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Changing Metrics of Organ Procurement Organization Performance in Order to Increase Organ Donation Rates in the United States

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The shortage of deceased-donor organs is compounded by donation metrics that fail to account for the total pool of possible donors, leading to ambiguous donor statistics. We sought to assess potential metrics of organ procurement organizations (OPOs) utilizing data from the Nationwide Inpatient Sample (NIS) from 2009–2012 and State Inpatient Databases (SIDs) from 2008–2014. A possible donor was defined as a ventilated inpatient death ≤75 years of age, without multi-organ system failure, sepsis, or cancer, whose cause of death was consistent with organ donation. These estimates were compared to patient-level data from chart review from two large OPOs. Among 2,907,658 inpatient deaths from 2009–2012, 96,028 (3.3%) were a “possible deceased-organ donor.” The two proposed metrics of OPO performance were: (1) donation percentage (percentage of possible deceased-donors who become actual donors; range: 20.0–57.0%); and (2) organs transplanted per possible donor (range: 0.52–1.74). These metrics allow for comparisons of OPO performance and geographic-level donation rates, and identify areas in greatest need of interventions to improve donation rates. We demonstrate that administrative data can be used to identify possible deceased donors in the US and could be a data source for CMS to implement new OPO performance metrics in a standardized fashion.

Abbreviations: AHRQ-NIS, agency for healthcare research and quality-nationwide inpatient sample; DCDD, donation after circulatory determination of death; DNDD, donation after neurologic determination of death; DSA, donor service area; EDCR, eligible death conversion rate; HCUP, healthcare cost and utilization project; HRSA, health resources and services administration; OPO, organ procurement organization; OTPPD, organs transplanted per possible donor; SIDs, state inpatient databases; UNOS, united network for organ sharing

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Introduction

Nearly 120,000 people in the US are waitlisted for a life-saving organ transplant. Organ transplantation increases a patient’s life expectancy (1), and kidney transplantation is cost-saving for the government as Medicare dialysis expenditures exceed $34 billion/year. To ensure the system of organ donation and procurement is effective, reliable and valid performance metrics are needed.

Aside from the generosity of the donor and the donor’s next-of-kin, the success of organ transplantation relies on three main entities: donor hospitals who identify and refer potential donors to the organ procurement organization (OPO), transplant centers who decide which organs to transplant, and OPOs. OPOs are the nonprofit organizations that are responsible for coordinating the complex multi-step process of organ donation, procurement, and distribution, including obtaining donation authorization and managing potential donors according to donor management protocols (2–6).

OPOs are evaluated by the Centers for Medicare and Medicaid Services (CMS) using two metrics. Although recent regulations have led to broadening of the metrics of OPO performance, the metrics are based on a donation rate and an organ yield rate (7). The principle donation metric is the donation rate ratio (also referred to as...
the eligible death conversion rate (EDCR): actual organ donors/"eligible deaths." A “donor” is defined as a patient whose organs are recovered with the intent to transplant, while an eligible death is now defined as a hospitalized, brain-dead patient ≤75 years of age (previous cutoff was ≤70 years of age) without contraindications to donation. Despite a recent provision that allows for an increase in the value of the numerator and denominator by one in the setting of a successful older donor and/or a donation after circulatory determination of death (DCDD) donor (7), the use of eligible deaths has been criticized because it systematically excludes a subset of actual and potential donors in the denominator (unless donation occurs): (1) excludes donors >75 years of age in the denominator unless donation occurs; (2) excludes potential DCDD donors in the denominator (unless donation occurs); (3) excludes potential donors for whom next-of-kin decline donation prior to brain-death declaration; (4) requires notification of all potential donors to the OPO; and (5) is self-reported by OPOs without routine audits, leading to "large inconsistencies and variations in how OPOs reported data"(8,9). Because of these limitations, 25% of all deceased-donors are not considered an eligible death, while many potential donors are never counted in the denominator (10). The principle yield metric is an observed-to-expected organ yield based on the number of organs transplanted per actual donor. This metric does not incentivize OPOs to pursue single-organ donors (i.e. older donors) because such donors are only counted in the metric’s denominator if at least one organ is recovered with the intent to transplant. The consequences of utilizing eligible death and yield metrics are ambiguous donor statistics, lost opportunities for donation, and barriers to process improvement. As a result, there have been calls to refine the metrics by which OPOs are measured, but to date, no new metrics have been adopted (11). There has been prior published work from Australia and Canada that demonstrated the potential to estimate and identify the donor potential in a given geographic area using administrative data (12,13). These landmark studies provided an important foundation for a study published in 2016 that was funded by the Health Resources and Services Administration (HRSA) that utilized administrative data to estimate the deceased donor potential in the US (14). This HRSA-sponsored study estimated that there may be as many as 38,000 potential deceased donors in the US, but unlike the studies from Australia and Canada, it was not compared to data collected from chart reviews or OPO referrals, and it did provide a framework to translate such administrative data into a mechanism to develop and evaluate OPOs (12–14). The goals of this study were to build upon the HRSA-sponsored Deceased Donor Potential Study to provide a more accurate estimate of the deceased donor potential in the US, while also proposing potential metrics of OPO performance that could be operationalized using these administrative data.

Methods

Estimating the possible deceased organ donor supply

The first goal was to estimate of the possible deceased-donor supply in the US using administrative data. The HRSA-funded “OPTN Deceased Donor Potential Study” had previously attempted to estimate the possible deceased-donor supply in the US, however we felt there were important limitations in that study (14,15): (1) certain exclusionary diagnoses were not included; (2) the donor estimates obtained using their methods were not compared to data obtained using chart review by individual OPOs; and (3) geographic differences in the possible donor supply were not reported (14,15). Although two previous studies had assessed the ability of administrative data to estimate the deceased donor supply in Australia and Canada, the current study was needed to assess the feasibility of using administrative data to propose metrics of OPO performance in the US (12,13).

The framework used to determine who was a possible donor was aligned with a published multi-national review focused on defining a uniform approach to identifying and classifying a possible organ donor, and used similar inclusionary causes of death as the two prior studies estimating the deceased-donor supply with administrative data (12,13,16). Filters were applied to the different administrative datasets with the goal to identify possible deceased donors, which the prior multi-national workgroup had defined as “the patient with a devastating brain injury or lesion...the possible deceased organ donor is apparently medically suitable for organ donation” (16).

Data from the Agency for Healthcare Research and Quality-National Inpatient Sample (AHRQ-NIS) from 2009–2012, capturing >95% of all US hospital discharges, was used to estimate the national supply of possible donors, based on key characteristics of deceased-donors (Figure 1A) (14,15). There was an additional exclusion of “severe sepsis,” analogous to multi-system organ failure: ICD-9-CM code(s) for sepsis/septic shock/ bacteremia in the primary position and ICD-9-CM code(s) for ≥1 organ failure (acute kidney injury, hepatic necrosis/“shock liver,” and/or metabolic encephalopathy) (17–19).

Because administrative data do not specify whether a patient died after neurologic determination of death (“brain-death”) or with some preserved neurological function (possible DCDD donor), we assumed that 40% of “possible donors” based on the aforementioned criteria would meet criteria for brain death and thus be a potential DNDD donor, while 60% would not meet brain death criteria, and thus be a potential DCDD donor. This breakdown was based on published data that 30–40% of patients dying in surgical, trauma, and/or neurologic intensive care units meet criteria for brain death (20–22). This breakdown was also similar to the patient-level data provided by one of the OPOs who contributed data to this study. Once assigned to being brain dead or not, the potential donor estimates underwent further refinements among the possible DCDD donors, we excluded: (1) all those ≥65 years of age because according to Organ Procurement and Transplantation Network (OPTN)/UNOS data, since 2002, fewer than 1% of all DCDD donors were over age 65; and (2) one-third of possible DCDD donors aged 65 years or younger based on data on the proportion of possible DCDD donors who die within one hour after removal of life support (the upper limit at which organs are generally considered usable) (23).

Validating data

We validated our estimates of the possible donor supply obtained using administrative data to data provided to us by two OPOs. Each of these OPOs collected their own data, separate from this study, to estimate the potential donor supply within their respective OPO. These OPOs defined a potential donor in a similar fashion to identify patients who had ≥1
organ available for transplant based on the OPOs medical criteria (potential donor): (1) all referrals to the OPO who met medical criteria as a potential donor, and (2) “missed referrals” within the OPOs donor service area. The data was derived as part of routine quality analyses performed by the OPOs, was separate from this research project. The OPOs examined death records from all donor hospitals within their DSA, and cross-referenced these lists with organ donor referrals. Medical records of all in-hospital deaths that were not referred to the OPO as a possible donor were reviewed after applying some basic medical exclusions (i.e. cancer) to determine if these nonreferred inpatient deaths were a potential donor.

Because the data from the State Inpatient Databases did not allow us to obtain direct patient health identifiers, we were unable to validate the

Figure 1: Flow diagram of creation of cohort of possible deceased organ donors in the US between 2009 and 2012. Characteristics of deceased-donors used for Figure 1: (1) all are hospitalized pre-donation; (2) 99% are ≤75 years of age; (3) all receive mechanical ventilation; (4) specific causes of deaths are associated with brain death or organ donation(14,15); and (5) >97% are hospitalized ≤14 days pre-donation. †Causes of death association with brain death and/or organ donation including but not limited to “external causes of injury and poisoning” (i.e. motor vehicle accident, drug intoxication, or other head trauma), cerebrovascular disease, or intracranial injury (14,15). ‡Metastatic or malignant cancers, excluding nonmelanoma skin cancers and primary brain cancers. DNDD, donation after neurologic determination of death; DCDD, donation after circulatory determination of death.
possible donors identified by our methods to direct patient chart review. Thus we could not determine if a possible donor identified using our methods matched exactly to the potential donor identified by the OPO based on direct patient health identifiers. This is different than the method of validation performed in the study by Rose et al. where potential donors in British Columbia who were identified using administrative data were directly compared to chart audits (13). The OPOs provided anonymized data on potential donors in different manners: hospital-level validation: OPO 1 (1) provided the month and year of donation, along with the donor’s age and donor hospital which could be compared to data in the State Inpatient Databases; and (2) aggregate-level validation: OPO 2 provided the number of potential donors by year which could be compared to the administrative data. For OPO 1, because we were provided with some patient-level data, we were able to calculate: (1) sensitivity (the proportion of potential donors identified by the OPO [true positive] who could be matched to a patient identified using administrative data based on age, hospital name, and month/year of death [test positive]); and (b) positive predictive value (the percentage of possible donors identified by administrative data [test positive] who were categorized as a potential donor from the OPO based on age, hospital name, and month/year of death [true positive]). We performed subgroup measures of sensitivity and positive predictive value by age subgroup (<40, 40–59, and ≥60). Sensitivity and positive predictive value could not be calculated for OPO 2 because individual patient-level data could not be provided.

Possible metrics of organ donation and OPO performance that were considered

Several metrics encompassed all possible organ donors were considered. State Inpatient Databases (SIDs), rather than NIS data, were used as they contained hospital-level zip codes which allowed for mapping to specific counties within a donor service area (DSA). For DSAs that encompassed multiple states, and not every state in the DSA had available SID data, only possible donors, donors, and organs from hospitals located in included states in those DSAs were included (Table S1). Of the 30 states with available data for purchase from the Healthcare Cost and Utilization Project (HCUP), the central distributor of NIS and SID data, we purchased data for 25 states that encompassed 35 OPOs. We developed a series of metrics using different denominators to define the potential donor pool, and utilized UNOS data on actual donors and organs transplanted. Spearman correlation coefficients were used to rank and compare the sampled OPOs using the current donor conversion ratio and the proposed metrics, and a separate commonly cited but not formally used alternative metric of donors-per-million population (24).

Results

Between 2009 and 2012, among 2,907,658 inpatient deaths, 96,028 (3.3%) were deemed a “possible deceased-donor” (mean 24,007 per year; Figure 1A). Of these 24,007 possible deceased donors, 13,985 (58.3%) were deemed a possible DNDD donor, while 10,022 (41.7%) were classified as possible DCDD donor. The patient-level data from OPO 2 estimated that 60% of potential deceased donors in the respective OPO met brain-death criteria, while 40% were not brain dead and were classified as a potential DCDD donor. There were differences in the age distribution of possible deceased donors from 2009–2012 and actual deceased donors during the study period (according to OPTN/UNOS data), although the distribution in the range of 18–65 was relatively similar (Table 1). The percentage of possible donors that became an actual donor was highest for possible donors under 40 years of age, and progressively decreased with increasing age (Table 1).

Data validation

The aggregated “gold-standard” patient level data from two large OPOs validated the estimated possible donor supply obtained using the SID data. In OPO 1, the estimated possible donor supply was 88.9% of the potential donor supply based on medical record review, while estimates from OPO 2 were 3.7% higher than the potential donor supply based on patient-level data (Figure 2A). The donor potential measured using the eligible death definition vastly underestimated the donor supply in these two large OPOs, and only captured 59.2% of potential deceased-donors based on patient-level data in OPO 1, and 49.0% of potential deceased-donors based on patient-level data in OPO 2 (Figures 2A).

The hospital-level validation from OPO 1 demonstrated a sensitivity of 80.3%, 95% CI: 75.2–84.7%. The positive predictive value was 71.5%, 95% CI: 66.2–76.4%. These values varied by age group: (1) age <40 years: sensitivity = 59.7% (95% CI: 47.9–70.8%); positive predictive value = 93.9% (95% CI: 83.1–98.7%); (2) age 40–59 years: sensitivity = 87.6% (95% CI: 80.6–92.7%); positive predictive value = 85.6% (95% CI: 78.4–91.1%); (3) age 60–75 years: sensitivity = 100.0% (95% CI: 95.5–100.0%); positive predictive value = 37.0% (30.6–43.8%). In comparison, the paper by Rose et al (13), that performed a more granular patient-level validation had a positive predictive value of 60.4% (134/266), meaning that of 266 potential donors in British Columbia identified using administrative data, 134 were classified categorized as a true potential donor by chart audit.

Table 1: Age distribution and donation percentage among possible deceased donors and actual deceased donors between 2009 and 2012

<table>
<thead>
<tr>
<th>Age group</th>
<th>Estimated possible deceased donors, N (% of total)</th>
<th>Actual deceased donors, N (% of total)</th>
<th>Donation percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;18</td>
<td>5475 (5.7)</td>
<td>3426 (11.5)</td>
<td>62.6%</td>
</tr>
<tr>
<td>18–39</td>
<td>17621 (18.3)</td>
<td>10696 (35.8)</td>
<td>60.7%</td>
</tr>
<tr>
<td>40–59</td>
<td>39941 (41.6)</td>
<td>12123 (40.6)</td>
<td>30.4%</td>
</tr>
<tr>
<td>60–65</td>
<td>16942 (17.6)</td>
<td>2156 (7.2)</td>
<td>12.7%</td>
</tr>
<tr>
<td>66–75</td>
<td>16050 (16.7)</td>
<td>1477 (4.9)</td>
<td>9.2%</td>
</tr>
<tr>
<td>Total</td>
<td>96,028</td>
<td>29,878</td>
<td>31.1%</td>
</tr>
</tbody>
</table>

1Based on analysis of Nationwide Inpatient Sample from 2009–2012.
2According to Organ Procurement and Transplantation Network/United Network for Organ Sharing data as of March 15, 2017, counting donors as those with at least one organ transplanted.
3Defined as percentage of possible deceased donors with at least one organ transplanted.
Developing OPO performance metrics

Table S2 displays the list of current and proposed metrics. The following metrics had the best face validity and used the most inclusive yet narrow denominator of potential deceased donors using administrative data: (1) donation percentage (percentage of possible donors who become actual donors); and (2) organs transplanted per possible donor (OTPPD). These metrics were felt to be superior because they: (1) could be uniformly applied across OPOs; (2) would not utilize the eligible death definition which is self-reported; (3) capture the entire pool of possible deceased-donors; (4) accounts for geographic differences in the number and causes of death; and (5) are easily reproducible year-to-year.

Data on OPO performance metrics from 25 states and 35 OPOs

The age distribution of possible deceased-donors was not different among OPOs. The among-OPO percentage of inpatient deaths categorized as a possible deceased-donor ranged from 1.7–5.5% (median: 3.8%), and was not correlated with the donation percentage ($p = 0.12$) or the OTPPD ($p = 0.05$).

The OPO-level donation percentage ranged from 20.0% to 57.0%, and the OTPPD ranged from 0.52 to 1.74 and with a strong correlation between these two metrics ($p = 0.88$; Figure 2B). The donation metric of OPO-level donation percentage was: (1) weakly correlated with the
eligible death conversion ratio ($p = 0.38$); (2) moderately correlated with donors-per-million population ($p = 0.55$); and moderately correlated with another potential donation metric we considered of donors per 100 in-hospital deaths ($p = 0.48$). The proposed organ yield metric was moderately correlated with both the donors-per-million population ($p = 0.47$) and organs transplanted per 1000 in-hospital deaths ($p = 0.53$). A comparison of how two hypothetical OPOs with the same population and number of possible donors would be measured under the current and proposed metrics is shown in Table 2—the OPO that produces 100 fewer donors and 150 fewer transplanted organs would be rated as a higher performer under the current metrics.

The racial/ethnic distribution among the 35 sampled OPOs varied significantly, yet there was no correlation between the racial/ethnic distribution of possible donors and the OPOs overall donation percentage ($p = -0.05$; Figure 2C) or the donation percentage among white, non-Hispanic possible donors and the donation percentage among racial/ethnic minority possible donors ($p = 0.007$; Figure 2D). The two OPOs with the lowest overall donation percentages had the first and fifth highest proportion of possible donors who were white and non-Hispanic. Additionally, the OPOs whose overall donation percentages were above the median ranged from a racial distribution of less than 20% of possible donors being a racial/ethnic minority to nearly 80% (Figure 2C).

**Potential gains in lives saved with maximized OPO performance**

The magnitude of the impact of maximized OPO performance among the 35 sampled OPOs is shown in Figure 3A. Maximizing OPO performance could increase the number of organ transplants in every OPTN/UNOS region for which we had available data, ranging from over 1000 more lifesaving organ transplants performed each year if the bottom 17 OPOs had organ yields at the level of the 50th percentile OPO, to nearly 5000 more lifesaving organ transplants if OPOs improved performance to that of the 90th percentile OPO. As shown in Figures 3B–D, the OPOs with the greatest potential gains from improved performance were not isolated to one geographic region, with OPO performance being very different among OPOs in the same state (i.e. California and New York). Furthermore, the OPOs with the greatest potential gains with improved OPO performance were not isolated to the DSAs with the most (or fewest) transplant centers, highlighted by the substantially different donation rates across the highly competitive DSAs in the mid-Atlantic and northeastern US (Figures 3B–D).

**Discussion**

Our data demonstrates that thousands of people eligible to become a deceased-organ donor every year never realize that opportunity. Using administrative data and previously described methods, we demonstrate that administrative data can be used to identify possible deceased donors in the US, which could transform how we estimate the possible donor supply and measure OPO performance in the US (12,13). Efforts to improve donation rates and maximize OPO performance would save more lives, and substantial savings in governmental healthcare expenditures as Medicare is the largest payer of dialysis, and kidney transplants yield average cost savings at $60,000/year compared to remaining on dialysis (25,26). Our data validate published work highlighting that the race/ethnicity of the donor population are not correlated with overall donation rates of a geographic area (27). Lastly, we present two metrics that can be applied prospectively to reliably compare donation rates across DSAs using a denominator that encapsulates all possible deceased donors.

The system of organ donation is not operating at utmost efficiency. Donation rates and OPO performance vary across the US and are not related to the differences in the causes of death or the underlying race/ethnicity of the population, despite what has been promulgated as the explanation for low donation rates in certain parts of the country (9,28). A hindrance to evaluating donation rates has been the metrics of OPO performance. Any metric predicated on eligible deaths, despite the definition’s recent broadening to include potential donors ages 71–75 years, is inadequate and incomplete, an opinion shared by the organization overseeing all OPOs, the Association of Organ Procurement Organizations (9,11). For this reason, despite recent changes in how the donation rate ratio is calculated, we would propose that the term eligible death be eliminated, and reliance on a self-reported denominator with the constraints of the eligible death definition no longer be used in evaluating OPO performance. Compared to the current metric that relies on eligible deaths, the benefits of our proposed donation metric are that: (1) it does not rely on self-reported data;
(2) utilizes a uniform process of estimating the donation potential within each DSA; (3) includes potential DCDD donors that are excluded from the eligible death definition; and (4) provides a reliable year-to-year measure of OPO performance to track changes in performance. Nevertheless it does have limitations compared to the current metric in that it uses administrative data to identify the donor potential rather than granular patient data, its availability may not be timely, and may overestimate the donor potential. The benefits of this approach outweigh the detracting aspects. It would ensure OPOs consider their own performance based on the total donor potential, and for those not tracking, ensure OPOs track their donor potential. In doing so, by creating a consistent measure of OPO performance and donor potential, it will provide metrics to achieve for systems improvement changes.

The denominator of “possible donors” includes possible DNDD and DCDD donors, and in the future, can be collected on a yearly basis for measuring OPO performance, without relying on self-reported data. The framework we used to define a possible deceased donor is consistent with the definition proposed by a multi-national workgroup of experts in organ donation, and prior work in Australia and Canada (12,13,16). We employed several assumptions to develop our estimate of the possible donor supply, albeit based on published data that could be extrapolated to our population of patients dying in an intensive care unit potentially eligible to be a deceased donor. We estimated an average of 13,985 possible DNDD donors, which we feel confident is close to the true donor potential for two reasons: (1) the estimates of the possible donor supply obtained using administrative data matched closely with patient-level data obtained from chart review from two OPOs; and (2) a large multi-year study that utilized medical record review of patients in 434 hospitals across 36 OPOs between 1997 and 1999 suggested the DNDD donor potential may be as high as 13,800 per year (29–31). Given increases in the number of deaths that could lead to donation (i.e., unfortunate deaths from opioid overdoses and increased deaths from cardiovascular and cerebrovascular disease) over the last five years, it is possible that the current supply of possible DNDD donors is even greater (27). The estimated potential of DCDD donors is higher than some reports that relied on a subset of hospitals within a

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single DSA, although it was similar to what was reported in OPO 2 (32,33). Nevertheless, the estimate of 10,022 possible DCDD donors is potentially an overestimate, likely due to: (1) an inability to account for all medical contraindications to DCDD donation; (2) the assumption that one-third of all possible DCDD donors would die within an hour of removal of life support; and (3) the reliance on mechanical ventilation codes that identify whether ventilation was used at any point during hospitalization, and not necessarily immediately preceding death. Yet even if only 50% of the possible DCDD donors we estimated were eligible to donate, this would lead to 5000 possible DCDD donors each year during the study period. And importantly, any overestimates in the donor potential using our methodology would be nondifferential across OPOs, and would be used to compare OPOs, and not reflect performance in isolation.

Although the current organ yield metric is an adjusted metric that accounts for the expected number of organs transplant for a given donor, it is insufficient as the sole yield metric. The current adjusted yield metric accounts for the expected organ yield from a given donor, which reflects both OPO performance and transplant center organ utilization. However, by only including actual donors in the denominator, there is no incentive to consider potential single-organ donors, because they only are included in the denominator if they become a donor. For this reason, our proposed organ yield metric could complement the current adjusted yield metric, and encourage OPOs to pursue organs from all potential donors, even “single-organ” donors, as all potential donors would be counted in the denominator of the metric.

Ultimately, capitalizing on organ recovery should be the hallmark of a high-performing OPO, which our proposed metrics capture in comparison to current metrics. The relative among-OPO differences between the highest and lowest performers are similar to those of current metrics, but the absolute differences with respect to the increased number of donors or organs with improved performance were much greater owing to the use of a more inclusive denominator reflective of the total pool of possible deceased-donors. It is important to recognize that the responsibility of maximizing organ utilization rests not only with the OPO, but the transplant centers who decide to accept or decline the organs procured by the OPOs. For this reason, metrics are being considered that account for a center’s organ acceptance rates. However, beyond procuring organs, an OPO must interact with transplant centers to maximize organ placement, and this is accounted for in these metrics. But because of the interplay between OPOs and transplant centers, a discordance between the donation rate and the organ yield could signify underutilization of organs by transplant centers, which if the case, should not be something to which the OPOs solely are held accountable.

Our analyses and data derived from our metrics of donation rates confirm that on an individual level, racial/ethnic minority groups have lower donation rates (27,34). However when the data are viewed from the level of the OPO, our data validate prior work, and we believe conclusively demonstrate that at the level of the DSA (OPO), there is no correlation between the proportion of minority possible donors within a DSA and the overall donation rates within that DSA.

These data highlight the need to address the true factors that lead to differences in among-OPO donation rates, including differences in how donation is discussed with donor families (35), enforcement of best practices, or relationships between OPOs and donor hospitals. However, without changing metrics, a mechanism does not exist by which CMS can accurately compare OPOs, and identify those OPOs who would benefit by engaging in a systems improvement agreement with CMS (currently available for transplant centers that exceed certain metrics), rather than simply being used to decertify an OPO, the only current CMS recourse for an OPO. These proposed metrics can help identify areas for improvement, while recognizing the highest performers to serve as a model for best practices and/or assist in leading professional development for other OPOs. For example, using a donation metric that includes all possible deceased donors in the denominator provides an OPO the opportunity to determine how it performs in different demographic groups (older vs. younger donors, racial/ethnic minority groups). In doing so, the OPO can determine whether donation rates are low in all populations and requires broad changes in their approach to donation, or are only suboptimal in certain groups who may benefit from targeted interventions, which has proven successful across diverse populations (i.e. ethnicity-matched requestors to approach next-of-kin of potential donors who were a racial/ethnic minority (36,37)).

This study had limitations. Administrative data are restricted with respect to determining all aspects of donation criteria (i.e. active infections). We excluded patients with bacteremia/sepsisemia and organ failure, and by using discharge diagnosis codes, accounted for most, if not all, of a patient’s medical conditions (i.e. diabetes) diagnosed during the hospitalization. Second, we applied data on the proportion of possible DCDD donors dying within one-hour of withdrawal of life support to our cohort of all ventilated possible donors (23). Given this, the estimated number of possible DCDD donors may reflect a uniform overestimate across all OPOs. Third, our analyses of state databases included 25 states and 35 OPOs. The included states were a geographically representative sample that included 10 out of 11 UNOS regions (Figures 3B–D), and only had limited sampling of the central Midwest portion of the US. Importantly, these data from 25 states were used to develop metrics of OPO performance, and would have to be (and can be)
measured prospectively using NIS data given that these data now reflect a 20% sample of each US hospital (currently AHRQ/HCUP do not release the geographic identifiers they have, but these could be used by an external source with a special agreement, or by CMS under an agreement with AHRQ/HCUP). Our data only evaluate the final end pathway of donation, and may not account for differences in willingness or intent to donate which may be affected by community level factors that include donor demographics (38). However, the wide variation in donation rates across geographic areas with similar demographics suggests that even these underlying differences in willingness to donate would not explain the large differences in donation rates that we describe. Lastly, we could not perform direct patient-level validation as was done in the study by Rose et al (13). The SID databases do not contain patient identifiers that could be linked to medical records used by the OPOs to estimate the potential donor supply. As a result, we cannot state with absolute certainty that the possible donors identified using administrative data are the same as those identified by chart review by the OPOs. We were only able to perform validation that incorporated some patient-level data in the case of one OPO. Nevertheless, our hospital-level validation in OPO 1 using age, hospital name, month/year of death, would suggest that our methods appear to have sufficient overall sensitivity and positive predictive value to be used as a means to estimate the denominator of possible deceased-donors in a given geographic area. However, the age group-specific validations suggest that further adjustments to our methods are needed to account for differences in donor eligibility criteria by age group. We agree that collaboration with other OPOs is needed before these methods can be applied and these metrics used as the sole metric of OPO performance. However, these methods demonstrate the feasibility of estimating the number of possible organ donors using administrative data in the US which would allow for a uniformly applied OPO performance metrics. These methods, if applied using administrative data collected at all US hospitals in a standardized fashion (i.e. NIS data), they could be used as a new metric of OPO performance to complement, and potentially in the future replace, the current metrics of OPO performance.

In conclusion, we have developed two metrics to assess OPO performance and geographic-level differences in organ donation rates. Such metrics have superior face validity to the current metrics and do not rely on self-reported data. They would allow for comparisons of OPO performance and geographic-level donation rates, and identify areas in greatest need of interventions to improve donation rates to save more lives through organ transplantation. To improve the system of organ donation, we propose that our metrics be implemented (as complementary to current metrics until the methods can be further validated and refined), closely monitored, and most importantly, combined with an assertive quality improvement effort to ensure that best OPO practices are widely and quickly adopted, while being used to raise performance nationally.

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Disclosure

The authors of this manuscript have no conflicts of interest to disclose as described by the American Journal of Transplantation.

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Supporting Information

Additional Supporting Information may be found in the online version of this article.

Table S1: List of states and years with SID data used for analyses.
Table S2: List of current, potential, and proposed metrics of OPO performance (donation and organ yield).