The Clinical and Financial Burden of Early Dialysis After Deceased Donor Kidney Transplantation

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Abstract

Background: The economic implications of dialysis-requiring allograft dysfunction early after kidney transplantation are not well-described.

Methods: Data for Medicare-insured adult kidney transplant recipients in 1995-2004 who did not develop permanent graft failure in the first 90 days were drawn from the United States Renal Data System. We identified dialysis treatment records from Medicare claims and categorized patients according to frequency and duration of post-transplant dialysis as: first week (delayed graft function, DGF), second week, weeks 3 or 4, second month, or third month. Associations of dialysis requirements with Medicare payments for the transplant hospitalization and over the next three years were estimated with multivariable linear regression. Graft and patient survival according to early dialysis requirements were examined with multivariable survival analysis.

Results: Among 37,533 recipients, 15,314 (41%) experienced DGF and 3,184 (21% of those with DGF) received dialysis beyond the first week. Compared with no dialysis in the first 3 months, adjusted marginal first-year costs associated with early post-transplant dialysis ranged from $6,467 for dialysis requirement limited to first week to $27,606 for dialysis in multiple periods (p<0.0001). Patients who experienced DGF and received dialysis in >2 early periods were more than twice as likely to lose their grafts within 3 years as those without early dialysis requirements.

Conclusions: While dialysis in the first week post-transplant is an adverse risk marker, early dialysis in weeks 2 to 12 is associated with similarly adverse, if not worse, costs and clinical consequences. This observation supports a need for broader definition of DGF.

Keywords: Delayed graft function; Economic analysis; Kidney transplantation; Medicare; Allograft survival; Outcomes

Introduction

Renal transplantation provides the best clinical outcomes, quality of life and cost-savings among the options for renal replacement therapy [1-3]. From 1997 through 2010 the number of patients on the wait-list for a renal transplant increased more than two-fold, to >80,000 patients [4]. The number of patients awaiting transplant in 2010 was almost five-times the number transplants performed [4]. To improve access to transplant in the context of this organ shortage, many centers have liberalized criteria for organ acceptance. From 1993 to 2008, the relative frequency of expanded criteria donor (ECD) allograft use rose from 7.4% to 22% among U.S. Transplantation of kidneys donated after cardiac death (DCD) also increased from <1% to 12.4% in this period [5].

The increased utilization of ECD and DCD kidneys has resulted in a higher rate of delayed graft function (DGF) [5-7]. In general, DGF is defined as receiving dialysis in the first week post-transplant. However, other investigators have attempted to further categorize the clinical implications of DGF according to the severity and persistence of graft dysfunction [8-10]. Typically, DGF results in increased costs in transplant recipients compared to those who do not experience DGF, in part due to a longer length of stay for the transplant hospitalization and need for hemodialysis [11,12]. DGF also increases the risk of rejection, graft failure and death, which can add substantial costs [6,13-15].

Current data on the cost implications of DGF are largely drawn from single center studies focused on the transplant hospitalization, and consider DGF as a binary event [2,6,11,12,16]. To improve understanding of the financial and clinical outcome implications of early post-transplant dialysis requirements after kidney transplantation, we performed a historical cohort study of large sample of Medicare beneficiaries registered in the United States Renal Data System (USRDS). Medicare claims records were used to identify the frequency and duration of dialysis requirements in the first 90 days after transplant. We also quantified associations of early graft function, as defined by the timing and persistence of dialysis requirements, with subsequent Medicare costs, permanent graft failure, and patient death over time.

Methods

Study data and sampling criteria

Study data were drawn from the USRDS [17]. The USRDS is a database that links the Organ Procurement and Transplantation...
network (OPTN) renal transplant registry data with administrative data from the Health Care Financing Administration (HCFA). The OPTN registry contains descriptive and clinical data on all kidney transplants performed in the United States. HCFA administrative data capture billing claims for Medicare-insured renal transplant recipients.

The study sample includes all adult (age >18 year old) deceased-donor renal transplant recipients in the USRDS registry from January 1995 to December 2004 with Medicare as their primary payer. Medicare primary payer status at transplant was defined by USRDS "Payer History" records and a total Medicare payment for the initial transplant hospitalization exceeding $15,000, as per previous reports [18]. Patients with multiple-organ transplants or previous transplants were excluded. Patients who experienced permanent graft failure, as reported to the OPTN registry, within the first 90 days post-transplant were also excluded. In addition, patients with Medicare claims for dialysis within 2 weeks after the initial 90 day assessment period (days 91-104 post-transplant) were also removed from the sample to ensure that patients with permanent early graft failure who return to chronic dialysis were not included in this study of delayed function.

**Dialysis records and categorization of early dialysis requirements**

Early post-transplant dialysis requirements were categorized using Medicare claims for dialysis within 90 days post-transplant as well as center reports of DGF to the OPTN registry. Medicare claims for dialysis were identified by a service code for dialysis, a place of service code for ESRD treatment, or indicated dialysis treatment modality on a billing claim. Dialysis claims were categorized according to occurrence in the following post-transplant periods: the first week, the second week, weeks 3 or 4, the second month, or the third month post-transplant. We defined DGF as an indication of DGF in the OPTN registry and/or any claims for dialysis in the first week post-transplant. Patients were then categorized into mutually exclusive groups based on DGF and subsequent dialysis claims as follows: 1) DGF with dialysis claims in the first week post-transplant only, 2) DGF and dialysis claims in one additional post-transplant period, 3) DGF and dialysis claims in >1 additional post-transplant periods, 4) no DGF but some claims for dialysis in days 8 to 90 post-transplant, and 5) no DGF and no dialysis claims within 90 days post-transplant.

**Outcomes**

The primary outcome was post-transplant costs, as defined by all post-transplant Medicare payments for a recipient within specified intervals. The cost measure includes Medicare payments to the recipients’ dialysis center, health providers, and treatment centers including hospitals. Payments were adjusted for inflation with the medical component of the consumer price index using the year 2004 as the base year [19]. Claims from the date of transplant until three years post-transplant (the time when Medicare coverage after transplant ends) were captured. The transplant hospitalization costs comprised all claims with a diagnosis-related group (DRG) code of 302, which indicates hospitalization for a kidney transplant. One, two, and three year post transplant costs were computed as the sum of the patient’s claims from transplant hospitalization to the indicated follow-up time. Patients who had incomplete follow-up due to loss of Medicare or end of study within an interval of analysis were excluded from that and subsequent intervals. Patients who died within an interval were included in all intervals with payments after date of death set to zero dollars.

Secondary outcomes included: reported creatinine and estimated glomerular filtration rate (eGFR) at discharge and at 6 and 12 months post-transplant, length of transplant hospitalization stay, rejection (within 3 years post transplant), death-censored graft failure, and mortality, as defined by OPTN reports. eGFR was calculated by the 4-variable MDRD equation, that has been demonstrated to perform well in transplant recipients [20]. Patients with missing creatinine values were excluded from the analysis of renal function for the periods in which they had missing data. Rejection was defined as any OPTN reported occurrence of acute or chronic rejection, rejection as a cause of graft failure, or administration of anti-rejection immunosuppression within one, two, or three years post-transplant. At time of discharge, data on length of stay and renal function were available for 22,269 (60%) and 36,867 (98%) of the patients in the study, respectively. At six months and one-year post-transplant there were 35,514 (95% of total) and 33,957 (90.5% of total) patients with renal function data available, respectively.

Covariate data were ascertained from OPTN records including: patient gender, race, ethnicity, age at transplant, body mass index (BMI), primary cause of ESRD, pre-transplant dialysis duration, and peak panel reactive antibody (PRA) percent; donor type (standard criteria donor [SCD], ECD, DCD), gender, race, ethnicity, age, BMI, cause of death, terminal creatinine ≥1.5 mg/dL, history of hypertension, diabetes; donor-recipient cytomegalovirus (CMV) sero-pairing, types and number of ABDR HLA mismatches, cold ischemia time, and year of transplant.

**Statistical analysis**

Distributions of recipient, donor, and transplant characteristic were compared between the groups defined by dialysis utilization using chi-square and t-tests. Missing baseline data was categorized as missing, other or unknown depending on the type of characteristic.

The unadjusted mean cost of transplant hospitalization, and costs incurred in one, two, and three years post-transplant were compared for all groups using the non-parametric Wilcoxon rank-sum test. Multivariate linear regression analysis was performed to compare costs within the four periods according to dialysis utilization, adjusting for recipient, donor, and transplant characteristics. Secondary outcomes were analyzed using chi-squared and ANOVA tests. Patient and graft survival after transplant were estimated by the Kaplan-Meier method. We used Cox Proportional Hazard analyses to examine the impact of early post-transplant dialysis on graft and patient survival, adjusting for the baseline covariates. An alpha level of 0.05 was used for all significance tests. Analyses were performed using SAS v.9.1 (SAS Institute, Cary, NC).

**Results**

We identified 37,533 Medicare insured adult renal recipients who met selection criteria. Of these recipients, 15,314 (41%) experienced DGF and 3,184 (21% of those with DGF) received dialysis beyond the first week post-transplant. Patients required varying intensity of post-transplant dialysis treatment: 12,130 (32.2%) patients had DGF but no dialysis beyond the first week post-transplant, 2,144 (5.7%) had DGF and dialysis in 1 additional period (week 1 and either week 2, weeks 3 or 4, the second month, or the third month), 1,040 (2.8%) had DGF and early dialysis in >1 additional period, 1,525 (4.1%) without DGF and but had some early dialysis in days 8 to 90, and 20,694 (55.1%) did not experience DGF or require dialysis in the 90 days after transplant.

The demographic characteristics of the transplant recipients varied...
significantly as a function of the need for and duration of dialysis treatment (Table 1). African Americans experienced more DGF than white recipients and were more likely to require some dialysis after the first week. Obese recipients were the most likely to experience DGF, but the percentage of obese patients requiring dialysis after the first two weeks was similar to non-obese recipients. Recipients of SCD allografts were less likely to experience DGF than patients transplanted with ECD or DCD organs (38.3% compared to 52.1 and 62.8%, respectively, p<0.0001). The percentage of transplants complicated by DGF increased substantially over the years of study, from 26% in 1995 to 54% in 2004 (p<0.0001).

| DGF with early dialysis in first week only, n(%) | DGF and early dialysis in 1 additional period, n(%) | DGF and early dialysis in >1 additional period, n(%) | No DGF but some early dialysis, n(%)* | No DGF and no dialysis, n(%)* | p-value† |
|-----------------------------------------------|-----------------------------------------------|-----------------------------------------------|--------------------------------------|--------------------------------------|----------|
| Recipient Characteristics                     |                                               |                                               |                                      |                                      |          |
| Female                                        | 4349 (29.8)                                   | 780 (5.4)                                     | 346 (2.4)                            | 572 (3.9)                            | 8546 (58.6) | <0.0001  |
| Race                                          |                                               |                                               |                                      |                                      |          |
| African American                              | 4193 (34.6)                                   | 851 (7.0)                                     | 440 (3.6)                            | 542 (4.5)                            | 6099 (50.3) | <0.0001  |
| White                                         | 7129 (31.0)                                   | 1165 (5.1)                                    | 543 (2.4)                            | 889 (3.9)                            | 13247 (57.7) | <0.0001  |
| Other                                         | 808 (33.2)                                    | 128 (5.3)                                     | 57 (2.3)                             | 93 (3.8)                             | 1348 (55.8) | <0.0001  |
| Hispanic                                      | 1336 (31.3)                                   | 263 (6.2)                                     | 135 (3.2)                            | 156 (3.7)                            | 2383 (55.8) | 0.08     |
| Age (years)                                   |                                               |                                               |                                      |                                      |          |
| 18-30                                         | 900 (27.5)                                    | 155 (4.7)                                     | 74 (2.3)                             | 135 (4.1)                            | 2015 (61.5) | <0.0001  |
| 31-44                                         | 3038 (30.1)                                   | 528 (5.2)                                     | 263 (2.6)                            | 441 (4.4)                            | 5852 (57.8) | <0.0001  |
| 45-59                                         | 4796 (33.1)                                   | 875 (6.0)                                     | 417 (2.9)                            | 594 (4.1)                            | 7828 (54.0) | <0.0001  |
| ≥ 60                                          | 3396 (35.3)                                   | 586 (6.1)                                     | 286 (3.0)                            | 355 (3.7)                            | 4999 (52.0) | <0.0001  |
| BMI category (kg/m²)                          |                                               |                                               |                                      |                                      |          |
| BMI < 10 or Missing                           | 2673 (28.6)                                   | 541 (5.8)                                     | 280 (3.0)                            | 420 (4.5)                            | 5423 (58.1) | <0.0001  |
| BMI ≥10 to <25                                | 3503 (29.0)                                   | 582 (4.8)                                     | 289 (2.4)                            | 499 (4.1)                            | 7206 (59.7) | <0.0001  |
| BMI ≥ 25 to <30                               | 3249 (34.8)                                   | 544 (5.8)                                     | 259 (2.8)                            | 355 (3.8)                            | 4929 (52.8) | <0.0001  |
| BMI ≥ 30                                      | 2705 (39.9)                                   | 477 (7.0)                                     | 212 (3.1)                            | 251 (3.7)                            | 3136 (46.3) | <0.0001  |
| Primary cause of ESRD                         |                                               |                                               |                                      |                                      |          |
| Diabetes mellitus                             | 3048 (31.8)                                   | 561 (5.8)                                     | 234 (2.4)                            | 369 (3.8)                            | 5389 (56.1) | <0.0001  |
| Glomerulonephritis                            | 2155 (30.8)                                   | 351 (5.0)                                     | 163 (2.3)                            | 277 (4.0)                            | 4049 (57.9) | <0.0001  |
| Polycystic kidney disease                     | 850 (31.7)                                    | 133 (5.0)                                     | 58 (2.2)                             | 113 (4.2)                            | 1530 (57.0) | <0.0001  |
| Hypertension                                  | 3001 (32.9)                                   | 567 (6.2)                                     | 327 (3.6)                            | 410 (4.5)                            | 4821 (52.8) | <0.0001  |
| Other                                         | 1594 (34.3)                                   | 241 (5.2)                                     | 109 (3.3)                            | 167 (3.6)                            | 2539 (54.6) | <0.0001  |
| Unknown                                       | 1482 (33.1)                                   | 291 (6.5)                                     | 149 (2.3)                            | 189 (4.2)                            | 2366 (52.9) | <0.0001  |
| Pre-Transplant Dialysis Duration              |                                               |                                               |                                      |                                      |          |
| None (pre-emptive)                            | 941 (35.9)                                    | 159 (6.1)                                     | 59 (2.3)                             | 105 (4.0)                            | 1356 (51.8) | <0.0001  |
| 0-12 months                                   | 784 (25.9)                                    | 94 (3.1)                                      | 48 (1.6)                             | 118 (3.9)                            | 1985 (65.5) | <0.0001  |
| 13-24 months                                  | 1594 (28.0)                                   | 233 (4.1)                                     | 104 (1.8)                            | 232 (4.1)                            | 3533 (62.0) | <0.0001  |
| 25-60 months                                  | 5905 (32.4)                                   | 1074 (5.9)                                    | 513 (2.8)                            | 750 (4.1)                            | 9972 (54.8) | <0.0001  |
| > 60 months                                   | 2906 (36.4)                                   | 584 (7.3)                                     | 316 (4.0)                            | 320 (4.0)                            | 3848 (48.3) | <0.0001  |
| Donor Characteristics                         |                                               |                                               |                                      |                                      |          |
| Female                                        | 5157 (34.0)                                   | 842 (5.5)                                     | 422 (2.8)                            | 630 (4.2)                            | 8137 (53.6) | <0.0001  |
| Hispanic                                      | 1336 (31.3)                                   | 263 (6.2)                                     | 135 (3.2)                            | 156 (3.7)                            | 2383 (55.8) | 0.08     |
| Race                                          |                                               |                                               |                                      |                                      |          |
| African American                              | 1394 (31.0)                                   | 274 (6.1)                                     | 138 (3.1)                            | 224 (5.0)                            | 2461 (54.8) | <0.0001  |
| White                                         | 10223 (32.3)                                  | 1786 (5.7)                                    | 860 (2.7)                            | 1232 (3.9)                           | 17515 (55.4) | <0.0001  |
| Other                                         | 513 (38.0)                                    | 84 (5.9)                                      | 42 (3.0)                             | 69 (4.8)                             | 718 (50.4) | <0.0001  |
| Age (years)                                   |                                               |                                               |                                      |                                      |          |
BMI category (kg/m²) | <0.0001
---|---
BMI < 10 or Missing | 326 (22.2) 68 (4.6) 49 (3.3) 86 (5.9) 938 (63.9)
BMI ≥ 10 to <25 | 5701 (29.5) 916 (4.7) 458 (2.4) 803 (4.2) 11480 (59.3)
BMI ≥ 25 to <30 |3574 (34.4) 695 (6.7) 313 (3.0) 400 (3.9) 5405 (52.0)
BMI ≥ 30 | 2529 (40.0) 465 (7.4) 220 (3.5) 236 (3.7) 2872 (45.4)

Death due to stroke | <0.0001
---|---
Terminal Creatinine ≥ 1.5 | 2083 (38.5) 430 (7.9) 234 (4.3) 233 (4.3) 2433 (45.0)
Hypertension history | <0.0001
---|---
Diabetes | 563 (39.3) 92 (6.4) 71 (5.0) 41 (2.9) 664 (46.4)
CMV sero-positive | 7539 (32.7) 1348 (5.9) 683 (3.0) 930 (4.0) 12562 (54.5)

Transplant Factors

Donor type

| | | | | | |
|---|---|---|---|---|
| ECD | 2037 (39.4) | 402 (7.8) | 253 (4.9) | 203 (3.9) | 2270 (44.0) | <0.0001
| DCD | 409 (44.3) | 121 (13.1) | 50 (5.4) | 23 (2.5) | 320 (34.7) | <0.0001
| SCD | 9684 (30.8) | 1621 (5.2) | 737 (2.3) | 1299 (4.1) | 18104 (57.6) | <0.0001

Peak Panel Reactive Antibody (%)

| | <0.0001
---|---
| 0-10 | 8342 (31.6) 1435 (5.4) 728 (2.8) 1088 (4.1) 14814 (56.1)
| 11-30 | 1236 (31.3) 220 (5.6) 106 (2.7) 175 (4.4) 2218 (56.1)
| >30 | 1688 (32.7) 355 (6.9) 163 (3.2) 198 (3.8) 2756 (53.4)
| Unknown | 864 (43.0) 134 (6.7) 43 (2.1) 64 (3.2) 903 (45.1)

HLA Mismatches

| | <0.0001
---|---
| 0 | 1072 (32.8) 145 (5.6) 60 (1.8) 104 (3.2) 1888 (57.8)
| 1 | 673 (28.6) 119 (4.4) 57 (2.4) 78 (3.3) 1424 (60.6)
| 2 | 1237 (30.5) 219 (5.1) 91 (2.2) 192 (4.7) 2318 (57.1)
| 3 | 2528 (31.2) 449 (5.5) 231 (2.9) 354 (4.4) 4547 (56.1)
| 4 | 3108 (33.3) 564 (6.0) 254 (2.7) 384 (4.1) 5036 (53.9)
| 5 | 2324 (33.6) 433 (6.3) 231 (3.3) 270 (3.9) 3653 (52.9)
| 6 | 930 (34.9) 169 (6.4) 92 (3.5) 99 (3.7) 1373 (51.6)
| Unknown | 258 (31.2) 46 (5.6) 24 (2.9) 44 (5.3) 455 (55.0)

CMV sero-pairing

| | <0.0001
---|---
| Donor - / Recipient - | 1289 (30.7) 209 (5.0) 97 (2.7) 173 (4.1) 2663 (57.5)
| Donor - / Recipient + | 2824 (33.1) 502 (5.9) 229 (2.7) 355 (4.2) 4627 (54.2)
| Donor + / Recipient - | 1930 (32.9) 313 (6.2) 168 (3.1) 256 (3.9) 3611 (53.8)
| Donor + / Recipient + | 4895 (29.1) 918 (4.7) 466 (2.2) 586 (3.9) 7998 (60.1)
| Unknown | 1192 (34.8) 202 (5.9) 80 (2.3) 155 (4.5) 1795 (52.4)

Year

| | <0.0001
---|---
| 1995 | 767 (20.1) 148 (3.9) 88 (2.3) 253 (6.6) 2562 (67.1)
| 1996 | 760 (20.5) 187 (5.0) 111 (3.0) 224 (6.0) 2433 (65.5)
| 1997 | 835 (21.4) 183 (4.7) 92 (2.4) 195 (5.0) 2595 (66.5)
| 1998 | 830 (22.0) 207 (5.5) 106 (2.8) 179 (4.8) 2449 (64.9)
| 1999 | 1132 (31.3) 220 (6.1) 90 (2.5) 158 (4.4) 2012 (55.7)
| 2000 | 1405 (38.2) 224 (6.1) 97 (2.6) 118 (3.2) 1837 (49.9)
| 2001 | 1544 (39.5) 239 (6.1) 126 (3.2) 108 (2.8) 1888 (48.4)
The average cost for patients who did not receive any dialysis in the 90 days post-transplant was less than all of the other groups across all time periods of interest (Table 2). Patients who did not experience DGF but required dialysis between 8 and 9 days were at least as expensive as those who were dialyzed within the first week post transplant. For all time periods the average total cost of medical care in patients who were dialyzed between days 8-90 was higher than that of recipients with DGF and dialysis in two or fewer periods. Compared to patients free of DGF and any early dialysis, those with dialysis in the first week incurred $4,000 in additional costs during the transplant hospitalization and $6,000 more by the end of the first year. Patients who had DGF who received dialysis in more than two periods had approximately $3,200 more in costs for the transplant hospitalization than those without any dialysis utilization.

After multivariate regression analysis, patients who received some dialysis in the 90 days post-transplant are more expensive to care for than those without any early dialysis utilization at each time period (Table 3). Receiving dialysis within the first week after transplant was independently associated with $2,727 in incremental costs compared to patients without DGF. The independent cost differential between these two groups increased over follow-up to $8,742 at three years post-transplant. The need for sustained early dialysis or dialysis which began between 8 to 90 days, was also independently associated with notably increased total costs where compared to no dialysis utilization. After accounting for dialysis utilization, ECD and DCD transplant were increased total costs where compared to no dialysis utilization. After accounting for dialysis utilization, ECD and DCD transplant were independently associated with $2,727 in incremental costs compared to patients without DGF. The independent cost differential between these two groups increased over follow-up to $8,742 at three years post-transplant. The need for sustained early dialysis or dialysis which began between 8 to 90 days, was also independently associated with notably increased total costs where compared to no dialysis utilization. After accounting for dialysis utilization, ECD and DCD transplant were increased total costs where compared to no dialysis utilization. After accounting for dialysis utilization, ECD and DCD transplant were independently associated with $2,727 in incremental costs compared to patients without DGF. The independent cost differential between these two groups increased over follow-up to $8,742 at three years post-transplant. The need for sustained early dialysis or dialysis which began between 8 to 90 days, was also independently associated with notably increased total costs where compared to no dialysis utilization. After accounting for dialysis utilization, ECD and DCD transplant were increased total costs where compared to no dialysis utilization. After accounting for dialysis utilization, ECD and DCD transplant were independently associated with $2,727 in incremental costs compared to patients without DGF. The independent cost differential between these two groups increased over follow-up to $8,742 at three years post-transplant. The need for sustained early dialysis or dialysis which began between 8 to 90 days, was also independently associated with notably increased total costs where compared to no dialysis utilization. After accounting for dialysis utilization, ECD and DCD transplant were increased total costs where compared to no dialysis utilization. After accounting for dialysis utilization, ECD and DCD transplant were independently associated with $2,727 in incremental costs compared to patients without DGF. The independent cost differential between these two groups increased over follow-up to $8,742 at three years post-transplant. The need for sustained early dialysis or dialysis which began between 8 to 90 days, was also independently associated with notably increased total costs where compared to no dialysis utilization. After accounting for dialysis utilization

### Table 2: Average accumulated costs for transplant hospitalization and care over 1, 2, and 3 years post transplant among Medicare-insured renal recipients from 1995-2004 according to early post-transplant dialysis utilization (N = 37,533).

| Period                  | Dialysis Use                      | N   | Mean (std)         | p-value* |
|-------------------------|-----------------------------------|-----|--------------------|----------|
| Transplant hospitalization | DGF with early dialysis first week only† | 12,130 | $31,451 (23,144) | <0.0001 |
|                         | DGF with early dialysis in 1 additional period‡ | 2,144 | $31,242 (17,649) |          |
|                         | DGF with early dialysis in >1 additional period‡ | 1,040 | $33,200 (20,487) |          |
|                         | No DGF but some dialysis†         | 1,525 | $33,035 (19,746) |          |
|                         | No DGF and no early dialysis†      | 20,694 | $30,068 (13,714) |          |
| One year post transplant | DGF with early dialysis first week only† | 10,721 | $74,081 (51,171) | <0.0001 |
|                         | DGF with early dialysis in 1 additional period‡ | 1,904 | $87,330 (71,645) |          |
|                         | DGF with early dialysis in >1 additional period‡ | 963 | $98,651 (64,521) |          |
|                         | No DGF but some dialysis†          | 1,419 | $90,590 (67,299) |          |
|                         | No DGF and no early dialysis†      | 19,304 | $68,089 (41,809) |          |
| Two years post transplant | DGF with early dialysis first week only† | 8,964 | $98,621 (69,100) | <0.0001 |
|                         | DGF with early dialysis in 1 additional period‡ | 1,699 | $112,002 (85,184) |          |
|                         | DGF with early dialysis in >1 additional period‡ | 859 | $129,105 (83,008) |          |
|                         | No DGF but some dialysis†          | 1,340 | $114,589 (86,538) |          |
|                         | No DGF and no early dialysis†      | 17,571 | $90,072 (59,685) |          |
| Three years post transplant | DGF with early dialysis first week only† | 7,273 | $121,063 (84,526) | <0.0001 |
|                         | DGF with early dialysis in 1 additional period‡ | 1,408 | $136,189 (102,254) |          |
|                         | DGF with early dialysis in >1 additional period‡ | 710 | $156,079 (102,681) |          |
|                         | No DGF but some dialysis†          | 1,235 | $138,264 (101,836) |          |
|                         | No DGF and no early dialysis†      | 15,776 | $10,109 (74,650) |          |

*P values differences in trait distributions according to dialysis utilization were computed by the Chi-square test for categorical variables and the t-test for continuous variables.

### Table 1: Characteristics of Medicare-insured renal transplant recipients in 1995-2004 according to early post-transplant dialysis utilization (N = 37,533).

| Period          | Dialysis Use                          | N   | Mean (std)     | p-value* |
|-----------------|---------------------------------------|-----|----------------|----------|
| Transplant      | DGF with early dialysis first week only† | 1576 | (40.7)        |          |
| hospitalization | DGF with early dialysis in 1 additional period‡ | 258 | (6.7)         |          |
|                 | No DGF but some dialysis†              | 127 | (3.3)         |          |
|                 | No DGF and no early dialysis†          | 98  | (2.5)         |          |
| 2002            | DGF with early dialysis first week only† | 1845 | (46.4)       | <0.0001 |
|                 | DGF with early dialysis in 1 additional period‡ | 227 | (5.7)     |          |
|                 | No DGF but some dialysis†              | 122 | (3.1)         |          |
|                 | No DGF and no early dialysis†          | 82  | (2.1)         |          |
| 2003            | DGF with early dialysis first week only† | 1436 | (43.7)       | <0.0001 |
|                 | DGF with early dialysis in 1 additional period‡ | 251 | (7.6)     |          |
|                 | No DGF but some dialysis†              | 81  | (2.5)         |          |
|                 | No DGF and no early dialysis†          | 110 | (3.4)         |          |
| 2004            | DGF with early dialysis first week only† | 2002 | (46.8)       | <0.0001 |
|                 | DGF with early dialysis in 1 additional period‡ | 223 | (8.8)     |          |
|                 | No DGF but some dialysis†              | 23.1 | (9.8)      |          |
|                 | No DGF and no early dialysis†          | 19.5 | (8.5)        |          |
| Cold-time( hours) | Mean(Std) | Mean(Std) | Mean(Std) | Mean(Std) |
|                 | 20.5 (6.6) | 22.3 (8.6) | 23.1 (9.8) | 19.5 (8.5) |

Table 2: Average accumulated costs for transplant hospitalization and care over 1, 2, and 3 years post transplant among Medicare-insured renal recipients from 1995-2004 according to early post transplant dialysis utilization (US dollars).
Variable

| Variable | Transplant hospitalization | One year post transplant | Two years post transplant | Three years post transplant |
|----------|---------------------------|--------------------------|--------------------------|---------------------------|
| Base Cost (Intercept) | 33173 (31410 to 34936) | 57337 (52327 to 62346) | 66255 (59137 to 73373) | 76000 (66675 to 85326) |
| DGF with early dialysis in first week only | 2727 (2323 to 3131) | 6476 (5299 to 7652) | 7246 (5537 to 8954) | 8742 (6456 to 11029) |
| DGF and early dialysis in 1 additional period | 1219 (449 to 1997) | 17070 (14777 to 21295) | 18036 (14777 to 21295) | 21481 (17107 to 25855) |
| DGF and early dialysis in >1 additional period | 2461 (1379 to 3544) | 27606 (24497 to 30716) | 33675 (29221 to 38129) | 39855 (33856 to 45855) |
| No DGF but some early dialysis | 1762 (868 to 2657) | 20013 (17448 to 22578) | 21984 (18408 to 25560) | 24846 (20265 to 29426) |

Recipient characteristics

| Variable | Reference | Reference | Reference | Reference |
|----------|-----------|-----------|-----------|-----------|
| Female | -226 (-599 to 146) | -93 (-1168 to 983) | 1207 (-334 to 2748) | 3086 (1053 to 5120) |
| Race | 1318 (879 to 1757) | 1969 (690 to 3249) | 4532 (2691 to 6734) | 7543 (5112 to 9974) |
| Age (years) | 18-30 | Reference | Reference | Reference |
| BMI category (kg/m²) | < 10 or Missing | -289 (-769 to 191) | 13 (-1358 to 1385) | 474 (-1462 to 2411) |
| Primary cause of ESRD | Diabetes mellitus | 2535 (1910 to 3160) | 13085 (11248 to 14923) | 22012 (19388 to 24636) |
| Hypertension | 1343 (706 to 1980) | 1343 (706 to 1980) | 1343 (706 to 1980) | 1343 (706 to 1980) |
| Glomerulonephritis | -480 (-1125 to 164) | -4148 (-6054 to -2241) | -5515 (-8233 to -2798) | -7745 (-11317 to -4173) |
| Polycystic kidney disease | 126 (-704 to 956) | -3593 (-6024 to -1161) | -5395 (-8838 to -1908) | -9005 (-13620 to -4389) |
| Other | 1385 (672 to 2098) | 577 (-1525 to 2680) | 1267 (-1752 to 4286) | 846 (-3120 to 4812) |
| Hispanic | 1385 (672 to 2098) | 577 (-1525 to 2680) | 1267 (-1752 to 4286) | 846 (-3120 to 4812) |
| Peripheral vascular disease | 233 (668 to 1133) | 6601 (4026 to 9176) | 11829 (8152 to 15505) | 14462 (9646 to 19278) |

Pre-Transplant Dialysis

| Variable | Reference | Reference | Reference | Reference |
|----------|-----------|-----------|-----------|-----------|
| Donor Characteristics | Female | -392 (-767 to -18) | -402 (-1487 to 683) | -229 (-1787 to 1329) |
| Race | 698 (143 to 1253) | 2977 (1368 to 4585) | 4979 (2681 to 7298) | 8448 (5370 to 11527) |
| Age (years) | < 18 | 125 (-436 to 686) | 561 (-1051 to 2172) | 742 (-1549 to 3032) |
| Death due to stroke | 361 (-73 to 795) | 2443 (1184 to 5417) | 3855 (795 to 6921) | 4895 (885 to 904) |
| Terminal Creatinine ≥ 1.5mg/dl | 967 (458 to 1477) | 586 (-891 to 2063) | 1036 (-1089 to 3161) | 1796 (-1008 to 4600) |
| Hypertension history | 609 (79 to 1139) | 2759 (1218 to 4300) | 4005 (1774 to 6236) | 5767 (2603 to 8732) |

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Dialysis utilization (p<0.0001), being best in those with no early follow-up points.

Patients without dialysis requirements had the shortest length of stay, lowest serum creatinine, and highest eGFR at all time periods. Patients without dialysis requirements had the lowest rejection (1.9%, 3 years post-transplant (12.5% and 14.5%, respectively) while those with no early dialysis utilization consistently had the lowest rejection (1.9%, 4.0%, and 5.1% at one, two, and three years). The intensity of dialysis was correlated with length of hospital stay, serum creatinine, and eGFR at all time periods. Patients without dialysis requirements had the shortest length of stay, lowest serum creatinine, and highest eGFR at all follow-up points.

Graft survival varied significantly based on post-transplant dialysis utilization (p<0.0001), being best in those with no early dialysis utilization and worst in those with DGF and dialysis in >2 subsequent periods (Figure 1A). Patterns were similar for patient survival, such that patients with DGF and dialysis in >2 early periods had approximately 10% lower survival by one year post-transplant compared to no early dialysis utilization (Table 5). After adjusting for recipient, donor, and transplant characteristics, post-transplant dialysis utilization was associated with lower graft and patient survival compared to no early dialysis utilization (Table 5).

Table 3: Multivariate regression estimates of adjusted cost drivers at transplant hospitalization and one, two, and three years in Medicare-insured transplant recipients from 1995–2004 (in US dollars).

**Diabetes**

-123 (-1050 to 804) 376 (-2326 to 3079) 1825 (-2180 to 5831) 4006 (-1447 to 9460)

**Transplant Factors**

**Donor Type**

| SCG | Reference | Reference | Reference | Reference |
|-----|-----------|-----------|-----------|-----------|
| ECD | 750 (-98 to 1598) | 2069 (-401 to 4538) | 3147 (-418 to 6711) | 4494 (-247 to 9235) |
| DCD | 1969 (831 to 3107) | 4453 (947 to 7959) | 5079 (-328 to 1048) | 4293 (-3404 to 1189) |

**Peak Panel Reactive Antibody (%)**

0-10 776 (197 to 1355) | 2547 (889 to 4205) | 3842 (1494 to 6190) | 4924 (1875 to 7972) |

11-30 Reference Reference Reference Reference

>30 2026 (1487 to 2566) | 6482 (4927 to 8037) | 10917 (8684 to 13149) | 12567 (9614 to 15520) |

Unknown 2950 (2054 to 3847) | 7985 (4395 to 11576) | 8113 (750 to 11476) | 4231 (-2866 to 11328) |

**HLA Mismatches**

0 Reference Reference Reference Reference

1 404 (-508 to 1316) | 452 (-2161 to 3065) | -196 (-3910 to 3517) | 2010 (-2888 to 6908) |

2 -326 (-1126 to 474) | 684 (-1608 to 2976) | 1147 (-2123 to 4417) | 1799 (-2517 to 6116) |

3 -387 (-1097 to 322) | 1106 (-944 to 3155) | 2319 (-620 to 5258) | 2181 (-1708 to 6067) |

4 391 (-308 to 1089) | 2600 (573 to 4628) | 3901 (379 to 6824) | 4697 (819 to 8576) |

5 976 (243 to 1709) | 5996 (3822 to 8080) | 8719 (5628 to 11810) | 10145 (6035 to 14254) |

6 1608 (711 to 2502) | 6829 (4229 to 9429) | 8405 (4633 to 12178) | 10601 (5541 to 15660) |

Unknown 2502 (1163 to 3842) | 7659 (3831 to 11487) | 13312 (7932 to 18691) | 16293 (9370 to 23217) |

**CMV sero-pairing**

Donor / Recipient - Reference Reference Reference Reference

Donor / Recipient + -325 (-961 to 706) | 6119 (4209 to 8029) | 8062 (5332 to 10792) | 10371 (6784 to 13959) |

Donor + / Recipient - 43 (-621 to 706) | 6119 (4209 to 8029) | 8062 (5332 to 10792) | 10371 (6784 to 13959) |

Donor - / Recipient + -325 (-961 to 706) | 6119 (4209 to 8029) | 8062 (5332 to 10792) | 10371 (6784 to 13959) |

Donor - / Recipient - Reference Reference Reference Reference

**Cold time (hours)**

0 - 14 Reference Reference Reference Reference

15 - 19 -325 (-817 to 167) | -1125 (-2553 to 303) | -1584 (-3637 to 469) | -794 (-3513 to 1924) |

20 - 25 890 (386 to 1394) | 648 (-810 to 2106) | 704 (-1389 to 2797) | 817 (-2143 to 3377) |

26+ 4037 (3501 to 4573) | 5325 (3784 to 6865) | 5649 (3455 to 7844) | 4429 (1550 to 7308) |

Unknown 2978 (2319 to 3637) | 5036 (3103 to 6970) | 4750 (1896 to 7605) | 8270 (2359 to 10181) |

**Year**

1995 Reference Reference Reference Reference

1996 -1458 (-2262 to -654) | -2277 (-4502 to -53) | -1673 (-4868 to 1338) | -1819 (-5519 to 1882) |

1997 -4418 (-5192 to -3643) | -6521 (-8684 to -4379) | -8239 (-1114 to -5336) | -9645 (-13213 to -6077) |

1998 -5952 (-6736 to -5168) | -11433 (-13602 to -9264) | -12815 (-15755 to -9675) | -13715 (-17332 to -10098) |

1999 -7277 (-8068 to -6485) | -13947 (-16138 to -11757) | -14616 (-17598 to -11647) | -15831 (-19488 to -12173) |

2000 -8297 (-9093 to -7500) | -11218 (-13426 to -9010) | -10232 (-13321 to -7233) | -10798 (-14500 to -7096) |

2001 -9399 (-10188 to -8609) | -13744 (-15932 to -11555) | -14396 (-17371 to -11421) | -15758 (-19434 to -12081) |

2002 -11555 (-13248 to -10761) | -18870 (-21070 to -16670) | -19225 (-22216 to -16233) | - |

2003 -13837 (-14632 to -13043) | -23061 (-25267 to -20854) | 12991 (3764 to 22219) | - |

2004 -15699 (-16600 to -14798) | 15414 (3619 to 27208) | -7226 (-23593 to 9140) | - |

Costs adjusted to 2004 as the base year

*Coefficient Estimates (95% CI).

*P-value < 0.05.

*Periods of early dialysis were first week, the second week, weeks 3 or 4, the second month and the third month post-transplant.

Table 3: Multivariate regression estimates of adjusted cost drivers at transplant hospitalization and one, two, and three years in Medicare-insured transplant recipients from 1995–2004 (in US dollars).
Discussion

Our study examined the cost of care for the transplant hospitalization and at one, two, and three years post transplant for adult Medicare recipients of deceased donor kidneys in 1995 to 2004 in the United States. We assessed the implications of dialysis utilization early after transplant. A major observation was that patients who receive early post-transplant dialysis are not a homogenous group with respect to costs of care and clinical outcomes. Patients experiencing DGF incurred an additional $1,200 to $2,700 in adjusted costs during the transplant hospitalization. By one year after transplant, there was a graded increase in the incremental cost of care according to the duration of early dialysis utilization, ranging from $6,500 in those with dialysis confined to the first week to $27,600 in those with DGF and dialysis in >2 additional early periods.

In addition to increased cost, dialysis utilization in the first 90 days post transplant is also a marker for poorer clinical outcomes including higher serum creatinine, lower eGFR and longer length of stay. Patients who require dialysis also have more common rejection in the 3 years post transplant, especially those with sustained early dialysis utilization. They also experience worse graft and patient survival. Our results are similar to those of Humar et al. [21,22] who found that both DGF and slow graft function (SGF) are associated with higher acute rejection rates and worse graft survival [21].

Our results show that not only is dialysis in the first week post-transplant a marker for worse clinical and cost outcomes but that early dialysis in the first 8 to 90 days is associated with similarly adverse, if not worse, outcomes. This observation supports a need for a broader definition of DGF that includes graft dysfunction which occurs after the first week post transplant. Some studies have explored the concept of SGF in terms of serum creatinine levels in patients who do not require dialysis, but thresholds of elevated creatinine varied across studies [21-23]. Further, most of these definitions consider function only within the first week post-transplant. The need for dialysis beyond the first week, yet still early after transplant needs to be considered. Definitions of DGF and SGF severity that reflect the amount and frequency of early post-transplant dialysis should be formalized. Prospective studies considering eGFR levels and the amount and frequency of dialysis requirements in relation to outcomes are warranted.

In recent years UNOS has been encouraging the utilization of ECD and DCD kidneys in order to increase the donor supply [24]. While these allografts may remove patients from the wait-list faster than waiting for an SCD kidney, the organs come with additional risk. While these allografts may remove patients from the wait-list faster than waiting for an SCD kidney, the organs come with additional risk. This includes an increased risk of DGF and graft failure compared to SCD kidneys [23,25]. These outcomes often lead to more frequent and longer hospitalizations which increase the cost of care [16,25]. Merion et al. [26] suggested that given these increased risks, the use of ECD kidneys should be targeted at specific recipient groups including older patients, those with diabetes, and patients who live in areas with very long waiting times.

A number of studies have demonstrated strong associations of...
### Variable | Odds Ratio | 95% CI | Odds Ratio | 95% CI
--- | --- | --- | --- | ---
**Patient Death**<br>DGF with early dialysis in first week only | 1.24 | (1.17 to 1.32)* | 1.24 | (1.18 to 1.3) *
DGF and early dialysis in 1 additional period* | 1.60 | (1.45 to 1.78) * | 1.66 | (1.53 to 1.8) *
DGF and early dialysis in >1 additional periods* | 2.08 | (1.83 to 2.36) * | 2.23 | (2.02 to 2.47) *
No DGF but some early dialysis* | 1.61 | (1.44 to 1.8) * | 1.54 | (1.41 to 1.69) *
No DGF and no early dialysis | Reference | Reference | Reference | Reference

**Graft Failure**

**Recipient characteristics**

**Female** | 0.92 | (0.87 to 0.97) * | 0.91 | (0.87 to 0.95) *
**Race**
African American | 0.94 | (0.88 to 1.01) * | 1.27 | (1.21 to 1.33) *
White | Reference | Reference | Reference | Reference
Other | 0.70 | (0.61 to 0.8) * | 0.79 | (0.71 to 0.88) *

**Age (years)**
18-30 | Reference | Reference | Reference | Reference
31-44 | 1.41 | (1.21 to 1.63) * | 0.86 | (0.8 to 0.94) *
45-59 | 2.17 | (1.88 to 2.5) * | 0.86 | (0.79 to 0.93) *
≥ 60 | 3.38 | (2.93 to 3.89) * | 1.06 | (0.98 to 1.16) *

**BMI category (kg/m²)**
< 10 or Missing | 1.01 | (0.95 to 1.08) | 1.04 | (0.99 to 1.1) |
> 10 to <25 | Reference | Reference | Reference | Reference
> 25 to <30 | 0.91 | (0.85 to 0.98) * | 0.95 | (0.9 to 1.01) |
≥ 30 | 1.02 | (0.94 to 1.11) | 1.09 | (1.02 to 1.16) *

**Primary cause of ESRD**
Diabetes mellitus | 1.55 | (1.41 to 1.7) * | 1.19 | (1.1 to 1.28) *
Hypertension | 1.05 | (0.95 to 1.16) | 1.07 | (0.99 to 1.15) |
Glomerulonephritis | 0.81 | (0.73 to 0.9) * | 0.90 | (0.83 to 0.98) *
Poly cystic kidney disease | 0.66 | (0.58 to 0.76) * | 0.70 | (0.63 to 0.78) *
Other | Reference | Reference | Reference | Reference
Unknown | 1.00 | (0.89 to 1.12) | 1.02 | (0.93 to 1.11) |
Hispanic | 1.49 | (1.36 to 1.63) * | 1.24 | (1.16 to 1.33) *
Peripheral vascular disease | 1.32 | (1.19 to 1.46) * | 1.24 | (1.13 to 1.36) *

**Pre-Transplant Dialysis**
None (pre-emptive) | 0.96 | (0.84 to 1.11) | 0.92 | (0.83 to 1.03) |
0-12 months | Reference | Reference | Reference | Reference
13-24 months | 1.02 | (0.92 to 1.14) | 1.00 | (0.92 to 1.08) |
25-60 months | 1.00 | (0.92 to 1.1) | 0.94 | (0.87 to 1.01) |
≥ 60 months | 1.15 | (1.03 to 1.28) * | 1.00 | (0.92 to 1.09) |

**Donor Characteristics**
Female | 1.03 | (0.98 to 1.09) | 1.08 | (1.04 to 1.13) *
Race
African American | 1.08 | (0.99 to 1.17) | 1.18 | (1.11 to 1.26) *
White | Reference | Reference | Reference | Reference
Other | 0.98 | (0.84 to 1.14) | 1.00 | (0.89 to 1.13) |

**Age (years)**
< 18 | 1.03 | (0.94 to 1.12) | 1.03 | (0.96 to 1.1) |
18-30 | Reference | Reference | Reference | Reference
31-44 | 1.05 | (0.97 to 1.13) | 1.10 | (1.03 to 1.17) *
45-59 | 1.17 | (1.07 to 1.26) * | 1.25 | (1.17 to 1.34) *
≥ 60 | 1.19 | (1.04 to 1.36) * | 1.44 | (1.29 to 1.6) *

**BMI category (kg/m²)**
< 10 or Missing | 0.97 | (0.86 to 1.1) | 1.01 | (0.91 to 1.11) |
> 10 to <25 | Reference | Reference | Reference | Reference
> 25 to <30 | 0.94 | (0.88 to 1) | 0.95 | (0.9 to 1) |
≥ 30 | 1.01 | (0.94 to 1.09) | 0.95 | (0.9 to 1.01) |
Death due to stroke | 1.09 | (1.02 to 1.16) * | 1.11 | (1.05 to 1.17) *
Terminal Creatinine ≥ 1.5mg/dl | 0.94 | (0.87 to 1.01) | 1.01 | (0.96 to 1.08) |
Hypertension history | 1.02 | (0.95 to 1.1) | 1.06 | (1 to 1.13) *
Diabetes | 1.14 | (1 to 1.29) * | 1.16 | (1.04 to 1.28) *
non-standard deceased-donor organs with increased need for early
dialysis after transplant [25,27,28]. For example, one large registry
study documented DGF in over 42% of DCD transplants in recent
US practice [28]. Another large registry study found DGF occurred
in 31% of ECD recipients, compared to 19% in non-ECD recipients
[29]. Thus, use of these organs is expected to increase expenditures
based on increased risk of early dialysis requirements. Further, we
also detected associations of DCD kidneys with significant increase in
cost even after adjusting for early post-transplant dialysis utilization.
ECD kidneys were associated with a trend towards higher incremental
costs after adjusting for early post-transplant dialysis utilization and
other covariates. This can have a detrimental effect on the finances
of a transplant center, as marginal organs are being used more often
and kidney transplantation is reimbursed by Medicare at a fixed rate,
regardless of the kidney quality or patient comorbidity [30-32].

Our results also support those of Englesbe et al. [6] who showed
that ECD transplants and cases of DGF are associated with a decrease
in their institution’s profit margin as well as an increase in cost and
decrease in Medicare reimbursement over time [6]. We not only found
early post transplant dialysis utilization to be costly, but also found
that Medicare is paying less per transplant per year. Total payments
have been decreasing at a rate of over $1,500 a year. Compared to 1995
Medicare reimbursed almost $16,000 less per transplant in 2004. These
results suggest there will be an increasing burden on transplant centers
which utilize organs associated with early post transplant dialysis
requirements to expand the organ supply.

ECDs and DCDs kidneys have been shown to be associated with
an increased risk of DGF, which in turn is associated with increased

| Transplant Factors                  |                      |                      |
|-------------------------------------|----------------------|----------------------|
| Donor Type                          | SCD                  | ECD                  |
|                                     | (1.06 to 1.33) *     | (1.01 to 1.2) *      |
|                                     | (1.07 to 1.3)        | (0.87 to 1.19)       |
| Peak Panel Reactive Antibody (%)    | 0-10                 | 11-30                |
|                                     | (0.94 to 1.1)        | (1 to 1.14)          |
|                                     | >30                  | (1.1 to 1.28) *      |
|                                     | (1.15 to 1.3) *      |
|                                     | Unknown              | (1.01 to 1.42) *     |
|                                     | (0.95 to 1.26)       |
| HLA Mismatches                      | 0                    | Reference            |
|                                     | 1.09                 | 1.08                 |
|                                     | (0.96 to 1.25)       | (0.97 to 1.22)       |
|                                     | 1.10                 | 1.18                 |
|                                     | (0.97 to 1.23)       | (1.07 to 1.3) *      |
|                                     | 1.16                 | 1.22                 |
|                                     | (1.04 to 1.29) *     | (1.11 to 1.33) *     |
|                                     | 1.18                 | 1.30                 |
|                                     | (1.06 to 1.32) *     | (1.19 to 1.42) *     |
|                                     | 1.21                 | 1.29                 |
|                                     | (1.08 to 1.35) *     | (1.17 to 1.41) *     |
|                                     | 1.22                 | 1.34                 |
|                                     | (1.06 to 1.4) *      | (1.2 to 1.5) *       |
|                                     | Unknown              | 1.27                 |
|                                     | (1 to 1.45) *        | (1.09 to 1.47) *     |
| CMV sero-pairing                    | Donor - / Recipient -| Reference            |
|                                     | 1.15                 | 1.12                 |
|                                     | (1.04 to 1.27) *     | (1.03 to 1.21) *     |
|                                     | 1.27                 | 1.24                 |
|                                     | (1.15 to 1.42) *     | (1.14 to 1.35) *     |
|                                     | 1.23                 | 1.16                 |
|                                     | (1.11 to 1.35) *     | (1.08 to 1.25) *     |
|                                     | 1.21                 | 1.17                 |
|                                     | (1.07 to 1.36) *     | (1.06 to 1.28) *     |
| Cold time (hours)                   | 0 - 14               | Reference            |
|                                     | 0.99                 | 1.02                 |
|                                     | (0.92 to 1.07)       | (0.96 to 1.08)       |
|                                     | 1.07                 | 1.11                 |
|                                     | (1 to 1.16)          | (1.05 to 1.18) *     |
|                                     | 1.05                 | 1.07                 |
|                                     | (0.97 to 1.13)       | (1.01 to 1.14) *     |
|                                     | Unknown              | 1.03                 |
|                                     | (0.9 to 1.13)        | (0.95 to 1.13)       |
| Year                                | 1995                 | Reference            |
|                                     | 0.94                 | 0.94                 |
|                                     | (0.85 to 1.03)       | (0.87 to 1.02)       |
|                                     | 0.99                 | 0.95                 |
|                                     | (0.9 to 1.09)        | (0.88 to 1.02)       |
|                                     | 1.01                 | 0.95                 |
|                                     | (0.91 to 1.11)       | (0.88 to 1.02)       |
|                                     | 0.99                 | 0.92                 |
|                                     | (0.89 to 1.1)        | (0.85 to 1)          |
|                                     | 1.09                 | 1.02                 |
|                                     | (0.97 to 1.21)       | (0.94 to 1.11)       |
|                                     | 1.04                 | 0.92                 |
|                                     | (0.92 to 1.17)       | (0.84 to 1.01)       |
|                                     | 0.96                 | 0.96                 |
|                                     | (0.83 to 1)          | (0.86 to 1.06)       |
|                                     | 0.96                 | 0.90                 |
|                                     | (0.82 to 1.14)       | (0.79 to 1.03)       |
|                                     | 0.92                 | 0.90                 |
|                                     | (0.7 to 1.22)        | (0.73 to 1.12)       |

* P-value < 0.05
† Periods of early dialysis were first week, the second week, weeks 3 or 4, the second month and the third month post-transplant
that patients who died or lost their graft and may have had worse renal function are not represented. Finally not all transplant centers submit separate charges to Medicare for dialysis that occurs in the first week post transplant as some bundle inpatient dialysis charges with the transplant hospitalization charge. Thus we were unable to determine how many sessions of dialysis and how frequently the sessions were occurring for the recipients who experienced DGF. Redefining how DGF is reported to the OPTN can allow for a more detailed study of DGF.

In summary, we found that Medicare is paying less each year for a transplant even as more marginal kidneys are being used to increase the donor supply. These marginal kidneys have an increase rate of DGF and dialysis initiated after the first post transplant week. DGF and additional early post-transplant early dialysis are costly at the time of transplant and result in higher longterm costs. In order to reduce the economic disincentive to use marginal kidneys, Medicare should consider reimbursement rates based on organ quality.

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Figure 1: Graft and patient survival of Medicare-insured renal transplant recipients in the USRDS 1995-2004 according to early post-transplant dialysis utilization.

Figure 1: Graft and patient survival of Medicare-insured renal transplant recipients in the USRDS 1995-2004 according to early post-transplant dialysis utilization.
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