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# Reexamining Risk Aversion: Willingness to Pursue and Utilize Nonideal Donor Livers Among US Donation Service Areas

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**Background.** Livers from “nonideal” but acceptable donors are underutilized; however, organ procurement organization (OPO) metrics do not assess how OPO-specific practices contribute to these trends. In this analysis, we evaluated nonideal liver donor avoidance or risk aversion among OPOs and within US donation service areas (DSAs). **Methods.** Adult donors in the United Network for Organ Sharing registry who donated  $\geq 1$  organ for transplantation between 2007 and 2019 were included. Nonideal donors were defined by any of the following: age  $> 70$ , hepatitis C seropositive, body mass index  $> 40$ , donation after circulatory death, or history of malignancy. OPO-specific performance was evaluated based on rates of nonideal donor pursuit and consent attainment. DSA performance (OPO + transplant centers) was evaluated based on rates of nonideal donor pursuit, consent attainment, liver recovery, and transplantation. Lower rates were considered to represent increased donor avoidance or increased risk aversion. **Results.** Of 97 911 donors, 31 799 (32.5%) were nonideal. Unadjusted OPO-level rates of nonideal donor pursuit ranged from 88% to 100%. In a 5-tier system of overall risk aversion, tier 5 DSAs (least risk-averse) and tier 1 DSAs (most risk-averse) had the highest and lowest respective rates of non-ideal donor pursuit, consent attainment, liver recovery, and transplantation. On average, recovery rates were over 25% higher among tier 5 versus tier 1 DSAs. If tier 1 DSAs had achieved the same average liver recovery rate as tier 5 DSAs, approximately 2100 additional livers could have been recovered during the study period. **Conclusion.** Most OPOs aggressively pursue nonideal liver donors; however, recovery practices vary widely among DSAs. Fair OPO evaluations should consider early donation process stages to best disentangle OPO and center-level practices.

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## INTRODUCTION

Organ procurement organizations (OPOs) are essential facilitators of organ donation and transplantation in the United States. Presently, the Centers for Medicare and Medicaid Services (CMS) evaluate OPO performance using donation and transplantation rate metrics.<sup>1</sup> These metrics, which evaluate organ recovery and transplantation, may partially reflect underutilization by transplant centers,

holding OPOs accountable for processes for which they are not solely responsible.<sup>2-5</sup> Recent reports have called for updated OPO metrics to improve objectivity, reflect performance early in the donation process, and encourage pursuit and utilization of all donor organs.<sup>4-7</sup> Of particular concern is use of “eligible deaths,” a subjective parameter representing a subset of potential donors, notably excluding groups including older and donation after circulatory death (DCD) donors.<sup>1,3</sup> Pursuit of these “noneligible,”

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“nonideal” donors is more expensive and generally yields fewer organs; lack of recognition afforded by current metrics may deter OPOs from expanding resources pursuing these donors.<sup>2,3</sup> At some OPOs, up to 30% of donors fall into this “noneligible,” “nonideal” group, whereas at others, no donors meet this definition.<sup>3,8</sup> Thus, metrics that appropriately incentivize donor pursuit and fairly reward performance are needed.<sup>3,8</sup>

In liver transplantation (LT), demand for suitable donor livers outpaces supply, and up to 30% of candidates die or are removed from the waitlist before transplantation.<sup>9</sup> A critical limiting factor is donor selection, which has traditionally focused on healthy young donors without liver lesions, steatosis, transmissible infections, or malignancies.<sup>10,11</sup> As “ideal” donors remain scarce, “nonideal” or “extended-criteria” donor livers may reduce waitlist mortality without compromising posttransplant survival.<sup>12–14</sup> There is no universally accepted definition of nonideal liver donor. Nevertheless, livers from older, hepatitis C virus seropositive (HCV-positive), DCD, and morbidly obese or steatotic donors that are commonly deemed suboptimal remain disproportionately underutilized.<sup>9,10,15–18</sup>

In lung transplantation, we recently proposed a novel 3-tier system to evaluate OPOs’ willingness to pursue and utilize nonideal donor lungs.<sup>19</sup> Our system provided a detailed account of performance at each stage of the donation process and demonstrated that performance in early donation process stages best differentiated overperforming and underperforming OPOs, highlighting opportunities for OPO-specific improvement to expand the donor pool for lung transplantation.<sup>19</sup> This motivated extension of these analyses to LT to (1) characterize OPO-level variability in pursuit of non-ideal donor livers and (2) provide a comprehensive assessment of donation service area (DSA) performance to characterize patterns of nonideal donor avoidance, or risk aversion, in LT.

## MATERIALS AND METHODS

### Data Source

We conducted a retrospective cohort analysis using United Network for Organ Sharing (UNOS) Standard Analysis and Research data. The data reported here have been supplied by UNOS as the contractor for the Organ Procurement and Transplantation Network (OPTN). The interpretation and reporting of these data are the responsibility of the authors and in no way should be seen as an official policy of or interpretation by the OPTN or the US Government. This study was deemed exempt by our Institutional Review Board.

### Study Population

Adult (age ≥ 18) donors who donated ≥ 1 organ for transplantation between December 1, 2007, and December 31, 2019, were included. Donors who were missing a documented recovery date, had organs recovered outside the United States, were missing an OPO identifier, and for whom liver disposition could not be determined were excluded. Based on review of the literature and clinical expertise of a multidisciplinary team,<sup>10,18</sup> nonideal liver donors were defined as those with any of age > 70, HCV seropositive, body mass index (BMI) > 40, DCD, or history of malignancy. Nonideal donors could have multiple nonideal characteristics, but only 1 was required to meet criteria. Biopsy-graded steatosis was not recorded for

64.4% of donors in our cohort; thus, BMI > 40 was included as a proxy for steatosis, as the prevalence of fatty liver disease in this group exceeds 80%.<sup>20</sup> Although fatty liver disease is also prevalent among patients with BMI 35–40, the degree of fatty infiltration increases with increasing BMI<sup>20</sup>; a cutoff of 40 kg/m<sup>2</sup> was therefore selected to approximate the presence of clinically significant steatosis, aligning with a cutoff previously used to designate potentially high-risk liver donors.<sup>21</sup> Only 0.17% of BMIs were missing from our data; donors who were missing this parameter were considered to have BMI ≤ 40.

### Assessment of Risk Aversion Throughout the Donation Process

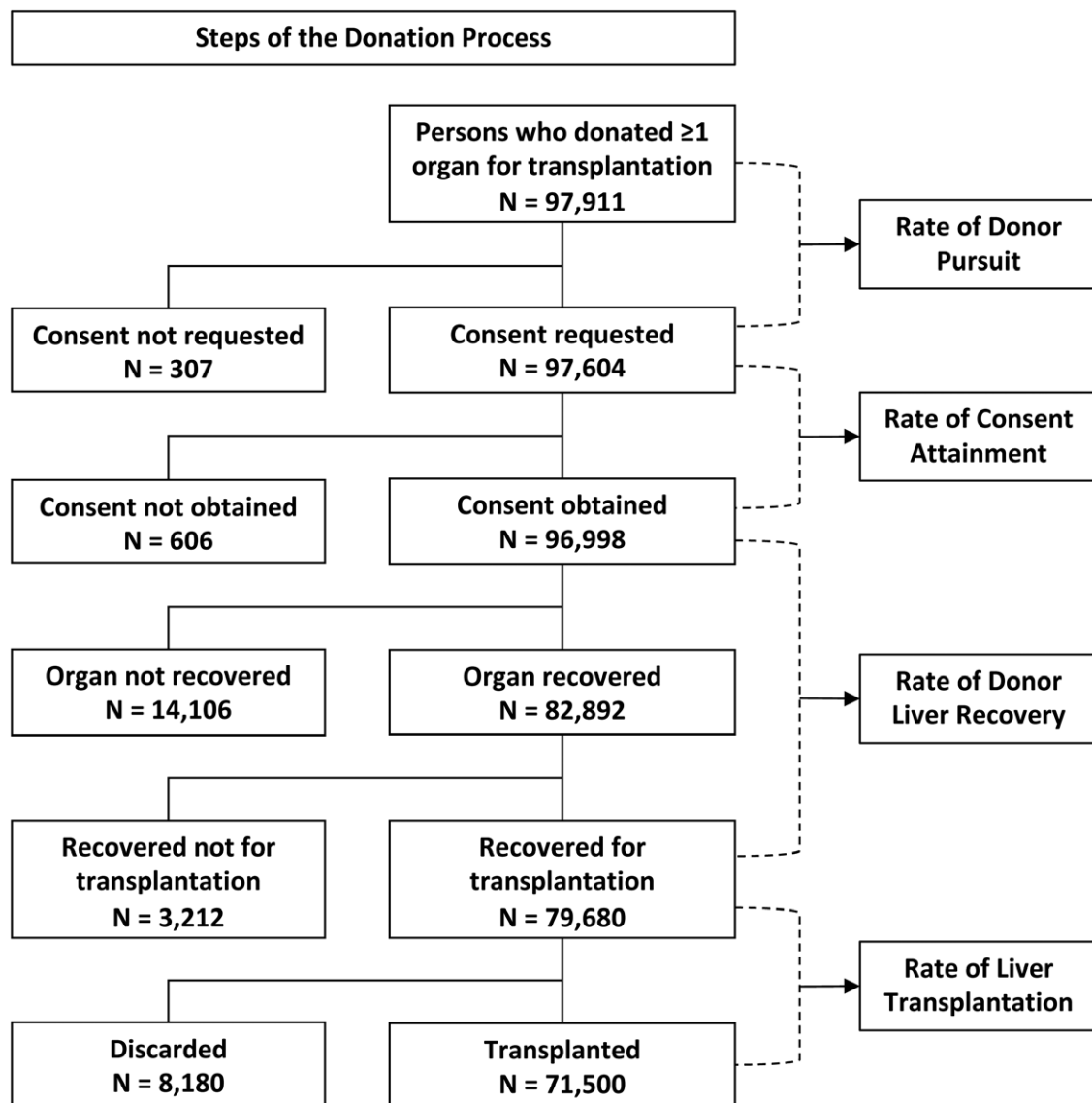
Unique donors were the units of analysis; donor disposition was determined based on the final liver disposition (Figure 1). OPOs were evaluated based on rates of nonideal donor pursuit and consent attainment; DSAs were evaluated based on rates of nonideal donor pursuit, consent attainment, liver recovery, and LT.<sup>19</sup> Donor pursuit was defined as an OPO requesting consent for liver donation. The rate of nonideal donor pursuit was defined as the proportion of nonideal donors at each OPO from whom consent for liver donation was requested; lower numbers correspond to increased donor avoidance or increased risk aversion (Table S1, SDC, <http://links.lww.com/TXD/A338>). The rate of overall donor pursuit was determined as the proportion of all donors (ideal and nonideal) at each OPO from whom consent for liver donation was requested. The correlation between nonideal and overall donor pursuit was estimated using a Spearman correlation coefficient. Rates of consent attainment, liver recovery, and transplantation each built upon the previous donation process stage (Table S1, SDC, <http://links.lww.com/TXD/A338>; Figure 1).

### Categorizing DSAs Based on Performance Throughout the Donation Process

Overall, DSA performance was evaluated based on levels of risk aversion across the entire donation process. Multivariable logistic regression was used to assign each DSA adjusted odds ratios (ORs) for nonideal donor pursuit, consent attainment, liver recovery, and transplantation; higher ORs represent increased DSA-specific odds of nonideal donor pursuit, consent attainment, liver recovery, or transplantation, corresponding to decreased risk aversion. For each donation process stage, DSA-specific adjusted ORs were ranked in ascending order and assigned a score from 1–58; accordingly, higher scores correspond to higher ORs and decreased risk aversion (Figure S1, SDC, <http://links.lww.com/TXD/A338>). Final DSA performance scores could range from 4 to 232 based on the sum of scores across all 4 steps of the donation process (donor pursuit, consent attainment, liver recovery, transplantation).

The distribution of individual DSA performance scores is shown in Figure S2 (SDC, <http://links.lww.com/TXD/A338>). DSAs were assigned to 5 tiers by quintile of performance score:

1. Tier 1 (<20th percentile, most risk-averse): score < 60.4
2. Tier 2 (20th percentile): 60.4 < score < 98.0
3. Tier 3 (40th percentile): 98.0 < score < 142.6
4. Tier 4 (60th percentile): 142.6 < score < 172.0
5. Tier 5 (80th percentile, least risk-averse): score > 172.0



**FIGURE 1.** Schematic representation of the donation process and study design.

DSAs in each group were characterized based on size (average annual liver donor volume during the study period) and rates of nonideal donor pursuit, consent attainment, liver recovery, and transplantation. Recipient characteristics, number of competing LT centers per DSA, and organ offer efforts and offer acceptance practices were explored to inform how center dynamics and potential liver recipients influence DSA-level risk aversion (Materials and Methods, SDC, <http://links.lww.com/TXD/A338>).

As transplant centers typically enter the donation process at organ recovery, patterns of recovery and transplantation may be more reflective of center-level risk aversion. To understand the relative contributions of OPO versus center-level risk aversion in LT, DSA performance scores were separated into component scores for nonideal donor pursuit+consent attainment (OPOs primarily responsible) and liver recovery+transplantation (transplant centers primarily responsible); scores could range from 2 to 116 based on the ranking scheme detailed above (Figure S1, SDC, <http://links.lww.com/TXD/A338>). The relationship between performance in OPO-specific domains

(nonideal donor pursuit+consent attainment) and transplant center domains (liver recovery+transplantation) was estimated using a Spearman correlation coefficient.

### Statistical Analysis

Based on guidance from Scientific Registry of Transplant Recipients models for deceased donor yield,<sup>22</sup> donor race/ethnicity, sex, and OPO were included as covariates in models of donor pursuit, consent attainment, liver recovery, and transplantation to adjust for case-mix heterogeneity across DSAs. Independent associations between individual nonideal donor characteristics and risk aversion at each step of the donation process were determined by adjusting for all other nonideal characteristics, in addition to the covariates detailed here. Models exploring the association between any nonideal donor characteristic, a binary indicator for presence of at least 1 nonideal characteristic, and risk aversion were adjusted for donor race/ethnicity, sex, and OPO but were not adjusted for other nonideal characteristics. DSA-specific ORs for performance ranking were determined using a fixed-effects model

with an interaction between OPO and presence of at least 1 nonideal donor characteristic to determine how the effect of “nonideal” characteristics on donor pursuit, consent attainment, liver recovery, and transplantation varied by DSA.<sup>19</sup> All analyses were performed using R version 3.6.1 (Vienna, Austria).

RESULTS

Study Population

Among 97911 donors, 31799 (32.5%) were nonideal. Compared with ideal donors, nonideal donors were older, more likely to be classified as increased risk for disease transmission, and more likely to have comorbidities including diabetes and hypertension (Table S2, SDC, <http://links.lww.com/TXD/A338>). The proportion of donors in each DSA with each nonideal characteristic is shown in Figure 2.

Risk Aversion in Non-ideal Donor Pursuit

Among 58 OPOs, unadjusted rates of nonideal liver donor pursuit ranged from 88% to 100% and varied within and across UNOS regions (Figure 3A). Nonideal liver donor pursuit was strongly correlated with overall liver donor pursuit ( $r=0.92$ , Figure 3B), corresponding to decreased risk aversion for OPOs that pursued more liver donors overall.

Factors Associated With Risk Aversion in Nonideal Donor Pursuit

Of 5 non-ideal donor characteristics, DCD and age>70 were associated with the most and least risk aversion, respectively (Figure 4). On adjusted analysis, only DCD was independently associated with significant risk aversion, corresponding to significantly decreased odds of donor pursuit. HCV, age>70, BMI>40, and history of malignancy were not associated with risk aversion in donor pursuit (Table 1, Donor Pursuit).

Risk Aversion Across the Donation Process

In consent attainment, DCD and age>70 were associated with the most and least risk aversion, respectively. On adjusted

analysis, only DCD was independently associated with significantly decreased odds of consent attainment. Age>70 was associated with increased odds of consent attainment (Table 1, Consent attainment).

The average rate of liver recovery among donors from whom consent was requested and obtained ranged from 42.1% (DCD) to 92.8% (age>70). On adjusted analysis, DCD, BMI>40, HCV, and history of malignancy were independently associated with significantly decreased odds of liver recovery. Age>70 was associated with increased odds of liver recovery (Table 1, Liver recovery for transplantation).

On average, rates of LT among donors from whom consent was requested, obtained, and liver was recovered ranged from 72.4% (DCD) to 87.9% (HCV). All 5 nonideal donor characteristics were independently associated with significantly decreased odds of transplantation (Table 1, Transplantation).

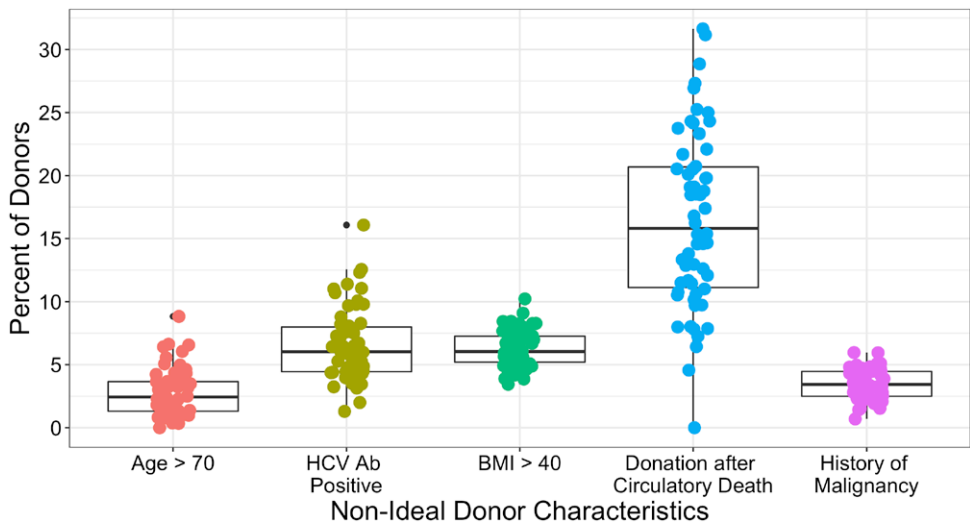
Assessment of DSA Performance

Overall, tier 5 DSAs (least risk-averse) had the highest rates of nonideal donor pursuit, consent attainment, liver recovery, and transplantation, while tier 1 DSAs (most risk-averse) had the lowest. On average, rates of nonideal liver recovery were over 25% lower among tier 1 DSAs compared with tier 5 DSAs (Table 2). If tier 1 DSAs increased their average nonideal liver recovery rate to match that of tier 5 DSAs, approximately 2100 additional livers could have been recovered during the study period, or approximately 175 additional livers per year. Performance in OPO-specific domains (nonideal donor pursuit+consent attainment) and transplant center domains (liver recovery+transplantation) were moderately correlated ( $r=0.65$ , Figure 5), corresponding to similar per-DSA risk aversion in early and late donation process stages.

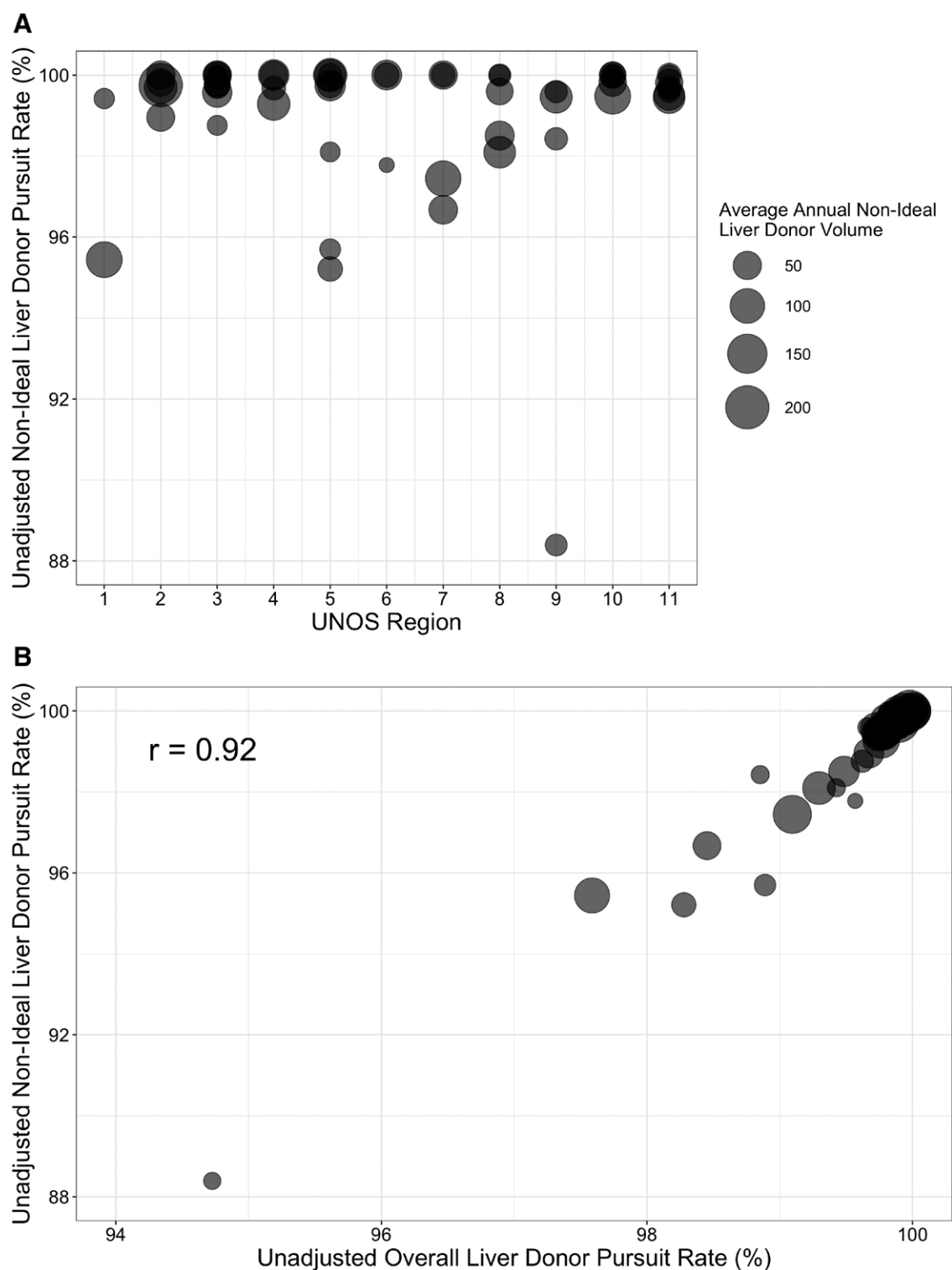
Factors Associated With DSA Performance

Transplant Center Competition

The proportion of DSAs serving multiple competing LT centers varied from 41.7% among tier 2 DSAs to 75.0%



**FIGURE 2.** Proportion of donors in each DSA with each nonideal donor characteristic. Points represent individual DSAs with proportions representing the proportion of donors with each nonideal donor characteristic who donated at least 1 organ for transplantation. BMI, body mass index; DSA, donation service area; HCV, hepatitis C virus.

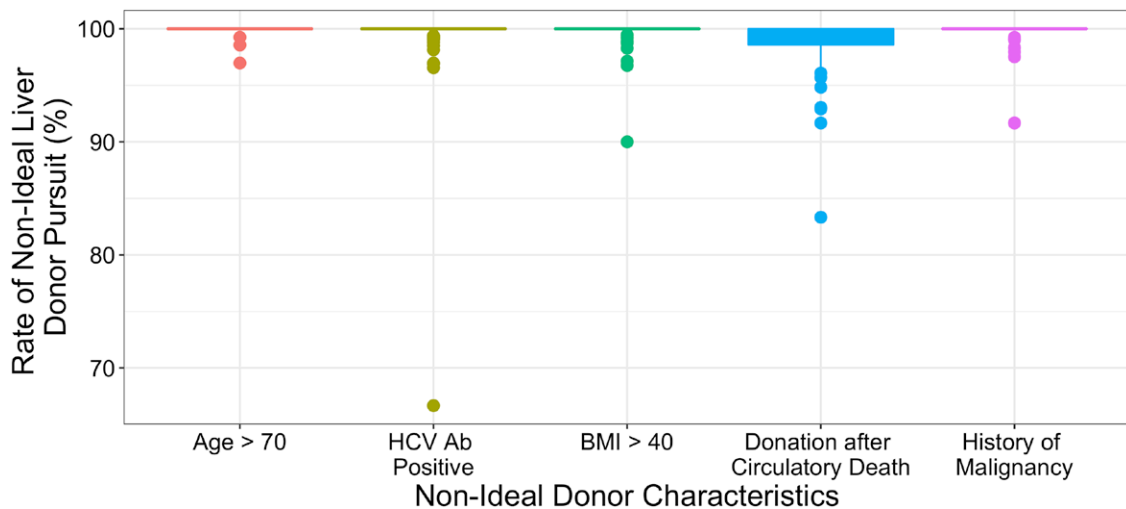


**FIGURE 3.** Individual OPO liver donor pursuit rates. A, Distribution of unadjusted nonideal liver donor pursuit rates among OPOs. OPOs were stratified by UNOS region. Circles represent unique OPOs with representative points scaled according to the average number of nonideal liver donors at that OPO for each year of the study period. B, Comparison of OPO-level nonideal and total liver donor pursuit rates ( $r=0.92$ ). OPO, organ procurement organization; UNOS, United Network for Organ Sharing.

among tier 4 DSAs; after tier 4 DSAs, the proportion of DSAs serving multiple LT centers was highest among tier 3 DSAs (72.7%). Two (18.2%) tier 5 DSAs and 2 (16.7%) tier 1 DSAs did not have a local LT center, meaning there was no LT center within those DSAs (Table 2).

**Liver Recipient Characteristics**

A total of 64162 adult patients underwent isolated LT with livers from donors in our study. Recipient characteristics, including age, sex, BMI, final Model for End-Stage Liver Disease (MELD), and etiology of liver disease, were similar



**FIGURE 4.** Distribution of unadjusted nonideal liver donor pursuit rates across OPOs separated by nonideal donor characteristic. HCV, hepatitis C virus; OPOs, organ procurement organizations.

across DSA performance groups (Table S3, SDC, <http://links.lww.com/TXD/A338>).

### Organ Offer Efforts and Offer Acceptance Practices

Among donors in our study, a total of 3791817 unique liver offers were made to adult, isolated LT candidates listed at 143 unique centers with an average offer acceptance rate of 4.63%. On average, OPOs in tier 1 DSAs made nearly 2-times more offers per nonideal donor liver than OPOs in tier 5 DSAs (112.55 versus 66.34 offers per liver). The proportion of nonideal livers for which an offer was eventually accepted was over 15% lower among tier 1 DSAs than tier 5 DSAs (Table 2).

## DISCUSSION

Based upon a framework we recently introduced to evaluate OPO performance and risk aversion in lung transplantation,<sup>19</sup> we evaluated patterns of risk aversion in LT among 58 US OPOs and DSAs. We found that risk aversion varies among OPOs and across stages of the donation process and depends upon specific nonideal donor characteristics including donor age, HCV, DCD, BMI, and history of malignancy. In a 5-tier system of DSA performance, rates of nonideal liver recovery by transplant centers varied widely, despite high rates of donor pursuit and consent attainment by OPOs. These findings suggest that risk aversion at the center, rather than the OPO level, may be the most significant factor in diminished utilization of nonideal donor livers. To expand the potential donor pool for LT, standardizing center-level acceptance and recovery practices may have the largest potential impact.

DCD and age >70 were associated with the lowest and highest respective rates of donor pursuit and consent attainment. Both DCD and older age have been previously identified as important predictors of donor nonpursuit and failure of consent authorization.<sup>19,23-25</sup> Several recent studies also demonstrated considerable variability in the proportion of DCD and older donors across DSAs, suggesting that pursuit of these donors is not uniform across OPOs.<sup>3,8</sup> Although reasons underlying these trends remain uncertain, family perceptions of older people as unsuitable candidates for organ donation, insufficient education surrounding donation of DCD and

older donor organs, and nonstandardized OPO and hospital protocols for approaching these potential donors may represent important contributing factors.<sup>23,25,26</sup> In this context, our findings of significant risk aversion in pursuit and consent of DCD donors suggest that existing guidelines for approach to consent and management of these donors may not offer sufficient instruction to encourage and standardize their pursuit.<sup>27</sup>

Conversely, high rates of pursuit and consent attainment for donors with age >70 contrast with previously reported associations.<sup>23-25</sup> Although livers from donors age 70 and older demonstrate improved outcomes in the contemporary era, these donors represent a declining proportion of liver donors<sup>17</sup> and comprised only 3% of donors in our study. Importantly, the UNOS registry includes only individuals from whom at least 1 organ was recovered. Thus, the older donors included in this study may represent a more favorable population of older donors without substantial comorbidities. Accordingly, our findings likely underestimate OPO-specific risk aversion toward older donors by failing to account for a potentially significant number of individuals with age >70 from whom no organs were recovered. Although the development of a national data source that captures all donor referrals to OPOs may eventually clarify the true extent of risk aversion toward nonideal liver donors early in the donation process, more immediate actions to dispel misconceptions surrounding the suitability of nonideal donor organs may encourage wider pursuit of these donors to expand the donor pool. In particular, updated OPTN deceased donor policies that further outline nuances of approach to consent and management of nonideal donors may standardize and optimize OPO-level practices across nonideal donor groups.

Transplant center practices also influence OPO-level risk aversion, potentially deterring OPOs from pursuing donor livers that they believe centers are unlikely to accept.<sup>2,3,7,8</sup> In LT, there is much greater variation in center-level rates of organ acceptance,<sup>28</sup> compared with relatively high rates of nonideal donor pursuit by OPOs in our study. Indeed, prior work suggests that utilization of high-risk or nonideal donor livers varies more among transplant centers than among OPOs.<sup>29</sup> Moreover, “aggressive” centers are significantly more likely to utilize livers from older, HCV-positive, DCD, and BMI >40 donors than “nonaggressive” centers.<sup>21</sup> Our findings of significant risk aversion in liver recovery and transplantation

**TABLE 1.****Unadjusted rates and adjusted odds ratios for nonideal liver donor pursuit, consent attainment, liver recovery, and transplantation**

Nonideal characteristic	Rate (%) <sup>a</sup>	OR (95% CI)		
		Adjusted <sup>b</sup>	Adjusted <sup>c</sup>	Adjusted <sup>d</sup>
Donor pursuit				
Any nonideal characteristics	99.13	0.07 (0.05-0.10)	0.08 (0.05-0.10)	0.09 (0.06-0.12)
Age >70 y	99.91	0.66 (0.24-2.72)	0.67 (0.25-2.76)	0.74 (0.27-3.05)
HCV seropositive	99.10	0.74 (0.48-1.20)	0.74 (0.48-1.22)	0.69 (0.44-1.14)
BMI >40	99.59	1.00 (0.66-1.60)	1.01 (0.67-1.61)	1.02 (0.67-1.64)
DCD status	98.54	0.04 (0.03-0.05)	0.04 (0.03-0.05)	0.05 (0.04-0.07)
History of malignancy	99.70	1.18 (0.62-2.61)	1.21 (0.64-2.69)	1.11 (0.58-2.48)
Consent attainment				
Any nonideal characteristics	99.43	0.26 (0.23-0.30)	0.24 (0.21-0.28)	0.26 (0.23-0.30)
Age >70 y	99.98	2.42 (1.18-6.14)	2.33 (1.13-5.89)	2.64 (1.29-6.70)
HCV seropositive	99.72	1.07 (0.81-1.46)	1.01 (0.76-1.38)	1.02 (0.77-1.40)
BMI >40	99.28	0.90 (0.71-1.16)	0.88 (0.69-1.14)	0.90 (0.70-1.17)
DCD status	98.46	0.14 (0.12-0.16)	0.13 (0.11-0.14)	0.14 (0.12-0.16)
History of malignancy	99.68	1.25 (0.85-1.96)	1.12 (0.76-1.76)	1.08 (0.72-1.69)
Liver recovery for transplantation				
Any nonideal characteristics	63.56	0.17 (0.16-0.17)	0.16 (0.16-0.17)	0.16 (0.16-0.17)
Age >70 y	92.83	1.54 (1.34-1.77)	1.53 (1.33-1.77)	1.49 (1.30-1.73)
HCV seropositive	77.39	0.56 (0.53-0.60)	0.55 (0.52-0.59)	0.52 (0.49-0.56)
BMI >40	70.16	0.45 (0.42-0.48)	0.45 (0.42-0.48)	0.44 (0.41-0.47)
DCD status	42.06	0.07 (0.07-0.07)	0.07 (0.07-0.07)	0.07 (0.07-0.07)
History of malignancy	79.75	0.77 (0.70-0.85)	0.76 (0.69-0.84)	0.75 (0.68-0.83)
Transplantation				
Any nonideal characteristics	81.15	0.19 (0.18-0.19)	0.18 (0.18-0.19)	0.18 (0.18-0.19)
Age >70 y	85.01	0.71 (0.65-0.78)	0.71 (0.65-0.78)	0.72 (0.66-0.78)
HCV seropositive	87.93	0.56 (0.52-0.59)	0.55 (0.51-0.58)	0.54 (0.51-0.57)
BMI >40	80.29	0.39 (0.37-0.41)	0.39 (0.37-0.41)	0.38 (0.36-0.41)
DCD status	72.41	0.08 (0.07-0.08)	0.07 (0.07-0.08)	0.07 (0.07-0.08)
History of malignancy	86.51	0.72 (0.66-0.78)	0.70 (0.65-0.76)	0.70 (0.65-0.76)

<sup>a</sup>Mean unadjusted rate among 58 DSAs.<sup>b</sup>ORs for individual non-ideal donor characteristics mutually adjusted for all other non-ideal donor characteristics.<sup>c</sup>ORs for individual non-ideal donor characteristics mutually adjusted for all other non-ideal donor characteristics. All ORs adjusted for donor race/ethnicity and donor sex.<sup>d</sup>ORs for individual non-ideal donor characteristics mutually adjusted for all other non-ideal donor characteristics. All ORs adjusted for donor race/ethnicity, donor sex, and OPO.

BMI, body mass index; CI, confidence intervals; DCD, donation after circulatory death; DSA, donation service area; HCV, hepatitis C virus; OPO, organ procurement organization; OR, odds ratio.

from donors with DCD status, HCV, BMI >40, and history of malignancy may be understood in the context of these data, which suggest that center-level risk aversion may be the most critical determinant of which livers are ultimately recovered and transplanted. Furthermore, DSA performance in donor pursuit+consent attainment (OPO-specific metrics) and liver recovery+transplantation (transplant center metrics) were only moderately correlated. This suggests a disconnect between OPO-level pursuit+consent attainment and transplant center acceptance practices for nonideal donors.

Interestingly, prior work suggests that transplant centers that compete within a DSA and those with greater proportions of high-MELD recipients demonstrate increased utilization of high-risk donor livers.<sup>21,29</sup> In our study, there was no clear association between the number of centers within a DSA and overall DSA risk aversion, nor were there notable differences in recipient acuity from more versus less risk-averse DSAs. Compared with transplant centers, OPOs are relatively removed from potential liver recipients. Regardless, as evidence supporting acceptable outcomes among recipients of nonideal livers accumulates,<sup>14-17,30</sup> OPOs and transplant centers must collaborate to facilitate widespread pursuit, acceptance, and utilization of nonideal donor organs across all DSAs.

Akin to our findings in lung transplantation, the close relationship between OPO and center-level practices and disproportionate influence of center-level risk aversion later in the donation process calls into question the appropriateness of quantifying OPO performance using measures of organ recovery and transplantation.<sup>19</sup> In contrast to our findings in lung transplantation,<sup>19</sup> our findings in LT suggest that current metrics may unfairly penalize OPOs for poor performance in areas for which they are not solely responsible, without recognizing optimal performance in areas most specifically under their control. In our 5-tier categorization of DSA performance in LT, OPOs in all 5 performance groups pursued and consented the majority of nonideal liver donors, whereas rates of nonideal liver recovery were over 25% lower among tier 1 DSAs (most risk-averse) than tier 5 DSAs (least risk-averse). Had tier 1 DSAs achieved the same average recovery rate as tier 5 DSAs, approximately 2100 additional livers could have been recovered during the study period, highlighting liver recovery as a critical means to expand the donor pool. Importantly, optimization of liver recovery depends upon reconciliation of OPO and transplant center practices. Despite lower rates of nonideal liver recovery, tier 1 DSAs demonstrated aggressive offer practices, making nearly

**TABLE 2.**  
**Characteristics of tier 1, 2, 3, 4, and 5 DSAs**

Characteristic	Tier 1 DSAs (most risk-averse)	Tier 2 DSAs	Tier 3 DSAs	Tier 4 DSAs	Tier 5 DSAs (least risk-averse)
Average annual liver donor volume <sup>a</sup>	149.01 (126.87)	113.98 (74.69)	157.76 (59.90)	157.04 (75.95)	125.78 (106.42)
Pursuit rate <sup>b</sup>	96.99% (3.11%)	99.28% (1.07%)	99.72% (0.21%)	99.78% (0.37%)	100.0% (0.00%)
Consent attainment rate <sup>b</sup>	97.82% (1.35%)	98.82% (0.91%)	99.25% (0.60%)	99.68% (0.46%)	99.81% (0.25%)
Recovery rate <sup>b</sup>	50.38% (11.50%)	56.27% (8.75%)	62.51% (7.41%)	73.38% (6.05%)	76.23% (9.53%)
Transplant rate <sup>b</sup>	77.33% (17.28%)	81.29% (6.57%)	77.18% (6.87%)	84.66% (6.05%)	85.29% (8.77%)
Liver transplant centers per DSA <sup>c</sup>					
No local center	2 (16.7%)	1 (8.3%)	0 (0%)	0 (0%)	2 (18.2%)
1 local center	2 (16.7%)	6 (50.0%)	3 (27.3%)	3 (25.0%)	2 (18.2%)
≥2 local centers	8 (66.7%)	5 (41.7%)	8 (72.7%)	9 (75.0%)	7 (63.6%)
Average listing center liver offer acceptance rate <sup>d</sup>	1.54% (0.44%)	2.54% (1.07%)	1.88% (0.65%)	2.55% (1.20%)	3.16% (1.53%)
Number of offers per liver <sup>e</sup>					
All donors	58.61 (207.59)	33.03 (151.28)	43.95 (154.58)	43.63 (207.05)	34.64 (135.63)
Nonideal donors	112.55 (287.12)	65.71 (212.70)	83.69 (224.52)	82.31 (288.62)	66.34 (207.74)
Proportion of donors from whom a liver offer was accepted <sup>e</sup>					
All donors	71.03% (6.33%)	75.04% (4.57%)	71.08% (7.02%)	78.07% (4.43%)	78.38% (8.69%)
Nonideal donors	49.46% (14.70%)	55.76% (7.63%)	51.84% (9.47%)	64.55% (5.85%)	66.79% (12.35%)

<sup>a</sup>Overall annual liver donor volume including both ideal and nonideal liver donors. Presented as the mean (SD) among all DSAs in each group.

<sup>b</sup>Restricted to nonideal liver donors. Presented as the mean (SD) unadjusted rate among all DSAs in each group.

<sup>c</sup>Local liver transplant centers are defined as those within an OPO's donation service area. Presented as the frequency (proportion) of DSAs in each group.

<sup>d</sup>Includes only offers made to adult (age ≥ 18) isolated liver transplant candidates from both ideal and nonideal donors. Presented as the mean (SD) among all DSAs in each group.

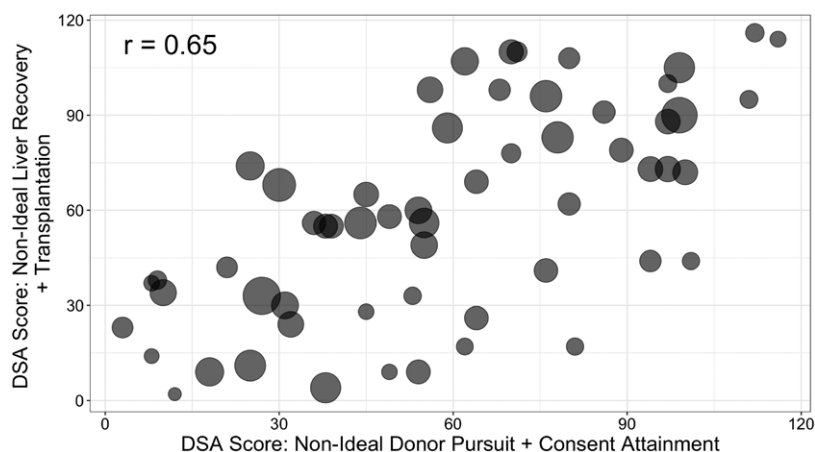
<sup>e</sup>Includes only offers made to adult (age ≥ 18) isolated liver transplant candidates. Presented as the mean (SD) among all DSAs in each group.

DSAs, donation service areas; OPO, organ procurement organization.

2-times more offers per nonideal liver compared with tier 5 DSAs. In this context, our findings suggest that conservative center-level offer acceptance practices, rather OPO-level reluctance to offer nonideal livers, may be more significant determinants of recovery, further emphasizing the need to standardize center-level acceptance criteria to facilitate widespread liver recovery and transplantation. Although incentives targeting liver recovery may eventually significantly expand LT, CMS's current system may nonetheless unfairly flag OPOs in tier 1 DSAs as underperformers without granting appropriate recognition for their efforts early in the donation process.

One year after CMS announced plans to update OPO performance metrics,<sup>31</sup> the transplant community faces a critical juncture in OPO evaluation, necessitating new metrics that not only indicate when OPO-specific performance improvement is due

but that also identify optimally performing OPOs and afford opportunities for fair recognition. Following CMS's announcement, a Scientific Registry of Transplant Recipients report found that under the proposed system, over 60% of OPOs may face decertification.<sup>32</sup> Moreover, recent data suggest that OPOs' rankings are relatively static over time, making it difficult for underperforming OPOs to improve relative to others within the current evaluation framework.<sup>33</sup> In contrast, our system may offer OPOs more concrete opportunities to demonstrate improvement while simultaneously facilitating more appropriate weighting and separation of OPO-specific and transplant center performance to avoid either penalizing or rewarding OPOs for center-level practices that may be partially reflected in current metrics. Taken together, our findings in lung and LT also suggest that OPO evaluations should remain separated by organ to identify action areas to expand their respective donor pools.<sup>19</sup>



**FIGURE 5.** Comparison of individual DSA performance in nonideal liver donor pursuit + consent attainment and liver recovery + transplantation. Circles represent unique DSAs with representative points scaled according to the average number of liver donors including both ideal and nonideal donors in that DSA for each year of the study period. Component scores could range from 2–116 ( $r = 0.65$ ). DSA, donation service area.

There are several limitations to our study. Retrospective reviews using large national databases have the inherent limitation of unmeasured confounders that cannot be accounted for within the analysis. Several key confounders include differences in OPOs' definitions and reporting of donor pursuit, OPO-specific donor management protocols, and specific reasons why consent for liver donation was not requested or obtained.<sup>19</sup> Additionally, we were unable to account for specific considerations that may influence the decision of whether to accept a donor liver, particularly in the setting of DCD organs, for which there is more variability in practice across transplant centers. As there is no universal definition of "nonideal" or "extended-criteria" donor in LT, nonideal donor characteristics explored in our study may not include all parameters considered suboptimal by OPOs or transplant centers. Although multiple studies cite macrosteatosis  $\geq 30\%$  as an important predictor of liver nonutilization,<sup>10,14,15</sup> liver biopsies are not routinely performed for all donors, and a high degree of missingness therefore precluded inclusion of steatosis in our definition of nonideal donor. Examining practices over a 12-y period also meant that our analysis included data before and after allocation policy was updated to replace DSA with concentric circles as the primary unit of liver allocation.<sup>34</sup> As this change may facilitate more frequent collaboration between OPOs and nonlocal transplant centers, it may have altered DSA-level risk aversion, particularly later in the donation process as OPOs interface with transplant centers with variable offer acceptance practices. Future studies should examine how provisions for broad liver sharing influence DSA-level risk aversion and implications for an evolving national allocation policy. Finally, OPO-specific definitions of "acceptable" donor are not readily available, and we, therefore, cannot assess OPO and DSA performance in the context of these individually specified constraints.<sup>19</sup>

## CONCLUSIONS

In this national analysis of risk aversion in LT, we found that risk aversion varies among DSAs and across stages of the donation process. Importantly, most OPOs already aggressively pursue nonideal liver donors, despite extreme variability in patterns of liver recovery, likely owing to low center-level offer acceptance rates. These findings highlight the need to evaluate DSA performance throughout the donation process to disentangle OPO and transplant center practices and fairly recognize optimal OPO-specific performance. Use of a tiered system may strike this balance between OPO performance evaluation and recognition, offer a detailed means by which to identify specific areas in which action is required, and reflect targeted efforts and improvements from OPOs independent of and in combination with transplant centers to best support expansion of the donor pool for LT.

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