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Brief Communication

What is visible is fixable: Visual dashboards for multi-domain assessment of organ procurement organization performance

Brianna L. Doby [1], Kylie Casey [2,3], Katie Ross-Driscoll [4], Musaddiqur Rahman Ovi [5], Md. Shabbir Hossain Bhuiyea [5], Istiak Ahmed Isty [5], Raymond J. Lynch [4,6,*]

[1] *Positive Rhetoric LLC, Bowling Green, Kentucky, USA*
[2] *River City Pulmonology, Baptist Health System, San Antonio, Texas, USA*
[3] *Johns Hopkins School of Nursing, Baltimore, Maryland, USA*
[4] *Department of Surgery, Division of Transplantation, Emory University School of Medicine, Atlanta, Georgia, USA*
[5] *Department of Statistics, Shahjalal University of Science and Technology, Sylhet-3411, Bangladesh*
[6] *Departments of Surgery and Public Health, Pennsylvania State University College of Medicine, Hershey, Pennsylvania, USA*

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ABSTRACT

With stakeholder focus on the United States organ procurement system, there is a need for tools that permit comparative assessment of organ procurement providers. We developed a public-facing dashboard for organ procurement organizations (OPOs), using data from multiple sources, to create an online, readily accessible visualization of OPO practice conditions and performance for the period 2010-2020. With this tool, OPOs can be compared on the CMS metric of donors procured per 100 donation-consistent deaths, as well as donation after circulatory death procurement, procurement of older and minority patient populations, procurement in smaller hospitals, and procurement of patients without a significant drug history. Patterns of higher performance were identified, and 74% of differences in overall donor procurement rates could be explained using model variables. Procurement differences were affected to a greater and more reproducible degree by OPO performance among Black and non-White patient populations, as well as in smaller hospitals, than by donation service area characteristics. Dashboards such as ours support OPOs and stakeholders in quality improvement actions, through leveraging benchmarked performance data among organ procurement clinical providers.

Abbreviations: CALC, cause; age, and location-consistent deaths; CMS, Centers for Medicare and Medicaid Services; DSA, donation service area; HIFLD, Homeland Infrastructure Foundation-Level Data; HRSA, Health Resources and Services Administration; IQR/M, interquartile range divided by median; NCHS, National Center for Health Statistics; OPO, organ procurement organization; OPTN, Organ Procurement and Transplantation Network; QI, quality improvement; SRTR, Scientific Registry of Transplant Recipients; UNOS, United Network for Organ Sharing.

* Corresponding author. Raymond J Lynch, Penn State Health Milton S. Hershey Medical Center, Hershey, Pennsylvania, USA.
E-mail address: rlynch2@pennstatehealth.psu (R.J. Lynch).

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Introduction

Recent improvements in the federal government's ability to measure organ procurement organizations (OPOs) performance highlighted wide variability in effectiveness at recovery of donors for organ transplant across the United States.[1] Differences in organ availability have profound implications for stakeholders and have been drivers for far-reaching policy changes by the Organ Procurement and Transplantation Network (OPTN) contractor, the United Network for Organ Sharing (UNOS).[2-4] In the face of the organ shortage, efforts to address areas for OPO practice improvement are critical. Reflecting this urgency, in March 2023, the Health Resources and Services Administration announced its OPTN Modernization Initiative, stating that "data dashboards detailing individual transplant center and organ procurement organization data" be developed to improve transparency and performance in the transplant system.[5]

OPOs, unlike most American healthcare organizations, do not have access to care comparison tools such as those available at Medicare.gov.[6] OPOs need visibility into how variation in care may relate to measurable outcome differences among patient populations. Although OPOs have a reporting mandate to the OPTN, there is little information on elements of OPO clinical practice.[7,8] The 2021 Centers for Medicare & Medicaid Services (CMS) metric assigns OPOs scores and peer-ranked tiers for donor and transplant performance, but does not assess patient- and hospital-level disparities in access to procurement clinical care or practice patterns that may drive variability.[1] These data provide actionable information for stakeholders in the field, including OPO leaders, potential donor patients, and families.

We sought to characterize procurement performance across multiple domains, using data from several sources, to understand commonalities and differences in OPOs' patient populations and performance. Our hypothesis was that differences in procurement as visible in the CMS metric might have disparate causes among OPOs. To this end, we developed a pilot dashboard with interpretable data visualizations to help stakeholders target OPO quality improvement efforts.

Methods

Data sources and populations

Data characterizing DSA-level donor potential and organ recovery were gathered for the period 2010-2020. Numbers of organ donors were obtained from Scientific Registry of Transplant Recipients (SRTR) data by year, recovering OPO, and donor age, race, and ethnicity.[9] OPTN data were used to identify recovery hospitals.[10] Homeland Infrastructure Foundation-Level Data files were used to characterize donor hospitals as previously described.[11,12] "Small hospitals" were defined as having $<$100 beds. Donor patients were further categorized as having a death related to drugs as previously described (inclusive of both "drug intoxication" mechanism and other deaths with current active drug use),[13,14] as well as brain death or donation after circulatory death (DCD) mechanisms. Puerto Rico was excluded due to lack of Homeland Infrastructure Foundation-Level Data on hospital-level identifiers. Data from the Centers for Disease Control and Prevention's (CDC) National Center for Health Statistics Detailed Mortality–Underlying Cause of Death database provided annual numbers of cause, age, and location-consistent (CALC) deaths.[15] As previously described, CALC deaths are those occurring in persons aged 75 years or younger in the inpatient acute care setting, from a donation-consistent mechanism of death (ICD-10 codes I20-I25, I60-I69, and V01-Y89, corresponding to ischemic cardiac disease, stroke, and external causes).[1,16] This study was determined to be exempt by the Emory University Institutional Review Board.

Visual dashboard for OPO and DSA parameters

For each OPO, 8 characteristics are visualized, with results for each domain represented as a percentage of the United States average. The metric used by CMS, overall number of organ donors recovered per 100 CALC deaths, is positioned at 12 o'clock (Fig. 1A). As we have previously described, procurement of DCD and older (65-75 years) donors has historically been drivers of performance gains[17,18]; so, these were placed at the 1 o'clock and 11 o'clock position on the visual tool (Fig. 1 B, H). The DCD domain was limited to donors aged $<$65 years to separate 'DCD' and 'age 65-75' years metrics. The percentage of donors recovered whose deaths were not related to drugs is positioned at 6 o'clock (Fig. 1E). The lower left and lower right quadrants of the visual tool present information on patient and hospital case-mix in the DSA of interest. For each, the relative proportion of the OPO's potential (CALC deaths among race/ethnicity population of interest (shown as Black patients in Fig. 1D) and small hospitals as a fraction of DSA inpatient acute care beds (Fig. 1F), as well as the OPO's performance with patients and hospitals in these groups (Fig. 1C, G), are displayed. DSA-level population considerations dictate which patient populations may be of more relevance in a given locale (ie, Black or Hispanic patients). A pilot online dashboard depicting OPOs' performance relative to the US average was created using the Shiny framework of R.[19] To maximize applicability across DSAs with varied population demographics, in this pilot the minority patient population was set to "non non-Hispanic White (non-NHW)." The finished dashboard was posted with a public URL on the Heroku cloud application program platform.[20]

Statistical analysis

Total CMS-defined donors per 100 CALC deaths were calculated nationally and for each OPO annually over the entire study period and sequential eras. OPOs were grouped in quartiles based on 2010-2020 performance. Comparisons were made across recovery year, OPO-performance quartile, and hospital and DSA characteristics. Chi-square analyses were used to evaluate for statistically significant differences between groups. Dispersion of performance indicators was described with interquartile range divided by the median (IQR/M). To evaluate variance between OPOs over time, we fit an empty generalized

linear model with an outcome of annual overall performance and a random intercept for OPO and calculated the intraclass coefficient (ICC). To estimate the proportion of variance explained by the fixed effects of annual OPO performance and population composition variables, accounting for clustering by OPO, we estimated the marginal R2 using the method of Nakagawa et al[21] We compared this to the marginal R^2 of a model with OPO-performance variables alone. Analyses were done in R.

Results

Visual dashboard of OPO and DSA-level procurement parameters

Figure 1 shows the degree of variation in each parameter across OPOs and over time. There was considerable variation in both OPO-level performance and DSA-level conditions. The "DCD" parameter was limited to donor patients aged <65 years, who accounted for 99.1% of all DCD donors in the study period. Dispersion was highest among DCD procurement (mean IQR/M over study years 0.80) and age 65 to 75 years donor recovery (mean IQR/M 0.85) performance. Non-White patient and Black, all-ethnicity patient performance dispersions were lower (0.42 for each) than the dispersion of these populations as proportion of DSA CALC deaths (0.69 and 0.89, respectively). Over the study period, mean overall, DCD and older-age performance all rose, with a concomitant decrease in the fraction of donor patients without a drug-related cause of death. DSA composition of CALC deaths varied greatly by race and ethnicity (Black deaths as a proportion of CALC deaths 0.8%-52.4%, non-White deaths 5.3%-78.3%). Similarly, while small hospitals composed 16.4% of all inpatient acute care beds, this fraction varied from 1.3% to 9.7% across DSA.

Comparison of OPO using a visual dashboard

Figure 2 and Supplementary Table 1 depict overlaid quartiles of OPO performance during the study period. As expected, when OPOs are grouped by overall procurement rates (12 o'clock position, Fig. 2A), the 4 quartiles are separate, with Quartile 1 OPOs having 1.85-fold higher donor recovery than Quartile 4 OPOs ($P < 0.001$). The dashboard also shows a pattern of higher performance across component domains of OPO practice, evident as a concentric arrangement of quartiles at positions A-C, E, G, and H (Fig. 2). Quartile 1 OPOs procured older donor patients at a rate 2.65-fold higher than quartile 4 OPOs, while their rate of procurement for Black patients was 1.77-fold higher, their fraction of donor patients without a drug-related history was 1.80 folder higher, their procurement rate at small hospitals was 2.17-fold higher, and recovery of DCD donors was 2.94-fold higher ($P <$ 0.001 for all comparisons). Overall, Quartile 1 OPOs had 45.7% of subdomains (excluding the DSA-level characteristics) rank in the top quartile of performance, while only 7.1% were in the bottom quartile. Similarly, Quartile 4 OPOs had only 12.5% of subdomain performance rates in the top quartile, with 48.4% in the bottom quartile (Supplementary Table 2). The stepwise pattern in performance domains is notably absent in the 2 characteristics showing DSA, rather than OPO, characteristics (Fig. 2D, F), suggesting that while levels of OPO performance differ, the underlying DSA conditions are not consistently different across performance quartiles.

In an empty model with a random intercept, the ICC was calculated as 0.61, indicating that 61% of the total variance in overall procurement rate was explained by between-OPO variation, and the remaining 39% was explained by within-OPO variation over time. In other words, 61% of the total variance in the model was attributable to differences in OPO performance

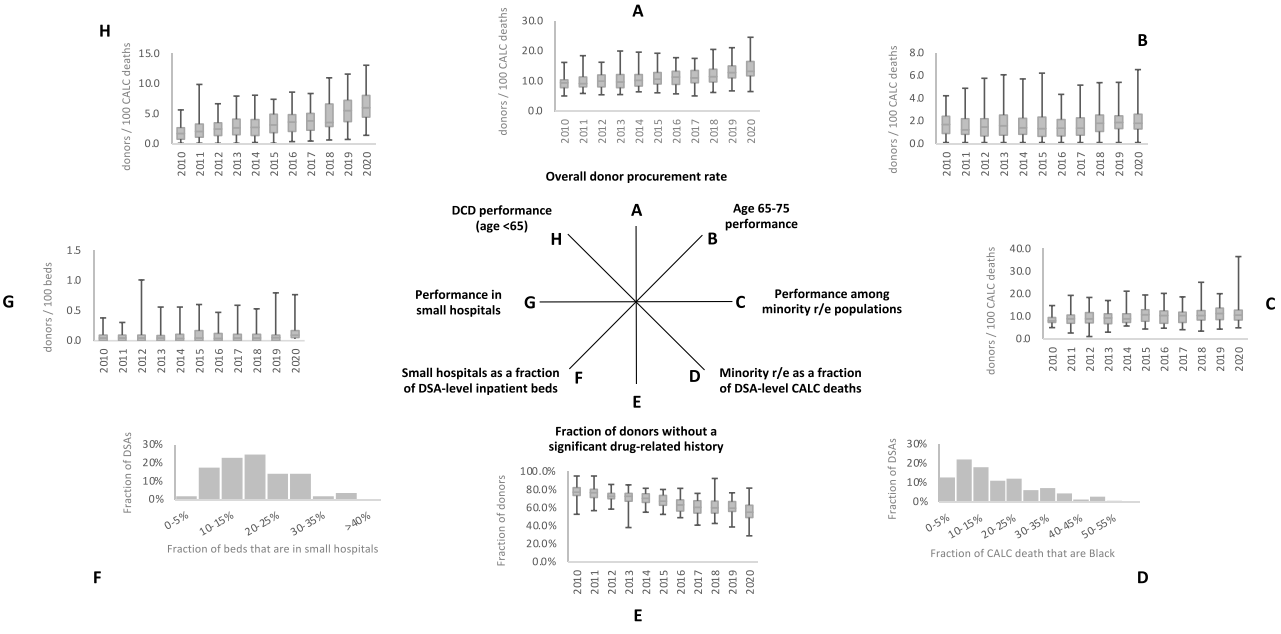

Figure 1. Pictorial representation of overall and selected-domain OPO characteristics, 2010-2020. Individual graphs show dispersion in performance domains (A-C, E, G, H) and distribution of hospital and patient case mixes (D, F) across DSAs.

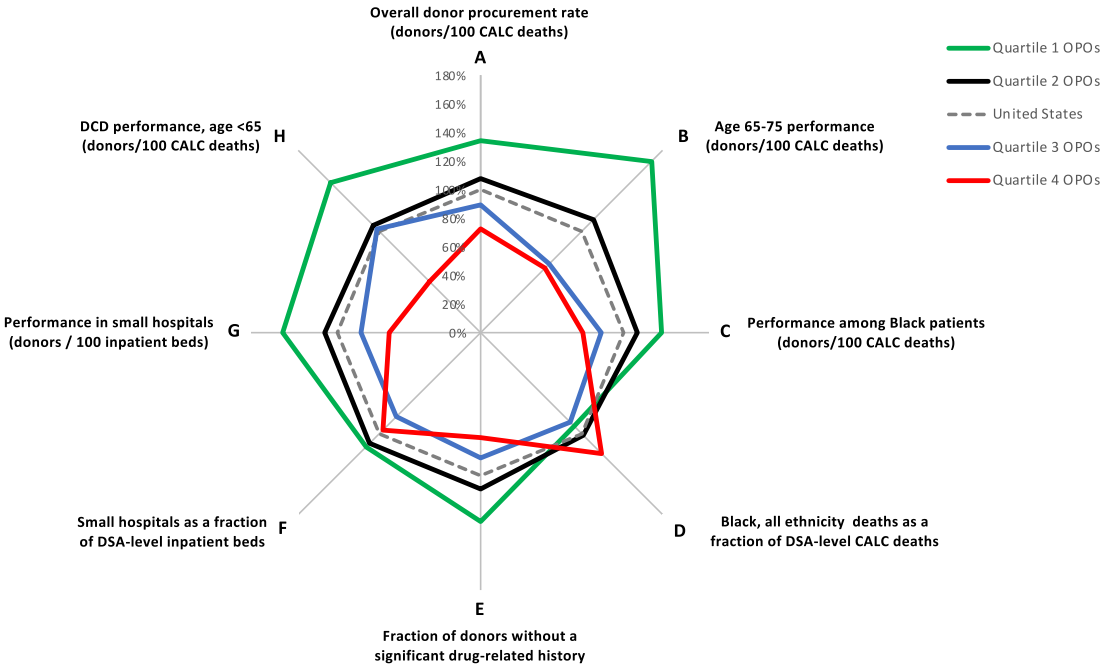

Figure 2. Comparison of procurement practice and DSA conditions by overall OPO performance quartile, 2010-2018. Quartiles are shown with US average values for each domain depicted as dashed gray lines for comparison. Note that OPO quartiles are nonoverlapping in procurement practice domains, despite overlapping DSA characteristics.

across individual OPOs, and the remainder of the variance was attributable to changes that occurred over time within the same OPO. In a model with a random intercept for OPO and fixed effects for each of the variables defined in the octagon above, the marginal R^2 value was 0.74, indicating that 74% of the variability in overall donation rate was explained by the fixed effects of the variables included in the model. This value was equivalent to the R^2 for a model excluding DSA-level donor potential variables (Fig. 2D, F described above; $R^2 = 0.74$).

The visual dashboard allows further exploration of inter-OPO and inter-DSA differences. As shown in Figure 3A, 2 OPOs serve DSA where Black patients comprise a large proportion of CALC deaths and a high fraction of inpatient beds are located in small hospitals. OPO 1 is just above the US average in overall procurement rate, while OPO 2 has a 32.7% lower rate of donor procurement than OPO 1. Both OPOs are below the US average in DCD and older-patient procurement. The visual dashboard shows that the observed difference is the result of lower performance by OPO 2 among Black donor patients, those without a drug-related cause of death, those located in small hospitals, and those recovered through the DCD pathway. Among these, the most striking is the 8.5-fold difference in effectiveness between the OPOs in small hospitals, both because of the scale of the variation and the above-average fraction of OPO 2 DSA's inpatient beds that are located in these hospitals.

Figure 3B shows visual dashboards for 2 OPOs with similar, below-average overall donor procurement and differing causes for visible deficits. The only OPO-performance domain in which OPO 3 exceeds the US average is in small hospitals, but these hospitals contribute only a small portion of the DSA's inpatient

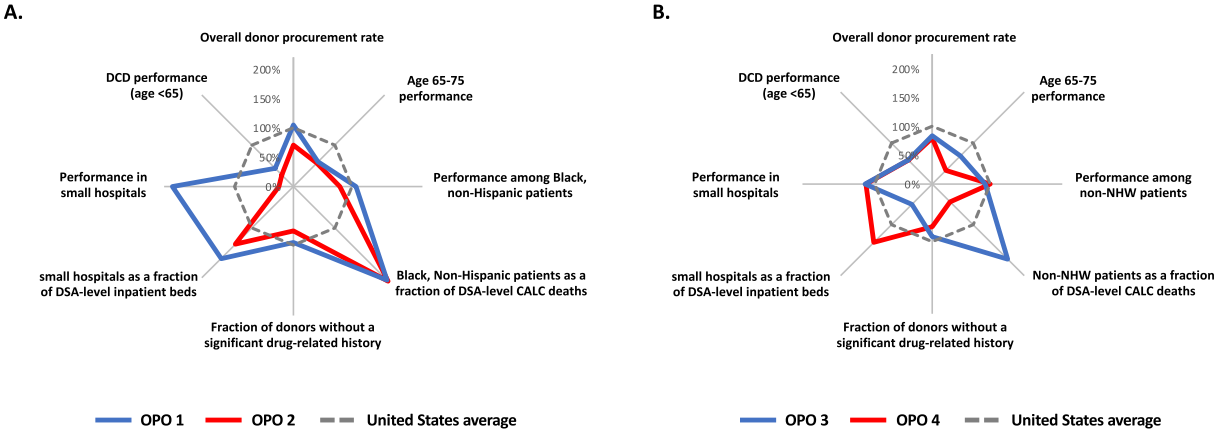

Figure 3. Comparisons between OPOs by overall donor procurement rate and selected OPO/DSA characteristics, 2010-2020.

beds. By contrast, OPO 3 DSA has an above-average fraction of CALC deaths originating among non-White patient populations and performs at only 70.3% of the national average among this group. OPO 4 has above-average performance at small hospitals, which constitute a larger portion of its DSA case mix, but has a low fraction of donor patients without a drug-related etiology and a low (33.3% of the US average) rate of recovery of older donors. Both OPOs are also underperforming with regard to DCD procurement.

Assessment of trends in performance using the dashboard

Figure 4A and Supplementary Figure 1 show 4 eras within the study period. OPO 5 progressively dropped in performance relative to the US average in each era. When the eras are overlaid, the drivers of this negative trend are visible as follows: a successive drop in recovery of older donor patients (140.0% of the US average in 2010-2012, declining to 82.3% in 2019-2020); DCD donor patients (138.6% to 85.9% by 2019-2020); and donor patients without a significant drug history (126.3% to 103.4% of US average). OPO 6, by contrast, grew its overall rate of donor procurement significantly practice with progressive gains in DCD procurement (rising from 43.3% of the US average in 2010-2012 to 183.5% in 2019-2020) and procurement among patients without a significant drug history (60.4% of the US average in 2010-2012 to 134.0% in 2019-2020).

Pilot website

The public-facing dashboard was published at https://opo-dashboard.herokuapp.com. This pilot version allows visual comparison of individual or multiple OPOs' performance relative to the US average over the entire study period. In this configuration, we chose to display aggregated non-White and Hispanic patients to demonstrate the feasibility of comparison by race/ethnicity among the broadest possible minority patient population view.

Discussion

In this study, we report the development of a dashboard depicting component elements of OPO practice, as well as data on the DSA-level composition of potential donor patient populations and hospitals. As a proof of concept, and to allow maximal access to critical data for OPO partners, an iteration of this dashboard has been posted on a public-facing internet platform. This tool allows comparisons of individual OPO contractors, and in this function, can serve as a template by which to provide OPOs, transplant centers, policymakers, and the public with a comprehensive picture of access to care for donor patients and outcomes of organ procurement clinical practice. We found that although DSAs vary widely in the composition of their community hospitals and the racial composition of their potential donor patients, diversity of DSA conditions contributed much less to overall OPO performance than did the effectiveness of the OPO within historically underserved practice areas. Multi-domain assessment of performance in this manner allows OPOs themselves, as well as stakeholders, to define areas of strength and weakness in practice, and target quality improvement initiatives.

The dashboard's novelty lies in its reliability and descriptive power compared to other data sources currently available to clinicians, researchers, and patient advocates. Despite the 2021 changes to the CMS Conditions of Participation, there remains a dearth of descriptive information on individual OPO performance in either OPTN or SRTR public-facing materials. The semi-annually-updated SRTR OPO-specific reports show land area, total population, and a list of hospitals, for example, but do not include CALC-powered analysis, such as number and composition of CALC deaths and hospitals.[22] Additionally, these reports continue to reference "eligible deaths," a concept that has been characterized by the CMS, OPOs, and researchers as

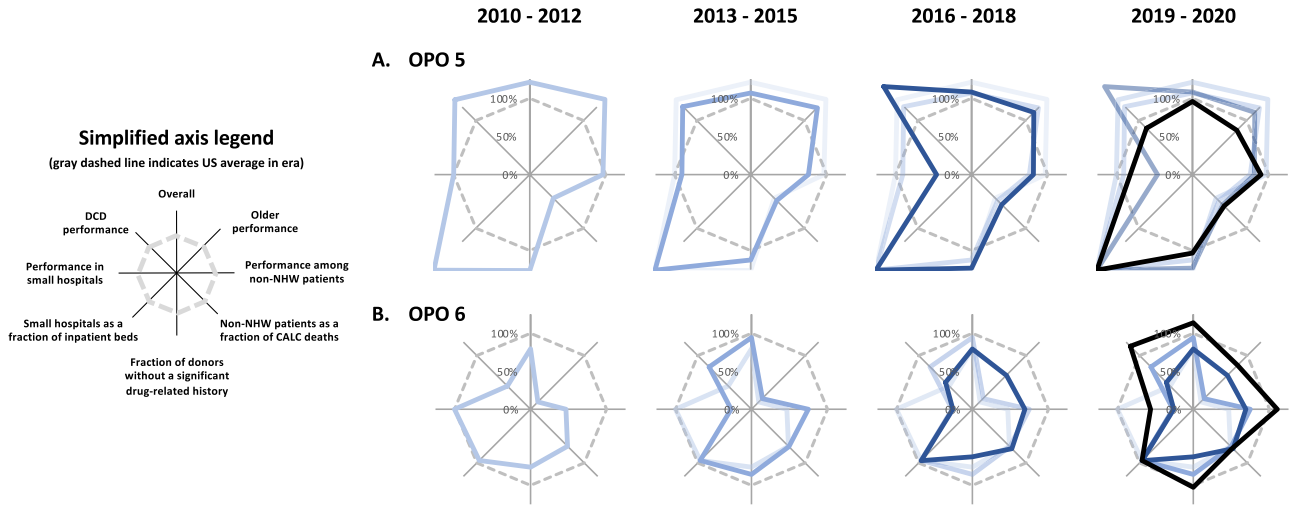

Figure 4. Visualization of procurement performance by domain over time for 2 different OPOs. The Gray dotted line shows the United States' overall procurement performance by era. Axis labels are simplified for clarity; lighter shading indicates earlier cohorts for comparison.

invalid.[23,24] The UNOS-hosted OPTN Organization Metrics Dashboard does not include individual OPO data, and does not present data on patient demographics, DCD recoveries, or any denominator by which to ascertain rates of performance.[25] The absence of readily available and reliable information leaves OPOs, regulators, potential organ donor registrants, and potential organ donor patients and families without the means to objectively assess areas for improvement in procurement clinical care, and contributes to ongoing confusion regarding opportunities to study patterns of procurement clinical care.[5,26] A visual dashboard depicting practice domains with proven variability and a high correlation with overall donor procurement rates has utility for all stakeholders and can direct performance improvement and practice changes for OPOs. Future, regulator-implemented iterations of this type of resource could include other procurement care-relevant data providing more organ-specific information, or integrating process-level data to add further context and utility to this pilot example.

As with all studies, our analysis has limitations. Our retrospective approach allows assessment of correlation, but not causality. OPOs serve DSAs, and as with all comparisons of conditions across geographic areas, there are unmeasured differences in the populations and conditions within these DSAs. Despite this, however, our results are credible, as OPOs with the highest performance tend to be above average in all component domains, while lower performance can be traced to deficits in specific areas. An additional consideration with our assessment of procurement at the OPO level, is that OPOs are part of a broader system including transplant centers, and that organ acceptance, or OPOs' assessment of the likelihood of placing an organ, has been suggested as a driver of differences in donor recovery.[27] We have previously shown, however, that the converse is true, and that local OPO performance is associated with center aggressiveness in the import and utilization of marginal organs.[2] Beyond this, for any assessment or initiative related to deceased donor patient procurement, the OPO should be the central consideration, as they exercise monopoly ability to provide procurement care within a given area. Finally, these data do not allow assessment of the underlying reasons for observed differences in procurement care. This shortcoming is shared with all current OPTN data and can be ameliorated by collection and reporting of process-level data.[8]

In summary, we created a dashboard facilitating assessment of procurement performance. The variables captured in this website represent a parsimonious model of OPO and DSA conditions that cumulatively account for three-quarters of observed differences in deceased donor organ procurement. These data are already collected by the OPTN and SRTR but are not readily available for use in process improvement initiatives by OPOs and stakeholders. Public dashboards will be critical to elevating procurement clinical care to the same level as other clinical subspecialties. Access to objective and reliable data on procurement care can help to correct unnecessary variation in clinical practice, with implications for the organ supply and access to care for donor patients and their families.

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Disclosure

The authors of this manuscript have conflicts of interest to disclose as described by the American Journal of Transplantation. B. L. Doby and R. J. Lynch have previously received research funding from the Mid-America Transplant Foundation. B. L. Doby reports consulting fees from Arkansas Regional Organ Recovery Agency, Mid-America Transplant, Justice Catalyst Law, and Organ Alliance, Inc, outside the submitted work. K. Ross-Driscoll reports consulting fees from Justice Catalyst Law outside the submitted work.

Data availability

Data included in this manuscript were gathered under data use agreements with the National Center for Health Statistics and the Scientific Registry of Transplant Recipients, and are available as such to interested parties. Additional publicly available data were gathered from online resources without the necessity of payment or data use agreements from the Organ Procurement and Transplantation Network contractor and the Department of Homeland Security's Homeland Infrastructure Foundation-Level Data websites.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.ajt.2023.08.020.

ORCiD

Brianna L. Doby https://orcid.org/0000-0001-9863-3276
Kylie Casey https://orcid.org/0000-0001-6318-9005
Katie Ross-Driscoll https://orcid.org/0000-0002-8432-7419
Musaddiqur Rahman Ovi https://orcid.org/0000-0002-2515-6189
Md. Shabbir Hossain Bhuiyea https://orcid.org/0000-0002-9817-7060
Istiak Ahmed Isty https://orcid.org/0009-0008-7427-4625
Raymond J. Lynch https://orcid.org/0000-0001-8371-7514

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