Transplant Research and Risk Management Dovepress

Open Access Full Text Article ORIGINAL RESEARCH

Influence of Recipient Education on the Outcome of Simultaneous Pancreas and Kidney Transplantation

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Introduction: Simultaneous Pancreas-Kidney (SPK) transplantation is an established treatment for insulin-requiring diabetics with either advanced chronic or end stage kidney disease (ESRD). The outcomes of SPK transplantation may vary according to socio-economic factors such as recipient education. The aim of this study was to assess the association between education level of transplant recipients and outcomes of SPK transplantation in the United States.

Methods: All adult primary simultaneous pancreas-kidney (SPK) transplants performed in the United States between January 1, 1988, and December 31, 2017, were included, using data from the national Organ Procurement and Transplantation Network (OPTN)/ Scientific Registry of Transplant Recipients (SRTR) database. A total of 16,642 adult simultaneous pancreas-kidney (SPK) transplant recipients were included in the study, after excluding patients who data for education or were lost at 90-day follow-up. Post-transplant outcomes were analyzed in terms of allograft and recipient survival.

Results: Recipients with higher education had significantly lower risks of late kidney graft loss (HR 0.88), late pancreas graft loss (HR 0.86), and late death (HR 0.82) compared to those with high school education or below. Higher education recipients had better 10-year and 15-year kidney, pancreas, and patient graft survival rates across most racial/ethnic groups.

Conclusion: This large national study found that higher recipient education level was associated with improved long-term outcomes after simultaneous pancreas-kidney transplantation. The protective effect of higher education in recipients persisted after adjusting for other recipient, donor, and transplant factors.

Keywords: SPK transplantation, education, socioeconomic factors, transplantation outcomes

Introduction

Simultaneous pancreas-kidney transplantation (SPK) is a proven treatment for patients with end-stage renal disease (ESRD) and type 1 diabetes.[1–3] Successful SPK transplantation may reduce diabetes-related complications, improve cardiovascular outcomes, and prolong patient survival.[4–10] More effective immunosuppressive strategies and maintenance therapy have reduced graft rejection and improved graft and patient survival.[11,12]

Healthcare disparities have been recognized as barriers in the United States and have attracted increasing attention from physicians and federal health officials.[13] Disparities in health care access, treatment options, and outcomes among various racial, ethnic, and socioeconomic groups have been identified in numerous studies.[14] Socioeconomic status can be determined by education level, household income, and occupation, and is a strong predictor of patient morbidity and mortality in many diseases.[15] Social determinants such as income, access to healthcare, and education influence the outcome and results of healthcare interventions.[16]

These healthcare disparities are due to lack of quality and access to effective surgical and medical procedures.[17] Successful transplantation depends on multidisciplinary care of patients.[18] Inadequate support or lack of compliance in any aspect of this care puts graft and patient survival at risk. The purpose of this study was to examine the effect of

Received: 14 August 2024
Accepted: 9 October 2024
Published: 15 October 2024

education status, as an indicator of socioeconomic status, on patient and graft survival in adult patients undergoing first-time simultaneous pancreas-kidney transplantation. We conducted a retrospective analysis of national registry data to determine recipient education specific graft survival and mortality risk in SPK transplant recipients.

Methods

We included all adult primary simultaneous pancreas-kidney (SPK) transplants performed in the United States between January 1, 1988, and December 31, 2017, using data from the national Organ Procurement and Transplantation Network (OPTN)/Scientific Registry of Transplant Recipients (SRTR) database. The SRTR data system contains comprehensive information on all donors, wait-listed candidates, and transplant recipients in the US, submitted by OPTN members and overseen by the Health Resources and Services Administration (HRSA), US Department of Health and Human Services. The OPTN database is de-identified and publicly available. This study was exempt from institutional review board (IRB) approval, as per the Code of Federal Regulations Part 45 Title 46 (45 CFR 46). All transplants were conducted voluntarily and with written informed consent.

Separate analyses were conducted for early and late graft failure outcomes. Early graft failure was defined as kidney and/or pancreas graft loss within the first 90 days post-transplant. Causes of early and late graft failure were examined separately. Baseline recipient and donor characteristics were analyzed and included in multivariate models as appropriate covariates. Steroid immunosuppression regimens were also obtained and included in the analyses. Transplant centers were grouped by annual SPK transplant volume and used as a covariate.

Demographic and baseline characteristics were compared between education groups using *t*-tests and chi-square tests. For early graft failure, multivariate logistic regression models adjusted for center volume were used to identify associated risk factors. For late outcomes in recipients surviving beyond 90 days with functioning grafts, conditional Kaplan-Meier survival and multivariate Cox proportional hazards regression with backward selection were performed for the composite outcome of graft failure (kidney and/or pancreas) and death, as well as for death-censored graft and patient survival. Causes of late kidney and pancreas graft loss were identified, and multivariate logistic regression assessed risk factors for acute and chronic rejection-related graft loss. Finally, subgroup analyses for 5, 10, and 15-year graft and patient survivals stratified by race were done. All analyses were conducted using SPSS v29 software, with statistical significance defined as $p \leq 0.05$.

Results

A total of 16,642 adult simultaneous pancreas-kidney (SPK) transplant recipients were included in the study, categorized into two groups based on their educational attainment: 7416 (44.6%) with high school education or below, and 9226 (55.4%) with higher education. Recipients with unknown education status were eliminated from the study.

Recipient baseline demographic and clinical characteristics of study population are shown in Table 1. Compared to the higher education group, the high school/below group was younger (mean age 40.1 years vs 41.3 years, $p<0.001$), had a higher proportion of males (65.5% vs 57.3%, $p<0.001$), and a shorter duration of diabetes (25.4 years vs 27 years, $p<0.001$). They also had a lower proportion of patients with type 1 diabetes mellitus (89.7% vs 91.4%, $p<0.001$).

Regarding race and ethnicity, the high school/below group had a lower proportion of White, non-Hispanic recipients (68.9% vs 73.5%) and Hispanic/Latino (1.4% vs 7.6%), but a higher proportion of Black, non-Hispanic (16.9% vs 16.2%) recipients compared to the higher education group ($p<0.001$).

There were no significant differences in donor characteristics such as age, body mass index (BMI), gender, race, smoking history, hypertension, or stroke between the two groups. However, the cold ischemia time was slightly shorter for the high school/below group (12.1 hours vs 12.2 hours, $p<0.001$), and there was no difference in the number of HLA mismatches.

Regarding center volume, the high school/below group was more likely to receive their transplant at lower-volume centers (≤10 transplants per year: 39.5% vs 39.5%), while the higher education group was more likely to receive their transplant at higher-volume centers (>20 transplants per year: 31.7% vs 31.9%, $p=0.958$).

Medicaid patients were also more likely to have a lower educational attainment, with 52.7% having a high school education or below, compared to 42.7% for Medicare and 28.9% for private insurance ($p<0.001$).

Table 1 Baseline Demographic and Clinical Characteristics of Study Population

	High School/ Below N= 7416	Higher Education N= 9226	p-value
Age (years)(SD)	40.1 (8)	41.3 (9)	<0.001
Gender (male)(%)	4855 (65.5)	5284 (57.3)	<0.001
Body Mass Index (kg/m^2)(SD)	24.8 (3.9)	24.9 (3.9)	0.063
Duration of diabetes (years)(SD)	25.4 (8.1)	27 (8.7)	<0.001
Patients with type 1 diabetes mellitus (%)	6653 (89.7)	8431 (91.4)	<0.001
Race (%)			
White, non-Hispanic	5108 (68.9)	6780 (73.5)	<0.001
Black, non-Hispanic	1256 (16.9)	1490 (16.2)	
Hispanic/Latino	920 (1.4)	700 (7.6)	
Others	132 (1.8)	256 (2.8)	
Donor age (years) (SD)	25.6 ± 10	25.6 ± 10	0.279
Donor BMI (kg/m^2)(SD)	23.9 (4)	23.9 (4)	0.316
Donor gender, male (%)	5071 (68.4)	6295 (68.2)	0.838
Donor race (%)			
White, non-Hispanic	5047 (68.1)	6219 (67.4)	0.419
Black, non-Hispanic	1199 (16.2)	1501 (16.3)	
Hispanic/Latino	964 (13.0)	1270 (13.8)	
Others	206 (2.8)	236 (2.6)	
Donor smoking, >20 pack years (%)	1251 (16.9)	1602 (17.4)	0.400
Donor hypertension (%)	355 (4.8)	503 (5.5)	0.054
Donor stroke (%)	1290 (17.4)	1609 (17.4)	0.939
Cold Ischemia Time (h) (SD)	12.1 (5.7)	12.2 (6)	<0.001
HLA mismatches (SD)	4.5 (1)	4.5 (1)	0.275
Center volume (number/year) (%)			
≤ 10	2928 (39.5)	3645 (39.5)	0.958
11–20	2136 (28.8)	2640 (28.6)	
>20	2352 (31.7)	2941 (31.9)	
Steroids, yes (%)	5058 (72.2)	6296 (71.9)	0.607

The use of steroids as part of the immunosuppressive regimen was similar between the two groups (72.2% for high school/below vs 71.9% for higher education, p=0.607).

Risk factors associated with early graft failure within 90 days after transplantation are shown in Table 2. A total of 1728 (10.4%) pancreas and 721 (4.3%) kidney transplants were lost in the first 90 days, the most common conjoined reason being thrombosis. For early kidney graft loss, higher recipient BMI (OR 1.12, 95% CI 1.01, 1.24, p=0.033) and donors of other races compared to White, non-Hispanic (OR 0.19, 95% CI 0.04, 0.83, p=0.027) were significant risk factors. Male recipients showed a trend towards lower odds of early kidney graft loss (OR 0.43, 95% CI 0.18, 1.03, p=0.057). Recipient education level, recipient race other than other races, cold ischemia time, donor characteristics, and center volume did not significantly impact early kidney graft loss risk.

Regarding early pancreas graft loss, higher recipient BMI (OR 1.13, 95% CI 1.02, 1.26, p=0.022) and recipients who received organs from donors of other races compared to White, non-Hispanic donors (OR 0.14, 95% CI 0.04, 0.46, p=0.001) were significant risk factors. Recipient education level, recipient race, cold ischemia time, donor age, donor race other than other races, donor hypertension, donor stroke, and center volume did not significantly impact early pancreas graft loss risk.

Risk factors associated with late graft loss among SPK transplant patients who survived up to 90 days with both graft function is shown in Table 3. During subsequent follow-up at 1 year, 1312 (7.9%) kidney and 2437 (14.6%) pancreas grafts were lost among SPK transplant recipients.

There was a significant difference in overall event-free survival with higher survival in patients with higher education levels (Figure 1A, log-rank $p < 0.000$). There was a significant difference in late graft survival between recipients with

Table 2 Risk Factors Associated with Early Graft Failure Within 90 Days After Transplantation

Variables	Kidney Graft Loss			Pancreas Graft Loss		
	OR	95% CI	p-value	OR	95% CI	p-value
Recipient Education						
High school/ Below	Ref	Ref	Ref	Ref	Ref	Ref
Higher education	0.81	0.36, 1.81	0.612	1.40	0.65, 3.00	0.387
Recipient Race						
White, non-Hispanic	Ref	Ref	Ref	Ref	Ref	Ref
Black, non-Hispanic	6.37	0.83, 48.93	0.075	3.18	0.55, 4.50	0.994
Hispanic/Latino	0.51	0.16, 1.59	0.245	0.94	0.11, 8.02	0.475
Others	0.99	0.10, 9.42	0.996	1.40	0.65, 3.00	0.956
Recipient gender (male)	0.43	0.18, 1.03	0.057	0.53	0.23, 1.23	0.138
Recipient BMI (kg/m^2)(SD)	1.12	1.01, 1.24	0.033	1.13	1.02, 1.26	0.022
Cold ischemia time (h)	0.99	0.93, 1.05	0.677	0.97	0.92, 1.03	0.343
Donor age (years)	1.02	0.98, 1.07	0.304	1.02	0.97, 1.06	0.463
Donor race						
White, non-Hispanic	Ref	Ref	Ref	Ref	Ref	Ref
Black, non-Hispanic	0.72	0.25, 2.10	0.551	0.87	0.29, 2.65	0.810
Hispanic/Latino	0.79	0.25, 2.48	0.690	1.16	0.32, 4.19	0.823
Others	0.19	0.04, 0.83	0.027	0.14	0.04, 0.46	0.001
Donor hypertension	0.79	0.17, 3.64	0.763	0.85	0.21, 3.46	0.825
Donor stroke	0.88	0.31, 2.50	0.814	0.80	0.30, 2.14	0.653
Center volume (number/year) (%)						
≤ 10	Ref	Ref	Ref	Ref	Ref	Ref
11–20	1.07	0.44, 2.64	0.879	0.89	0.39, 1.04	0.780
>20	1.91	0.68, 5.34	0.217	1.81	0.61, 5.33	0.283

Table 3 Risk Factors Associated with Late Graft Loss Among SPK Transplant Patients Who Survived Up to 90 Days with Both Graft Function

Variables	Kidney Graft Loss			Pancreas Graft Loss		
	HR	95% CI	p	HR	95% CI	p
Recipient Education						
High school/ Below	Ref	Ref	Ref	Ref	Ref	Ref
Higher education	0.88	0.84, 0.93	<0.001	0.86	0.82, 0.90	<0.001
Recipient Race						
White, non-Hispanic	Ref	Ref	Ref	Ref	Ref	Ref
Black, non-Hispanic	1.25	1.16, 1.34	<0.001	1.14	1.06, 1.23	<0.001
Hispanic/Latino	0.89	0.81, 0.98	0.019	0.83	0.75, 0.91	<0.001
Others	0.997	0.83, 1.20	0.978	0.90	0.74, 1.10	0.298
Recipient age, (years)	1.001	0.99, 1.005	0.557	1.001	0.997,1.005	0.577
Duration of diabetes, (years)	0.99	0.991,0.998	0.002	0.998	0.995,1.002	0.405
HLA mismatch, (zero)	1.02	0.996, 1.04	0.120	1.004	0.98, 1.03	0.715
Donor age, (years)	1.011	1.009,1.014	<0.001	1.008	1.005,1.011	<0.001
Donor race						
White, non-Hispanic	Ref	Ref	Ref	Ref	Ref	Ref
Black, non-Hispanic	1.24	1.16, 1.33	<0.001	1.28	1.19, 1.37	<0.001
Hispanic/Latino	0.99	0.92, 1.08	0.852	1.05	0.97, 1.14	0.228
Others	0.96	0.81, 1.14	0.678	1.02	0.86, 1.21	0.841
Donor smoking, (>20 pack years)	1.14	1.07, 1.22	<0.001	1.10	1.03, 1.18	0.004

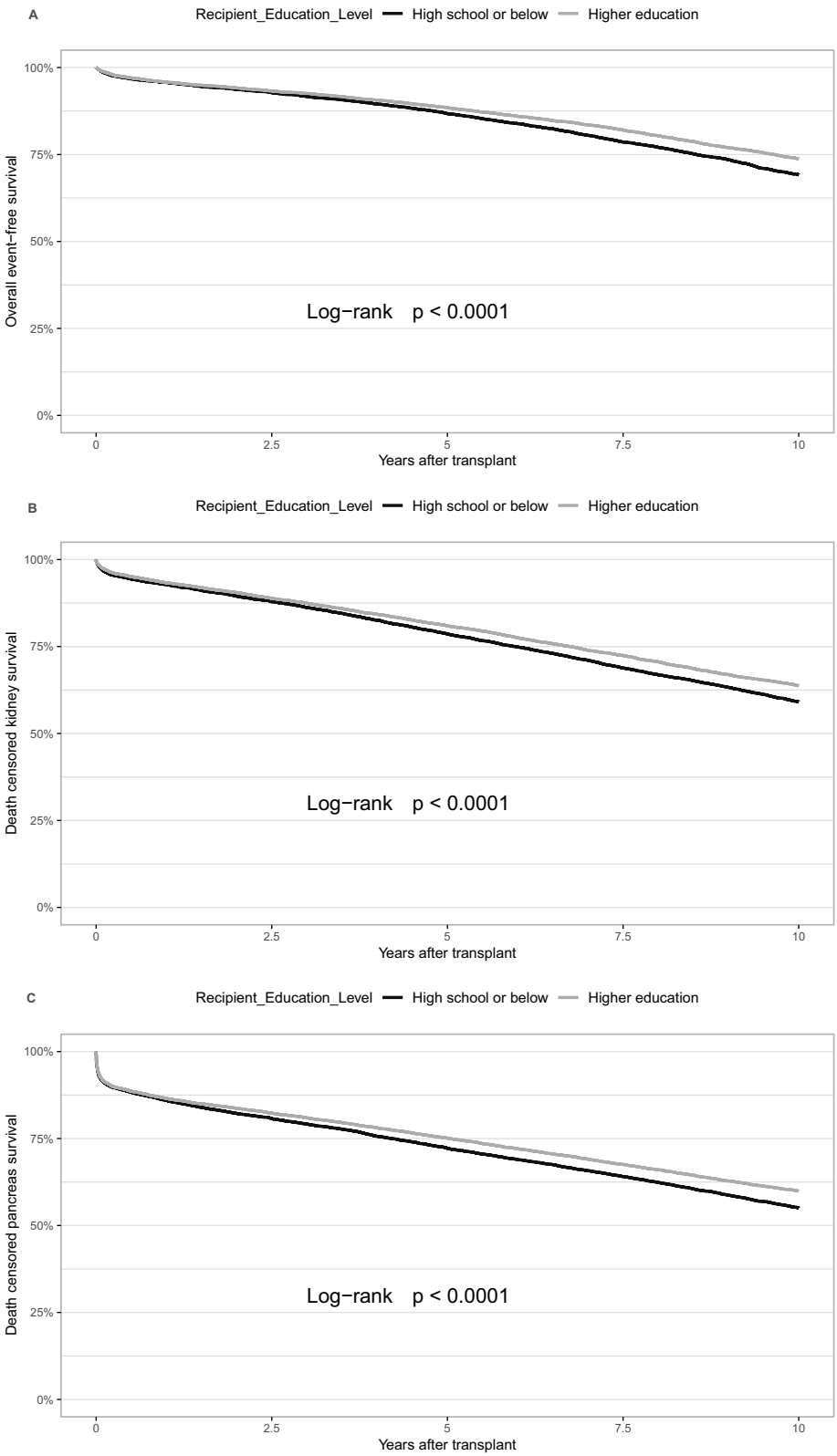

Figure 1 (A) Overall event-free survival. **(B)** Death censored kidney graft survival. **(C)** Death censored pancreas graft survival.

different education levels (Figure 1B and C, log-rank, p<0.0001). This difference was mainly due to lower death-censored graft failure rates among higher education recipients for both kidney and pancreas grafts.

For late kidney graft loss after simultaneous pancreas-kidney (SPK) transplantation, multivariate analysis showed that recipients with higher education had a lower risk compared to those with high school education or below (HR 0.88, 95% CI 0.84, 0.93, p<0.001). Black, non-Hispanic recipients had a higher risk of late kidney graft loss compared to white, non-Hispanic recipients (HR 1.25, 95% CI 1.16, 1.34, p<0.001), while Hispanic/Latino recipients had a lower risk (HR 0.89, 95% CI 0.81, 0.98, p=0.019).

Recipient age and HLA mismatch were not significantly associated with late kidney graft loss risk. However, longer duration of diabetes was associated with a lower risk (HR 0.99, 95% CI 0.991, 0.998, p=0.002).

Older donor age (HR 1.011, 95% CI 1.009, 1.014, p<0.001), black, non-Hispanic donors (HR 1.24, 95% CI 1.16, 1.33, p<0.001), and donors with a smoking history of more than 20 pack-years (HR 1.14, 95% CI 1.07, 1.22, p<0.001) were all associated with an increased risk of late kidney graft loss.

Regarding late pancreas graft loss, recipients with higher education also had a lower risk compared to those with high school education or below (HR 0.86, 95% CI 0.82, 0.90, p<0.001). Black, non-Hispanic recipients had a higher risk of late pancreas graft loss compared to white, non-Hispanic recipients (HR 1.14, 95% CI 1.06, 1.23, p<0.001), while Hispanic/Latino recipients had a lower risk (HR 0.83, 95% CI 0.75, 0.91, p<0.001) (Table 4).

Recipient age, duration of diabetes, and HLA mismatch were not significantly associated with late pancreas graft loss risk. Older donor age (HR 1.008, 95% CI 1.005, 1.011, p<0.001), black, non-Hispanic donors (HR 1.28, 95% CI 1.19, 1.37, p<0.001), and donors with a smoking history of more than 20 pack-years (HR 1.10, 95% CI 1.03, 1.18, p=0.004) were all associated with an increased risk of late pancreas graft loss.

For late death after simultaneous pancreas-kidney (SPK) transplantation, recipients with higher education had a lower risk compared to those with high school education or below (HR 0.82, 95% CI 0.78, 0.86, p<0.001). Black, non-Hispanic recipients had a higher risk of late death compared to white, non-Hispanic recipients (HR 1.12, 95% CI 1.04, 1.20, p=0.002), while Hispanic/Latino recipients had a lower risk (HR 0.86, 95% CI 0.78, 0.95, p=0.003). Older recipient age was associated with an increased risk of late death (HR 1.026 per year increase, 95% CI 1.023, 1.029, p<0.001).

Regarding donor characteristics, donors who died of stroke were associated with an increased risk of late death among SPK transplant recipients (HR 1.15, 95% CI 1.08, 1.22, p<0.001). Black, non-Hispanic donors were also associated with an increased risk of late death compared to white, non-Hispanic donors (HR 1.27, 95% CI 1.19, 1.36, p<0.001). However, donor race of Hispanic/Latino or other races did not significantly impact the risk of late death.

Table 4 Risk Factors Associated with Late Death Among SPK Trans- Plant Patients Who Survived 90 Days with Both Graft Function

Variables	HR	95% CI	p
Recipient Education			
High school/ Below	Ref	Ref	Ref
Higher education	0.82	0.78, 0.86	<0.001
Recipient Race			
White, non-Hispanic	Ref	Ref	Ref
Black, non-Hispanic	1.12	1.04, 1.20	0.002
Hispanic/Latino	0.86	0.78, 0.95	0.003
Others	0.90	0.73, 1.11	0.329
Recipient age, (years)	1.026	1.023, 1.029	<0.001
Donor stroke, yes (no)	1.15	1.08, 1.22	<0.001
Donor race			
White, non-Hispanic	Ref	Ref	Ref
Black, non-Hispanic	1.27	1.19, 1.36	<0.001
Hispanic/Latino	0.99	0.92, 1.08	0.891
Others	1.02	0.86, 1.20	0.860

For the total study population, recipients with higher education had significantly better 5-year (78.5% vs 73.5%, p=0.004), 10-year (33.2% vs 40.2%, p<0.001), and 15-year (23.0% vs 21.5%, p<0.001) kidney graft survival rates compared to those with high school education or below among white recipients, those with higher education showed a trend towards better 5-year graft survival (74.3% vs 72.5%, p=0.052) and had significantly better 10-year (42.1% vs 40.7%, p<0.001) and 15-year (19.8% vs 18.1%, p<0.001) kidney graft survival rates compared to the high school/below group. (Table 5).

Survival among black recipients did not differ significantly by education. Among Hispanic recipients, the higher education group had significantly better 10-year (33.9% vs 32.8%, p=0.005) and 15-year (13.1% vs 13.3%, p=0.034) graft survival rates, but not 5-year rates (76.0% vs 70.9%, p=0.662), compared to the high school/below group. For Asian and other recipients, there were no significant differences in 5-year (73.4% vs 69.7%, p=0.303), 10-year (27.7% vs 34.1%, p=0.127), or 15-year (7.4% vs 12.1%, p=0.181) graft survival between the higher and lower education groups.

For the total study population, there was no significant difference in 5-year pancreas graft survival between the higher education group and high school/below group (80.8% vs 79.6%, p=0.386). However, the higher education group had significantly better 10-year (47.3% vs 46.5%, p<0.001) and 15-year (23.0% vs 21.5%, p<0.001) pancreas graft survival rates. (Table 6).

Among White recipients, those with higher education had significantly better 10-year (38.2% vs 36.7%, p<0.001) and 15-year (18.3% vs 17.0%, p<0.001) survival rates compared to the high school/below group. Survival among black recipients did not differ significantly by education at any time point. Among Hispanic recipients, the higher education group had significantly better 10-year pancreas graft survival (31.4% vs 30.8%, p=0.011).

For Asian and other recipients, the higher education group had significantly better 5-year (68.8% vs 62.9%, p=0.049), 10-year (26.2% vs 29.5%, p=0.013), and 15-year (7.8% vs 14.4%, p=0.012) pancreas graft survival rates compared to the high school/below group.

The higher education group had significantly better 10-year (47.3% vs 46.5%, p<0.001) and 15-year (23.0% vs 21.5%, p<0.001) patient graft survival rates compared to the high school/below group. Among White recipients, those with higher education had significantly better 10-year (50.4% vs 49.7%, p<0.001) and 15-year (25.9% vs 23.9%, p=0.027) patient graft survival rates.

Table 5 Effect of Education Level on Crude Kidney Graft Survival Stratified by Race

Race	Five-year (%)	Ten-year (%)	Fifteen-year (%)
Total			
High school/ Below	73.5 (65.5–80.4)	40.2 (32.1–48.7)	21.5 (20.6–22.4)
Higher-education group	78.5 (73.2–83.2)	33.2 (27.6–39.1)	23.0 (22.1–23.8)
P value	0.004	<0.001	<0.001
White			
High school/ Below	72.5 (71.2–73.7)	40.7 (39.4–42.1)	18.1 (17.1–19.2)
Higher-education group	74.3 (73.3–75.4)	42.1 (40.9–43.2)	19.8 (18.9–20.8)
P value	0.052	<0.001	<0.001
Black			
High school/ Below	68.8 (66.2–71.3)	28.3 (25.8–30.8)	10.5 (8.9–12.3)
Higher-education group	69.1 (66.7–71.4)	30.0 (27.7–32.4)	10.3 (8.8–11.9)
P value	0.541	0.848	0.313
Hispanic			
High school/ Below	70.9 (67.9–73.7)	32.8 (29.8–35.9)	13.3 (11.2–15.6)
Higher-education group	76.0 (72.7–79.1)	33.9 (30.4–37.4)	13.1 (10.8–15.8)
P value	0.662	0.005	0.034
Asian and others			
High school/ Below	69.7 (61.5–77)	34.1 (26.4–42.5)	12.1 (7.4–18.5)
Higher-education group	73.4(67.8–78.6)	27.7 (22.5–33.4)	7.4 (4.7–11.1)
P value	0.303	0.127	0.181

Notes: The data in parentheses represent 95% confidence interval.

Table 6 Effect of Education Level on Crude Pancreas Graft Survival Stratified by Race

Race	Five-year (%)	Ten-year (%)	Fifteen-year (%)
Total			
High school/ Below	79.6 (78.7–80.5)	46.5 (45.4–47.7)	21.5 (20.6–22.4)
Higher-education group	80.8 (79.9–81.5)	47.3 (46.3–48.4)	23.0 (22.1–23.8)
P value	0.386	<0.001	<0.001
White			
High school/ Below	65.7 (64.4–67.0)	36.7 (35.4–38.0)	17.0 (16.0–18.0)
Higher-education group	68.2 (67.1–69.3)	38.2 (37.0–39.3)	18.3 (17.4–19.2)
P value	0.287	<0.001	<0.001
Black			
High school/ Below	64.6 (62.0–67.3)	27.3 (24.9–29.8)	10.1 (8.5–11.9)
Higher-education group	65.6 (63.1–68.0)	28.9 (26.7–31.3)	9.9 (8.4–11.5)
P value	0.884	0.162	0.096
Hispanic			
High school/ Below	66.6 (63.5–69.6)	30.8 (27.8–33.8)	12.2 (10.2–14.4)
Higher-education group	71.0 (67.6–74.3)	31.4 (28.1–34.9)	11.9 (9.6–14.4)
P value	0.678	0.011	0.092
Asian and others			
High school/ Below	62.9 (54.4–70.8)	29.5 (22.3–37.7)	14.4 (9.2–21.1)
Higher-education group	68.8 (62.9–74.2)	26.2 (21.1–31.8)	7.8 (5.0–11.6)
P value	0.049	0.013	0.012

Notes: The data in parentheses represent 95% confidence interval.

For Hispanic recipients, the higher education group had significantly better 10-year patient graft survival (36.9% vs 39.5%, p=0.005) compared to the high school/below group. Among Asian and other recipients, the higher education group had significantly better 10-year (33.2% vs 40.2%, p=0.010) and 15-year (10.2% vs 15.9%, p=0.017) patient graft survival rates. The differences in 5-year patient graft survival between education groups were non-significant for the total population (p=0.050), as well as when stratified by White (p=0.055), Black (p=0.817), Hispanic (p=0.120), and Asian/ other (p=0.075) races. For Black recipients, the differences in 10-year (p=0.268) and 15-year (p=0.904) patient graft survival between education groups were also non-significant. (Table 7).

Table 7 Effect of Education Level on Crude Patient Graft Survival Stratified by Race

Race	Five-year (%)	Ten-year (%)	Fifteen-year (%)
Total			
High school/ Below	79.6 (78.7–80.5)	46.5 (45.4–47.7)	21.5 (20.6–22.4)
Higher-education group	80.8 (79.9–81.5)	47.3 (46.3–48.4)	23.0 (22.1–23.8)
P value	0.050	<0.001	<0.001
White			
High school/ Below	80.2 (79.1–81.3)	49.7 (48.2–51.1)	23.9 (22.8–25.1)
Higher-education group	81.1 (80.1–82.0)	50.4 (49.2–51.6)	25.9 (24.8–26.9)
P value	0.055	<0.001	0.027
Black			
High school/ Below	79.4 (77.1–81.5)	39.5 (36.8–42.2)	16.2 (14.2–18.3)
Higher-education group	79.4 (77.3–81.4)	39.4 (36.9–41.9)	15.0 (13.3–16.9)
P value	0.817	0.268	0.904

(*Continued*)

Table 7 (Continued).

Race	Five-year (%)	Ten-year (%)	Fifteen-year (%)
Hispanic			
High school/ Below	77.4 (74.6–80.0)	39.5 (36.3–42.6)	16.1 (13.8–18.6)
Higher-education group	81.4 (78.4–84.2)	36.9 (36.3–43.5)	16.4 (13.8–19.3)
P value	0.120	0.005	0.505
Asian and others			
High school/ Below	73.5 (65.5–80.4)	40.2 (32.1–48.7)	15.9 (10.4–22.9)
Higher-education group	78.5 (73.2–83.2)	33.2 (27.6–39.1)	10.2 (6.9–14.3)
P value	0.075	0.010	0.017

Notes: The data in parentheses represent 95% confidence interval.

Discussion

This is the largest study to date reporting the effect of recipient education on outcomes in SPK transplantation. Socioeconomic factors have been shown to affect health care outcomes.[19,20] Factors that may affect graft and patient survival include low education level, poverty, and unemployment.

Our analysis demonstrated that recipients with a higher education level have lower graft failure and higher survival rates than recipients with low-education levels. This is consistent with other conditions where healthcare outcomes are superior in higher educated patients with gastric cancer, and liver and kidney transplant recipients.[21–23] Higher education levels may lead to better transplantation outcomes for several reasons. Higher education levels lead to employment with higher income,[21] which may lead to better insurance and healthcare outcomes. Several studies have shown that transplant recipients with lower income and public insurance have worse outcomes compared to private insurance.[24,25] To address this potential confounding effect of education level and insurance status we constructed two separate models with each one having the recipient's insurance or level of education – the results were similar to the primary analysis that included both variables. This supports an independent association between recipient education level and transplantation outcomes.

Patients with lower socioeconomic position are less likely to finish the pre-transplant evaluation and contemplate organ transplantation as a treatment option. Individuals who do receive a transplant are more likely to exhibit indirect indicators of late referral patterns, such as shorter wait times for transplantation, longer dialysis stays, and significant organ failure at the time of listing.[26] For this group of patients, an earlier diagnosis and referral to transplant institutions may result in improved outcomes. Patients with higher education levels may have a better understanding of medications, including immunosuppression and compliance with follow up. Worse outcomes may result from noncompliance with medicine due to expense, pharmacy accessibility, and failure to follow up owing to transportation difficulties.[27]

Our analysis demonstrates that black transplant recipients have worse transplant outcomes compared to white and Hispanic recipients. When recipient education level and insurance were included in multivariate analysis, race was still a strong independent predictor of survival. Racial differences exist across the board in the natural history and management of renal failure and renal replacement. This may include, to name a few, biological factors, lower patient health literacy and education, socioeconomic status, access to healthcare, and insurance status. It is challenging to quantitate social issues and differentiate from biological issues related to race.

To improve outcomes, transplant programs should consider recipient education level as a marker of poorer post-transplant survival in order to implement changes in post-transplant strategies. This may involve addressing deficits in patient education, transportation to appointments, improving patient compliance and more frequent follow up.

This study has several limitations. This was a retrospective study and selection bias for transplantation may influence the findings. Although this was a large retrospective analysis there may be inaccuracies related to missing and potentially misclassified data. Patients with missing data with regard to recipient education level were excluded from the analysis. However, the results are likely still valid due to the large number of remaining subjects. An additional limitation is that the UNOS database did not have data that may reflect patient outcomes including patient compliance with medications

and follow up, opportunistic infection rates, blood pressure and glycemic control. As with all retrospective analyses independent variables can only demonstrate association rather than causality, and lead to the need for additional studies.

Conclusion

This large national study found that a higher recipient education level was associated with improved long-term outcomes after simultaneous pancreas-kidney transplantation. Recipients with higher education had significantly lower risks of late kidney graft loss (HR 0.88), late pancreas graft loss (HR 0.86), and late death (HR 0.82) compared to those with high school education or below.

Higher education recipients also had better 10-year and 15-year kidney, pancreas, and patient graft survival rates across most racial/ethnic groups. The protective effect of higher education persisted even after adjusting for other recipient, donor, and transplant factors.

Author Contributions

All authors made a significant contribution to the work reported, whether that is in the conception, study design, execution, acquisition of data, analysis and interpretation, or in all these areas; took part in drafting, revising or critically reviewing the article; gave final approval of the version to be published; have agreed on the journal to which the article has been submitted; and agree to be accountable for all aspects of the work.

Disclosure

This paper was presented as a poster presentation with interim findings:

Location: American Transplant Congress Conference in Philadelphia on June 2nd 2024.

The poster presentations for this conference were published as abstracts in the American Journal of Transplantation. Reference: Zaidi RA and Agha A. Outcome of pancreas-kidney transplantation in adult recipients: Influence of education and insurance.

Am J Transplant. 2024;24(6 Supp. 1):S831-S832.doi:10.1016/j.ajt.2024.05.008.

The authors report no conflicts of interest in this work.

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