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Assessment of risk factors for increased resource utilization in kidney transplantation

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Abstract

Background—There are only a limited number of studies that have sought to identify patients at high risk for medication errors and subsequent adverse clinical outcomes. This study sought to identify risk factors for increased health care resource utilization in kidney transplant recipients based on drug-related problems and self-administered surveys.

Methods—In this prospective observational study, adult kidney transplant recipients seen in the transplant clinic between September and November 2015 were surveyed for self-reported demographics, medication adherence, and health status/outlook. Subsequently, patients were assessed for associations between survey results, pharmacist-derived drug-related problems, and health resource utilization over a minimum 6-mo follow-up period. Based on univariate associations, two risk cohorts were identified and compared for health care utilization using multivariable Poisson regression.

Results—A total of 237 patients were included, with a mean follow-up of 8 mo. From the patient survey data, Medicaid insured or self-rated poor health status were identified as a significant risk cohort. From pharmacist assessments, those who received incorrect medication or lacked appropriate follow-up medication monitoring were identified as a significant risk cohort (pharmacy errors). The Medicaid insured or self-rated poor health status cohort experienced 43% more total health care encounters (incident rate ratios [IRR] 1.43, 1.01–2.02) and 35% more transplant clinic visits (IRR 1.35, 1.03–1.77). The pharmacy errors cohort experienced 4.2 times the rate of total health care encounters (IRR 4.17, 1.55–11.2), 4.1 times the rate of hospital

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readmissions (IRR 4.09, 1.58–10.6), and 2.3 times the rate of transplant clinic visits (IRR 2.31, 1.04–5.11).

Conclusions—Medicaid insurance, self-rated poor health status, and errors in the medication regimen or monitoring were significant risk factors for increased health care utilization in kidney transplant recipients. Further research is warranted to validate these potential risk factors, determine the long-term impact on graft/patient survival, and assess the mutability of these risks through prospective identification and intervention.

Keywords

Kidney transplantation; Risk factors; Outcomes; Health care utilization; Clinical tool

Introduction

Long-term care after kidney transplantation is complex and can lead to suboptimal outcomes. The management of multiple comorbidities, coupled with extensive medication regimens, and intensive follow-up care are substantial challenges in this population.^{1,2} Medication-related problems (MRPs) are common among kidney recipients. Based on a recent study, over half of kidney transplant recipients experienced at least one medication error (ME) and three-quarter experienced at least one adverse drug reaction.³ In spite of this, there is limited literature regarding risk factors and outcomes associated with MRPs in kidney transplant recipients.^{4,5}

Extensive health care system utilization has been documented among kidney transplant patients after transplant. Literature demonstrates that nearly one-third of transplant patients are admitted within 30 d of discharge.⁶ By 3 y post-transplant, more than three-quarter of transplant patients are readmitted at least once.⁷ Emergency department (ED) visits are also a common occurrence among kidney transplant recipients.⁸ Outside of the hospital setting, extensive outpatient clinic visits have been documented across a variety of sub-specialties.⁷ Generally speaking, health care encounters are costly and present risk for deleterious outcomes, especially among immunosuppressed patients.⁹

Although research has identified numerous patient and care factors that are predictive of outcomes after transplant, there are limited studies that seek to identify patients at high risk of MEs and subsequent adverse clinical outcomes. We previously developed a predictive model for MRPs, composed of nine patient-reported variables. This model includes factors pertaining to insurance coverage, medication access, medication understanding, perceived medication impact on daily function, and health status.¹⁰ The model was reasonably predictive of MRPs, as identified by a blinded pharmacist and may potentially serve as a tool for managing patient care in the clinic. Given the predictive value of the patient self-report survey in discerning which patients are at greater risk for MRPs, the goals of this follow-up study were to comprehensively capture health care utilization in this patient population and determine if a correlation between patient self-report, pharmacist-determined risk factors, and health care utilization exists. We hypothesized that there are patient-reported and pharmacist-determined factors that significantly predict health care utilization in kidney transplant recipients.

Materials and methods

Study design and patients

This study was a prospective observational cohort study. Patients aged >18 y who visited the chronic renal transplant clinic and spoke with a transplant pharmacist were eligible to participate and complete the initial survey. Patients who received multi-organ transplants were included in the study. Patients were verbally consented and given the self-administered survey during their visit which occurred between September 16, 2015, and November 30, 2015. All patients who received the survey were at least 90 d posttransplantation. This visit was not included in the assessment of health care utilization. Subsequent to the completion of the survey, assessment of the pharmacist and transplant clinic visit, patients were monitored and all health care encounters were captured until June 28, 2016, the end date of the study. This study was approved by the local institutional review board.

Survey instrument

The self-administered patient surveys consisted of 24 multiple-choice and fill in the blank questions and took roughly 5 min to complete. Questions pertained to transplant information, baseline demographics, insurance information, health status/outlook, past medical history, and medication adherence. Survey variables were identified in the literature and adapted for use in this application. The medication adherence questions were adapted from the Morisky Medication Adherence Scale.¹¹ Surveys were completed in either paper form or electronically on iPads and responses were transferred or entered into a REDCap database for analysis. The full survey is available in the Supplemental Material section.

Pharmacist-determined risk factors

Before seeing the transplant physician, patients met with a transplant pharmacist who conducted a blinded medication history assessment during the patient's routine clinic visit to identify drug-related problems (DRPs). Assessed DRPs included nonadherence, over- or under-dosing, duplication of therapy, preventable of adverse drug reaction, medication omissions, erroneous medication, conflicting provider information, under or lack of monitoring, and wrong medication received. These DRPs were adapted and standardized from a comprehensive literature review as detailed by Covert *et al.*¹²

Health care utilization outcomes

Patient care records for study subjects were accessed for a minimum of 6 mo after survey completion using electronic medical records systems. Patient data were compiled systematically from provider notes, pathology reports, laboratory reports, and external records scanned into the health record system. Health care utilization data included hospital readmissions (number and admitting diagnosis), inpatient days, ED visits, ED diagnoses, outpatient transplant clinic visits (OTXP), and other outpatient clinic visits. In addition to health care utilization data, we collected clinical outcomes, including serum creatinine, estimated Glomerular Filtration Rate, graft loss, acute allograft rejection, and death.

Statistical analysis

Initially, we assessed univariate associations between patient-reported characteristics, pharmacist-derived DRPs, and health care utilization. This was done using the chi-square test for categorical data and bivariate correlation for continuous data (Pearson's r). This preliminary analysis revealed four variables that demonstrated associations with health care utilization ($P < 0.15$). Two variables, Medicaid insurance and poor health status rating, were derived from the patient survey, whereas the other variables, patient received the wrong medication from the pharmacy and under or lack of monitoring for medications or comorbidities, were derived from the DRP-pharmacist assessment. We used these four variables to develop two aggregate risk cohorts based on the preliminary analysis, one that was patient derived and one that was pharmacist derived. We then compared the risk cohorts to non-risk cohorts for baseline characteristics and health care utilization outcomes using univariate statistics including chi-square for categorical data and the Man- n -Whitney test for continuous or ordinal data.

Multivariable models were used (Poisson regression) to estimate incident rate ratios (IRRs), controlling for potential baseline confounders (age, gender, race diabetes, panel reactive antibody (PRA), human leukocyte antigen mismatches, cold ischemic time, dialysis, donor age, and donor type). To avoid overfitting our model and generating unstable estimates with wide variability, we had to restrict the number of variables selected for analysis. Knowing this, we chose covariates that have previously been demonstrated to impact post-transplant outcomes, including health care utilization, in kidney transplantation. Age, gender, and race are important baseline covariates to include in most models, as they are usually strongly associated with outcomes and can differ substantially by insurance status and medication use and/or access. Diabetes is a known risk factor for graft loss, death, and health care utilization. It is one of the most common and important risk factors in transplantation. PRA, human leukocyte antigen mismatches, cold ischemic time, dialysis use before transplant, and donor criteria (age and type) are also important baseline clinical transplant characteristics that influence the risk of acute rejection, graft function, graft loss, and health care utilization. Thus, we chose these variables based on empirical evidence from previous studies as well as our clinical judgment based on experience.

Fifteen models (three exposure variables for five independent outcomes) are presented in the results. Overdispersion was assessed and found not to be an issue (Deviance/df range: 0.447–1.384). Model fit of data was assessed using Akaike information criterion, which demonstrated stable and adequate data fit performance (Akaike information criterion range: 446.4–1578.2). Multicollinearity was also assessed and was not demonstrated to be an issue. If overdispersion was present based on model deviance, negative binomial regression was used in lieu of Poisson (total encounter rate, length of stay rate, outpatient transplant clinic visit rate, and other outpatient clinic visit rate). A two-sided P value of < 0.05 was considered statistical significant. All analyses were conducted using SAS version 9.4 (SAS Institute, Cary, NC).

Results

Baseline characteristics and patient survey results

A total of 237 patients transplanted between 1998 and 2015 were included in the study. The median age was 55 y, with 49% being female; 57% of patients were African American. A history of diabetes was present in 42% of patients, whereas a history of hypertension in 93% of patients. Most patients (76%) received deceased donor kidneys. Of the 237 patients included, 27% used Medicaid. The median follow-up time for this study was 7.8 ± 1.0 mo after enrollment. In total, 76% of respondents were unemployed, with 58% relying on Social Security Disability as their source of income; 41% of patients received a high school diploma or general education development, whereas 47% received a college degree or higher. With regard to health status, 78% of patients reported good, very good, or excellent health status. In addition, 84% reported complete medication adherence and 85% of patients reported good or very good medication understanding.

Risk cohorts

Initial analysis demonstrated that two patient-reported factors were found to be associated with increased health resource utilization: Medicaid-insured and self-rated poor health status. Because of small numbers, these were combined into one risk cohort (M/PHS). M/PHS baseline characteristics are displayed in Table 1. For the pharmacist-determined DRPs, those with an ME or under monitoring were associated with increased resource utilization, which were also combined into one risk cohort (pharmacy error [PE]). The PE cohort baseline characteristics are displayed in Table 2. African Americans comprised 76% of the M/PHS cohort and 100% of the PE cohort, while comprising only 50% and 56% of respective nonrisk cohorts. Living donor kidneys were transplanted into 4% of M/PHS patients and 0% of PE patients, compared with 17% and 14% in respective nonrisk cohorts. The proportion of patients receiving Social Security Disability did not vary significantly between PE and respective nonrisk cohorts, but did between M/PHS and respective nonrisk cohorts (55% and 28% respectively, $P < 0.0003$).

Health resource utilization

Total health care encounters (defined as days in hospital + ED visits + clinic visits) numbered 1499 during the follow-up period. In total, 61 of these encounters were hospital admissions, 47 were ED visits, 577 were transplant outpatient clinic visits, and 564 were other outpatient clinic visits. Among the 237 study patients with a total of 154 patient-years of follow-up, 311 d were spent in the hospital. Table 3 displays the health care utilization rates for the M/PHS cohort, and Table 4 displays the same rates for the PE cohort. The rates of total encounters for the M/PHS and PE cohorts were 11.4 and 34 total encounters per patient-year, respectively. These rates are significantly higher than total encounter rates for the nonrisk cohorts ($P = 0.0496$ and $P = 0.0195$, respectively). Both risk cohorts also experienced numerically higher hospital readmissions and length of stay (Figure). Table 5 displays the IRRs for health care encounters. The M/PHS cohort experienced a 43% larger total encounter rate per patient-year ($P < 0.05$), whereas the PE cohort experienced a 4.17 times greater total encounter rate per patient-year ($P < 0.05$). A composite cohort comprised of both M/PHS and PE experienced a 56% greater total encounter rate per patient-year ($P <$

0.05). Both the M/PHS and PE cohorts experienced greater OTXP rates. The M/PHS cohort experienced a 35% greater OTXP rate per patient-year ($P < 0.05$), whereas the PE cohort experienced a 2.31 times greater OTXP rate per patient-year ($P < 0.05$). The composite cohort experienced a 41% greater OTXP rate per patient-year ($P < 0.05$). The M/PHS cohort had a 31% greater hospital readmission rate per patient-year, the PE cohort had a 4.09 times greater hospital readmission rate per patient-year ($P < 0.05$), and the composite cohort had a 58% greater hospital readmission rate per patient-year ($P < 0.05$), compared with the nonrisk groups. Length of stay and other outpatient clinic visit rates were numerically higher in the risk cohort rates as well.

Discussion

The results of this prospective observational study demonstrate that patient variables derived from a self-administered survey and pharmacist assessment can be useful in predicting increased health care utilization rates in kidney transplant recipients. We identified two variables from both the patient survey and pharmacist-derived data that were associated with increased health care utilization rates. The Medicaid or poor health status cohort and PE cohort experienced higher rates of all measured health care utilization outcomes. Notably, the M/PHS cohort experienced a 43% greater total encounter rate and a 35% greater outpatient transplant clinic rate, per patient-year. Similarly, the PE cohort experienced four times the total encounter rate, four times the admission rate and over two times the outpatient transplant clinic rate, per patient-year.

High health care utilization rates for the kidney transplant recipient population, as a whole, are well documented in literature. In an analysis of 10,533 kidney transplant recipients, Schold *et al.* demonstrated that the median time to ED visit after transplantation was 19 mo with the estimated rate of ED visits within this population being 126.9 per 100 patient-years.⁸ In addition, 48% of these visits led to hospitalization. The authors also demonstrated that Medicaid patients experienced significantly increased rates of ED visits (IRR: 155.5; 95% confidence interval [CI] 150.7–160.2, $P < 0.001$). We did not find a significant difference in ED visits between Medicaid and non-Medicaid patients, but we did identify that Medicaid patients had significantly greater total encounter rates than non-Medicaid and ED visits did contribute to the total encounter computation.

MEs are also associated with increased health care utilization in transplantation. In one study, patients who had a documented ME were found to have more posttransplant readmissions ($P = 0.01$).³ MEs included patient-induced MEs, accessibility errors, prescription errors, and PEs. Our study found that the PE cohort experienced a significantly higher admission rate. Although our cohort does not include individuals that had accessibility errors, the association between MEs and hospital admissions is similar in both studies.

Covert *et al.* identified a number of risk factors that placed patients at higher risk for DRPs.¹⁰ Patients who experienced ≥ 6 DRPs after transplant were significantly more likely to be unemployed ($P = 0.007$) and report misunderstanding their medication regimen ($P = 0.032$). In addition, patients at greater risk for DRPs were more likely to have Medicare

insurance, a finding congruent with the associations within the ME group in Taber *et al.*³ In both studies, patients who were covered by private insurance were less likely to experience a DRP or ME.^{3,10} These trends were echoed in our results (Table 2). African Americans comprised 100% of the PE cohort in our study, compared with only 56% of the nonrisk cohort. This finding is not mirrored in the Covert *et al.* data, where percentage of African Americans in the ≥ 6 and <6 DRP cohorts does not vary significantly. Although our definition of PE is not as broad as the definition of DRP, this disparity in racial composition is noteworthy.

The ability to identify patients at risk for increased health care utilization is promising in efforts to mitigate health care expenditures and improve long-term outcomes. Patients identified as at increased risk can be more closely monitored to ensure that risks can be mitigated to the greatest extent possible, with the hope of reducing transplant follow-up complications. Technological advances in the field of tele-health are promising and could aid in the monitoring process of the patients identified at increased risk, but this still needs to be proven effective in prospective clinical trials. In addition, the survey tool could facilitate targeted patient education interactions that are tailored to the patient's understanding and current needs. Finally, if providers deem it necessary during their targeted interactions, social worker consultations could screen and assist at-risk patients for non-health care-related factors that could increase the risk for deleterious outcomes, including transportation issues and outside stressors. Future research should focus on identifying additional risk factors for health care utilization among kidney transplant recipients. Recent studies have identified risk factors for graft failure include extremes of age, high PRA, increasing body mass index, previous kidney transplant, dialysis at time of transplant, hepatitis C infection, and educational level.¹³ Adaptations can be made to the survey used in our study to reflect the aforementioned associations.

This study has a number of limitations. Patients included in the study were interviewed by one of number of pharmacists within the clinic depending on availability. Given this potential interviewer variability, all notes were reviewed and assessed by a single transplant pharmacist to eliminate any gross inconsistencies. The sample size of this study limited the number of meaningful cohorts that could be used for comparative purposes; thus, we created two aggregate risk groups, one using the patient self-identified factors and one using the pharmacist-identified medication issues. We were limited in the number of variables we could assess in our models given the relatively small sample size in this study. Including too many variables in the model would inevitably have led to overfitting and subsequent unstable estimates with large variation. We deliberately chose our covariates based on previously demonstrated empirical evidence and clinical judgment. As such, we were unable to assess for all potentially significant variables in this study. In addition, this study only assessed follow-up care within the MUSC Health network. We were unable to access utilization outside of the MUSC network, and therefore, no extra-network utilization was included in the analysis.

This study identified patient risk factors associated with increased health care utilization rates based on survey responses and pharmacist-derived assessments. These factors included Medicaid insurance, poor self-reported health status, MEs, and lack of proper follow-up

monitoring. These risk factors were associated with a 30%–400% increase in the rate of health care encounters during an 8-mo follow-up period and can potentially be used to identify high-risk patients in need of increased monitoring.

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References

1. Wu C, Evans I, Joseph R, et al. Comorbid conditions in kidney transplantation: association with graft and patient survival. *J Am Soc Nephrol*. 2005; 16:3437–3444. [PubMed: 16176999]
2. Siegal B, Greenstein SM. Profiles of noncompliance in patients with a functioning renal transplant: a multicenter study. Compliance Study Group. *Transplant Proc*. 1999; 31:1326–1327. [PubMed: 10083591]
3. Taber DJ, Spivey JR, Tsurutis VM, et al. Clinical and economic outcomes associated with medication errors in kidney transplantation. *Clin J Am Soc Nephrol*. 2014; 9:960–966. [PubMed: 24763866]
4. Friedman AL, Geoghegan SR, Sowers NM, Kulkarni S, Formica RN. Medication errors in the outpatient setting: classification and root cause analysis. *Arch Surg*. 2007; 142:278–283. [PubMed: 17372053]
5. Abbott KC, Viola RA, Agodoa LY. Hospitalized poisonings after renal transplantation in the United States. *BMC Nephrol*. 2002; 3:10. [PubMed: 12450414]
6. McAdams-DeMarco MA, Grams ME, Hall EC, Coresh J, Segev DL. Early hospital readmission after kidney transplantation: patient and center-level associations. *Am J Transplant*. 2012; 12:3283–3288. [PubMed: 23016838]
7. Khan S, Tighiouart H, Kalra A, Raman G, Rohrer RJ, Pereira BJ. Resource utilization among kidney transplant recipients. *Kidney Int*. 2003; 64:657–664. [PubMed: 12846763]
8. Schold JD, Elfadawy N, Buccini LD, et al. Emergency department visits after kidney transplantation. *Clin J Am Soc Nephrol*. 2016; 11:674–683. [PubMed: 27012951]
9. CDC. HAI data and statistics. Centers for disease control and prevention; 2016. Available at: <http://www.cdc.gov/hai/surveillance/> [Accessed September 1, 2016]
10. Covert KL, Mardis CR, Fleming JN, et al. Development of a predictive model for drug-related problems in kidney transplant recipients. *Pharmacotherapy*. 2017; 37:159–169. [PubMed: 27997676]
11. Morksy DE, Ang A, Krousel-Wood M, Ward HD. Predictive validity of a medication adherence measure in an outpatient setting. *J Clin Hypertens*. 2008; 10:348–354.
12. Basger BJ, Moles RJ, Chen TF. Development of an aggregated system for classifying causes of drug-related problems. *Ann Pharmacother*. 2015; 49:405–418. [PubMed: 25614526]
13. Molmenti EP, Alex A, Rosen L, et al. Recipient criteria predictive of graft failure in kidney transplantation. *Int J Angiol*. 2016; 25:29–38. [PubMed: 26900309]

Appendix

Research Study Number: _____, Kidney Transplant Clinic Questionnaire.

You are being invited to participate in a research study. The purpose of this study is to develop a tool that will identify kidney transplant patients who would benefit the most from being seen by a transplant pharmacist at their clinic visits. If you agree to participate, we would like you to fill out the survey below, which will take approximately 5 to 10 minutes to complete. We will review your medical record for additional information about your transplant. You may skip any question you choose not to answer. This survey is confidential and will not be distributed to anyone within the institution. If you have any questions regarding the study, please contact Kelly Covert, PharmD (covert@muscle.edu) or Caitlin Mardis, PharmD (musgrave@muscle.edu).

Baseline Demographics

- 1 Age: _____
- 2 Race (may circle one or more of the following):
 - A. Asian
 - B. Black or African American
 - C. White
 - D. Other (American Indian or Alaska Native, Native Hawaiian or Other Pacific Islander, or other): _____
- 3 Ethnicity
 - A. Hispanic or Latino
 - B. Not Hispanic or Latino
- 4 Are you currently employed?
 - A. Yes
 - B. No
- 5 Highest level of education obtained:
 - A. Did not complete high school
 - B. High school diploma/GED
 - C. College or higher degree
- 6 Source of income (circle all that apply):
 - A. Currently employed
 - B. Disability
 - C. Retirement

- D.** Spouse
- E.** Other: _____
- 7** Prescription insurance (circle all that apply):
- A.** Medicare
- B.** Medicaid
- C.** Private (insurance paid for you or by your employer)
- 8** Do you use a coupon card or a discounted copay in order to pay for your medicines?
- A.** Yes
- B.** No
- 9** What year did you receive your transplant? _____
- 10** How would you rate your current health status?
- A.** Excellent
- B.** Very good
- C.** Good
- D.** Fair
- E.** Poor
- 11** How many medicines do you take each day?
- A.** 2–4
- B.** 5–7
- C.** 8–10
- D.** More than 10

Diabetes Questions

- 12** Did you have diabetes prior to your transplant?
- A.** Yes, and I used insulin
- B.** Yes, and I used oral medications
- C.** Yes, and I used both insulin and oral medications
- D.** Yes, but it was controlled without medication
- E.** No
- 13** Do you currently use insulin or medications to help control your blood sugars?
- A.** Yes, and I use insulin

- B. Yes, and I use oral medications
- C. Yes, and I use both insulin and oral medications
- D. No

Hypertension Questions

- 14 Do you have a history of high blood pressure?
- A. Yes
 - B. No
- 15 How many medications do you take to control your blood pressure?
- A. 0
 - B. 1
 - C. 2
 - D. 3
 - E. 4
 - F. 5
 - G. 6 or more

Adherence Questions

- 16 In an average week, how many times do you miss a dose of a scheduled medication?
- A. Never
 - B. 1–2 times weekly
 - C. 3–4 times weekly
 - D. 5–6 times weekly
 - E. More than 7 times weekly
- 17 Are there times when you cannot afford your medications?
- A. Yes
 - B. No
- 18 Do you sometimes have difficulty obtaining medicines from the pharmacy (due to transportation issues, lack of refills, or other causes)?
- A. Yes
 - B. No
- 19 How well do you understand what your medications are for?

- A.** Not well
- B.** Moderately well
- C.** Well
- D.** Very well
- 20** How confident are you in managing your transplant medications?
- A.** Not confident
- B.** Moderately confident
- C.** Confident
- D.** Very confident
- 21** Does a friend or family member help you manage your medicines?
- A.** Yes
- B.** No
- 22** Do you have difficulty reading or understanding instructions on your medicines?
- A.** Yes
- B.** No
- 23** How many times per day do you take medicines?
- A.** 2 times
- B.** 3 times
- C.** 4 times
- D.** 5 or more times per day
- 24** Does taking your medications prevent you from doing the things you want to do in life (circle all that apply)?
- A.** Yes, the number of medications I have to take throughout the day makes it hard to leave the house.
- B.** Yes, the cost of my medications prevents me from spending money on other things.
- C.** Yes, my medications make me feel poorly.
- D.** No

Figure. Health care utilization rates for M/PHS and PE cohorts compared with respective nonrisk cohorts. (Color version of figure is available online.)

Table 1

Baseline characteristics for Medicaid/poor health status and nonrisk cohorts.

Baseline characteristics	Nonrisk (<i>n</i> = 171)	Medicaid or poor health status (<i>n</i> = 66)	<i>P</i> value
Median transplant year	2013 (2010, 2014)	2013 (2011, 2014)	0.2071
Median age (IQR)	59 (50, 67)	51 (40, 62)	0.0078
Female gender	49%	50%	0.8401
Race/ethnicity			
African American	50%	76%	0.0003
Hispanic	0.58%	0%	0.5336
Employment			
Working	24%	11%	0.0305
Social security/disability	28%	55%	0.0003
Education			0.7780
Below high school/GED	7%	18%	
High school/GED	43%	36%	
College or higher	47%	44%	
Health insurance			
Medicare	71%	82%	0.0983
Medicaid	0%	99%	<0.0001
Patient Assistance Program	19%	18%	0.9248
Health status			0.1142
Excellent	11%	12%	
Very good	32%	35%	
Good	40%	32%	
Fair	18%	17%	
Poor	0%	5%	
Comorbidities			
History of diabetes	43%	44%	0.6659
History of hypertension	93%	94%	0.7924
Immunologic factors			
Calculated PRA	3 (0, 44)	3.5 (0, 52)	0.2137
HLA mismatched	4 (3, 5)	4 (4, 5)	0.1769
Cold ischemic time (h)	14 (7, 22)	16.5 (12, 24)	0.0492
Warm ischemic time (min)	35 (29, 41)	33 (28, 40)	0.8483
Dialysis at transplant	67%	79%	0.678
Previous transplant	8%	12%	0.2725
Donor factors			
Female donor	42%	47%	0.4476
Kidney donor risk index	0.98 (0.81, 1.19)	1.02 (0.81, 1.26)	0.9139
Donor African American	25%	24%	0.9592

Baseline characteristics	Nonrisk (<i>n</i> = 171)	Medicaid or poor health status (<i>n</i> = 66)	<i>P</i> value
Donor age	35 (22, 48)	34 (22, 47)	0.9739
Living donor	17%	4%	0.0096
Immunosuppression			
Tacrolimus	94%	96%	0.693
Cytolytic induction	31%	50%	0.0064
Mycophenolate	92%	96%	0.4005
Follow-up time (y)	0.67 (0.60, 0.71)	0.67 (0.64, 0.72)	0.0773
Delayed graft function	20%	18%	0.7666

IQR = interquartile range.

Table 2

Baseline characteristics for PE and nonrisk cohorts.

Baseline characteristics	Nonrisk (<i>n</i> = 232)	PE (<i>n</i> = 5)	<i>P</i> value
Median transplant year	2013 (2011, 2014)	2014 (2010, 2015)	0.5686
Median age (IQR)	56 (47, 55)	61 (58, 66)	0.2147
Female gender	49%	60%	0.6172
Race/ethnicity			
African American	56%	100%	0.0496
Hispanic	0.43%	0	0.883
Employment			
Working	21%	0%	0.5139
Social security/disability	35%	40%	0.9588
Education			0.8809
Below high school/GED	10%	20%	
High school/GED	41%	40%	
College or higher	47%	40%	
Health insurance			
Medicare	74%	100%	0.1833
Medicaid	27%	60%	0.0989
Coupon card	19%	20%	0.9335
Health status			0.0083
Excellent	12%	0%	
Very good	33%	0%	
Good	37%	60%	
Fair	17%	20%	
Poor	86%	20%	
Comorbidities			
History of diabetes	49%	40%	0.9694
History of hypertension	93%	100%	0.5431
Immunologic factors			
Calculated PRA	3 (0, 47)	3 (0, 5)	0.7937
HLA mismatched	4 (3, 5)	4 (0, 5)	0.3628
Cold ischemic time (h)	15 (9, 22)	22 (11, 26)	0.5867
Warm ischemic time (min)	34 (28.5, 40)	37 (29, 41)	0.7743
Dialysis at transplant	70%	80%	0.6232
Retransplanted	9%	0%	0.481
Donor factors			
Female donor	42%	80%	0.0916
Kidney donor risk index	0.98 (0.81, 1.21)	1.22 (0.96, 1.45)	0.2252
Donor African American	24%	40%	0.4144

Baseline characteristics	Nonrisk (<i>n</i> = 232)	PE (<i>n</i> = 5)	<i>P</i> value
Donor age	34 (22, 47)	47 (45, 49)	0.0705
Living donor	14%	0%	0.3634
Immunosuppression			
Tacrolimus	94%	100%	0.5861
Cytolytic induction	35%	80%	0.0399
Mycophenolate	93%	100%	0.5431
Follow-up time (y)	0.67 (0.61, 0.71)	0.69 (0.64, 0.69)	0.7364
Delayed graft function	19%	60%	0.0204

IQR = interquartile range.

Table 3

Health care utilization rates for Medicaid/poor health status and nonrisk cohorts.

Outcome	Nonrisk	Medicaid or poor health status	<i>P</i> value
Mean total encounters	8.8 ± 12.1	11.4 ± 12.4	0.0496
Mean total admissions	0.37 ± 0.93	0.46 ± 0.92	0.2386
Mean total length of stay (d)	1.1 ± 4.13	1.7 ± 5.55	0.1630

Results reported as rate per patient-year with standard deviation noted.

Table 4

Health care utilization rates for PE and nonrisk cohorts.

Outcome	Nonrisk	PE	P value
Mean total encounters	9.0 ± 10.96	34 ± 32.6	0.0195
Mean total admissions	0.38 ± 0.89	1.2 ± 1.87	0.185
Mean total length of stay (d)	1.1 ± 3.42	14 ± 19.1	0.1048

Results reported as rate per patient-year with standard deviation noted.

Table 5

Results of predictive model for health care utilization rates.

Exposure	Estimated incident rate ratio (95% CI)			
	Total encounter rate	Admit rate	Total hospital LOS	Transplant outpatient visits
Medicaid or poor health status *	1.43 (1.01–2.02) [†]	1.31 (0.83–2.07)	1.43 (0.30–6.84)	1.35 (1.03–1.77) [†]
PE *	4.17 (1.55–11.2) [†]	4.09 (1.58–10.6) [†]	32.09 (1.17–878) [†]	2.31 (1.04–5.11) [†]
Composite *	1.56 (1.11–2.18) [†]	1.58 (1.01–2.47) [†]	2.93 (0.71–12.1)	1.41 (1.07–1.85) [†]

LOS = length of stay.

Results reported as IRR with 95% CI.

* The model was adjusted for age, gender, race, diabetes, PRA, HLA mismatches, cold time, dialysis, donor age, and donor type.

[†] $P < 0.05$.