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Running Title: The Impact of CMS CoP on Kidney Transplant Waiting Times

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Abbreviations:

SRTR	Scientific Registry of Transplant Recipients
HRSA	Heath Resources and Services Administration
CMS	Centers for Medicare and Medicaid Services
CoP	Conditions of Participation
BMI	Body Mass Index
PRA	Panel Reactive Antibody

Abstract:

SRTR program reports provide detailed information on transplant center performance relative to risk-adjusted expected values. Designed to improve outcomes, the behavioral implications of these reports may generate a longer wait time for transplant. UNOS data for 28,839 deceased donor kidney transplants performed during 6/2007- 6/2010 and 79,725 registered patients waiting for a kidney transplant during this time period were merged with SRTR program report data; Patient-specific and transplant center controls were created. An indicator variable was constructed for whether or not a transplant center did not meet the Centers for Medicare and Medicaid Services (CMS) Conditions of Participation (CoP) during a patient's waiting period for a transplant. A censored Cox-proportional hazard model was utilized to investigate the impact of CMS CoP on the length of time until transplant. Data analysis reveals that a transplant center's failure to meet either the 1-year graft or patient survival rates, according to CMS criteria, is associated with the expected waiting time until transplantation. Further the results suggest that

centers may elect to transplant healthier patients and patients for whom they would receive a risk compensation in the SRTR model.

INTRODUCTION

End Stage Renal Disease (ESRD) is a significant health burden in the United States, with more than 300,000 people being dialysis–dependent (1) The rapid expansion of the kidney transplant waiting list, particularly of older and higher risk patients, has heightened the awareness of the transplant and medical community to the importance of optimizing the use of scarce organs. However, the transplant surgeon's decision to accept and utilize an organ is made in the presence of considerable regulatory (2-4) and patient health-related risks (5, 6).

Transplant centers are required to report patient and graft outcomes. The Scientific Registry of Transplant Recipients (SRTR) reports risk adjusted outcome data for each transplant center using a 2½ year rolling cohort that is updated and published every 6-months. When outcomes deviate from an expected value, a peer review process is initiated with the intent of stimulating improvement and best practices in underperforming transplant centers. CMS assumed an increased role in transplantation on June 28, 2007 and as a result certifies transplant centers for participation in the Medicare program using outcome requirements outlined in the CoP (7). Failure to meet performance standards may result in a center entering a Systems Improvement Agreement and potential loss of funding by CMS.

CMS currently uses a three-pronged trigger system to determine when a transplant center does not meet performance standards under the CoP. In terms of graft survival rates, a CMS trigger results when all three of the following triggers are met: (1) (observed graft failures – expected graft failures) > 3; (2) (observed graft failure/expected graft failure) > 1.5; and (3) differences are statistically significant at the 5% level using a one-sided t-test. Failure to meet only one or two of these triggers does not cause a center to not meet the CoP, all three triggers must be simultaneously met. Each of these statistics is reported in the SRTR transplant center

reports as well as a two-tailed test of statistical significance. A 10% signifigance level, as reported in the SRTR reports, is equivalent to the 5% level one-tailed test used by CMS for the CoP. Furthermore, all of the expected outcomes calculated are risk-adjusted based on both recipient and donor characteristics (2).

While quality assurance has led to significant improvements in the care of transplant patients (8, 9)there are potential negative implications of such efforts (10). In particular, the CMS CoP may induce more risk-averse and/or loss-averse preferences (11). A byproduct of the regulation then may be an increased waiting time for patients as the behavioral response of surgeons is to be more selective and therefore may cause transplant centers to reduce the number of organs accepted for transplant. However, it is worth noting that these behavioral responses may be consistent with the objective of the CMS CoP. The purpose of this study is to not to investigate the efficacy of the CMS CoP but to investigate its impact on deceased donor waiting times for kidney transplantation in the United States. We leave the question of whether or not the CMS CoP results are welfare enhancing for future research. Our primary hypothesis is that waiting times will increase at a transplant center after it learns that it does not meet its CMS CoP.

METHODS:

Data acquisition:

UNOS data for 28,839 deceased donor kidney transplants performed during 6/2007-6/2010 and 79,725 registered patients waiting for a kidney transplant during this time period were merged with SRTR program report data. 1-year graft and patient survival rates expressed as both the total number of transplants and by deceased donors only were analyzed. 187 transplant centers performing an average of at least one transplant per month during 1/2004-6/2010 were included. This larger time window for center selection was utilized because it captured all transplant patients included in the 2 ½ year rolling cohort reported in the June 2007 SRTR center reports. Transplant center averages, used to determine their inclusion in our

study, were determined by adding up the total number of transplants conducted between 1/2004 and 6/2010, as reported in the UNOS data set, and then dividing by the total number of months. Our data set contains approximately 91% of all the transplants conducted and 88% of patients waiting for a deceased donor kidney transplant during this time period.

For each deceased-donor kidney transplant performed the waiting time was estimated using the patient's transplant date and their initial waiting list date. For those patients awaiting transplant the waiting time was similarly calculated but truncated at 06/30/2010, the end date of analysis. All patients currently waiting are censored and controlled for in the empirical model.

Cummulative distribution and censored Cox-proportional hazard model:

The cummulative distribution function of patient waiting times when their center meets the CMS CoP before transplantation and when their center does not meet the CMS CoP at least once during their wait time are shown in Figure 2.

To investigate the impact that the CMS CoP has on patient waiting times a censored Cox-proportional hazard model was estimated. The hazard function, i.e. the instaneous probability that a patient receives a kidney at t is specified as,

$$h(t) = h_0(t)e^{X'b} \quad (1)$$

where t represents current time period, X is the matrix of exogenous variables that affect the length of time until transplant, exp(b) is the estimated vector of hazard ratios of the exogenous variables and $h_0(t)$ is the baseline hazard rate.

Two alternative specifications of $X'b$ were estimated. In both specifications, the common set of covariates include the following variables: transplant center fixed effects and patient specific factors (i.e., gender, ethnicity, medical insurance, working status, functional status at listing, diabetes, vascular disease, angina, hypertension, body mass index (BMI), age and panel reactive antibody (PRA)). In the first specification an indicator variable is added, defined as C, that takes a value of one if a patient's transplant center does not meet the CMS

CoP at least once during their waiting time. The second specification interacts the variable C with a subset of patient-specific factors that may be used to differentiate between a high and low risk patient including a patient's functional status at listing, diabetes status, the presence of vascular disease, hypertension, BMI, age and PRA. Given the importance of a patient's PRA level in transplantation we have elected to define PRA two different ways: (1) initial PRA at listing and (2) maximum observed PRA level recorded in the UNOS data set. The initial PRA is recorded at the time of listing, however the PRA values are updated during the course of a patient's wait time and at the time of transplantation. Therefore, by defining the PRA levels both ways we can investigate the sensitivity of our results to alternative PRA specifications. However, we do treat both measures of the PRA as time-invariant variables in Equation (1) because we do not know the precise PRA for all days that a patient is waiting for a transplant (e.g., we do not have real-time PRA data for the patient). The patient's functional status is further partitioned into four types: (1) performs activities of daily living with no assistance, (2) performs activities of daily living with some assistance, (3) performs activities of daily living with total assistance, and (4) unknown functional status.[1] Four different specifications of C are used in the model: (1) 1-year total graft survival; (2) 1-year deceased donor graft survival; (3) 1-year total patient survival; and (4) 1-year deceased donor patient survival.

RESULTS:

The percentage of transplant centers that do not meet CMS CoP criteria

Nine SRTR report dates were analyzed with data from the period 6/2007-6/2010. The results are displayed in Figure 1, and categorized by the respective triggers used by CMS for the CoP. On average, 9.73% of transplant centers did not meet the 1-year CMS CoP for total

[1] Functional status 1 aggregates the following UNOS codes:1, 2090, 2080, 4100, 4090 and 4080. Functional status 2 aggregates the following UNOS codes: 2, 2060, 2070, 2050, 2040, 4070, 4060, 4050 and 4040. Functional status aggregates the following UNOS codes: 3, 2040, 2030, 2020, 2010, 4030, 4020 and 4010.

graft survival, 8.21% for deceased donor graft survival, 7.83% for total patient survival and 6.23% for deceased donor patient survival.

The percentage of transplants occuring at centers that do not meet CMS CoP criteria

Of the 28,839 transplants analyzed, 9.36% [2,698] occurred at transplant centers that did not meet the CMS CoP standards for 1-year total graft survival at least once during the waiting time. The percentages of transplants conducted at centers failing to meet other (stated) standards were: 9.54% [2,751] (1-year deceased donor graft survival), 11.28% [3,253] (1-year total patient survival), and 8.68% [2,502] (1-year deceased donor patient survival) respectively.

The percentage of registered patients on the waitlist at a center that does not meet CMS CoP criteria

Of the 79,725 registered patients waiting for a kidney transplant, 8.96% [7,147] were waiting for a transplant at a center that had not met the CMS CoP standard for 1-year total graft survival at least once during their waiting time. The percentages of registered patients waiting for a kidney transplant at centers failing to meet other (stated) standards were: 8.93% [7,119] (1-year deceased donor graft survival, 11.10% [8,857] (1-year total patient survival) and 9.40% [7,497] (1-year deceased donor patient survival) respectively.

Univariate analysis of wait times when a center does not meet the CMS CoP

Table 1 shows the descriptive statistics for the data set partitioned by the four specifications of C as well as by those patients who received transplants and those who did not. For all of the four CMS CoP criteria and across the two partitions of the data set, those who received a transplant and those who were still waiting (treating each unique patient as an independent observation), a two-tailed, two-sample t-test with unequal variances indicate that a patient's waiting time is longer when a center does not meet one of the CoP relative to when they do (all p-values less than 0.01).

A limitation of this univariate analysis is that it treats each observation as an independent observation. Given that observations within a transplant center may not be independent, we

also conducted a series of two-sample t-tests at the transplant center level. For each of the four CMS CoP criteria and two partitions of the data set (transplanted and waiting patients) we determined the unique centers within each partition and then averaged the waiting times at the transplant center level. Using this transplant center level data set all of our two-tailed, two-sample t-tests with unequal variances indicated that a patient's waiting time is longer when a center does not meet one of the CoP relative to when they do (all p-values less than 0.05).

Waiting time increases when a center does not meet the CMS CoP

Figure 2 shows the cummulative distributions of waiting time for transplant for patients whose centers did not meet the CMS CoP at least once during their waiting time period categorized by graft and patient type. These data strongly suggest that a patient's waiting time increases when a center does not meet the CMS CoP. In all of the panels (analyzed by graft and patient survival as well as total transplants and deceased donors only) the cummulative distribution for centers that did not meet the CMS CoP at least once lies within those that met the CMS CoP the entire time period.

The hazard rates for the CMS CoP criteria using the first specification are reported in Table 2 and for the second specification in Table 3. The hazard ratios reported in Table 2 vary from 0.34181 (1-year deceased donor graft survival and maximum observed PRA level) to 0.43433 (1-year deceased donor patient survival and initial PRA level) and are statistically significant at the 95^{th} percentile. The coefficients indicate that the instantaneous probability of receiving a transplant conditional on having not received a transplant by that time period, a patient's hazard rate, decreases by nearly 64% when a patient's transplant center has not met the CMS CoP at least once for 1-year total patient graft survival, by nearly 66% for 1-year deceased donor graft survival, over 62% for 1-year total patient survival and over 56% for 1-year deceased donor patient survival. These hazard ratios are also robust to our use of either the initial PRA level or the maximum observed PRA level for each patient (PRA variables take a value of one if the PRA level is greater than or equal to 80 and zero otherwise). A graphical

analaysis of our empirical results, using the maximum observed PRA level, are illustrated in Figure 3.

Impact at patient level on 1-year total patient and deceased donor graft survival

The results in Table 3 illustrate that impacts on waiting time are not homogenous across patients and depend on which of the CMS CoP criteria are not being met by the transplant center. The results for the 1-year total patient graft survival model illustrate that the hazard function increases for patients who have hypertension by approximately 8% and for those who have previously received a transplant by between 20% and 24%, depending on which PRA data are being used in the model. The hazard function decreases by approximately 14% for those with a functional status of two and and a little over 2% and approximately 0.07% per a unit increase in a patient's BMI and age respectively. Lastly, the hazard function decreases by over 12% when the patient's maximum observed PRA level exceeds 80.

When a transplant center has not met the 1-year deceased donor graft survival CoP at least once during a patient's waiting time the hazard function increases for patients with PVD and hypertension by approximately 25% (26% using maximum observed PRA) and 18% respectively. The hazard function decreases by nearly 22% when a patient has a functional status of two and we observe similar reductions to those observed when a center does not meet the 1-year total transplant graft survival measures for a patient's BMI, age and maximum PRA levels.

Impact at patient level on 1-year total patient and deceased donor patient survival

The 1-year total patient and deceased donor survival models generate very similar results for BMI, age and PRA as those observed in the graft survival models, however the negative impact of PRA (maximum observed PRA >=80) on the hazard function is slighlty larger. Additionally, when a transplant center has not met the 1-year total patient survival CMS CoP criteria at least once during their waiting time the hazard function increases for patients with diabetes by approximately 12%. This increase reduces to approximately 10% when we

focus on the 1-year deceased donor patient survival. The hazard function for those patients with a functional status of two falls by nearly 22% and slightly over 20% for the 1-year total patient survival and 1-year deceased donor patient survival respectively. Lastly, the observed increase in the hazard function for PVD and hypertension, with the exception of hypertension in the 1-year total patient survival model when we use maximum observed PRA (signficant at the 90% level), in the graft survival models are not observed in the patient survival models.

DISCUSSION:

Transplant centers frequently maintain large waiting lists of patients waiting to receive a deceased donor transplant. When an organ is accepted or rejected for an individual on the waiting list, it affects not only that individual, but also those individuals who remain on (or get into) the waiting list. This decision is made in the presence of data that suggest there is a quality of life and life expectancy benefit of renal transplant as compared to dialysis (12-14)as well as the need to maintain excellent recipient and graft survival as monitored by considerable regulatory oversight. The latter factor may influence transplant centers to be more selective with the transplants they conduct (15, 16) which may generate longer waiting times. Therefore, it is important to investigate how these regulations impact not only the transplant centers, but also the patients who are awaiting transplantation.

While many investigators have focused on the transplant center, this innovative approach examines outcomes at the patient level and may have the potential to inform the transplant community on what affects the decisions to accept organs and what impacts the decisions may have on our patients. This research complements the recent work of Schnier et al. and Schold et al(11, 17). Schnier et al. highlight the behavioral responses of physicians at the patient level while Schold et al. discuss the effects at a center level, more specifically the volume of transplants at a center that may result from the CMS CoP. The finding that failure of a center to meet the CMS CoP during a patient's waiting period for transplantation increases their waiting time is consistent with the findings of Schold et al, (17) and further highlights a potential

mechanism generating this center-level effect; physicians may become more risk averse when their center does not meet the CMS CoP. Risk aversion would manifest itself as the selection of healthier patients for transplantation, and/or higher quality donor organs, in order to better ensure that their transplant center meets the CMS CoP. This may in fact be a desirable outcome in terms of improved outcomes at the center, but it comes at a cost of a reduced transplantation rate and increased waiting times. This further illustrates the benefits of focusing on patient-level decisions in the broader transplant community.

Interestingly, the regulatory impact is not homogeneous across the waiting list population or the different CoP measures. There are two general consistencies across all four models estimated. First, patients with a higher BMI, age or a maximum observed PRA greater than 80 will have a longer waiting time when any of the four CoPs are not met. These results confirm the suggestion that providers may limit access of perceived high risk patients to transplantation (4). Our second consistency is that patients with a functional status of two will have a longer waiting time than those patients with a functional status of one or three. This result suggests that physicians are maintaining their normal flow of transplants for those patients that are either at the upper (i.e., no assistance patients) or lower end (i.e., total assistance patients) of the health spectrum, but are electing to not conduct transplants as much for those in the middle health status class.

Interestingly, a number of the models demonstrate shorter waiting times for patients whose risk factors are compensated for in the CMS model (i.e., diabetes, hypertension, PVD, and previous transplant). One interpretation is that physicians are aware of the risk adjustment and are therefore not as concerned with the impact these patients may have on outcomes. Another is that phyicians are aware of the risks of these high risk patient populations remaining on dialysis. And lastly, both factors may be influencing the decision.

Our analysis suggests that regulatory oversight may have an impact on transplant centers, potentially resulting in fewer transplants and longer waiting times. The question is

whether fewer transplants and longer waiting times is a positive or a negative outcome. Examining the findings with a negative lens would yield an interpretation that increased selectivity in the acceptance of organs for transplant may lead to longer waiting times, decline in health status of waitlist candidates, fewer transplants, longer cold ischemia times, higher organ discard rates, and a potential disincentive to perform innovative research protocols (11). Alternatively, these data may demonstrate that centers are acutely aware of performance and outcomes measures and are becoming appropriately selective, thus serving their patient population better. Perhaps centers were selecting candidates that were not suitable candidates or accepting organs that were of lesser quality with the intention of transplanting more patients and decreasing the waiting times, or both. It is clear that a better understanding of the impact longer wait times have on the patients on the waiting list needs to be balanced with the positive aspect of reviewing best practices and improving outcomes (i.e., graft and patient survival). These results underscore the need for additional research on the individual decision-making of transplant physicians under a wide range of conditions.

A limitation of our model is the use of large retrospective databases that include subjective data (i.e, functional status) that may compromise the validity of our results depending on consistency of data reporting and capture. Additionally, although our findings indicate that a patient's waiting time increases if their center did not meet the CMS CoP during the course of their waiting time, they do not address anticipatory actions taken by a transplant center to prevent not meeting the CMS CoP, nor do they illustrate whether the longer waiting times result in either worse or better outcomes for the transplant community.

Transplant centers continually monitor their performance outside of the six-month intervals used by SRTR. Presumably centers that anticipate themselves not meeting the CMS CoP may alter their behavior without ever being triggered for review. Furthermore, our analysis uses a restrictive form of behavioral response as all three CMS CoP triggers must be met before we estimate its impact on waiting times. Presumably once a transplant center does not

meet any of the three triggers they may alter their behavior to improve their outcomes. Our current model does not capture the marginal effect that each of the triggers has on waiting times, nor does it provide an ordinal rank for the impact that the three triggers have on waiting times. Our empirical estimates only address the responses of those who did not meet the CMS CoP and treats those centers that are altering behavior to prevent a trigger the same as those who are well above meeting the triggers. Therefore, we are estimating an average effect for these two types of centers that currently meet the CMS CoP.

Longer waiting times presumably imply an increase in dialysis time but we do not know whether this results in a better donor organ for that recipient in the future. This could result in an increase in graft and patient survival rates, or an increase in adverse outcomes (i.e., delisting of patients due to deteriorated health, deaths on waiting list). Either of these two outcomes may result and further research is required to definitively answer this question. In addition, the timing of non CMS CoP compliance during the study observation period is a potential limitation in that noncompliance at the end of the observation period may have a very different effect on behavior during the study period as compared to noncompliance at the beginning that could have a long-lasting effect throughout the study.

CONCLUSION:

SRTR reports and CMS review are intended to improve performance and outcomes throughout the transplant community. When a transplant center does not meet one of the CMS CoP for 1-year patient survival or graft survival waiting times are longer. While quality of care for our patients is the most important priority, the transplant community should focus on the balance between quality outcomes and the full range of outcomes that may affect patients who have not been transplanted. Longer times on the waitlist may mean more deaths and sicker patients coming to transplant as a result of remaining on dialysis or better quality care for our patients. As the United States transplant community debates a proposed new kidney allocation system and works to develop better risk adjusted models, perhaps including behavioral factors will

guide us to the balance between quality outcomes and utilization. From these data it is clear that further research is needed on the individual decision-making of transplant physicians to obtain a better understanding of whether regulatory oversight tips the balance too far in either direction.

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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Figure 1: Fraction of transplant centers (N=188) that do not meet different performance standards: (1) Observed minus expected exceeds 3 (solid blue line), (2) ratio of observed to expected exceeds 1.5 (dashed green line with circles), and (3) both (1) and (2) hold and the differences are statistically significant at the 0.10 level as reported in the SRTR reports (orange dashed line).

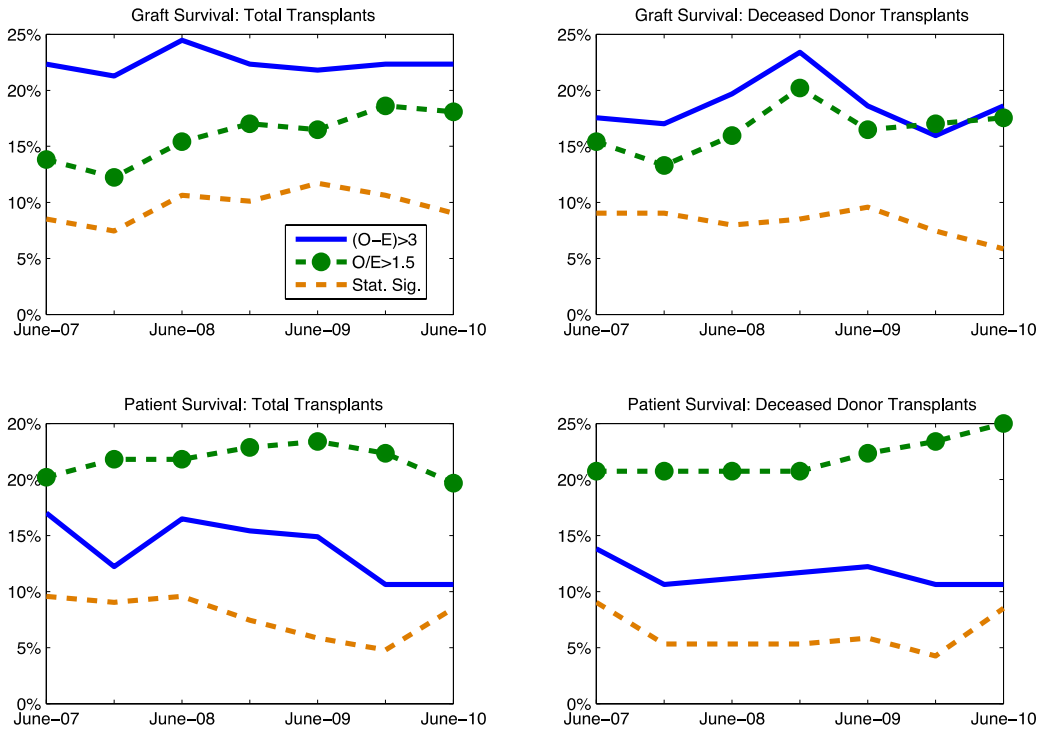

Figure 2: Cumulative Distribution Function (CDF) of waiting time until transplant for patients whose centers met the CMS CoP the entire time of their waiting period (blue line) and did not meet the CMS CoP at least once during their waiting time period (blue dashed line) broken down by graft and patient type. Plot also contains the CDF for the current wait time status of patients who have not received a transplant broken down by those centers who have met CMS CoP the entire wait time (orange line) and those that have not met the CMS CoP at least once during their wait time (orange dashed line).

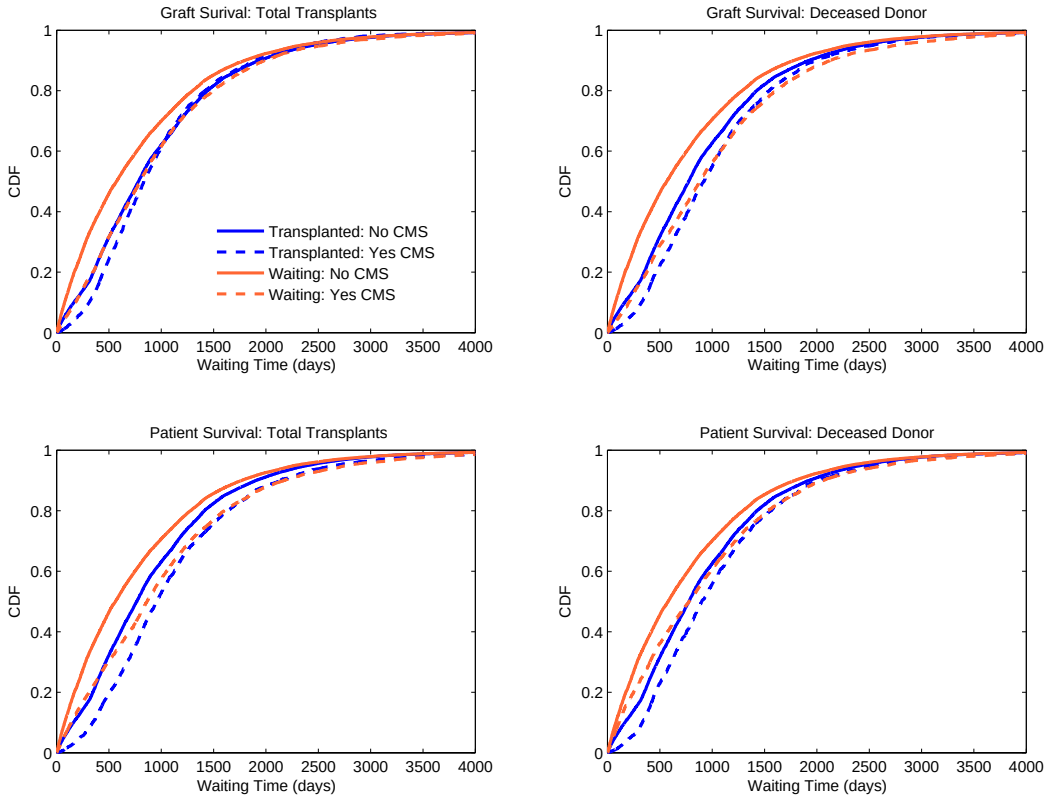

Figure 3: Estimated probability of having received a transplant conditional on a patients current waiting time for those patients whose center met the CMS CoP the entire time of their waiting period (blue line) and did not meet the CMS CoP at least once during their waiting time period (blue dashed line) broken down by graft and patient type. Estimated probabilities were obtained using the duration model results illustrated in Table 2.

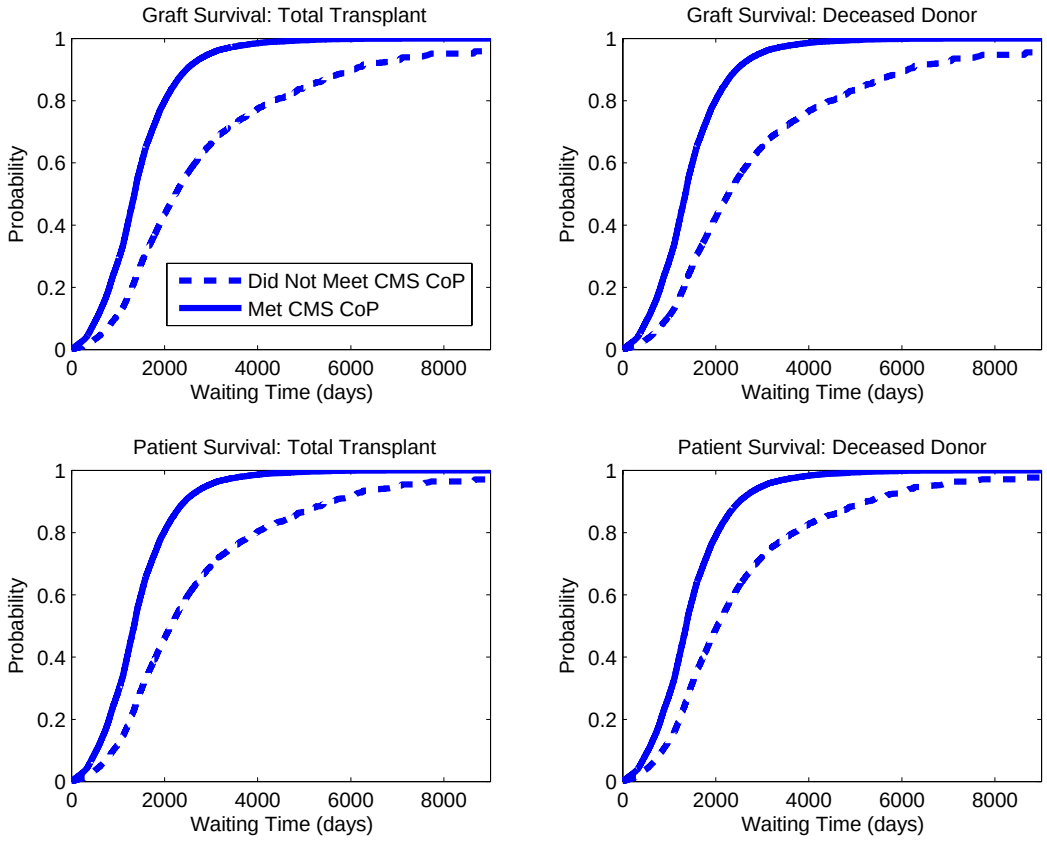

Table 1: Descriptive Statistics: Patient-specific factors broken down by CMS CoP and those registered patients who have received a transplant and are waiting for a transplant. Averages illustrated with standard deviations in parentheses. Total number of observations, transplanted (28,839) and not transplanted (79,725), is 108,564 observations.

	Transplanted: No CMS	Transplanted: Yes CMS	Waiting: No CMS	Waiting: Yes CMS
1-year graft: Total Patients				
Wait Time (dys)	962.726 (791)	1,006.718 (779)	804.596 (809)	990.573 (847)
Previous TX	0.060 (0.24)	0.060 (0.24)	0.024 (0.15)	0.020 (0.14)
BMI	28.220 (5.71)	27.977 (5.67)	28.541 (5.82)	28.285 (5.89)
Hypertension	0.319 (0.47)	0.334 (0.47)	0.212 (0.41)	0.242 (0.43)
Age	50.246 (12.87)	49.085 (13.01)	50.319 (12.95)	49.473 (13.12)
Initial PRA>=80	0.024 (0.15)	0.020 (0.14)	0.023 (0.15)	0.015 (0.12)
Maximum PRA>=80	0.105 (0.31)	0.099 (0.30)	0.073 (0.26)	0.075 (0.26)
Diabetes	0.376 (0.48)	0.350 (0.48)	0.404 (0.49)	0.371 (0.48)
Number of Obs.	26,141	2,698	72,578	7,147
1-year graft: Dec. Donor				
Wait Time (dys)	954.366 (787)	1,085.146 (812)	796.113 (802)	1,077.825 (894)
Previous TX	0.060 (0.24)	0.062 (0.24)	0.024 (0.15)	0.024 (0.15)
BMI	28.203 (5.70)	28.150 (5.78)	28.533 (5.81)	28.370 (6.02)
Hypertension	0.313 (0.46)	0.389 (0.49)	0.208 (0.41)	0.284 (0.445)
Age	50.244 (12.87)	49.125 (12.99)	50.322 (12.95)	49.441 (13.10)
Initial PRA>=80	0.025 (0.15)	0.017 (0.13)	0.023 (0.15)	0.015 (0.12)
Maximum PRA>=80	0.105 (0.31)	0.101 (0.30)	0.072 (0.26)	0.078 (0.27)
Diabetes	0.378 (0.48)	0.340 (0.47)	0.404 (0.49)	0.371 (0.48)
Number of Obs.	26,088	2,751	72,606	7,119
1-year patient: Total Patients				
Wait Time (dys)	943.479 (777)	1,150.591 (863)	791.095 (792)	1,062.874 (938)
Previous TX	0.061 (0.24)	0.055 (0.13)	0.023 (0.15)	0.025 (0.16)
BMI	28.194 (5.69)	28.226 (5.83)	28.508 (5.81)	28.600 (6.00)
Hypertension	0.315 (0.46)	0.359 (0.48)	0.207 (0.41)	0.277 (0.45)
Age	50.278 (12.90)	49.024 (12.76)	50.387 (12.97)	49.092 (12.89)
Initial PRA>=80	0.024 (0.15)	0.022 (0.15)	0.022 (0.15)	0.025 (0.16)
Maximum PRA>=80	0.104 (0.31)	0.105 (0.31)	0.070 (0.26)	0.093 (0.29)
Diabetes	0.377 (0.48)	0.350 (0.48)	0.406 (0.49)	0.365 (0.48)
Number of Obs.	25,586	3,253	70,874	8,851
1-year patient: Dec. Donor				
Wait Time (dys)	955.608 (786)	1,085.085 (821)	805.054 (805)	977.473 (882)
Previous TX	0.061 (0.24)	0.050 (0.22)	0.024 (0.15)	0.015 (0.12)
BMI	28.202 (5.69)	28.156 (5.82)	28.506 (5.81)	28.636 (6.04)
Hypertension	0.319 (0.47)	0.335 (0.47)	0.211 (0.41)	0.248 (0.43)
Age	50.204 (12.88)	49.432 (12.90)	50.305 (12.98)	49.652 (12.88)
Initial PRA>=80	0.024 (0.15)	0.023 (0.15)	0.021 (0.14)	0.028 (0.16)
Maximum PRA>=80	0.105 (0.31)	0.096 (0.30)	0.072 (0.26)	0.083 (0.28)
Diabetes	0.375 (0.48)	0.360 (0.48)	0.403 (0.49)	0.385 (0.49)
Number of Obs.	26,337	2,502	72,228	7,497

Table 2: Cox proportional hazard model parameter estimates. Parameter estimates are the hazard ratios for the binary indicator variable of whether or not a transplant center did not meet the CMS CoP during a registered patient's waiting time. All regression models were estimated seperately. Additional control variables in the model are: transplant center fixed effects and patient specific factors (i.e., gender, ethnicity, medical insurance, working status, functional status at listing, diabetes, vascular disease, angina, hypertension, BMI, age and pra). Statistical significance: *significant at the 90% level; **significant at the 95% level. LR (chi-squared) tests for each of the Cox-proportional hazard models indicated next to the parameter estimates.

CMS CoP	Hazard Ratio (Initial PRA)	LR (χ^2) test (p-value)	Hazard Ratio (Max. PRA)	LR (χ^2) test (p-value)
1-year graft survival: total transplants	0.35835** (0.015)	23,136.47 (0.00)	0.35602** (0.014)	23,101.45 (0.00)
1-year graft survival: deceased-donors	0.34225** (0.012)	23,409.32 (0.00)	0.34181** (0.012)	23,369.87 (0.00)
1-year patient survival: total transplants	0.37995** (0.013)	23,266.76 (0.00)	0.37818** (0.013)	23,231.27 (0.00)
1-year patient survival: deceased-donors	0.43433** (0.016)	23,001.83 (0.00)	0.43109** (0.16)	22,968.26 (0.00)

Table 3: Cox proportional hazard model parameter estimates. Parameter estimates are the hazard ratios for the binary indicator variable of whether or not a transplant center did not meet the CMS CoP during a registered patient's waiting time interacted with patient specific risk factors. All regression models were estimated seperately. Additional control variables in the model are: transplant center fixed effects and patient specific factors (i.e., gender, ethnicity, medical insurance, working status, functional status at listing, diabetes, vascular disease, angina, hypertension, BMI, age and pra). Statistical significance: *significant at the 90% level; **significant at the 95% level.

Variable	1-year graft survival		1-year graft survival		1-year patient survival		1-year patient survival	
	Total Trans.	Total Trans.	Dec. Donor	Dec. Donor	Total Trans.	Total Trans.	Dec. Donor	Dec. Donor
Functional Status 1	1.0302	1.0291	0.9856	0.9852	0.9547	0.9536	1.0429	1.0478
	(0.06)	(0.06)	(0.05)	(0.05)	(0.05)	(0.05)	(0.06)	(0.06)
Functional Status 2	0.8575**	0.8595**	0.7814**	0.7812**	0.7778**	0.7843**	0.7946**	0.7962**
	(0.06)	(0.06)	(0.06)	(0.06)	(0.05)	(0.05)	(0.06)	(0.06)
Functional Status 3	0.6958	0.6860	0.6647	0.6579	0.6438	0.6336	0.5834	0.5735
	(0.19)	(0.19)	(0.20)	(0.25)	(0.19)	(0.18)	(0.24)	(0.24)
Diabetes	1.0870*	1.0836*	1.0742	1.0669	1.1204**	1.1191**	1.1061**	1.0948*
	(0.05)	(0.05)	(0.05)	(0.05)	(0.05)	(0.05)	(0.05)	(0.05)
Angina	0.8788	0.9022	0.9556	0.9751	1.0529	1.0280	1.0519	1.0154
	(0.13)	(0.14)	(0.13)	(0.13)	(0.12)	(0.12)	(0.15)	(0.15)
CAD	1.0845	1.1589	1.0497	1.1026	1.0038	0.9886	0.8880	0.8883
	(0.22)	(0.23)	(0.20)	(0.21)	(0.17)	(0.17)	(0.22)	(0.22)
PVD	1.1302	1.1312	1.2478**	1.2609**	1.1389	1.1323	1.0926	1.0995
	(0.12)	(0.12)	(0.13)	(0.13)	(0.11)	(0.11)	(0.12)	(0.12)
Hypertension	1.0780*	1.0793*	1.1783**	1.1766**	1.0657	1.0784*	0.9799	0.9745
	(0.05)	(0.05)	(0.05)	(0.05)	(0.04)	(0.05)	(0.05)	(0.04)
Previous TX	1.1979**	1.2402**	1.0921	1.1292	0.9313	1.0346	1.1277	1.2588**
	(0.11)	(0.12)	(0.09)	(0.10)	(0.08)	(0.09)	(0.11)	(0.13)
BMI	0.9772**	0.9774**	0.9767**	0.9772**	0.9782**	0.9783**	0.9778**	0.9784**
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Age	0.9931**	0.9930**	0.9923**	0.9923**	0.9947**	0.9948**	0.9966**	0.9965**
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
PRA>=80 (Initial PRA)	1.0450	----	0.8729	----	0.8611	----	1.0670	----
	(0.15)		(0.13)		(0.11)		(0.15)	
PRA>=80 (Maximum PRA)	----	0.8768*	----	0.8541**	----	0.8106**	----	0.8076**
		(0.06)		(0.06)		(0.05)		(0.06)
LR (C^2) test – (p-value)	23,110.26 (0.00)	23,077.11 (0.00)	23,373.49 (0.00)	23,338.43 (0.00)	23,228.72 (0.00)	23,200.68 (0.00)	23,000.00 (0.00)	22,973.86 (0.00)