characteristics from the UNOS STAR file for deceased donors including age, gender, race, body-mass index (BMI), donor class (coded categorically as either DCD or DBD), history of cancer, diabetes, and hypertension, were merged into the organ offer data from the Potential Transplant Recipient file. However, the deceased donor STAR file only contains donor characteristics for donors who had an organ successfully placed through the match process. We therefore requested additional information from UNOS regarding characteristics of the potential donors who had no organs successfully placed. While we were able to obtain information for some of these donors, a significant portion (~15% for many variables) of the donor characteristics had missing data. Because data missingness was particularly significant for those donors with our outcome of interest, these data were considered Missing Not At Random (MNAR) and

Table 1
Patient characteristics.

Patient Characteristic	Donors Around Age 60			Donors Around Age 70		
	Procured Before Birthday (N = 2018)	Procured After Birthday (N = 1585)	P-Value	Procured Before Birthday (N = 705)	Procured After Birthday (N = 504)	P-Value
Age, mean years (SD)	59.5 (0.3)	60.5 (0.3)	NA	69.5 (0.3)	70.5 (0.3)	NA
Sex						
Male	806 (39.9)	609 (38.4)	0.40	302 (42.8)	211 (41.9)	0.70
Female	982 (48.7)	788 (49.7)		315 (52.8)	225 (44.6)	
Missing	230 (11.4)	188 (11.9)		65 (9.2)	68 (13.5)	
BMI, mean (SD)*	29.1 (6.6)	29.3 (7.0)	0.34	28.9 (6.9)	28.5 (6.1)	0.29
Race			0.38			0.74
White	1155 (57.2)	270 (69.4)		422 (70.7)	270 (69.4)	
Black	258 (12.8)	55 (14.1)		90 (15.1)	55 (14.1)	
Hispanic	193 (9.6)	41 (10.5)		56 (9.4)	41 (10.5)	
Asian	47 (2.3)	13 (3.3)		19 (3.2)	13 (3.3)	
American Indian/Alaska Native	3 (0.1)	0 (0.0)		1 (0.2)	0 (0.0)	
Native Hawaiian/other Pacific Islander	6 (0.3)	1 (0.3)		0 (0.0)	1 (0.3)	
Multiracial	14 (0.7)	9 (1.8)		9 (1.3)	9 (1.8)	
Missing	342 (16.9)	115 (22.8)		108 (15.3)	115 (22.8)	
History of Diabetes			0.80			0.80
None	1309 (64.9)	253 (66.1)		409 (68.9)	253 (66.1)	
Yes, 0–5 years duration	130 (6.4)	40 (10.4)		57 (9.6)	40 (10.4)	
Yes, 6–10 years duration	73 (3.6)	25 (6.5)		37 (6.2)	25 (6.5)	
Yes, >10 years duration	110 (5.5)	55 (14.4)		72 (12.1)	55 (14.4)	
Yes, Duration Unknown	44 (2.2)	10 (2.6)		19 (3.2)	10 (2.6)	
Missing	352 (17.4)	121 (24.0)		111 (15.7)	121 (24.0)	
History of Hypertension			0.41			0.41
Yes	666 (33.0)	313 (62.1)		452 (64.1)	313 (62.1)	
No	1084 (53.7)	107 (21.2)		174 (24.7)	107 (21.2)	
Missing	268 (13.3)	85 (16.7)		79 (11.2)	85 (16.7)	
History of Cancer			0.002			0.46
Yes	86 (4.3)	104 (6.6)		68 (9.6)	38 (7.5)	
No	1580 (78.3)	1189 (75.0)		525 (74.5)	344 (68.3)	
Missing	352 (17.4)	292 (18.4)		112 (15.9)	122 (24.2)	
History of Myocardial Infarction			0.55			0.41
Yes	118 (5.8)	84 (5.3)		63 (8.9)	35 (6.9)	
No	1533 (76.0)	1193 (75.3)		524 (83.8)	394 (78.2)	
Missing	367 (18.2)	308 (19.4)		106 (15.0)	110 (21.8)	
Deceased by Cardiac Death			0.011			0.021
Yes	326 (16.2)	206 (13.0)		8 (1.3)	0 (0)	
No	1353 (67.0)	1096 (69.1)		591 (83.8)	394 (78.2)	
Missing	339 (16.8)	283 (17.9)		106 (15.0)	110 (21.8)	
Any Organ Placed	1530 (75.8)	1160 (73.2)	0.07	527 (74.8)	341 (67.7)	0.007

*BMI data are available for 1675/2018 donors procured prior to their 60th birthday and 1301/1585 donor procured after their 60th birthday, 596/705 donors procured prior to their 70th birthday and 389/504 donors procured after their 70th birthday Data presented as a count and proportion (%) unless otherwise indicated Abbreviations: NA, Not Applicable; SD, Standard Deviation; BMI, Body Mass Index.

as no methods currently exist to robustly handle this data condition, we therefore chose to present estimates adjusted only for organ type (which is complete). This missingness is described in detail in Table 1.

2.3. Statistical analysis

Our primary analysis was predicated on the assumption that potential donors who died within 1 year of their birthday for a given age would be virtually identical to potential donors who died 1 year after their birthday. In this way, the only meaningful difference between a donor at age 69 and a donor at age 70 would be their numerical age, and notably the left most digit. To this end, we compared baseline characteristics between potential donors 1 year before compared to 1 year after their birthday for which they entered a new decade of age. We additionally compared re-transplant free survival between potential donors 1 year before compared to 1 year after their birthday for which they entered a new decade of age for kidney and liver recipients. To compare unadjusted outcomes, we generated a separate multivariable logistic regression model for donors from 1 year before and 1 year after each year of age where the dependent variable was whether or not a potential donor organ was ever accepted with the independent variable being a categorical variable for death within 1 year prior vs. within 1 year following the potential donor's birthday for that decade. In this way, the effect estimate for each year is based only on potential donors over the 2-year period surrounding the presented age. We also included a categorical variable for organ type (heart, lung, liver, or kidney) and the models were built with clustered variance estimation due to organs clustering within potential donors. This multivariable logistic regression model was repeated for cohorts of only kidney and only liver potential donors.

Our secondary analysis compared the mean number of organs successfully placed for a given potential donor. For this analysis, we first built a Poisson regression model with the outcome being the number of organs successfully placed and including the single categorical covariate for death within 1 year prior vs. within 1 year following the potential donor's birthday for that whole year age as described above.

We report the results of χ^2 for categorical data (presented as proportions), Student's t-test for normally distributed continuous data (presented as mean with standard deviation) and Wilcoxon rank-sum test for non-normally distributed continuous data (presented as median with interquartile range). Cluster-robust standard errors were used for all organ level analyses as organs cluster within donors. Two-sided $P < 0.05$ was used to indicate statistical significance. All analyses were performed using Stata, version 16.1/MP, (StataCorp, LLC).

3. Results

3.1. Donor and recipient characteristics

Donors 1 year before (n = 2018) and after (n-1585) their 60th birthday and 1 year before (n = 705) and after (n = 504) their 70th birthday were compared, baseline characteristics are presented in Table 1. There were no significant differences in the distribution of sex, BMI, race, history of diabetes, hypertension or MI. Donors entering a new decade of age were significantly less likely to be deceased by cardiac death (DCD) donors around both age 60 (p = 0.011) and 70 (p = 0.021). Donors entering a new decade of life were significantly less likely to have any organs placed after age 70 (p = 0.007). There were no significant differences in five-year re-transplant free survival of recipients when comparing donors around age 60 or 70, for either kidney or liver recipients.

3.2. Organ acceptance

Overall, as age increases the number of donors at each age decreases with a disproportionate drop in number of donors as you enter a new, left digit altering, decade of age (Fig. 1). The probability of having any organ placed was analyzed for donors around age 60 and 70 (Fig. 2, Supplemental Fig. 1). At age 60 there was not a significant change in the probability of organ placement for donors before and after entering their 60s. At age 70 there was a 5.4% (95% CI 1.1–9.7) decrease in the probability of placing any organ for patients after entering a new decade of age, with the lower probability of organ placement sustained through that decade.

3.3. Organ placement

Mean number of organs placed per donor was compared around ages 60 and 70. On average, 0.09 (95% CI 0.01–0.16, p = 0.026) less organs were placed per donor after vs before their 60th birthday, and 0.25 (95% CI 0.13–0.37, p < 0.001) less organs were placed per donor after vs before their 70th birthday (Fig. 2, Supplemental Fig. 1).

3.4. Analysis by organ

The probability of having an organ placed was analyzed for kidney donors around age 70 (Fig. 3). At age 70 there was a 7.0% (95% CI 0.4–13.7%) decrease in the probability of placing a kidney for patients after entering the new decade of age. The probability of having an organ placed was analyzed for liver donors around age 70 (Fig. 4). At age 70 there as a 5.3% (95% CI -0.2-10.7%) decrease in the probability of placing a liver for patients after entering a new decade of age.

4. Discussion

Cognitive biases are prevalent across the medical field and increasing attention has been given to identifying and addressing them.[10,11] This paper aimed to examine the presence of any left-digit bias in the evaluation of deceased organ donor age. A left digit bias was demonstrated in both donor selection and organ acceptance, indicating that we are losing valuable organs to a simple cognitive bias from determination of donor candidacy to organ acceptance. A process that includes Organ Procurement Organizations (OPOs) and transplant centers. Although organs suitable for donation are a limited and lifesaving resource in the U.S and great measures have been taken towards making their allocation fair and equitable, our data suggests that approximately 1 in 18 donors over age 70 have no organs placed due to this bias.[17,18]

The left digit bias demonstrated here has previously been seen in donor kidney utilization practices as well as evaluation for cardiac surgery and cholecystectomy.[2,6,14] The biases demonstrated put older patients at a disadvantage when undergoing cardiac surgery evaluation at age 79 vs 80, and the same effect is seen in rates of organ discard for deceased kidney donors at ages 69 vs 70.[2,6] Finally this left digit bias has again recently been demonstrated against older patients diagnosed with cholecystitis undergoing cholecystectomy around age 80 and 90.[14] The findings presented in the study add to the growing body of work on the pervasive impact of left digit biases in surgical practice. Overall, medicine has been demonstrated to be prone to many other cognitive biases as well that are associated with diagnostic errors, surgical complications, and lower quality care.[3,7,10] Transplant surgery is not alone in the effect of cognitive biases on patientcare, particularly one as simple as a left digit bias, and we must join the growing conversation in how to address them.

This demonstrated left digit bias is not limited to a single transplant center, OPO, or even step in the transplant process and is seen across organ types. It likely that left digit bias is present at the first step of transplantation, donor selection, as we see a restriction in the sheer number of donors with a higher left digit in age disproportionate to what we would expect based on a simple increase in age of one year. This bias is also pervasive at the level of the receiving institutions, where we see a lower probability of organ acceptance and number of organs per donor for donors with a higher left digit age. It is likely that a left digit bias is

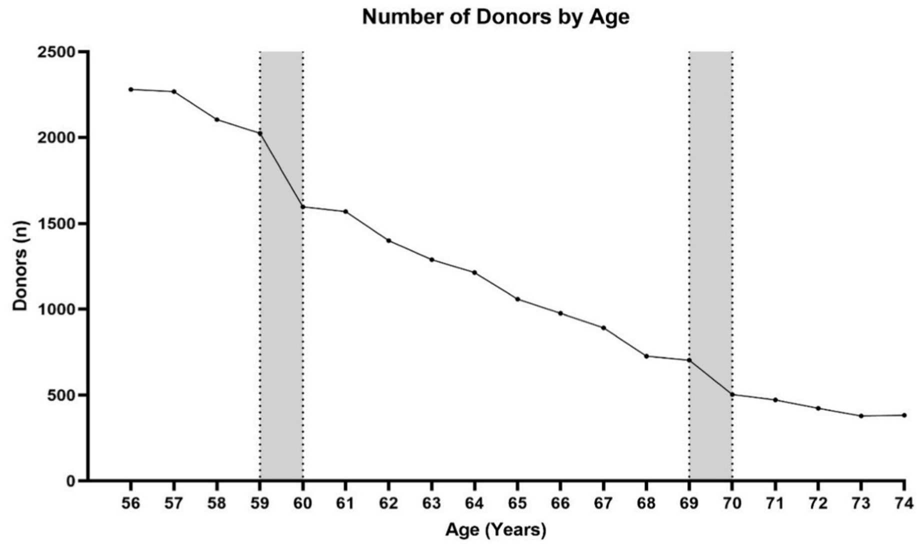

Fig. 1. Number of organ donors with organ offers by age.

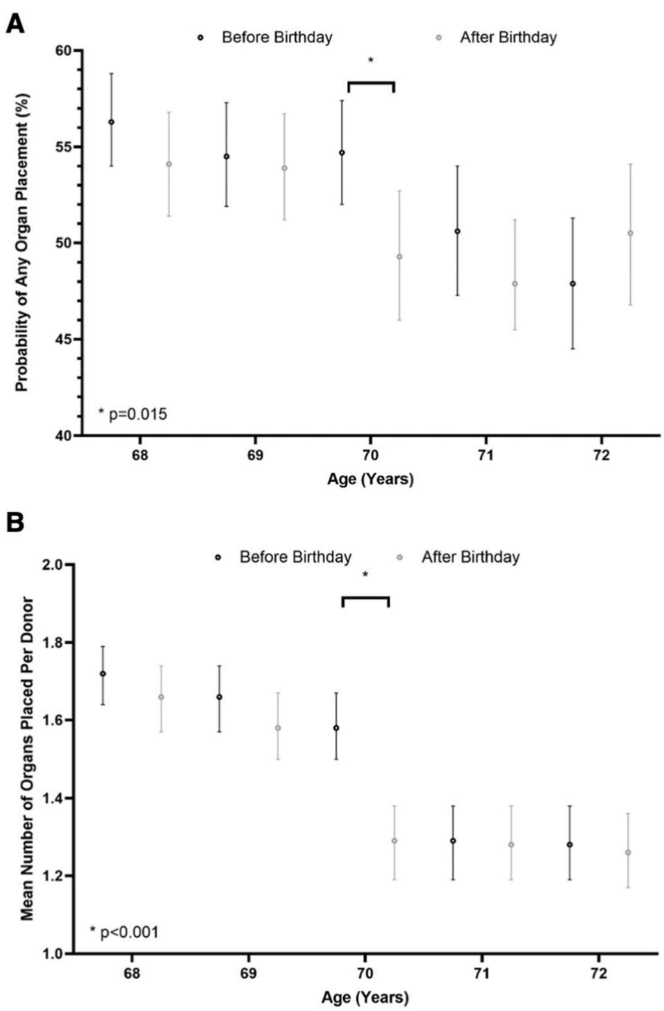

Fig. 2. Probability of any organ placement and mean number of organs placed per Donor for all Donor types.

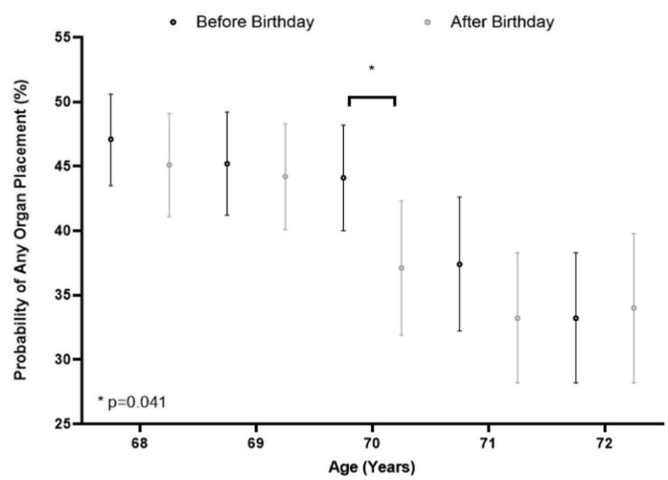

Fig. 3. Probability of kidney placement by age.

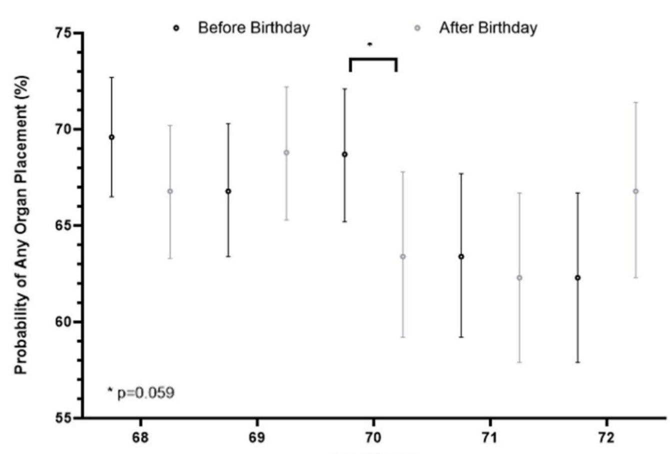

Fig. 4. Probability of liver placement by age.

being perpetuated by many different individuals involved in the transplant process. In our role as stewards of these gifted organs and for all patients waiting for a transplant, interventions must target every step in the transplantation process to overcome our heuristic thinking.

A limitation of our analysis is the missing data in our cohort for some donors regarding clinical characteristics, which did not allow us to adjust our models. While this may raise the concern that donors entering a new decade of age may have a higher level of comorbidities or suboptimal conditions at time of donation, older donors in this study tended to be more, not less, healthy as evidenced by the presence of DCD donors in the group aged 69 but the complete absence of DCD donors in the group aged 70. It seems likely that there is an interaction between characteristics considered to lower the quality of an organ such that a DCD donor "in their 60's" may be considered acceptable whereas a DCD donor "in their 70's" is not. Additionally, center-level policies that limit organ acceptances based on age were not accounted for in this analysis. However, these types of institutional policies are only further evidence of age bias against older donors. Other limitations of our study include the finite amount of data available in the match-run dataset collected by OPTN. This type of retrospective review also lacks the physician and OPTN staff decision maker perspective and there may be other influences on donor evaluation not portrayed in the data available to us.

Our data suggests the supply of life saving organs is being restricted by heuristic thinking and left digit bias. Moving forward this left digit cognitive bias must be addressed at both individual and systematic levels. Awareness alone of a cognitive bias can lead to more conscious decision making on the part of physicians, although the current research is limited.[10,19,20] Institutional efforts to create processes to facilitate more deliberate thinking, such as trainings, simulations, or reminder systems, have also been demonstrated to mitigate cognitive biases.[21–26] On a systematic level we can turn our attention to how we present information as a means of limiting bias. UNOS and OPOs could consider the impact of presenting age as a range or in days, both taking the emphasis off of the left digit. These types of changes are likely to be low risk but may increase organ use for these older donors by 5.4%. Regardless of the avenue taken, efforts need to be made to challenge this cognitive bias and utilize all available organs to the maximum of their potential.

5. Conclusions

There was a significant left digit bias in the acceptance of any organs for transplantation at ages 60 and 70 as well as a significant bias in the acceptance of a kidney at age 70. This bias was seen at both selection and acceptance steps in the transplantation process. Targeting this bias is an opportunity to increase the use of potentially transplantable organs in the US and expand the donor pool.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.amjsurg.2022.03.039.

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