The Donor Risk Index: A Decade of Experience

Avegail Flores and Sumeet K. Asrani

Division of Gastroenterology, Washington University School of Medicine, St. Louis, MO; and Hepatology, Baylor University Medical Center, Dallas, TX

In 2006, derivation of the donor risk index (DRI) highlighted the importance of donor factors for successful liver transplantation. Over the last decade, the DRI has served as a useful metric of donor quality and has enhanced our understanding of donor factors and their impact upon recipients with hepatitis C virus, those with low Model for End-Stage Liver Disease (MELD) score, and individuals undergoing retransplantation. DRI has provided the transplant community with a common language for describing donor organ characteristics and has served as the foundation for several tools for organ risk assessment. It is a useful tool in assessing the interactions of donor factors with recipient factors and their impact on posttransplant outcomes. However, limitations of statistical modeling, choice of donor factors, exclusion of unaccounted donor and geographic factors, and the changing face of the liver transplant recipient have tempered its widespread use. In addition, the DRI was derived from data before the MELD era but is currently being applied to expand the donor pool while concurrently meeting the demands of a dynamic allocation system. A decade after its introduction, DRI remains relevant but may benefit from being updated to provide guidance in the use of extended criteria donors by accounting for the impact of geography and unmeasured donor characteristics. DRI could be better adapted for recipients with nonalcoholic fatty liver disease by examining and including recipient factors unique to this population.

Liver Transplantation 23 1216–1225 2017 AASLD.
Received March 23, 2017; accepted May 24, 2017.

The liver allocation policy in the United States, based on an assessment of recipient factors using the Model for End-Stage Liver Disease (MELD) score, is established and straightforward. However, organ acceptance involves complex decision making wherein donor and recipient matching occurs. In their seminal article in 2006, Feng et al. quantified surrogates of donor quality and highlighted the importance of donor factors for successful liver transplantation (LT). Over the last decade, the donor risk index (DRI) has served as a useful metric of donor quality across multiple studies and enhanced our understanding of donor factors and their impact upon selected recipients (eg, recipients with hepatitis C virus [HCV] or low MELD score). With the expansion of the donor pool, either due to aggressive procurement, use of extended criteria donors (ECDs), or utilization of donation after cardiac death (DCD) donors, the DRI may be useful in decision making and in assessing organ and patient outcomes. In national surveys, 46% of transplant specialists feel that incorporation of the DRI would improve shared decision making. Despite these putative benefits, the DRI (unlike the MELD score) has not entered the common parlance of transplantation in quantifying donor risk and has not been incorporated into liver allocation policy.

In this review, we discuss the derivation of the DRI, as well as its strength, limitations, and impact on transplantation practices. We describe more recent models that incorporate donor factors to predict posttransplant outcomes.
Derivation of the Donor Risk Index

Using data from adult deceased donor liver transplants in the United States from 1998 to 2002, Feng et al. identified 7 donor characteristics that were significantly associated with organ failure. The model also included cold ischemia time (CIT) and sharing outside of the local donor service area (Table 1). In the final model, a reference donor (age < 40 years, death due to trauma, white race, CIT ≥ 8 hours, height 170 cm, local organ procurement, and whole non-DCD organ) accounted for 19% of transplants and had an estimated 1-year organ survival of 87%-89% and 3-year organ survival of 80%-83%. On the other hand, the highest-risk livers from donors with liver donor risk index (LDRI) ≥ 2 (6% of patients) had an estimated 1-year organ survival of 69%-74% and 3-year organ survival of 57%-63%.

Validation of the Donor Risk Index

Subsequent studies validated DRI as an independent predictor of organ failure in populations within and outside the United States in the post-MELD era. For example, use of high-risk donor livers (DRI ≥ 1.7) was associated with a significant increase in relative risk of allograft failure in each MELD category. In addition, the DRI was an independent predictor of development of complications (hepatic artery thrombosis, biliary complications, end-stage renal disease).

### Table 1. Calculated DRI and 1-Year Organ Survival Estimates for Specified Donor Profiles (1998-2002)

<table>
<thead>
<tr>
<th>Donor Profile</th>
<th>n (%)</th>
<th>Range of Calculated DRI</th>
<th>95% CI for Adjusted 1-Year Survival Estimates</th>
</tr>
</thead>
<tbody>
<tr>
<td>None</td>
<td></td>
<td>Reference</td>
<td>84.8-86.4</td>
</tr>
<tr>
<td>40-49 years</td>
<td>1174</td>
<td>1.17</td>
<td>82.9-86.9</td>
</tr>
<tr>
<td>50-59 years</td>
<td>653</td>
<td>1.32</td>
<td>79.0-84.5</td>
</tr>
<tr>
<td>60-69 years</td>
<td>299</td>
<td>1.53</td>
<td>7.7-85.9</td>
</tr>
<tr>
<td>70+ years</td>
<td>140</td>
<td>1.65</td>
<td>61.3-76.3</td>
</tr>
<tr>
<td>COD-Other or COD-Stroke or Black</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Under 40 years</td>
<td>2683</td>
<td>1.16-1.20</td>
<td>81.8-84.6</td>
</tr>
<tr>
<td>40-49 years</td>
<td>2128</td>
<td>1.35-1.40</td>
<td>79.8-83.1</td>
</tr>
<tr>
<td>50-59 years</td>
<td>2293</td>
<td>1.52-1.58</td>
<td>77.2-80.5</td>
</tr>
<tr>
<td>60-69 years</td>
<td>1445</td>
<td>1.77-1.84</td>
<td>73.4-77.8</td>
</tr>
<tr>
<td>70+ years</td>
<td>655</td>
<td>1.91-1.99</td>
<td>72.4-78.7</td>
</tr>
<tr>
<td>(COD-Other + Race-Black) or (COD-Stroke + Race-Black)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Under 40 years</td>
<td>276</td>
<td>1.38-1.43</td>
<td>71.7-81.3</td>
</tr>
<tr>
<td>40-49 years</td>
<td>365</td>
<td>1.61-1.67</td>
<td>73.7-82.0</td>
</tr>
<tr>
<td>50-59 years</td>
<td>290</td>
<td>1.81-1.89</td>
<td>73.7-92.9</td>
</tr>
<tr>
<td>60-69 years</td>
<td>132</td>
<td>2.11-2.19</td>
<td>63.4-78.4</td>
</tr>
<tr>
<td>70+ years</td>
<td>58</td>
<td>2.27-2.37</td>
<td>71.6-91.0</td>
</tr>
<tr>
<td>DCD or partial/split</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Under 40 years</td>
<td>344</td>
<td>1.51-1.52</td>
<td>75.4-83.8</td>
</tr>
<tr>
<td>40-49 years</td>
<td>34</td>
<td>1.76-1.78</td>
<td>45.6-78.0</td>
</tr>
<tr>
<td>50-59 years</td>
<td>17</td>
<td>1.98-2.01</td>
<td>73.0-100.0</td>
</tr>
<tr>
<td>60-69 years</td>
<td>6</td>
<td>2.30-2.33</td>
<td>33.3-100.0</td>
</tr>
<tr>
<td>70+ years</td>
<td>3</td>
<td>2.49-2.52</td>
<td>23.9-100.0</td>
</tr>
<tr>
<td>(DCD or partial/split) + at least one other factor</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Under 40 years</td>
<td>129</td>
<td>1.74-3.30</td>
<td>64.9-80.5</td>
</tr>
<tr>
<td>40-49 years</td>
<td>51</td>
<td>2.03-3.85</td>
<td>60.7-84.7</td>
</tr>
<tr>
<td>50-59 years</td>
<td>20</td>
<td>2.29-4.34</td>
<td>49.0-91.5</td>
</tr>
<tr>
<td>60-69 years</td>
<td>14</td>
<td>2.66-5.04</td>
<td>46.4-97.0</td>
</tr>
<tr>
<td>70+ years</td>
<td>0</td>
<td>2.88-5.45</td>
<td>N/A</td>
</tr>
</tbody>
</table>

NOTE: Calculation: DRI = \exp(0.154 \text{ if age is } < 40 \text{ to } < 50 \text{ years}) + 0.274 \text{ if age is } \leq 50 \text{ to } < 60 \text{ years} + 0.424 \text{ if age is } \leq 60 \text{ to } < 70 \text{ years} + 0.501 \text{ if age is } \leq 70 \text{ years} + 0.079 \text{ if COD = anoxia} + 0.145 \text{ if COD = CVA} + 0.184 \text{ if COD = other} + 0.176 \text{ if race = African American} + 0.126 \text{ if race = other} + 0.411 \text{ if DCD} + 0.422 \text{ if partial/split} + 0.066 \left(170 - \text{ height} / 10\right) + 0.105 \text{ if regional share} + 0.244 \text{ if national share} + 0.010 \times \text{ cold time}).

Used with permission from Feng et al. (1)
morbidity (increased cost of care and readmissions), progression of fibrosis among patients with HCV, and survival in selected subsets, such as those undergoing transplantation for hepatocellular carcinoma (HCC) as well as those undergoing retransplantation.\(^{(8-14)}\)

Strengths and Influences on Transplant Practices

OBJECTIVE RISK ASSESSMENT AND ANALYSIS OF PRACTICE PATTERNS

The need for an objective tool was underscored in a study demonstrating that physician intuition of donor-specific risk of organ failure was inaccurate insofar as it systematically underestimated rates of graft failure particularly for higher-risk organs.\(^{(15)}\) DRI classifies organs as high or low risk and enables observation of transplant practices with these organs based on perceived risk.\(^{(1)}\) In addition, DRI has facilitated identification of disparities in organ use. For example, Hispanics were 21% more likely to get a lower-quality organ as compared with Caucasians. For the same donor quality, African Americans had higher rates of organ failure, and Hispanics had higher organ survival despite the use of worse organs.\(^{(16)}\) More recently, DRI served as an important tool in showing unintended changes in practice pattern since Share 35. Share 35 allowed for broader sharing of organs within regions for patients with MELD  35 to improve access for the sickest candidates. Following this policy change, offers after Share 35 were 36% less likely to be accepted compared with offers before Share 35 (adjusted odds ratio, 0.64). There was no clinically meaningful difference in DRI of organs that were declined either pre–Share 35 or post–Share 35.\(^{(17)}\)

ACCEPTANCE OF HIGH-RISK DONORS

High DRI livers were most likely used for low disease severity recipients (MELD score 10–14) and least likely used for status 1 recipients.\(^{(1)}\) Less urgent candidates received the highest-risk organs leading to reduced posttransplant survival among patients with low MELD scores (Fig. 1).\(^{(18)}\) The detrimental effect of high DRI organs on the lowest MELD (6–8) category of patients was confirmed by Schaubel et al., who later proposed that transplantation of high DRI organs is effective for high but not for low-MELD candidates.\(^{(19)}\) In high-MELD patients, waiting time was more important than DRI, suggesting that earlier transplantation for high-MELD patients superseded the need for an optimal organ.\(^{(20-22)}\) In decision analysis, transplantation with an available extended criteria organ was preferable to waiting for a standard criteria donor among patients with advanced MELD scores.\(^{(23)}\)

ORGAN SELECTION FOR RECIPIENTS WITH HEPATITIS C VIRUS

Use of the DRI supported a paradigm shift toward transplanting organs with favorable characteristics into recipients with HCV. HCV recurrence and subsequent organ failure were more likely for older donor organs.\(^{(6,24-26)}\) Donor age  > 50 years and DRI  > 1.7 were associated with fibrosis progression, organ failure, and patient death after liver transplant for HCV.\(^{(27)}\) Maluf et al. reported transplantation of a high DRI organ in a HCV-positive recipient predicted worse outcome compared with a HCV-negative recipient, indicating a significant interaction between DRI and HCV \((P < 0.01)\).\(^{(6)}\)

ORGAN SELECTION FOR RETRANSPANTATION

Use of the DRI has facilitated donor-recipient matching after retransplantation. Among patients...
undergoing retransplantation, the DRI is a significant predictor of overall mortality (hazard ratio, 2.2; 95% confidence interval [CI], 1.6–2.9). In order to achieve at least 50% survival at 1 year after retransplantation, donor characteristics would have to be strategically matched to the recipient’s MELD score, HCV status, and age. Lower-risk recipients (HCV-negative and age < 50 years) exhibit acceptable 1-year organ survival regardless of the DRI or MELD score. Older HCV-positive recipients required lower DRI (<1.4) organs or have a lower MELD score to achieve acceptable survival. (9)

DEVELOPMENT OF EUROTRANSPLANT DONOR RISK INDEX

More recently, validation of the DRI in a large European study performed with the European Liver Transplant Registry (3) led to the subsequent development of the Eurotransplant donor risk index (ET-DRI), which combines an adaptation of the DRI with additional donor factors, mainly latest laboratory gamma-glutamyl transpeptidase (GGT; \( P < 0.005 \)) and rescue allocation (\( P = 0.007 \)). The c-index for this model was significantly higher (\( P = 0.002 \)) at 0.62 versus that of DRI = 0.61. (28)

Limitations and Barriers to Acceptance

There is an inherent assumption that no degree of statistical manipulation can accurately capture, characterize, or predict the donor-recipient matching that happens at the time of organ acceptance. (29) In a survey of LT physicians, 73% of respondents believed that DRI did not adequately describe a liver’s relative risk of organ failure, and 88% believed it included factors making DRI potentially misleading. (2)

LIMITATIONS OF STATISTICAL MODELING

The DRI is a succinct and parsimonious model. However, it was developed using over 60 variables and included factors that may lack biological plausibility (eg, donor race, see below). Factors unavailable prior to allocation (eg, CIT) were included. Overall, the concordance statistic (C-statistic) for the model is low, ranging from 0.50 to 0.65 in separate studies. (1,30,31) As an example, a C-statistic of 0.60 implies that 40 out of 100 times the model would incorrectly predict the first patient to die out of a randomly drawn pair of patients. In contrast, the MELD score has a C-statistic of 0.85 to predict mortality within 3 months on the waiting list. (32) Posttransplant outcomes are inherently hard to predict. Even recent comprehensive attempts at identifying posttransplant survival (eg, survival benefit posttransplant model) have a concordance statistic of 0.62. (33) Differences in the prevalence of certain characteristics across populations (eg, high rates of DCD or older donors or uniform race in certain countries) may limit any attempt at risk stratification afforded by a fixed liver donor risk model. (34)

LIMITATIONS OF ACCOUNTED AND UNACCOUNTED DONOR FACTORS

A significant amount of variability in posttransplant outcomes is predominantly influenced by 2 factors, namely, donor age and DCD organs. (6,26,35–43) Certain donor factors, such as donor race, are included primarily due to statistical significance and have not been demonstrated to be uniform predictors of organ failure once the center of transplantation is considered. (44,45) Factors not routinely collected or reported may influence outcomes. Macrosteatosis on donor biopsy is a significant predictor of allograft failure. (46,47) Donor diabetes, a potential surrogate for donor steatosis or other vascular changes (such as hyaline arteriolar changes), is associated with organ failure. (31,48) There is an effect of warm ischemia time whereby DCDs with longer warm ischemia time have increased organ failure rates. (49)

CHANGING RECIPIENT AND DONOR CHARACTERISTICS

The allocation system prioritizes the sickest candidates by virtue of their MELD score. The potential impact of the patient’s health status and frailty on organ quality or DRI is not well characterized. Patients undergoing transplantation are globally sicker in the current era as compared with the initial inception of MELD-based organ allocation. As compared with 2002, candidates on the waiting list in 2012 have a higher MELD score at transplant (mean MELD > 30, 34% versus 15%), are older (age > 65 years, 15% versus 8%), and have more comorbidities, such as obesity (32% versus 26%), portal vein thrombosis (10% versus 3%),
previous abdominal surgeries (43% versus 36%), and spontaneous bacterial peritonitis (9% versus 7%). There has been a reduction in wait-list registration and transplants for patients with HCV with an increase in transplants for cryptogenic cirrhosis and nonalcoholic fatty liver disease. Furthermore, there has been a reduction in wait-list registration and transplants for patients with HCV with an increase in transplants for cryptogenic cirrhosis and nonalcoholic fatty liver disease. There is a yearly increase in simultaneous liver-kidney transplantation, which may skew assessment of the impact of donor factors for the sickest patients who undergo dual organ transplant versus LT alone.

The DRI was formulated from data before the MELD era and since then numerous policy changes have occurred in the allocation of organs. The most recent changes are Share 35 implemented in 2013, HCC cap and delay in 2015, and MELD-sodium in 2016. These recent allocation changes limit the number of HCC-driven transplants, which was unregulated at the time DRI was derived. In addition, Share 35 and MELD-sodium bring to attention recipient factors and potential interaction with donor factors.

The median waiting time has decreased especially in patients with a MELD score > 35, partly driven by the regional Share 35 policy and increased donor recovery. Compared with 2008, the percentage of livers transplanted out of all livers recovered for donor age >50 and >65 years has increased. Increasing ECD organ use has significantly decreased wait-list mortality, encouraging aggressive utilization of higher-risk organs to bridge the gap in organ shortage. The ability of transplant centers to handle a high-risk donor has improved with equivalent survival associated with transplantation of a high-risk donor compared with low-risk donors in the current era.

**IMPACT OF CENTER OF TRANSPLANT AND GEOGRAPHIC FACTORS**

Center of transplantation and region play an important role with regard to when patients get transplanted across the region or country. Certain characteristics attributed to donor characteristics may instead reflect center-specific practices. For example, though biliary complications are higher in patients with higher DRI, biliary complications are higher at centers that accept organs with lower donor age and lower DRI among DCD organs, suggesting a center-level effect that may not be captured by DRI. Similarly, the impact of donor race may be explained by center of transplantation. The impact of DRI on organ failure may vary by region and center of transplant, especially after incorporation of Share 35. First, in competitive donor service areas, there is an increased number of donors with higher DRI and higher donor conversion rate. Increased competition is associated with higher acceptance of higher DRI organs. Second, high-volume centers or those in highly competitive regions may be more adept at handling (and absorbing the risk of) high DRI organs. Despite the higher risk associated with high DRI (>1.90) organs, high-volume centers (>78 transplants per year) more frequently use higher DRI livers and achieved better risk-adjusted allograft and recipient survival. Finally, the number of offers for centers with a larger percentage of high-MELD patients are 2-3 times higher after Share 35, allowing such centers with more opportunities to evaluate both low- and high-DRI organs. Therefore, the purported impact of DRI may vary by unmeasured geographic considerations.

**MODELS TO PREDICT POSTTRANSPLANT OUTCOME IN THE MODEL FOR END-STAGE LIVER DISEASE ERA**

Limitations of the DRI had stirred interests in developing a model for more accurate prediction of posttransplant outcomes. Several models (Table 2) have been proposed using donor factor(s), recipient factors, and even operative factors to predict posttransplant survival. Some models suggest that an optimal combination of these factors may prove more accurate than the DRI and facilitate transplant decision making.

However, almost all proposed models represent a form of donor-recipient matching and hence are qualitatively different than DRI. This necessitates calculation of multiple scores at the time of an offer and limiting widespread use.

**Donor Age and Recipient Model for End-Stage Liver Disease**

Donor Age and Recipient Model for End-Stage Liver Disease (D-MELD), the mathematical product of donor age and preoperative MELD, has been proposed to optimize donor-recipient matching. In this model, avoidance of D-MELD score > 1600 by avoiding matching organs from a donor of age ≥ 60 years with high-MELD recipients improved patient and organ survival. MELD prioritizes the sickest patient on the waiting list, and with the increase in
### TABLE 2. Summary of Selected Models to Predict Posttransplant Outcomes in the MELD Era

<table>
<thead>
<tr>
<th>Variables included</th>
<th>ET-DRI</th>
<th>DRI</th>
<th>D-MELD</th>
<th>LDLT DRI</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Donor factors:</strong></td>
<td>age, COD, COD, partial/split, race, height, regional/national share</td>
<td>age, COD, COD, partial/split, regional/national share</td>
<td>age</td>
<td>age, weight, graft type</td>
</tr>
<tr>
<td><strong>Operative factor:</strong></td>
<td>CIT</td>
<td>CIT</td>
<td>CIT</td>
<td>CIT</td>
</tr>
<tr>
<td><strong>Recipient factors:</strong></td>
<td>age, BMI, previous transplants, abdominal surgery, albumin, dialysis, ICU hospital admission, MELD &gt; 30, life support, encephalopathy, portal vein thrombosis, portal bleed, ascites</td>
<td>age, BMI</td>
<td>age, MELD, retransplantation, life support</td>
<td>age, weight, albumin, diagnosis</td>
</tr>
</tbody>
</table>

#### Available online calculators

#### Advantages
- Readily available variables at the time of transplant, most widely recognized and studied model, well-validated in selected recipients
- Readily available variables at the time of transplant
- Multiple levels of risk, identified futility
- Readily available variables at the time of transplant, included relevant recipient factors
- Simple to use
- Parsimonious, all factors available at time of transplant

#### Limitations
- Included factors that lacked biological plausibility, low C-statistic, exclusion of salient donor factors, needs validation in current donor/recipient pools, center impact unaccounted, donor factors not all available at time of offer
- Lower C-statistic in validation studies, donor factors not all available at time of offer
- Multiple factors, complex statistical modeling, emphasis on short-term survival, donor factors not all available at time of offer
- Exclusion of salient donor factors, lack of longterm data, majority of liver transplants would fall in favorable category (< 18), donor factors not all available at time of offer
- Many significant factors excluded, center and geography unaccounted, lacks further risk assessment for older donor livers
- C-statistic is only comparable to models with deceased donor, which is rather low
older donors (18% > 65 years in 2015), D-MELD may not provide nuanced risk assessment for older donor livers.\(^{(51)}\)

### Survival Outcomes Following Liver Transplantation

In contrast, the survival outcomes following liver transplantation (SOFT) score used 18 risk factors to predict 3-month survival after LT. In this model, the most significant risk factors were previous transplants, warm ischemia time, and the need for life support. The SOFT score predicted 3-month mortality with a concordance statistic of 0.70.\(^{(68)}\) Complex statistical modeling and inclusion of multiple risk factors limit the application of this model. Focus on short-term survival and similar C-statistic, with and without the inclusion of donor factors, implied that the score can be influenced more so by recipient and operative factors. Hence, its application as a tool to solely assess donor risk may be suboptimal.

### Balance of Risk Score

The balance of risk (BAR) score was proposed after identifying six strong predictors of posttransplant survival from 2002 to 2010 United Network for Organ Sharing data. Recipient MELD score, CIT, recipient age, donor age, previous liver transplant, and life support dependence prior to transplant were significant predictors of outcome \((P < 0.001)\). A BAR score was calculated with a range from 0 to 27 points, reflecting an exponential increase in 3-month mortality. An exponential decay in patient survival was observed above BAR score 18, marking futility of transplant. The score was internally validated with a C-statistic of 0.70.\(^{(69)}\) A BAR score of \(>18\) represented only 3% of the liver transplant. The lack of longterm data and the fact that 97% of liver transplants would fall in the favorable BAR score \(<18\) would result in limited applicability and a lack of granularity for more nuanced decision making.

### EUROTRANSPLANT DONOR RISK INDEX

ET-DRI was derived using information on deceased donors from 2003 and 2007 in the Eurotransplant region. Factors included age, cause of death (COD), GGT, DCD, split liver, and 3 transplant factors (CIT, allocation, rescue allocation). The C-statistic was 0.61 in validation.\(^{(28,70)}\) Survival differences were predominantly driven by events in the first year.\(^{(71)}\) However, later validation studies assigned a lower C-statistic of 0.48-0.52.\(^{(72,73)}\) A refinement of ET-DRI that combined recipient factors showed a significantly higher c-index of 0.62 versus 0.59 \((P < 0.001)\).\(^{(70)}\)

### Donor Risk Index for Living Donors

Living donor liver transplantation (LDLT) outcomes are equivalent to deceased donor transplants when performed at experienced centers. Development of a risk score to optimize donor and recipient selection for LDLT was undertaken by Goldberg et al., using data from 2100 LDLTs from 2002 to 2012. A full model (included 15 variables) and a parsimonious model proposed yielded similar results for the area under the curve. The parsimonious model included the following variables: recipient age, recipient weight, recipient albumin, and recipient diagnosis, donor age, donor weight, and graft type. The area under the curve for 1-, 3-, and 5-year graft survival was 0.60, 0.61, and 0.62, respectively.\(^{(74)}\)

### Accuracy of Models in Predicting Outcomes

Accuracy offered by all of the above scores is low.\(^{(32,75)}\) For example, the C-statistic for predicting outcomes after LT was 0.66 for MELD, 0.62 for D-MELD, 0.67 for BAR, and 0.54 for LDRI.\(^{(30)}\)

### Future Directions

DRI was initially developed to include donor factors significant to organ quality to aid decision making and risk discussion with the patient at the time of organ acceptance. The intent of the DRI was to serve as a quantitative tool of donor quality to assist (and not replace) the decision making during an organ offer.\(^{(76)}\) Patients want to be involved in the decision-making process, and an objective tool that encapsulates donor risk is highly relevant. Volk et al. showed that patients may accept high-risk organs if presented with risks of graft failure.\(^{(77)}\) Similar findings were presented in a larger European cohort showing that the majority of patients want to be informed of donor-related risks \((60\%-75\%\%).\(^{(78)}\) Hence the utility of a donor risk score lies not only in the hands of the transplant team but also aids in discussion with the potential recipient.

Despite the current limitations of DRI, the individual components of the model continue to influence...
transplant decisions.\textsuperscript{(2)} In so much as the MELD score needed refinements to improve its prediction, the DRI would benefit from being updated to provide guidance, specifically in the use of ECD or high-DRI organs.\textsuperscript{(79,80)} First, an ideal model would include effortlessly collected, readily available objective variables and offer a statistical output that is easy to calculate. This may necessitate removal of variables that may not be available at the time of offer (eg, CIT) or lack biological plausibility (eg, donor race), and the exclusion of factors that may be impractical to reliably obtain (eg, donor steatosis or warm ischemia time). Factors that may enhance prediction (eg, donor diabetes) may need to be considered. Second, with the rise in transplants for nonalcoholic fatty liver disease, the DRI needs to be tailored for recipients with nonalcoholic fatty liver disease to remain relevant. Third, the past decade showed increasing utilization of HCV-positive organs.\textsuperscript{(51)} DRI may be augmented to include other potential donor factors from these higher-risk organs. The introduction of extremely highly effective direct-acting antiviral therapy for HCV in 2013 is changing the transplant waiting list\textsuperscript{(51)} and will likely transform the relationship of recipient age with HCV organ quality with favorable posttransplant outcomes. Fourth, exploration of other relevant characteristics such as geography and unmeasured donor characteristics is crucial. Finally, the impact of donor characteristics in patients undergoing simultaneous liver kidney transplant (SLKT) needs to be further studied.\textsuperscript{(81–84)}

Though it is highly unlikely that the entire spectrum of donor-recipient matching can ever be reduced to a statistical model, using donor models such as DRI may offer a significant crutch for the science to support the art of decision making. It would be ideal to allocate the healthiest organ to everyone, but the art lies in matching the marginal donor to the perfect recipient while still producing excellent outcomes. The DRI is definitely a step forward; further research by the transplant community is encouraged to complete the journey and keep it relevant in the next decade.

\textbf{REFERENCES}


21) Maluf DG, Edwards EB, Kauffman HM. Utilization of extended donor criteria liver allograft: is the elevated risk of failure independent of the model for end-stage liver disease score of the recipient? Transplantation 2006;82:1653-1657.


53) Bardes NR, Horwitz IB, Franzini L, Vierling JM, Goss JA. Waitlist mortality decreases with increased use of extended