Public Policy Impact

Benchmarking Organ Procurement Organizations: A National Study

Yasar A. Ozcan, James W. Begun, and Martha M. McKinney

Objective. An exploratory examination of the technical efficiency of organ procurement organizations (OPOs) relative to optimal patterns of production in the population of OPOs in the United States.

Data Sources. A composite data set with the OPO as the unit of analysis, constructed from a 1995 national survey of OPOs ($n = 64$), plus secondary data from the Association of Organ Procurement Organizations and the United Network for Organ Sharing.

Study Design. The study uses data envelopment analysis (DEA) to evaluate the technical efficiency of all OPOs.

Principal Findings. Overall, six of the 22 larger OPOs (27 percent) are classified as inefficient, while 23 of the 42 smaller OPOs (55 percent) are classified as inefficient. Efficient OPOs recover significantly more kidneys and extrarenal organs; have higher operating expenses; and have more referrals, donors, extrarenal transplants, and kidney transplants. The quantities of hospital development personnel and other personnel, and formalization of hospital development activities in both small and large OPOs, do not significantly differ.

Conclusions. Indications that larger OPOs are able to operate more efficiently relative to their peers suggest that smaller OPOs are more likely to benefit from technical assistance. More detailed information on the activities of OPO staff would help pinpoint activities that can increase OPO efficiency and referrals, and potentially improve outcomes for large numbers of patients awaiting transplants.

Key Words. Efficiency, organ procurement organizations, performance, benchmarking

A major concern to the public, healthcare providers, and policymakers is the well-documented and continuous shortage of organs available for transplantation. The United Network for Organ Sharing (UNOS) recorded 56,000 individuals on the waiting list for organs as of January 1998, and the median wait for an organ was 414 days (UNOS 1998). On average, several patients daily die while waiting for organs. The medical condition of others may deteriorate significantly during the waiting period, with financial and emotional consequences.

The Health Resources and Services Administration (HRSA) contracts with UNOS to operate a 24-hour per day patient waiting list and organ matching system. UNOS coordinates the placement and distribution of donated organs; collects, analyzes, and publishes transplant data; and educates health professionals about the donation process. Organ procurement organizations (OPOs) coordinate the organ procurement and transplantation process in designated service areas. Their activities include educating health professionals and the general public about organ and tissue donation, evaluating potential donors, discussing donation with family members, and arranging for the surgical removal of donated organs (Prottas 1994). The organ procurement process is highly variable across hospitals, depending on hospital and state policies for required referral of potential organ donors; historical practice in the hospital; relationships among physicians, nurses, and OPO staff; and public and health professional attitudes.

Variation in the success of OPOs in procuring organs is well documented. In 1993, for example, organ donors per million service area population varied from 2.2 to 38.0 (UNOS 1994). Noting that "individual OPO policies, initiatives, and methods for obtaining organs probably contribute to this variation," a General Accounting Office (GAO) report urged HRSA to assess OPO effectiveness in procuring organs and to target technical assistance toward the least effective OPOs (U.S. GAO 1993:32,45).

Among a variety of strategies to increase the number of organs available for transplantation are hospital development activities conducted by OPOs. Professionals in the organ procurement and transplantation community, as well as policymakers, have expressed interest in the possibility that the donor pool could be increased by the OPOs' involvement in improving hospital development. Hospital development includes activities to maximize the awareness, commitment, and skills of hospital professionals in donor referral and in organ and tissue procurement. Some evidence of a positive

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Address correspondence and requests for reprints to Yasar A. Ozcan, Ph.D., Professor, Department of Health Administration, Virginia Commonwealth University, P.O. Box 980203, Richmond, VA 23298-0203. James W. Begun, Ph.D. is Professor, Department of Healthcare Management, University of Minnesota. Martha M. McKinney, Ph.D. is President, Community Health Solutions, Richmond, KY. This article, submitted to *Health Services Research* on December 19, 1997, was revised and accepted on September 16, 1998.

relationship between hospital development and OPO performance exists on an anecdotal basis or small-sample basis (Campbell and Layne 1993; McCartney 1994; POD 1990; Thorne 1996).

This study is an exploratory effort to relate the hospital development activities of OPOs, and other resources of OPOs, to the outcomes achieved by the OPOs. The primary data were attained in a national survey of OPOs conducted in 1995. The purpose of the study is to benchmark OPOs based on technical efficiency: to evaluate the technical efficiency of OPOs relative to "optimal" patterns of production in the population of OPOs. Technical efficiency is defined by the level of inputs used to produce given levels of outputs. In concert with other measures of OPO performance, the results of efficiency analysis may suggest ways to improve the performance of OPOs. The study does not address the larger question of the cost-effectiveness of OPOs. Instead, it assumes that OPOs play an important role and that the efficiencies of some OPOs (the "benchmarks") are worthy of emulation by other OPOs.

PERFORMANCE ANALYSIS OF OPOS

Few assessments of OPO performance exist in the research literature. Prottas (1989) offers a list of five OPO effectiveness measures, including referrals of potential donors per capita, permission rates from donor families, kidney and nonrenal organs donated per capita, and the rate of kidneys discarded. OPOs were recently studied with regard to their individual efficiency in obtaining potential donors (Evans, Orians, and Ascher 1992). In this analysis, donors per million population was the primary indicator of performance. Efficiency was defined as the percentage of potential donors who became actual donors when measured across a single geographic entity. Donor procurement efficiency ratings were calculated for states and OPOs, suggesting that the number of available donors in the United States could be increased by 80 percent. This measure of efficiency is problematic because of the lack of standardized criteria for accepting donors across OPOs (Hauptman and O'Connor 1997). In addition, distinctions were not made between geographically dispersed and concentrated OPOs (i.e., it may be more difficult to maximize donor rates where potential donors are less accessible geographically). In contrast to the present study, the Evans, Orians, and Ascher study used a single indicator of OPO output and did not control for activities and resources of the OPO in evaluating efficiency.

In its assessment of the state of the U.S. organ procurement system in 1993, GAO used two major indicators of outcomes: donors per million population and organs per million population. As noted previously, an overriding question in OPO assessment is the source of variability in the number of donors procured per million population in their respective service areas. Noting that "individual OPO policies, initiatives, and methods for obtaining organs probably contribute to this variation," the GAO report urged HRSA to assess OPO efficiency in procuring organs (U.S. GAO 1993). GAO recognized a need to establish some standard of OPO performance, described as "OPO procurement effectiveness." GAO further suggested that the procurement rate is not an adequate measure of procurement success, and that more meaningful measures should be developed for assessment purposes. GAO's major concerns were for targeting special assistance toward less-effective OPOs.

The Association of Organ Procurement Organizations (AOPO) is the professional organization to which most OPOs belong. This organization has joined in efforts to identify predictors of OPO performance. By far the most comprehensive list of OPO performance indicators was compiled by a special joint UNOS/AOPO task force in 1994. Performance indicators encompassed a wide range of outcome measures (including organs recovered and organs recovered per million population), process measures, and customer satisfaction measures.

Finally, reimbursement and certification standards serve as a source of commonly used indicators of OPO performance. The Omnibus Budget Reconciliation Act of 1986 required that OPOs meet performance-related standards prescribed by the Secretary of Health and Human Services. Performance standards today require that an OPO meet performance standards that would place it at 75 percent of the national mean for at least four out of five categories of procurement performance (i.e., donors, kidneys recovered, kidneys transplanted, extrarenal organs recovered, and extrarenal organs transplanted, all per million population) averaged over the preceding two calendar years. Because the numbers of potential donors vary systematically by geography, efforts are being directed at identifying the number of potential donors by OPO region. The goal is to use potential donors, rather than total population, as the denominator in assessing performance (U.S. GAO 1997).

Clearly, a wide variety of indicators of OPO performance exist, as well as multiple inputs that produce those performance outcomes. To date, assessments of OPO performance have analyzed inputs and outputs one at a time. Each output ratio measures a single dimension of performance, with limited utility for assessing the direction of overall performance. The performance measures do not indicate how well or poorly resources were used to produce the output. For example, two OPOs with the same rate of kidneys procured per million population may use vastly different levels of resources to obtain the same output. Output quotas permit only a summative evaluation (i.e., is a particular OPO producing at a target level?). Ideally, one also would have information on inputs used to produce the output, which would allow for a formative evaluation (i.e., findings could be used to plan appropriate technical assistance). In addition, common statistical approaches for explaining performance, such as regression, are central tendency methods, and comparative evaluations are based on an average provider, in this case an OPO. In contrast, we use a technique, Data Envelopment Analysis (DEA), that makes comparisons with only the "best" providers; the technique is described in detail in the Appendix.

DEA allows for an evaluation of OPO performance that considers multiple inputs and outputs while it identifies the most efficient providers. Numerous examples are now available in which DEA has been successfully applied to the study of healthcare organizations and professionals. Articles by Sherman (1984) and Nunamaker (1983) were among the first to illustrate the application of DEA measures in examining hospitals in Massachusetts and Wisconsin, respectively. Huang and McLaughlin (1989) applied DEA to rural primary healthcare programs, and Sexton, Leiken, Nolan, et al. (1989), employed the technique for the Veterans Administration Medical Centers. Applications have proliferated in the 1990s, including studies of physicians (Chilingerian and Sherman 1990; Ozcan 1998), mental health programs (Tyler, Ozcan, and Wogen 1995), aging agencies (Ozcan and Cotter 1994), and hospitals (Ozcan, Luke, and Haksever 1992; Ozcan and Luke 1993).

Collectively, such studies demonstrate that DEA is an effective research tool for evaluating the efficiency of healthcare providers, given the varying input mixes and types and numbers of outputs. Because no previous work exists that used DEA in OPO performance evaluation in constructing the DEA model, we incorporate selected output and input measures of performance used in other healthcare studies as well as the previous OPO studies mentioned earlier.

METHODS

Data Sources

Data sources are noted in the list of measures in Table 1. Central to the study design is a mail survey of all OPOs in the United States. The mail survey, sponsored by HRSA, was conducted by the authors after pilot testing in six OPOs in June 1995. Executive directors of the nation's 66 OPOs were asked to provide information on OPO hospital development activities, expenditures, and staffing for the 1994 calendar year (McKinney, Begun, and Ozcan 1998). The number of OPOs that returned completed questionnaires was 65, for a response rate of 98 percent. One OPO's responses were excluded from statistical analyses because it had changed ownership during 1994. Follow-up telephone calls to ensure completeness and consistency of data were conducted with 21 OPOs. Although the survey responses used in this study are relatively objective, data reliability is untested and depends on the accuracy of the OPOs' responses to the surveys. Secondary data from AOPO and UNOS were also used for this study.

DEA Model

An OPO efficiency model can be formulated using steps similar to those models for other healthcare provider organizations. The first step in this process is the conceptualization of the outputs and inputs. The most recognized output of OPOs is organs recovered. The quantity of organs transplanted, which is highly associated with the quantity of organs recovered, is an alternative way of conceptualizing outputs in this case. Other outputs of OPOs exist, such as public education, professional education, and tissue recovery; however, using these outputs may not contribute to the robustness of the efficiency model because of (1) the difficulties in measuring these outputs and (2) the fact that these outputs are not systematically represented in all OPOs. Using either organs recovered or organs transplanted likely captures the bulk of outputs for OPOs. However, because these two categories of outputs are highly correlated, only one of the concepts can be employed in a model. Organs transplanted (successfully) perhaps would be the most relevant outcome to study in assessing the overall procurement and transplantation system. However, organs transplanted, more so than organs recovered, are a function of various other factors that may not be under the control of OPOs. For example, recovered organs may be sent out of the OPO's region for transplant, or no appropriate match for the recovered organ may be located. Transplant centers vary in their criteria for accepting donated organs. As a result, in this assessment of OPO efficiency we chose the more direct output of OPOs, organs recovered, to model efficiency.

For further delineation of organs recovered into subsets, kidneys recovered can be separated from extrarenal organs recovered. It would be ideal to separate the outputs into more product lines, such as heart, lung, and liver, but the data to estimate that more detailed efficiency model were not available for this project. In summary, kidneys recovered and extrarenal organs recovered are two product lines that this study conceptualized as outputs in the efficiency model.

The next step is identifying inputs, or resources used by OPOs to produce the forementioned outputs (i.e., product lines). Again, we will borrow from other provider studies, in which capital/structure, labor, and other operational expenses such as like supplies have been used to conceptualize input resources. Often one cannot find an exact measurement for every category identified; however, measures developed in this study provide close proxies. More specifically, in terms of measuring capital inputs of OPOs, one can encounter difficulties resulting from variations in the arrangements that OPOs have made for the use or purchase of office space and equipment; this makes capital inputs measured in dollars an unreliable measure. However, the measure of hospital development formalization developed in this study provides an excellent proxy for the capital/structure dimension of the input resources because it reflects the degree to which the OPO has formal structures in place to produce outputs. The hospital development formalization index indicates whether an OPO has a hospital development director, department, and written standards for effectiveness (see Table 1).

The other categories of inputs are relatively simple and directly measurable. These inputs include hospital development labor (measured by fulltime equivalent [FTE] hospital development personnel), other labor (measured by FTE other personnel), and operating expenses not devoted to hospital development (measured by non-FTE operating expenses), all calculated from the survey data. As defined in the survey (see Table 1), OPO hospital development personnel work with and educate hospital staff to improve the likelihood that organ and tissue donors will be procured. Hospital development typically includes reviewing hospital death records to assess donor potential; collaborating with hospital nursing and medical staff to develop policies and procedures for the early identification of potential donors; agreeing on a process for evaluating donor suitability; agreeing on who will offer the option of donation to families; and ongoing review and follow-up of successful and unsuccessful referrals and donation (Dunn and McBride 1994). Although some OPOs employ fulltime hospital development personnel, the activity often is performed part-time by organ procurement coordinators whose primary tasks include educating the public and medical communities regarding the need for organ donation and its procedures, assisting hospital staff in identifying and maintaining patients declared brain dead, discussing

Table 1: Variable Definitions and Sources

Outputs

Extrarenal organs recovered, 1994 (UNOS)

Kidneys recovered, 1994 (UNOS)

Discretionary Inputs

Hospital Development Formalization Index, 1994 (National Survey of OPOs). Integer scale index with range 0–3, based on whether OPO has (1) written standards for hospital development effort effectiveness, (2) a director of hospital development, and/or (3) a department of hospital development. The scale has a Cronbach's alpha coefficient of .68. "Hospital development" was defined in the survey as "a formalized process that establishes relationships between the OPO and its service area hospitals in order to maximize organ and tissue procurement. Hospital development activities include professional education for hospital staff and a wide variety of other activities designed to maximize the awareness, commitment, and skills of hospital professionals in relation to donor referral and organ and tissue procurement."

Hospital Development FTEs, 1994 (National Survey of OPOs)

Other FTEs, 1994 (National Survey of OPOs). Other FTEs were calculated by subtracting Hospital Development FTEs from total FTE personnel employed by the OPO.

Operating expenses excluding Hospital Development FTE salary and fringes, 1994 (National Survey of OPOs)

Non-Discretionary Inputs

Referrals, 1994 (AOPO)

Note: Abbreviations

AOPO = Association of Organ Procurement Organizations; FTE = Fulltime equivalent; OPO = Organ procurement organization; UNOS = United Network of Organ Sharing.

the procedures entailed in donation with the families, obtaining legal consent for the donation procedure, and facilitating the recovery of organs (Smith-Brew and Yanai 1996).

Although these variables capture the essence of efficiency modeling, one can also assess the effect of nondiscretionary factors that may affect efficiency. For example, donor referrals may have a bearing on organ recovery. However, referrals to an OPO cannot be conceptualized as a discretionary input because most of the referrals are not under the direct influence of the OPO's management. However, as a nondiscretionary (exogenous) variable, referrals can be added to the model. In this way, OPOs classified as inefficient can then be assessed on whether more referrals would improve their efficiency. In the final analysis, for those inefficient OPOs, one can examine their excessive input consumption and make recommendations for precise adjustments in inputs that would produce greater efficiency. Conceptualizing referrals as a straightforward, nondiscretionary input would require a reduction in these resources for inefficient OPOs, which is counterintuitive. To correct this directional problem, one must employ the reciprocal value of the referrals as an input: lower reciprocal values indicate higher quantities of referrals. In this way, the results can be interpreted appropriately.

In summary, this study employs four discretionary inputs—hospital development formalization, hospital development labor measured in FTEs, other labor measured in FTEs, operating expenses measured by non-hospital development FTE expenses—and one nondiscretionary input measured by the reciprocal of referrals.

Efficiency assessments by DEA are either relative in time (comparisons of multiple years) or relative to other OPOs. Because this study uses measures in one time period, the measurement of performance for a given OPO will be made relative to other OPOs. Thus, efficient OPOs will be classified, forming a "frontier" of efficiency, and the correlates of poor performance will be delineated for those inefficient OPOs. In doing so, one must consider the compatibility of the OPOs in the comparisons. Would it be appropriate to compare a large-volume OPO to a relatively small-volume OPO, or should one compare OPOs serving large population centers to those serving sparsely populated areas? Would their structures function similarly to produce outputs at the same efficiency level? In many performance studies, reporting agencies classify the organizations in peer groups based on size, and report the performance relative to peer group benchmarks. In this study we found discernible differences in OPOs that are different in size or service area population. Thus, using the distribution of population size that the OPOs serve, OPOs are classified into two peer groups. The cut-off point was 4.0 million service area population for larger versus smaller OPOs. The cut-off point was selected by visual examination of the frequency distribution of OPO population size for a natural breakpoint. By distinguishing larger and smaller OPOs in this way, two efficiency frontiers are constructed. The comparisons can then be made relative to these two efficiency frontiers.

The next issue in efficiency modeling using DEA technology is the assumed relationships between input and outputs. If one is to increase resources of an OPO, should the OPO's managers expect constantly proportional, or linear, increases in outputs? Previous studies have shown that a linearity assumption does not produce robust models of efficiency; variability exists in the input-output relationship. Thus, this study employs a variable returns to scale–type DEA model to accommodate the input–output relationship.

Finally, in DEA modeling, one must consider how to orient the model toward inputs or outputs to provide a course of action for inefficient OPOs.

Table 2: Descriptive Statistics for the Variables Used in the Efficiency Model

	Smaller OPOs n = *42*		*Larger OPOs* n = *22*		*Total* N = *64*	
Variable	*Mean*	*s.d.*	*Mean*	*s.d.*	*Mean*	*s.d.*
Outputs						
Extrarenals recovered	98.14	59.28	241.59	108.49	147.45	104.53
Kidneys recovered	92.52	43.52	246.36	83.63	145.41	94.80
Discretionary Inputs						
HD Formalization	1.24	1.21	1.91	1.02	1.47	1.18
HD FTEs	3.67	2.29	9.30	4.16	5.61	4.05
Other FTEs	9.99	7.40	25.27	10.76	15.24	11.30
Expenses ($00,000)	22.11	15.01	61.36	27.62	35.60	27.46
Non-discretionary Input						
Referrals	162.66	87.68	400.41	197.41	244.39	175.92

Note: Abbreviations

HD = Hospital development; FTEs = Fulltime equivalents.

More specifically, if an OPO is inefficient, does the director of the OPO have more flexibility to augment the outputs or to reduce the inputs? To put it another way, how much more output (organs recovered) can one expect from that OPO, given its resources? This is referred to as the orientation of the model. In this study, we assume that managers want to know how much shortfall in outputs they have with given resources compared to equivalent peer OPOs. Thus, the model is oriented toward outputs, which means that an OPO classified as inefficient OPO could become efficient if the lacked output (i.e., organs recovered) is attained. However, situations could exist in which OPOs must both increase their outputs and reduce some of their inputs to achieve efficiency.

RESULTS

Based on a two-output, five-input, variable returns to scale, output-oriented model, we estimated two peer-grouped (larger and smaller OPOs) DEA models using data from the National Survey of 1994 Hospital Development Activities of OPOs (McKinney, Begun, and Ozcan 1998). Table 2 depicts the descriptive statistics for the output and input variables for smaller and larger OPOs.

Table 3: OPO Efficiency Analysis and Source of Inefficiency

	Smaller OPOs			*Larger OPOs*			*Total*		
Variable	n	*Mean*	*s.d.*	n	*Mean*	*s.d.*	N	*Mean*	*s.d.*
Efficiency score	42	0.789	0.244	22	0.948	0.114	64	0.843	0.221
Number efficient	19	NA	NA	16	NA	NA	35	NA	NA
Efficiency score of inefficients	23	0.614	0.202	6	0.809	0.150	29	0.655	0.206
Measured Inefficients									
Outputs									
Extrarenals recovered	23	65.50	43.34	6	77.86	43.55	29	68.05	42.90
Kidneys recovered	23	52.24	27.48	6	45.56	47.16	29	50.86	31.59
Discretionary Inputs									
HD Formalization	11	−0.28	0.67	2	0.60	0.40	13	−0.14	0.70
HD FTEs	9	−1.79	2.05	4	−4.42	3.10	13	−2.60	2.61
Other FTEs	11	−4.95	4.86	2	−9.43	0.18	13	−5.64	4.74
Expenses ($00,000)	9	−6.68	7.76	2	−16.82	15.81	11	−8.53	9.47
Non-discretionary Input									
Referrals	12	91.67	19.46	0	NA	NA	12	91.67	19.46

Note: Abbreviations

NA = Not applicable; HD = Hospital development; FTEs = Fulltime equivalents.

On average, the larger OPOs produced approximately 2.5 times more outputs. Their hospital development activity was 50 percent more formalized, and they used two to three times more other inputs (i.e., hospital development and other FTEs, and non-FTE related expenses). Similarly, the larger OPOs had 2.5 times more referrals than smaller OPOs.

The results of the efficiency analysis by peer group, as well as overall results, are presented in Table 3. Overall, 55 percent ($n = 35$) of the OPOs were classified as efficient by the DEA model in comparison to their peers in the two-frontier (larger versus smaller) approach. More specifically, in the smaller OPO ($n = 42$) frontier, the average efficiency of the 42 OPOs was 0.789 (on a scale of 0 to 1), whereas in the larger OPO ($n = 22$) frontier the average efficiency score of the 22 OPOs was 0.948. These average scores, however, combine the efficient and inefficient OPO scores, with efficient OPOs assigned a score of 1.0. When the efficiency scores of inefficient OPOs were examined in the smaller and larger OPO frontiers, the results showed that only six larger inefficient OPOs exist, with an average score of 0.809, which is more efficient than the 23 smaller inefficient OPOs, with an average score of 0.614. Six of the 22 larger OPOs (27 percent) are classified as inefficient, compared to 23 of the 42 smaller OPOs (55 percent).

We now turn to the source of inefficiencies in the 23 smaller and the six larger inefficient OPOs, also displayed in Table 2. In this discussion, we specify the amount of an input or output required to move an OPO's classification from inefficient to efficient. Because of the limitations in the design of this study, the results are not meant as recommendations for change in management practices, but as an illustration of a way to interpret the empirical results. To move from inefficient to efficient, inefficient OPOs, on average, would need to increase extrarenal organs recovered by 66, and kidneys recovered by 52. However, increasing outputs alone would not make the OPOs perfectly efficient. They also would have to use fewer resources and receive more referrals. For example, nine inefficient, smaller OPOs spent, on average, $668,000 more than their efficient peers. Two of the larger OPOs did so by $1,682,000.

On the output side, inefficient smaller OPOs, on average, lack 65.5 extrarenal organ recoveries, whereas this number increases to 77.86 in larger OPOs. On the other hand, the kidney recovery deficit in larger inefficient OPOs is less (45.56) than in smaller OPOs (52.24).

Although all inefficient OPOs (large and small) would require higher extrarenal organ and kidney recovery to be classified as efficient, some of them would need different levels of inputs as well. For example, in order to match the profile of efficient OPOs in their peer group, 11 of the smaller inefficient OPOs would require hospital development formalization scores lower by an average of 0.28, and two of the larger OPOs would need formalization scores higher by an average of 0.60. In terms of labor resources, hospital development FTEs would need to be lower by an average of 1.79 FTEs in nine smaller OPOs and by 4.42 FTEs in four larger OPOs. Other FTEs would need to be lower in 11 of the smaller OPOs by 4.95 FTEs, and by 9.43 FTEs in two larger OPOs.

In examining the number of referrals in inefficient OPOs, an interesting pattern emerges. None of the inefficient larger OPOs records a lower quantity of referrals compared to their efficient peers. However, 12 of the smaller OPOs would need an average of 91.67 additional referrals to be classified as efficient.

The data in Table 3 also provide some estimates of the capacity of the OPO system at peak performance. Peer comparison of the output production and resource consumption patterns of OPOs suggests that an additional 1,974 extrarenal organs and 1,475 kidneys would have been recovered nationwide

Table 4: Descriptive Statistics for Efficient and Inefficient OPOs

	Efficient OPOs (n = 35)		*Inefficient OPOs (n = 29)*		
Variable	*Mean*	*s.d.*	*Mean*	*s.d.*	t-*Value*
Outputs					
Extrarenals recovered	179.26	117.89	109.97	70.12	2.95***
Kidneys recovered	168.91	100.93	117.03	79.54	2.30**
Discretionary Inputs					
HD formalization	1.40	1.17	1.55	1.21	0.50 (ns)
HD FTEs	5.37	3.85	5.89	4.34	0.50 (ns)
Other FTEs	16.75	11.58	13.41	10.87	1.19 (ns)
Expenses ($00,000)	41.15	29.90	28.90	22.93	1.85*
Non-discretionary Input					
Referrals	297.27	190.24	180.56	134.05	2.87***
Other Variables					
Organ donors	90.77	55.36	62.21	42.14	2.34**
Extrarenal transplants	145.66	87.77	92.58	61.65	2.83***
Kidney transplants	149.71	88.16	106.45	71.60	2.17**

*Significant at $p < .10$ level; **significant at $p < .05$ level; ***significant at $p < .01$ level.

Note: Abbreviations
ns = not significant; HD = Hospital development; FTEs = Fulltime equivalents.

with 33.8 FTE fewer in hospital development, a reduction of 73.4 FTE in other personnel, and $9,376,000 less in expenses. Nationwide, predominantly in smaller OPOs, an additional 1,100 referrals would have been needed to reach the same efficiency levels on all OPOs.

Table 4 provides a summary of differentials on inputs and outputs between efficient and inefficient OPOs for organ service processes. Efficient OPOs recover significantly more kidneys and extrarenal organs; have higher operating expenses; and have more referrals, donors, extrarenal transplants, and kidney transplants. Overall, then, the efficient OPOs are much busier than the inefficient OPOs. Their hospital development FTEs, other FTEs, and hospital development formalization indexes do not significantly differ, however.

CONCLUSIONS

This analysis is an exploratory attempt to model the technical efficiency of OPOs using DEA. We examined the efficiency of OPOs in converting five inputs (referrals, hospital development formalization, hospital development FTEs, other FTEs, and non-FTE operating expenses) into two outputs (extrarenal organs recovered and kidneys recovered). OPOs were compared to their peers in two groups: those having service area populations at or above 4.0 million (22 OPOs), and those with service area populations below 4.0 million (42 OPOs). Overall, six of the 22 larger OPOs (27 percent) were classified as inefficient, while 23 of the 42 smaller OPOs (55 percent) were classified as inefficient.

OPOs classified as efficient recover significantly more kidneys and extrarenal organs; have higher operating expenses; and have more referrals, donors, extrarenal transplants, and kidney transplants. Their hospital development FTEs, other FTEs, and hospital development formalization indexes do not differ significantly. The activities of the hospital development personnel may differ across OPOs, however, and further details on OPO activities would be useful in differentiating the more efficient OPOs and in providing guidance on ways to increase the quantities of referrals. For example, hospital development personnel in more efficient OPOs may be focusing their time and resources on hospitals with the greatest donor potential while servicing other hospitals in a less time-consuming manner. Or they may be doing a better job of identifying hospitals with greater donor potential. Methods of identifying and better serving such hospitals include conducting retrospective death record reviews at least quarterly, targeting educational programs for categories of hospital personnel that most need improvement, and giving appropriate recognition to units that meet their identified potential for referrals.

In addition, factors not investigated in this study, such as public education, qualifications of OPO staff, and success in obtaining family consent, should be investigated as potential inputs that are related to higher quantities of referrals or that contribute to greater efficiency. One recent review concludes that more donors can be obtained from the standardization of hospital procedures in three areas: declaring brain death, ensuring that all families of potential donors are asked about donating, and following proven procedures for approaching families with the donation request (DeJong, Drachman, Gortmaker, et al. 1995). In particular, success in obtaining family consent is clearly an important part of the donation process (POD 1990; Siminoff, Arnold, and Caplan 1995).

Findings that a relatively higher proportion of smaller OPOs are classified as inefficient relative to their peers (55 percent versus 27 percent of larger OPOs) and that more efficient OPOs have higher gross operating expenses suggest the possibility that larger OPOs are able to operate with greater technical efficiency. This possibility needs further exploration to help pinpoint the level of size at which efficiency is optimal and the causal reasoning for the finding (e.g., the existence of economies of scale). Other variables that may be associated with efficiency include the geographic concentration of the OPO: OPOs serving a larger service area may be at a disadvantage in establishing efficiency in internal processes. DEA models have been used in private industry for a number of years to measure and improve efficiency in business units (Norton 1994), but application to populations of loosely linked governmental organizations, such as OPOs, requires more consensus development and more widespread legitimation of the DEA methodology.

This study is relatively exploratory and narrow in scope because it considers only a small number of inputs and outputs and contrasts efficient and inefficient OPOs on a small number of characteristics. The next steps in developing a more comprehensive and useful DEA model would require consensus development within the organ procurement and transplantation community regarding appropriate inputs and outputs to be used in the model, the classification of inputs as nondiscretionary or discretionary, and peer groups for comparison. The resulting DEA model could be used for quality improvement efforts within the OPO community. Efficiency scores could be used as one piece of evidence to identify OPOs that could perform at a higher level, and technical assistance could be directed to those OPOs based on the identification of specific inputs related to efficiency. In concert with other ongoing efforts to better identify effective and efficient OPOs (U.S. GAO 1997), such research could result in improved health outcomes for large numbers of patients awaiting transplants.

APPENDIX

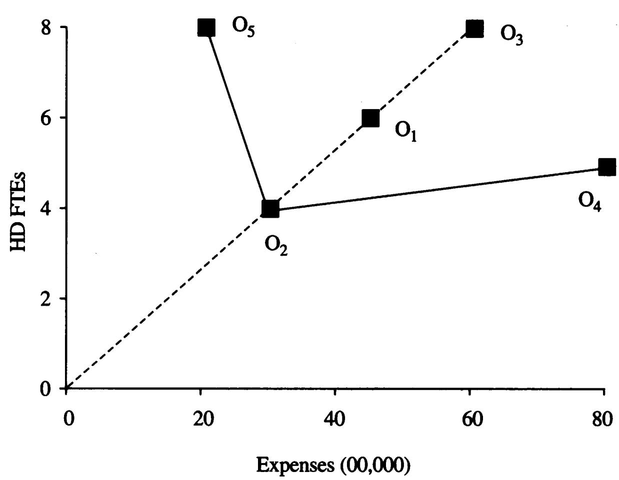
Multidimensional Performance Measurement via Data Envelopment Analysis

Data envelopment analysis (DEA) is a technique in which linear programming is used to search for optimal combinations of inputs and outputs based on the actual performances of, in this case, OPOs. DEA evaluates the technical efficiency of each OPO relative to "optimal" patterns of production, patterns that are computed using the performance of OPOs whose inputs and outputs are not bested by those of any other comparison or peer OPO.

DEA will compute the relative efficiencies with which OPOs combine major categories of inputs to generate general categories of outputs typically produced by OPOs. In doing so, controllable and uncontrollable inputs/outputs by OPO management will be taken into consideration, as well as the size of the OPOs. A graphical conceptualization of the technique is seen in Figure 1. This is a simple two-input, one-output example. In the example, five hypothetical OPOs utilize two inputs—fulltime equivalent (FTE) labor used in hospital development (HD) and operational expenses—to produce the same output. At each point, O_i represents an OPO using different combinations of inputs to produce the same level of output (i.e., kidneys recovered). For instance, provider O_1 recovers kidneys using 6 HD FTEs with operational expenses incurred of $4,500,000. Another OPO, O_2, which uses 4 HD FTEs and $3,000,000 in operational expenses, is relatively more efficient than provider O_1. The optimally performing OPOs in this case, O_2, O_4, and O_5, comprise the efficiency frontier.

Figure 1: A Conceptualization of the Efficiency Frontier

	Organ Procurement Organization (OPO)				
INPUT	O_1	O_2	O_3	O_4	O_5
HD FTEs	6	4	8	5	8
Expenses (00,000)	45	30	60	80	20



HD = Hospital development; FTEs = Full-time equivalents.

Source: Adapted from Y. Ozcan, J. Watts, M. Harris, and S. Wogen. 1998. "Benchmarking the Providers for Stroke Cases." *Journal of the Operational Research Society* 49:1–10.

DEA also calculates inefficiency values for each OPO. The inefficiencies represent the degree of deviance from the frontier. Input inefficiencies show the degree to which inputs must be reduced for the inefficient OPO to lie on the best practice frontier, while output inefficiencies represent the needed increase in outputs for the OPO to become efficient. If a particular OPO either decreases its inputs by the inefficiency values or increases its outputs by the amount of inefficiency, it could become efficient; that is, it could obtain an efficiency score of one. For example, in Figure 1, O_1 can become efficient (i.e., reach the frontier) by reducing HD FTEs by 2 and expenses by $1,500,000. Inefficiency analysis aids the policy analyst in determining what changes need to be made to reach a consistent level of technical efficiency.

The way in which the DEA program computes efficiency scores can be explained briefly using mathematical notations (adapted from Charnes and Cooper 1980). The efficiency scores (E_j) for a group of peer OPOs ($j = 1, \ldots n$), are computed for the selected outputs ($y_{rj}, r = 1, \ldots s$) and inputs ($x_{ij}, i = 1, \ldots m$) using the following fractional linear programming formula:

$$\text{Maximize: } E_o = \frac{\sum_{r=1}^{s} u_r\, y_{ro}}{\sum_{i=1}^{m} v_i\, x_{io}}$$

Subject to:

$$\frac{\sum_{r=1}^{s} u_r\, y_{rj}}{\sum_{i=1}^{m} v_i\, x_{ij}} <= 1$$

$$u_r,\ v_r > 0 \text{ for all } r \text{ and } i.$$

In this formulation, the weights for the outputs and inputs, respectively, are u_r and v_i and o denotes a focal OPO (each OPO, in turn, becomes a focal

OPO when its efficiency score is being computed). Note that input and output values, as well as all weights, are assumed by the formulation to be greater than zero. The weights u_r and v_i for each OPO are determined entirely from the output and input data of all OPOs in the peer group. Therefore, the weights used for each OPO are those that maximize the focal OPO's efficiency score. The program also identifies a group of optimally performing OPOs that are defined as efficient and assigns them a score of one. These efficient OPOs are then used to create an "efficiency frontier" or "data envelope" against which all other OPOs are compared. In sum, OPOs that require relatively more weighted inputs to produce weighted outputs, or alternatively, to produce less weighted output per weighted inputs than do OPOs defined by the program to be on the efficiency frontier, are considered technically inefficient. They are given efficiency scores of less than one, but greater than zero.

Various types of DEA models may be used depending on conditions of the problem at hand. The type of DEA model for this study can be distinguished based on scale and orientation of the model. If one cannot assume that economies of scale do not change as size of the service facility increases, then a variable returns to scale (VRS)–type DEA model, selected here, is an appropriate choice (versus constant returns to scale [CRS]). Further, to achieve better efficiency, if managers' priorities are to adjust their outputs (before inputs), then an output-oriented DEA model rather than an input-oriented model, is appropriate (Seiford 1996).

Although DEA is a powerful optimization technique to assess the performance of each OPO, it has certain limitations that need to be addressed. When one has to deal with large numbers of inputs and outputs in the service production process and a small number of organizations are under evaluation, the discriminatory power of the DEA will be limited. However, analysts can overcome this limitation by including only those factors (input and output) that provide the essential components of the service production process, thus not distorting the outcome of the DEA results. This is generally done by eliminating one of a pair of factors that are strongly positively correlated with each other.

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