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Education Strategies in Dialysis Centers Associated with Increased Transplant Wait-listing Rates

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List of abbreviations

CMS: Centers for Medicare and Medicaid Services

CVD, CVA, or TIA: Cardiovascular disease, cerebrovascular accident, or transient ischemic attack

DDKT: Deceased donor kidney transplant

ESRD: End-stage renal disease

IRR: Incident rate ratio

LDKT: Living donor kidney transplant

OR: Odds ratio

RCT: Randomized controlled trial

RUCA: Rural Urban Community Areas

TEP: Technical Expert Panel

U.S.: United States

USRDS: United States Renal Data System

Abstract (300 words max)

While transplant education disseminated in dialysis centers can increase access to kidney transplant, dialysis-center barriers to transplant are common. Also, little research has examined which specific approaches to transplant education are most effective. To address these gaps, we surveyed transplant educators in 1,694 U.S. dialysis centers about their transplant knowledge, use of 12 specific education practices, and 8 identified barriers to providing education. Transplant wait-listing rates were calculated using data from the USRDS. After categorizing the education practices into combined strategies, 52% of educators orally recommended transplant to patients, 31% had in-center discussions about transplant with patients, 17% distributed print educational resources, and 3% used intensive education approaches. Distribution of print education [Incident rate ratio (IRR): 1.021.15_{1.30}] and using >1 intensive education practice (1.001.11_{1.23}) within dialysis centers were associated with increased wait-listing rates. Several dialysis center characteristics were associated with reduced odds of using education strategies leading to increased wait-listing. Centers with greater percentages of patients without health insurance in the zip code [Odds ratio (OR): 0.960.97_{0.99}], in rural locations (OR:

0.660.79_{0.95}), with for-profit ownership (OR: 0.640.77_{0.91}), and with greater percentages of patients older than 65 years (OR: 0.050.11_{0.23}) had lower odds of recommending transplant to patients, while centers with a higher patient-to-staff ratio were more likely to do so (OR: 1.011.03_{1.04}). Language barriers (OR: 0.480.64_{0.86}) and having competing work priorities (OR: 0.400.53_{0.70}) reduced the odds of distributing print education. Providers with greater transplant knowledge were more likely to use >1 intensive educational strategy (OR: 1.011.27_{1.60}) while providers who reported competing work priorities (OR: 0.510.66_{0.84}) and poor communication with transplant centers (OR: 0.580.76_{0.98}) were less likely to use intensive education strategies. With the many challenges of delivering transplant education in dialysis centers, educators should prioritize education strategies shown to be associated with increasing wait-listing rates.

Introduction

Access to comprehensive transplant education increases pursuit of transplant evaluation and receipt of transplant (1, 2). However, much of the published research has been conducted within randomized controlled trials (RCTs), which fail to take into account the challenges and diversity of how transplant education is delivered across a complex system involving thousands of community nephrologist's offices, dialysis centers, and transplant centers.

Effective strategies for transplant education within dialysis centers are particularly important to understand since 70% of end-stage renal disease (ESRD) patients are on dialysis United States Renal Data System (3), some of whom may

never present to a transplant center for evaluation. However, the current mandate by the Center for Medicare and Medicaid Services (CMS) requiring providers to inform patients of their transplant options within 45 days of initiating dialysis has significant limitations. Even when providers report informing patients about transplant, those same patients may not acknowledge receiving transplant information (4). While a national study found that 70% of providers reported informing patients of transplant as documented on Form 2728 (5), research shows that most providers spend very little time providing transplant education to patients (6). Other studies found that less than half of dialysis patients receive comprehensive discussions or counselling about the risks and benefits of transplant (7).

Across over 6,000 dialysis centers nationwide, many other potential barriers to successful delivery of transplant education also exist. Only a minority of dialysis centers have formal education programs or provide transplant education to share with potential living donors (6-8). Recent evidence suggests that the dialysis center's administrative culture plays a critical role in access to transplant (9), but it is unclear how variation in administrative approaches in dialysis centers impacts the specific transplant education practices used by staff. For these and many other reasons, evidence suggests that not all dialysis patients receive appropriate information about transplant (5-7, 10, 11).

Recently, a CMS Technical Expert Panel (TEP) agreed that more specific metrics for defining adequate transplant education delivery in dialysis centers to increase transplant wait-listing was needed (12). The few studies examining transplant education practices have found that not being informed of transplant options is associated with lower transplant rates and that the provision of multiple

educational practices (vs. any single education practice) increases access to transplant (5, 7). However, a large-scale examination of the impact of different educational delivery approaches is still needed to understand how to help dialysis educators be more effective at increasing transplant wait-listing rates for their interested patients. Thus, we performed a national study of 1,694 dialysis centers to: 1) identify the most common transplant education practices and barriers to education among dialysis facilities; 2) examine which specific transplant education practices were associated with increased transplant wait-listing rates at dialysis centers; and 3) determine center-level barriers and characteristics associated with the use of effective transplant education strategies, defined as those significantly associated with increased transplant wait-listing. Data from a national survey of representatives of the dialysis centers throughout the U.S. in all 18 ESRD Networks were linked to wait-listing records from the USRDS to address these aims.

Methods

Study Participants

Dialysis centers were recruited through invitations to one of 78 kidney transplant education one-day trainings conducted from 2011-2015. Trainings were supported by local transplant centers and ESRD Networks throughout the United States.

Dialysis centers could send more than one representative to trainings. In these cases, the one dialysis staff representative most involved in providing transplant education to patients was selected to report on center education practices, per methods published elsewhere (7). In this manuscript, these representatives are referred to as “transplant educators.” Participants completed a written informed consent form before beginning study activities. The survey data collected from educators was then linked to USRDS data.

Study Data

Data for this study were compiled from four sources. First, data on the characteristics of transplant educators from each dialysis center were collected from surveys administered before the start of the trainings. Recorded characteristics of the transplant educator include gender, race/ethnicity, age, job title, and number of years working in dialysis. The survey also asked whether transplant educators had used any of 12 different educational practices with at least 5 of their patients in the last 12 months (e.g., referring patients to an education program at a transplant center or kidney organization, having a detailed discussion about the advantages/risks of living donor transplant) (See Table 2 for complete list). Transplant educators were asked whether they faced any of 8 barriers to providing transplant education to their patients (e.g., completing other work priorities prevents educating about transplant, poor communication between nearby transplant centers and the dialysis center) (Table 2). Their level of transplant knowledge was assessed with 12 true/false and multiple choice questions whose correct responses were summed to create a scale ranging from 0-12, with higher scores indicating greater knowledge.

Second, dialysis patient records from the USRDS were aggregated by center and linked to transplant educator survey data using an anonymous, randomly generated, de-identified linkage key for each dialysis center with the linkages facilitated through a USRDS contractor. Analytic data were anonymous with all center names removed. No patient identifiers were accessible to study investigators. The linked data were used to characterize the centers and their patient populations including the percentage of patients in each dialysis center who were: female; White, Black, Hispanic, Asian, or White; aged ≥ 65 years; had

diabetes; had cardiovascular disease (CVD), cerebrovascular accident (CVA), or transient ischemic attack (TIA); had vascular access fistula present at ESRD start; and current smokers. Other variables obtained from this database included the number of patients at each center at the time of the training; the number of full-time staff; the number of dialysis stations; and whether the dialysis center was owned by a for- or non-profit organization. These dialysis center characteristics previously have been demonstrated to be associated with dialysis center wait-listing or transplant rates (13, 14). Third, U.S. Census data from the 2015 American Community Survey were accessed to determine the median income and percent uninsured in each dialysis center's zip code. Finally, data from the Rural Health Research Centers' Rural Urban Commuting Areas (RUCA) was obtained to categorize each dialysis center as rural or urban using RUCA codes.

In addition to data about the centers' characteristics, dialysis center-aggregated transplant wait-listing rates were calculated using data from the USRDS. For prospective wait-listing rates, each patient who initialized dialysis in the 6 months before or after the training date was followed for up to 12 months from the training date at their center (or time since initializing dialysis for patients starting dialysis after the training date), censored if a death occurred or end of study. For retrospective outcomes, each patient who initialized dialysis in the 6 to 12 months before the training date was followed for up to 12 months from initializing dialysis, censored if a death occurred or the end of the study period. Center-specific listing rates were defined as the total wait-listing events among the center's patients during observation, divided by the total observation time contributed by these patients.

Statistical analyses

For all statistical tests, a p-value of 0.05 was considered statistically significant. Dialysis staff and center characteristics were described with frequencies, proportions, means, and standard deviations. We used principal components analysis with Varimax rotation to categorize the set of 12 individual educational practices into broader categories of strategies, selecting variables that loaded on a component at ≥ 0.40 . We created variables to represent the resulting factors and tested their association with prospective and retrospective transplant wait-listing rates.

Negative binomial regression models with an offset for log of follow-up time were employed to examine the impact of each of the combined strategies on dialysis center wait-listing rates (incident rate ratio [(IRR), 95% LCL IRR 95% UCL]). For each educational strategy (4 in total), separate univariate models were used to examine the association between each transplant education strategy and wait-listing rates (each strategy in a separate model). To each of these models, potentially confounding dialysis staff and center characteristics were added simultaneously to determine whether effects found in the univariate models were maintained, including: percentage of female patients; percentages of Black, White, Hispanic, and Asian patients; percentage of patients aged >65 years; percentage with diabetes; percentage with CVD, CVA, or TIA; percentage of vascular access fistula present at ESRD start; percentage who are current smokers; the ratio of the number of patients served in the center to the number of the center's full time staff; the number of dialysis stations in the center; for- or non-profit center ownership; the median income from the center's zip code; the percentage without health insurance in the center's zip code; and rural or urban center location.

To determine the best predictors of using these educational strategies [adjusted odds ratio (aOR), $_{95\% \text{ LCL aOR } 95\% \text{ UCL}}$], multiple logistic regression analysis was conducted using a manual backward selection procedure with all barriers and center characteristics entered initially. In this analysis, continuously distributed center characteristics (e.g., % of Black patients) were dichotomized at their medians to ease interpretation.

Missing data were handled in two ways. If key variables were missing $\leq 1\%$ of cases, then complete case analysis was used. If $> 1\%$ of analysis variables were missing, then multivariate imputation by chained equations (MICE) with 10 imputations over 100 iterations was used. Continuous variables and categorical variables were imputed using Bayesian linear regression and logistic regression respectively. All analyses were performed in Stata Version 14 (College Station, TX) and R version 3.4.1 (The Comprehensive R Archive Network: <http://cran.r-project.org>).

Approvals

This study protocol was approved by the Internal Review Board at Washington University in St. Louis, St. Louis University, and UCLA (protocol numbers 14-000591), Saint Louis University (25893) and the USRDS.

Results

Study participants

Representatives from 1,991 unique dialysis centers attended trainings, but 297 centers were excluded from analysis. Of the 297, 36 were deemed ineligible due to only providing acute dialysis (compared to chronic; $n=19$) or serving only pediatric patients ($n=27$). An additional 23 dialysis center representatives refused to participate in the study. Of those eligible and who agreed to participate, 38 were

excluded due to excessive missingness of survey data, and 199 were excluded for not dialyzing at least 1 new patient in the 6 months before and after the educational training (so that an associative link between educational practices and wait-listing rates could be made). This resulted in a sample of 1,694 unique dialysis centers, each with a single transplant educator representative. The characteristics of these 1,694 participating dialysis centers are detailed in Table 1. Most of the transplant educators representing the centers were female, White, and either social workers or nurses.

Variable Reduction of Education Practices

After conducting principal components analysis with Varimax rotation, a 4-component solution defining sets of educational practices was chosen. Each variable loaded on its respective component at 0.47 or above (loading range: 0.47-0.90), with most items loading > 0.60. These four components accounted for 97% of the variance in the original 12 educational practices. (**Table S1**) The first component was labelled *Oral Transplant Recommendations*, where recommending learning more about transplant, recommending being evaluated for transplant, and referring patients to external programs at transplant centers or kidney organizations all loaded highly. The second component was labelled *Distribution of Print Education*, as variables loading highly included distributing transplant center phone numbers, providing handouts/brochures about transplant, and providing lists of transplant websites. The third component was labelled *In-Center Patient Discussions*, since the two variables loading on it were having detailed discussions about the advantages and risks of living and deceased donation. The final component was labelled *Intensive Education*, as showing transplant video(s), providing education to share with prospective living donors, offering an opportunity

to talk to a kidney recipient, and displaying transplant information in center waiting rooms loaded highly. For each component, the new variables created to represent them were defined as having performed all of the practices associated with the strategy (yes) or less than all the practices (no) unless otherwise noted.

Use of Transplant Education Practices and Reports of Barriers to Education

Among the 1,694 centers, the most frequently reported individual transplant education practices were recommending that patients be evaluated for transplant (84%) and recommending that patients learn more about transplant (83%) (**Table 2.**) Of the four education strategy components, 52% of centers used Oral Transplant Recommendations, 31% used In-Center Patient Discussions, 17% used Distribution of Print Education, and 3% used Intensive Education.

The most common barriers to providing transplant education reported were having other work priorities competing with transplant education (49%), having difficulty educating patients who do not speak English (46%), and not having enough time to educate about transplant (36%). Transplant educators surveyed could only answer 42% (5 of 12) of the transplant knowledge questions correctly. Over 75% were unable to answer the following 3 individual questions correctly: “On average, how many years is a kidney transplant from a living donor expected to last?” (79% answered incorrectly); “On average, how many years is a kidney transplant from a deceased donor expected to last?” (77%); “Dialysis does what percent of the work of one functioning kidney?” (75%).

Effect of Transplant Education Strategies on Prospective Transplant Wait-listing Rates

Examining the prospective wait-listing rates, before adjustment for dialysis center characteristics, use of the Oral Transplant Recommendations strategy (IRR:

1.021.13_{1.25}), use of the Distribution of Print Education strategy (IRR: 1.041.19_{1.36}), and use of the Intensive Education strategy (IRR: 1.001.31_{1.74}) were all associated with increased prospective transplant wait-listing rates within 1-year (**Table 3**). After adjusting for dialysis center characteristics, only use of the Distribution of Print Education strategy (IRR: 1.021.15_{1.30}) remained associated with prospective transplant wait-listing rates.

Since only 3% of the dialysis centers (n=46) used the Intensive Education strategy defined as having conducted all four practices associated with this strategy, we examined an alternative definition of this strategy, using >1 of these practices (n=670), which was associated with higher unadjusted wait-listing rates (IRR: 1.031.15_{1.30}) and wait-listing rates adjusted for dialysis center characteristics (IRR: 1.001.11_{1.23}). Among the individual education practices included in the Intensive Education strategy, 27% of educators provided education to share with prospective living donors, 26% displayed transplant information in dialysis center waiting rooms, 24% offered an opportunity to talk to a kidney recipient, and 11% showed transplant videos. These results reflect analyses with multiple imputations for missing data.

Effect of Transplant Education Strategies on Retrospective Transplant Wait-listing Rates

Overall, associations between transplant education strategies and retrospective wait-listing rates were comparable to associations with prospective wait-listing rates. Before adjustment for dialysis center characteristics, use of the Oral Transplant Recommendations strategy (IRR: 1.071.22_{1.39}) was associated with increased transplant wait-listing (**Table 3**). After adjusting for dialysis center characteristics, use of the Oral Transplant Recommendations strategy (IRR:

1.06-1.20_{1.36}) remained significantly associated with transplant wait-listing. Examining the alternative definition of the Intensive Education strategy, using >1 of these practices (n=670) was associated with higher unadjusted transplant wait-listing (IRR: 1.07-1.24_{1.43}) and transplant wait-listing rate adjusted for dialysis center characteristics (IRR: 1.02-1.17_{1.34}).

Association of Reported Barriers to Providing Transplant Education and Dialysis Center Characteristics with Use of Transplant Education Strategies

Since the Oral Transplant Recommendations, Distribution of Print Education, and >1 Intensive Education strategies were associated with increased dialysis center transplant wait-listing rates, we examined which barriers to education and center characteristics were associated with using these strategies.

After fitting a multiple logistic regression model with backward selection, several barriers to transplant education were associated with lower odds of providing Oral Transplant Recommendations, including having greater than the median percentage of patients > 65 years old (aOR: 0.05-0.11_{0.23}), for-profit center ownership (aOR: 0.64-0.77_{0.91}), and rural center location (aOR: 0.66-0.79_{0.95}).

Barriers associated with lower odds of Distributing Print Education included having competing work priorities (aOR: 0.40-0.53_{0.70}) and difficulty educating non-English speaking patients (aOR: 0.48-0.64_{0.86}). Centers with a greater than median percentage of current smokers had lower odds of Distributing Print Education (aOR: 0.59-0.76_{0.99}), while centers with greater than median percentage of Black patients (aOR: 1.09-1.42_{1.84}) and with higher than the median zip code-level income (aOR: 1.03-1.34_{1.78}) had higher odds of using this strategy. (**Table 4.**)

Barriers associated with lower odds of using >1 Intensive Education included having competing work priorities (aOR: 0.520.66_{0.84}) and poor communication between dialysis and transplant centers (aOR: 0.580.76_{0.98}). Notably, centers with transplant educators who had greater than the median transplant knowledge (aOR: 1.011.27_{1.60}) and greater than the median years of experience in dialysis (aOR: 1.261.59_{2.01}) had higher odds of using the Intensive Education strategy.

Discussion

With access to transplant still restricted for many dialysis patients, it is critical for dialysis organizations and individual educators to design effective transplant education initiatives. This national study determined that the most common transplant education practices occurring in dialysis centers, general recommendations by educators to learn more about transplant and referrals to programs outside of the dialysis center, were not associated with increased wait-listing rates. However, when controlling for center characteristics, having print transplant education available, which included combinations of distributing phone numbers of the transplant centers, transplant brochures and videos, education for prospective living donors, and access to a transplant recipient, was associated with increased transplant wait-listing rates.

While early education within dialysis centers can seem very distal to the outcome of eventual transplant wait-listing and transplant, these findings, along with others, confirm the importance of education occurring within dialysis centers. Previous research has shown that patients who present to a transplant center more knowledgeable and ready to pursue transplant are significantly more likely to complete transplant evaluation and receive LDKTs (11) and that provision of more transplant education practices (>3 vs. ≤3) with dialysis patients has been

associated with a 36% increase in dialysis center wait-listing rates (7). In a national study of more than 200,000 dialysis patients, Kucirka and colleagues found that failure to inform dialysis patients of their option for transplant per CMS Form-2728 was associated with a 53% decrease in access to transplant, defined as either joining the waitlist or receiving LDKT (5). Several trials have also shown that improved education outside of transplant centers is associated with increased rates of transplant evaluation, wait-listing, and living donor evaluations (1, 2, 15, 16). A recent regional RCT by Patzer and colleagues examining the impact of a multi-level intervention in dialysis centers that included patient-level transplant education, training of dialysis staff about transplant, and improving center-level protocols for referral reduced racial disparities and resulted in increased transplant referrals overall (2).

Dialysis educators also reported many barriers to delivering transplant education, including limited time to educate, competing work priorities and poor knowledge about transplant themselves. This study found that transplant educators in dialysis centers who reported having competing work priorities were less likely to use education strategies associated with increased transplant wait-listing rates, and educators with greater transplant knowledge were more likely to use them. Previous studies have found that the dialysis center “culture” or philosophy is important for promoting transplant education and pursuit. Balhara and colleagues found that although a sample of dialysis nephrologists rated >20 minutes as the ideal amount of time to counsel their patients about transplant, less than 50% of nephrologists in the study spent this amount of time counseling (6). Gander and colleagues found that dialysis centers that reported a “pro-transplant” philosophy had significantly higher wait-listing performance (9). Established administrative

policies and training within centers that ensure that dialysis educators are both knowledgeable about and have sufficient time and resources to educate may increase transplant wait-listing rates. To support these efforts, transplant centers must share educational resources and expand their outreach to dialysis centers to partner more effectively to ensure transplant referral and communication with dialysis centers. For-profit dialysis centers may be important targets for efforts to improve transplant education approaches, since this study, like others, found that for-profit centers are less likely to use some common transplant education approaches (6).

Difficulty communicating with non-English speaking patients also prevented the use of effective educational strategies and is one potential cause for these patients' known disparity in access to transplant (17). Dialysis educators must increase their cultural competence and ability to educate non-English speaking patients. Special attention must be placed on ensuring that educational resources in multiple languages and translators are available. A suitable model may be the resources and culturally-tailored transplant education and evaluation process at Northwestern University (18, 19), which is available in Spanish and addresses culturally-relevant concerns of Hispanic patients.

This study has many limitations that should be considered when interpreting its results. While the sample of dialysis centers studied here is relatively large and includes centers throughout the U.S., it is a convenience sample and may not fully represent the national dialysis center population. Similarly, while this sample is larger than previous studies, it is still insufficient to estimate the effect of infrequently used transplant education strategies. The transplant education practices and barriers studied here are also self-reported by dialysis staff, which

may be subject to bias (4). Finally, while a range of dialysis staff are included in the study, few dialysis nephrologists, who have an important role in determining the transplant education activities dialysis patients receive, are included. Future studies should include both dialysis patients, educators, and nephrologists to ensure inclusion of all important perspectives. One strength of the method includes use of two sets of transplant wait-listing rates, prospective and retrospective. The overall consistency observed between two sets of results instills confidence in our findings.

In the future, more research is needed to determine whether dialysis educators could simply distribute transplant education resources more widely or more often or whether more intensive educational strategies like access to a peer mentor and educating living donors directly are more successful at increasing transplant wait-listing rates. Only 46 of the 1,694 dialysis centers (3%) surveyed used all of the intensive educational strategies. Given the barriers to delivering comprehensive transplant education to both patients and living donors reported by dialysis educators, greater distribution of transplant print and video educational resources, a less time-intensive and cost-effective educational strategy, should be further explored as a stand-alone strategy. Large, well-powered RCTs in dialysis centers that isolate and directly compare these strategies are needed to clarify these issues.

In summary, the present study adds new evidence to a growing body of national research that demonstrates that education occurring in dialysis centers play a critical role in determining whether the majority of ESRD patients make informed choices and receive access to transplant as a treatment option. These findings indicate that interventions to ensure increased transplant wait-listing rates must look to improve both the specific educational approaches taken by dialysis

staff as well as the center's administrative policies and support for providing transplant education. This study offers novel evidence on the range and effectiveness of transplant education practices used in U.S. dialysis centers, informs guidance as to how dialysis staff should approach educating patients, and highlights specific interventions that may lead to more ESRD patients receiving kidney transplants. With the many challenges of delivering transplant education in dialysis centers, educators should prioritize education strategies shown to be associated with increasing wait-listing rates.

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Disclosures

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Tables

Table 1. Characteristics of Dialysis Centers (n=1,694)		
<i>Transplant Educator Characteristics</i>	N	%
Gender		
Female	1529	90%
Male	161	9%
Missing	4	1%
Race/ethnicity		
White	1149	68%
Black	216	13%
Asian	157	9%
Hispanic or Latino (considered mutually exclusive from White, Black, & Asian)	108	6%
Other	50	3%
Missing	14	1%
Job title		
Social Worker	941	56%
Nurse	257	15%
Dialysis Technician	171	10%
Nurse Manager/Center Administrator	134	8%
Dietician	113	7%
Other	76	5%
Missing	2	0.2%
	Mean	SD
Age (years)	45	11
Number of years working with dialysis patients	10	9
<i>Dialysis Center Characteristics</i>		
% Female patients	42%	19%
% Black non-Hispanic patients	25%	28%
% Hispanic patients	12%	18%
% Asian non-Hispanic patients	6%	14%
% White non-Hispanic patients	56%	32%
% aged \geq 65 years	48%	20%
% with diabetes	56%	20%
% with cardiovascular disease, cerebrovascular accident, or transient ischemic attack	8%	10%
% vascular access fistula present at ESRD start	2%	6%
% current smoker	6%	10%
Number of patients served	80	52
Number of stations in center	19	8
Number of full time staff	13	8
Dialysis center ownership status	N	%

For-profit	1447	85%
Non-profit	247	15%
Dialysis Center Geographical Location		
Rural	339	20%
Urban	1319	78%
	Mean	SD
Median Income in Dialysis Center Zip Code	\$52,940	\$20,616
Percent Uninsured in Dialysis Center Zip Code	14%	7%

Table 2. Transplant Education Approaches and Barriers within Dialysis Facilities (n=1,694)	
	% (n)
<i>Transplant Education Practices Used by Dialysis Centers</i>	
Recommend being evaluated for transplant	84% (1422)
Recommend learning more about transplant	83% (1402)
Provide handouts/brochures about transplant	61% (1030)
Refer patients to educational program at a transplant center/kidney organization	60% (1017)
Distribute transplant center phone numbers	57% (964)
Have a detailed discussion about the advantages/risks of living donation transplant	36% (609)
Have a detailed discussion about the advantages/risks of deceased donation transplant	35% (588)
Provide education to share with prospective living donors	27% (448)
Display transplant posters in waiting room	26% (434)
Offer an opportunity to talk to a kidney recipient	24% (399)
Provide list of transplant websites	22% (370)
Show transplant video(s)	11% (177)
<i>Combined Transplant Education Strategies</i>	
Oral transplant recommendations	52% (878)
In center patient discussions	31% (527)
Distribution of print education	17% (284)
Intensive education (used all 4 practices)	3% (46)
Intensive education (used >1 practice)	40% (670)
<i>Reported Barriers to Providing Transplant Education</i>	
Completing other work priorities prevents educating about transplant	49% (827)
Has difficulty educating patients who are unable to speak English	46% (778)
Does not have enough time to educate about transplant	36% (605)
Does not have a way to watch DVDs at their dialysis center(s)	27% (462)
Poor communication between nearby transplant centers and the dialysis center	29% (493)
Dialysis center administration does not support taking the time needed to educate patients about transplant	12% (202)
Dialysis center administration does not value transplant education as an important priority	9% (159)
Dialysis center administration does not support living donation as a transplant option	4% (73)
	<i>Mean (SD)</i>
Level of transplant knowledge of providers ^a	5.2 (2.1)
^a Rated on a scale from 0-12, with higher scores indicating higher knowledge.	

Table 3. Association between Transplant Education Strategies with Prospective and Retrospective 12 mo. Wait-listing Rates among Dialysis Centers (n=1,694)

Combined Educational Strategies	Prospective		Retrospective	
	Unadjusted IRR (95% CI)	Adjusted ^{a,b} IRR (95% CI)	Unadjusted IRR (95% CI)	Adjusted ^{a,b} IRR (95% CI)
Oral transplant recommendations	1.13 (1.02-1.25)	1.08 (0.98-1.19)	1.22 (1.07-1.39)	1.20 (1.06-1.36)
In-center patient discussions	1.00 (0.89-1.11)	0.96 (0.87-1.07)	1.07 (0.94-1.23)	1.09 (0.95-1.24)
Distribution of print education	1.19 (1.04-1.36)	1.15 (1.02-1.30)	1.15 (0.97-1.36)	1.16 (0.99-1.36)
Intensive education (conducted all practices)	1.31 (1.00-1.73)	1.17 (0.90-1.51)	1.30 (0.93-1.82)	1.25 (0.90-1.72)
Intensive education (alternative definition: conducted >1)	1.15 (1.03-1.30)	1.11 (1.00-1.23)	1.24 (1.07-1.43)	1.17 (1.02-1.34)

^aAdjusts for dialysis center characteristics, including: percentage of female patients; percentages of Black, White, Hispanic, and Asian patients; percentage of patients aged ≥ 65 years; percentage with diabetes; percentage with CVD, CVA, or TIA; vascular access fistula present at ESRD start; percentage who are current smokers; the ratio of the number of patients served in the center to the number of the center's full time staff; the number of dialysis stations in the center; for- or non-profit center ownership; the median income from the center's zip code; the percentage without health insurance in the center's zip code; and rural or urban center location.

^bDue to missingness among transplant center characteristics, results presented include multiple imputations.

Table 4. Association between Dialysis Center Characteristics and Reported Barriers to Use of Transplant Education Strategies (n=1,694)	
	Adjusted ^{a,b} OR (95% CI)
<i>Odds of Providing Oral Transplant Recommendations</i>	
% > 65 years old (dichotomized at median)	0.11 (0.05-0.23)
Ratio of number of patients served in the center to the number of the center's full time staff	1.03 (1.01-1.04)
For-profit center ownership	0.77 (0.64-0.91)
% without health insurance in the center's zip code (dichotomized at median)	0.97 (0.96-0.99)
Rural center location	0.79 (0.66-0.95)
<i>Odds of Using Distribution of Print Education Strategy</i>	
% Black patients (dichotomized at median)	1.42 (1.09-1.84)
Median income of dialysis center zip code (dichotomized at median)	1.34 (1.03-1.78)
% current smoker (dichotomized at median)	0.76 (0.59-0.99)
Has difficulty educating patients who are unable to speak English	0.64 (0.48-0.86)
Completing other work priorities prevents educating about transplant	0.53 (0.40-0.70)
<i>Odds of Using Intensive Education Strategy (>1 practice)</i>	
Years of working with dialysis patients (dichotomized at median)	1.59 (1.26-2.01)
Transplant knowledge score (dichotomized at median)	1.27 (1.01-1.60)
Poor communication between nearby transplant centers and the dialysis center	0.76 (0.58-0.98)
Completing other work priorities prevents educating about transplant	0.66 (0.52-0.84)
^a The variables presented were retained from a backward selection procedure in which the following variables were initially entered: all reported barriers to providing transplant education; percentage of female patients; percentages of Black, White, Hispanic, and Asian patients; percentage of patients aged ≥ 65 years; percentage with diabetes; percentage with CVD, CVA, or TIA; vascular access fistula present at ESRD start; percentage who are current smokers; the ratio of the number of patients served in the center to the number of the center's full time staff; the number of dialysis stations in the center; for- or non-profit center ownership; the median income from the center's zip code; the percentage without health insurance in the center's zip code; and rural or urban center location.	
^b Due to missingness among reported barriers to providing transplant education variables, results presented include multiple imputations.	

Table S1. Principal Components Analysis of Education Strategies (n=1,694)				
	Factor 1: Oral Transplant Recommendations	Factor 2: Distribution of Print Education	Factor 3: Patient Discussions	Factor 4: Intensive Education
Refer patients to educational program at a transplant center/kidney organization	0.540	0.423	0.201	0.122
Recommend learning more about transplant	0.670	0.146	0.194	0.267
Recommend being evaluated for transplant	0.728	0.212	0.162	0.294
Distribute transplant center phone numbers	0.390	0.686	0.170	0.078
Provide handouts/brochures about transplant	0.239	0.657	0.066	0.334
Provide list of transplant websites	0.054	0.653	0.125	0.267
Show transplant video(s)	0.162	0.242	0.153	0.625
Display transplant posters in waiting room	0.235	0.146	0.123	0.473
Provide education to share with prospective living donors	0.247	0.368	0.301	0.510
Have a detailed discussion about the advantages/risks of living donation transplant	0.215	0.151	0.900	0.280
Have a detailed discussion about the advantages/risks of deceased donation transplant	0.230	0.180	0.892	0.285
Offer an opportunity to talk to a kidney recipient	0.161	0.143	0.304	0.588
% of total item variance accounted for	23%	25%	26%	23%
Note: Cells contain component loadings.				