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Kidney transplant candidacy evaluation and waitlisting practices in the US and their association with access to transplantation

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Abstract

There are limited data on the degree of variability in practices surrounding prioritization of referrals for transplant evaluation and criteria for transplant candidacy and their association with transplantation rates. We surveyed transplant programs across the US between January 2020-May 2020 to determine current pre-transplantation practices. We examined the relation between these reported practices and the outcomes of waitlisted patients at responding programs between January 2015-March 2021 using Scientific Registry of Transplant Recipients data. We used adjusted Cox models with random effects to accommodate clustering by program. Primary outcomes included living or deceased donor transplantation. Of 172 surveyed programs, 90 participated. Substantial variations were noted in when the candidacy evaluation began (13% reported when eGFR was <30mL/min/1.73m^2 and 17% reported no set policy) and the approach to pre-transplantation cardiac workup (multi-modality [58%], stress echocardiogram [20%]). Using adjusted models, a program policy of using other measures of body habitus to determine transplant candidacy rather than requiring patients to meet a body mass index (BMI) threshold of ≤35 kg/m^2 (reference group)

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Supporting information statement

Additional supporting information may be found online in the Supporting Information section.

for candidacy was associated with a higher hazard of living donor transplantation (HR 1.83 [95% CI 1.10–3.03]). Pre-transplant practices vary substantially across the US, and select practices were associated with transplantation rates.

1. Introduction

Kidney transplant programs in the US are known to have substantial variations in pre-transplantation practices and policies that may reflect the lack of consensus surrounding many aspects of transplant care.[1–9] For example, variability has been described in evaluation practices related to the domains of frailty, body size, and other candidacy considerations across different transplant programs.[3–7] However, data on the degree of variability in pre-transplant practice patterns in the contemporary era and the extent to which such variations in practice may be associated with outcomes following waitlist registration and transplantation are limited.

Many aspects of transplant program practices related to acceptance of referrals, criteria for candidacy for transplantation, and pre-transplantation evaluation are not captured routinely in the data reported by transplant programs to the United Network for Organ Sharing (UNOS) or national registries. Granular data surrounding these practices require additional survey of transplant programs. The last survey to comprehensively evaluate pre-transplantation practices of kidney transplant programs was completed in 2001.[3] Since then, several surveys have assessed transplant program practices regarding specific aspects of pre-transplant care, such as the role of frailty and advanced age, presence of liver disease, or practices related to cardiac evaluation.[2,4–7,10] However, these prior studies were completed before changes in the organ allocation system,[3,4,10] focused on targeted aspects of evaluation practices,[2,4–7,10] and often allowed for multiple responses from different providers at each transplant program.[2,6] Prior surveys have also not examined whether system-level variations in program practices are associated with patient outcomes such as access to transplantation or graft survival. If variations in practice are associated with outcomes, then system-level practices may need better standardization to optimize patient access to kidney transplantation and graft survival.

The objectives of this study were to determine contemporary pre-transplantation practices of adult kidney transplant programs through a national survey. We also aimed to determine if variations in practice were associated with patient outcomes (access to living or deceased donor transplantation, preemptive transplantation, and graft survival after transplantation) at participating programs using data from the Scientific Registry of Transplant Recipients (SRTR).

2. Methods

2.1 Study population and survey administration

We invited active adult kidney transplant programs in the US to participate in an electronic survey via email. We considered an active adult kidney transplant program to be one with

a program-specific report for adult patients on the SRTR website in 2019 (N=202). We excluded 30 programs from our study due to inability to identify an email contact.

We aimed to have one response from each program. We initially distributed the survey to Medical Directors of each kidney transplant program. If there was no response from the Medical Director or we could not identify the Medical Director or their contact information, then an alternate transplant nephrologist or transplant surgeon at the program was invited to participate. We completed three separate waves of invitations to participate in our survey between January and May 2020. Each wave consisted of an initial email invitation with a link to our survey followed by a weekly reminder for three weeks. We contacted only one provider at each program in each wave. Programs that completed the survey were not included in subsequent waves of invitations to limit each program to one response. All surveys were distributed using Research Electronic Data Capture (REDCAP) and data stored in secure fashion, and a gift card was provided to respondents.

Patient-level data from participating centers were extracted from the SRTR. The SRTR includes data on all kidney donors, wait-listed candidates, and transplant recipients in the US, submitted by the members of the Organ Procurement and Transplantation Network (OPTN). The Health Resources and Services Administration, U.S. Department of Health and Human Services provides oversight to the activities of the OPTN and SRTR contractors. This study was approved by the Institutional Review Board of the University of California, San Francisco (approval number 18-26996).

2.2 Survey content

We assessed practice patterns in the pre-transplant evaluation phase of care (see Appendix for survey questions). We included questions surrounding practices regarding screening and prioritization of referrals and program-specific criteria for transplant candidacy. We also included questions surrounding practices for the cardiac evaluation of potential transplant candidates and frequency of follow-up testing for new-onset cardiac disease. We focused on these areas following discussion among co-authors and review of the literature surrounding pre-transplantation practices. We developed our survey in a hybrid approach in which we developed and tested new questions in an iterative process, but also adapted questions from a prior survey of pre-transplantation practices.[3] We piloted the survey among six different providers (nephrologists and surgeons) to ensure clarity of the survey questions and solicited feedback on important subject areas to address. We then refined our questions prior to distribution of our finalized survey. The options for responses were designed to be mutually exclusive and collectively exhaustive, with the option to provide free text if none of the response choices were applicable.

2.3 Transplant Program Practices and Patient Outcomes

We evaluated the association between transplant program practices (pre-screening and prioritization of referrals, estimated glomerular filtration rate (eGFR) threshold for evaluation prior to transplantation, body mass index (BMI) criteria for transplant eligibility, and cardiac evaluation approach) with outcomes determined using patient-level data from the CAND_KIPA and TX_KI Standard Analysis Files according to the SRTR. We included

all patients who were newly registered on the waitlist between January 1, 2015 and December 31, 2019 at responding programs. Follow up for outcomes were available through March 31, 2021. We excluded candidates listed for multi-organ transplants from analyses since the criteria for combined kidney and other organ transplants may differ and were not the focus of our survey.

The primary outcomes of interest included receipt of a living donor (LD) kidney transplant within two years of waitlisting or deceased donor (DD) transplantation at any time during follow-up. Secondary outcomes included preemptive transplantation (i.e., without prior initiation of dialysis) among the subset who were registered on the waitlist prior to dialysis initiation, and graft survival among the subset of patients who received kidney transplantation.

2.4 Statistical Analysis

We compared patient-level characteristics among those waitlisted or transplanted as well as the annual volume of new waitlist registrations and kidney transplant procedures at responding and non-responding programs using chi-square, t-test or Wilcoxon rank-sum tests as appropriate. We examined the distribution of responses to survey questions using histograms. To protect anonymity of individual transplant programs, any responses selected by a single program were combined in an “other responses” category in our histograms. We assessed for differences in reported practice patterns by tertile of program size (defined as number of kidney transplants completed during the study) using chi-square tests.

Next, we selectively grouped conceptually related questions that were relevant to LD or DD transplantation, cardiac evaluation, and preemptive transplantation. We then used univariable and multivariable Cox proportional hazards models to assess the relation between these groups of related practices and the hazard of LD transplantation within two years of waitlisting, DD transplantation, or preemptive transplantation at any time during follow-up in separate models. Our multivariable analyses were adjusted for the other conceptually related practice patterns besides the particular practice of interest, as well as for patient age at waitlisting, sex, race/ethnicity, and UNOS region of the transplant program. In sensitivity analysis, we additionally adjusted these models for patient comorbidities (diabetes, coronary artery disease, cerebrovascular disease, and history of malignancy). All models included random effects (shared frailty terms) to accommodate clustering by transplant program and were censored for death. We did not release results for any response option selected by fewer than three programs to protect the anonymity of individual transplant programs.

In order to assess if our results could have been influenced by competing risks, we completed additional analyses to directly compare a Cox model (without the shared frailty term) with a Fine-Gray competing risk model for our primary outcomes of living and deceased donor transplantation where we treated death and deceased or living donor transplantation, respectively, as competing risks.

Finally, we examined the association between practice patterns and death-censored graft failure using similar models as noted above but including only the subset of waitlisted individuals who received a kidney transplant during follow-up and using age

at transplantation rather than age at waitlisting as a co-variate. Time on dialysis (dialysis vintage) was included additionally as a covariate in the graft failure models, and we assigned a value of 0.25 days to patients who underwent pre-emptive transplantation.

We used Stata 15 statistical software (StataCorp LLC, College Station, TX) in all analyses.

3. Results

3.1 Participating programs

Ninety (52%) of the 172 invited programs completed the survey (Supplemental Figure 1). In total, participating transplant programs waitlisted 90,148 adult patients and performed 37,359 kidney transplants during follow-up, accounting for 57% and 59% of all waitlist registrations and transplants, respectively, at adult kidney transplant programs in the US. Demographic characteristics of patients served by responding versus non-responding programs were not substantially different, although there were minor differences in age and racial and ethnic distribution of the populations served by these programs (Table 1). Responding programs had higher volumes of waitlist registrations and kidney transplantations compared with non-responding programs (Table 1). In addition, responding programs were more likely to reside in UNOS region 5 (23.9%) versus region 6 (4.4%).

Of the survey respondents, 45% were Medical Directors at the transplant program, 48% were Transplant Nephrologists, and 7% were other providers. No duplicate responses were received. Missing survey responses were rare (<0.2% of responses).

Among the responding programs, a median of 52 transplants occurred per year (Interquartile range 22–80, Table 1).

3.2 Referral screening, program-specific criteria related to candidacy for kidney transplantation, and organ offers

We first ascertained practices surrounding management of referrals for the assessment of transplant candidacy. The majority of programs (59%) noted that they screened referrals for transplant evaluation before scheduling an in-person evaluation, although 40% evaluated all referred patients at scheduled visits (Figure 1). We also asked respondents whether their programs prioritized candidates with a potential living donor for the initial transplant candidacy evaluation. About one-quarter (26%) indicated that they always prioritized such patients, 22% indicated that they prioritized some patients in this setting, and 52% indicated that their centers did not consider this factor during the scheduling of candidacy evaluation (Figure 1). For programs reporting that prioritization of scheduling of candidates with a potential living donor “sometimes” occurred, the most important factor that guided the timing of the evaluation was whether preemptive transplantation was likely to occur.

The kidney function threshold at which programs began to evaluate patients for transplant candidacy if they had not yet started dialysis varied substantially across the US (Figure 1), with 17% of programs reporting no set policy and the majority of programs using an eGFR threshold of either 20 mL/min/1.73 m^2 (38%) or 25 mL/min/1.73 m^2 (30%).

The majority of programs reported having a BMI threshold for the determination of candidacy for kidney transplantation, but these criteria also varied (Figure 1). The majority of programs (54%) had a BMI threshold of ≤40 kg/m^2. For 18% of programs, the BMI threshold depended on the presence or absence of other patient comorbidities. Programs that used "other" thresholds of body habitus (9% of respondents) generally reported using waist-height ratio or considered body composition rather than BMI when determining transplant candidacy.

Decisions about organ offers were typically made by the transplant surgeon (68%) or by the transplant surgeon and nephrologist jointly (28%, Supplemental Figure 2).

Referral screening practices, criteria related to candidacy for kidney transplantation, and decisions surrounding organ offers did not differ statistically by transplant program size ($p>0.05$, Supplemental Table 1).

3.3 Cardiac evaluation of patients prior to transplantation

We surveyed programs about their practices surrounding cardiac evaluation prior to transplantation. Although cardiac catheterization was rarely required for all potential transplant candidates (less than 3% of programs), 20% of programs required all patients with a history of diabetes to undergo cardiac catheterization prior to transplant (Figure 2). Among candidates who required cardiac catheterization but were not yet on dialysis, the majority of programs (84%) routinely defer cardiac catheterization until after the initiation of dialysis. The most common approach to cardiac evaluation (if cardiac catheterization was not required) was use of a combination of different testing modalities depending on the individual patient's risk factors (58%), but 20% of programs specifically preferred stress echocardiography and 19% preferred nuclear medicine perfusion studies. In the absence of a new or suspected cardiac event among patients registered on the waitlist, a similar proportion of programs required a repeat cardiac evaluation in all patients (47%) versus only requiring a repeat cardiac evaluation in patients with specific risk factors (49%, Figure 2). However, programs varied considerably in the frequency of such repeat testing, ranging from every year (47%) to every 2 years (33%), or repeating cardiac studies only when candidates approached the top of the waitlist (13%, Figure 2).

Cardiac evaluation practices did not statistically significantly differ by transplant program size ($p>0.05$, Supplemental Table 1).

3.4 Relation between program-specific practices and access to transplantation

The eGFR at which transplant candidacy evaluation was begun was not associated with hazard of LD transplantation within two years of waitlisting in adjusted models (Table 2A). However, for deceased donor transplantation, starting the evaluation earlier (eGFR <30 mL/min/1.73 m^2) than the reference group (eGFR <20 mL/min/1.73 m^2) was associated with substantially lower access to deceased donor transplantation in unadjusted (HR 0.63 [95% CI 0.43–0.91]) and adjusted analyses (HR 0.58 [95% CI 0.41–0.82], Table 2B).

Using other measures of body habitus to determine transplant eligibility rather than requiring patients to meet a BMI threshold ≤35 kg/m^2 for candidate eligibility was

associated with a higher hazard of LD transplantation in unadjusted (HR 1.84 [95% CI 1.07–3.14]) and adjusted analyses (HR 1.83 [95% CI 1.10–3.03]; Table 2A). A BMI threshold of ≤40 kg/m^2 compared with reference (BMI ≤35 kg/m^2) was associated with a higher hazard of LD transplantation, although this finding did not achieve statistical significance in adjusted analysis (HR 1.38 [95% CI 0.96–1.97]). The BMI threshold for transplant eligibility was not statistically significantly associated with the hazard of DD transplantation (Table 2B). We found that using a BMI threshold of ≤40kg/m^2 compared with a BMI threshold of ≤35 kg/m^2 for transplant candidacy was associated with a higher likelihood of preemptive transplantation (adjusted HR 1.58 [95% CI 1.07–2.32]; Supplemental Table 2A). Using other BMI thresholds than provided in the survey question was also associated with higher likelihood of preemptive transplantation (adjusted HR 1.80 [95% CI 1.04–3.12]; Supplemental Table 2A). The results of our sensitivity analyses adjusting for comorbidities or using Fine-Gray competing risk models were not substantively different (Supplemental Tables 3 and 4).

Cardiac evaluation practices were not associated with the hazard of LD transplantation (Table 3A). However, when cardiac catheterization was not required for candidacy evaluation, routine use of stress echocardiography rather than using a combination of different methods depending on risk factors was associated with higher hazard of DD transplantation (adjusted HR 1.62 [95% CI 1.19–2.22]; Table 3B). Regular cardiac retesting of waitlisted patients with cardiac risk factors was associated with a higher hazard of DD transplantation (adjusted HR 2.21 [95% CI 1.13–4.43]; Table 3B) compared with no retesting. However, regular cardiac testing following waitlist registration was not associated with the hazard of LD transplantation (Table 3A).

We also found that cardiac evaluation practices were associated with the likelihood of preemptive transplantation. At programs where cardiac catheterization was not required for transplant candidacy evaluation, routine use of stress echocardiography was associated with a higher hazard of preemptive transplantation (adjusted HR 1.56 [95% CI 1.13–2.14]; Supplemental Table 2B) compared with using a combination of different methods based on patient risk factors for the evaluation of cardiovascular risk.

3.5 Relation between program-specific practices and graft failure

The mean follow-up time for the outcome of graft failure was 2.5 years. We found that a BMI threshold of ≤40kg/m^2 or a BMI threshold that varied based on patient comorbidities as compared to our reference group (BMI ≤35 kg/m^2) was associated with a lower hazard of graft failure in adjusted analyses (HR 0.61 [95% CI 0.45–0.82] and HR 0.57 [95% CI 0.37–0.87], respectively; Supplemental Table 5A). Cardiac evaluation practices were not associated with the risk of graft failure (Supplemental Table 5B).

4. Discussion

Prior studies have described substantial differences in the evaluation and determination of patient candidacy for kidney transplantation across different programs.[2–7] These studies have focused on variability in policies surrounding transplant candidacy, the approach to frailty, and management of other comorbidities at transplant programs.[2,4–7] Although these

studies have informed our knowledge surrounding transplant program practices in the US, studies have seldom linked these practices to clinical outcomes. Our study is novel in its assessment of program-level pre-transplant practices in a contemporary era and our link of reported practices to transplantation access and graft survival. Our data suggest that adult kidney transplant programs continue to vary considerably in practice patterns related to screening of referrals received by the transplant program, determination of candidacy for kidney transplantation, and pre-transplantation cardiac work up. Of the many eligibility criteria used commonly in transplant evaluation, timing of the initial candidacy evaluation, BMI policy for transplant candidacy, and cardiac evaluation practices were associated with access to transplantation. For example, BMI thresholds for transplant eligibility were associated with the hazard of living donor transplantation, preemptive transplantation, and graft failure. Also, the approach to cardiac evaluation was associated with hazard of both deceased donor and preemptive transplantation.

Successful kidney transplantation is the ultimate goal of any transplant program when developing the center-specific protocol for candidate evaluation and pre-transplantation management. What defines success, however, is dependent upon perspective. The OPTN has historically focused on one- and three-year patient and graft survival, which has influenced the evaluation and listing practices of individual programs. More recently with the Advancing American Kidney Health Initiative (AAKHI) which went into effect in 2019 has focused on improving patient access to kidney transplantation, especially from living donors.[11] This coincides with a revised focus of the OPTN on program-specific transplantation rates. Understanding the evaluation and waitlisting practices at transplant programs and their association with access to transplantation may help programs adopt changes to meet the goals of the AAKHI and governing bodies, but also to optimize access to transplantation. Furthermore, quality improvement initiatives to ensure pre-transplant practices are delivered consistently may also serve as an important mechanism to promote equitable access to transplantation and to ensure appropriate use of medical resources.

Early referral and evaluation for transplant eligibility determination is one of the key factors to maximizing accrual of time on the waitlist for patients who have not yet started dialysis.[12–14] Although there is considerable variability across the US in when transplant programs begin to evaluate patients, we found that the majority of transplant programs that responded to our survey currently use an eGFR threshold to determine if candidates are evaluated. Interestingly, our study showed that starting the evaluation very early (when eGFR first falls to <30 mL/min/1.73 m^2) was associated with lower access to deceased donor transplantation. The reasons for this observation are unclear and deserves further study, but we surmise that some patients may have slowly progressive disease and did not need a kidney transplant, while others may not have accrued additional waiting time despite earlier evaluation by the transplant center due to failure to ever meet the allocation policy threshold for waiting time accrual (GFR < 20 mL/min). Further studies are indicated to understand this finding.

Obesity is a known factor that limits access to living and deceased donor transplantation among adults.[15,16] Most transplant programs continue to have program-specific BMI criteria for transplant candidacy. One persistent question is whether BMI alone is a valid measure

of obesity. Although BMI is a readily available measure of body size, it is less informative regarding body composition or level of physical fitness. Our study suggests that programs that do not have stringent BMI thresholds may have higher rates of living donor and preemptive transplantation as well as lower rates of graft failure, and that a BMI threshold of ≤40 kg/m^2 may help improve the rates of these outcomes. It remains unclear whether fixed body size thresholds should continue to be enforced when determining transplant candidacy.[17,18]

The majority of transplant programs required routine cardiac retesting in their waitlisted patients, some as frequently as annually. Interestingly, we did find that use of stress echocardiogram (when cardiac catheterization was not deemed to be required) was associated with better access to deceased donor and preemptive transplantation. The reasons for these findings remain unclear. Our study also found that transplant program practice with regard to the need for regular cardiac testing following waitlist registration was not associated with LD or preemptive transplantation or with graft survival, but regular retesting among those with risk factors may be associated with higher rates of DD transplantation. However, only a minority of programs (3%) did not perform regular cardiac testing following waitlist registration which limits the inferences which can be made. Whether regular cardiac testing following waitlist registration improves outcomes remains uncertain and an area of active study, including the Canadian-Australasian Randomized Trial of Screening Kidney Transplant Candidates for Coronary Artery Disease (CARSK) study which aims to determine the utility of routine cardiac screening in asymptomatic waitlisted patients.[19–21]

Our study has several strengths including a relatively high survey response rate and inclusion of programs who were collectively responsible for almost 60% of waitlist registrations and kidney transplantations in the US between 2015–2019. Our survey was also linked to de-identified patient-level outcomes at responding programs, which is a novel aspect of our methodology. Limitations included the potential for non-responder bias and residual confounding and our limited power to detect significant associations for outcomes that occurred less frequently, such as graft failure. Our patient population is also limited to those who were ultimately registered on the waitlist and excludes those who were deemed ineligible for waitlist registration. We do not have granular data on how individual patient comorbidities influence transplant center practices, if at all. Additionally, we did not ask programs about the method used to determine kidney function for transplant evaluation or details of their practices related to organ offer acceptance and evaluation and acceptance of living donor candidates. We acknowledge the increased possibility of type 1 errors due to the large number of hypotheses tested. Finally, our findings may not apply to the practices of other countries with different transplant evaluation processes, healthcare systems, and frameworks for organ allocation.

In conclusion, in a national survey of adult kidney transplant programs in the US, we identified substantial variability in practice patterns in many aspects of pre-transplantation care and found important associations between practice patterns and access to transplantation and graft outcomes. Careful attention to policies related to timing of the initial transplant candidacy evaluation could improve access to deceased donor

transplantation, and re-evaluating stringent BMI thresholds for transplant candidacy has the potential to improve access to living donor and preemptive transplantation as well as graft outcomes. Further studies to understand the contribution of practice patterns and policies to observed variations in kidney transplant access and graft outcomes are warranted.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Data availability statement

The registry data that support the findings of this study are available from the Scientific Registry of Transplant Recipients. The survey data that support the findings of this study are available from the corresponding author upon reasonable request.

Abbreviations:

eGFR	estimated glomerular filtration rate
BMI	body mass index
CARSK	Canadian-Australasian Randomized Trial of Screening Kidney Transplant Candidates for Coronary Artery Disease
DD	deceased donor
HR	hazard ratio
LD	living donor
OPTN	Organ Procurement and Transplantation Network
REDCAP	Research Electronic Data Capture
SRTR	Scientific Registry of Transplant Recipients
UNOS	United Network for Organ Sharing

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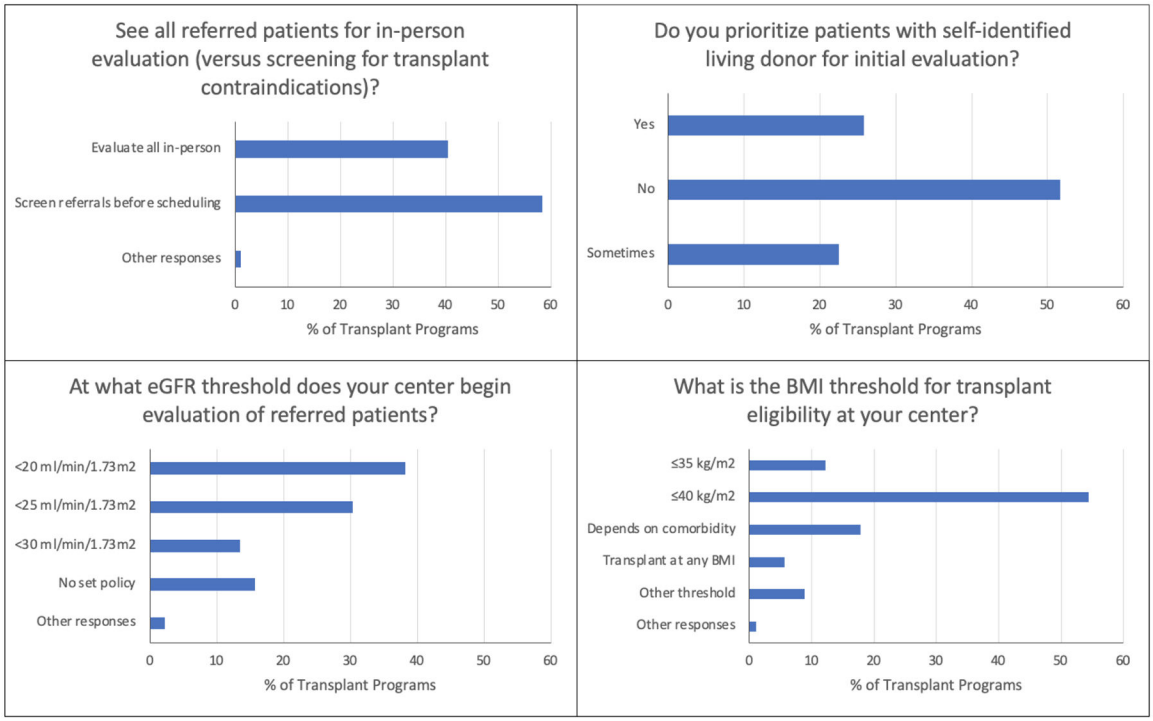

Figure 1.

Responses from a survey conducted between January and May 2020 surrounding referral screening and program-specific criteria related to candidacy for kidney transplantation.

BMI = body mass index

eGFR = estimated glomerular filtration rate

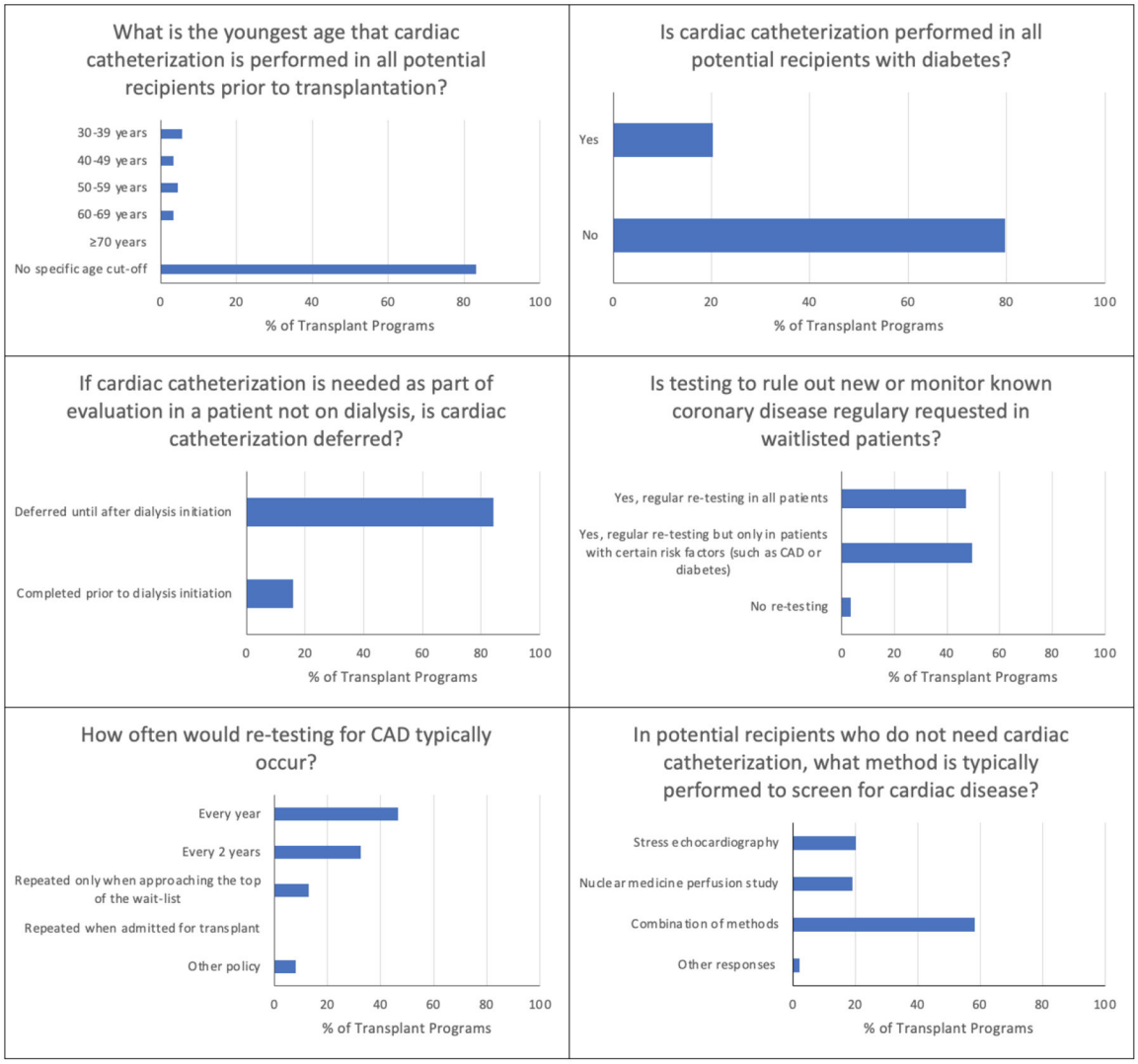

Figure 2.

Responses from a survey conducted between January and May 2020 surrounding cardiac evaluation of patients prior to transplantation.

Table 1.

Characteristics of transplant programs that responded versus did not respond to our survey.

Program characteristic	Non-responders (112 transplant programs)	Responders (90 transplant programs)	P-value [a]
Waitlist registrations			
Mean age at waitlist registration (SD) in years	53.0 (13.1)	52.8 (13.1)	<0.001
Male, n (%)	41,962 (62.6)	56,272 (62.4)	0.48
Race, n (%)			<0.001
White	26,606 (39.9)	38,354 (42.5)	
Black	21,113 (31.7)	24,339 (27.0)	
Hispanic	13,562 (20.3)	16,941 (18.8)	
Asian	3,954 (5.9)	8,546 (9.5)	
Other/multi-racial	1,434 (2.2)	1,968 (2.2)	
Waitlists per year, median (IQR)	92.0 (53.5, 152.5)	158.0 (88.0, 280.0)	<0.001
UNOS region, n (%)			<0.001
1	910 (1.4)	5,567 (6.2)	
2	7,050 (10.5)	12,749 (14.1)	
3	12,077 (18.0)	11,051 (12.3)	
4	11,902 (17.8)	6,252 (6.9)	
5	6,066 (9.0)	21,517 (23.9)	
6	551 (0.8)	4,004 (4.4)	
7	6,008 (9.0)	5,596 (6.2)	
8	3,172 (4.7)	5,033 (5.6)	
9	7,468 (11.1)	3,911 (4.3)	
10	5,017 (7.5)	5,714 (6.3)	
11	6,817 (10.2)	8,754 (9.7)	
Kidney transplantations			
Mean age at transplantation (SD) in years	52.5 (13.7)	52.6 (13.7)	0.84
Male, n (%)	16,467 (61.3)	22,821 (61.1)	0.52
Race, n (%)			<0.001
White	11,754 (44.4)	17,941 (48.0)	
Black	7,335 (27.7)	9,661 (25.9)	
Hispanic	5,388 (20.3)	6,127 (16.4)	
Asian	1,429 (5.4)	2,903 (7.8)	
Other/multi-racial	572 (2.2)	727 (1.9)	
Kidney transplants per year, median (IQR)	29.0 (16.0, 47.0)	52.0 (22.0, 80.0)	<0.001

SD= standard deviation

IQR= interquartile range

[a] chi-squared, t-test or Wilcoxon rank-sum test as appropriate

Table 2A.

Association between program practice patterns (reported January to May 2020) and hazard of living donor transplantation within two years of waitlist registration using Cox regressions with random effects (shared frailty terms).

Hazard ratio (95% CI) of living donor transplant within 2 years		**Percentage of transplant programs***	**Cox regression**	
Survey question	**Response options**		**Univariable**	**Multivariable**
Do you see all patients referred to your center for in-person evaluation (versus screen referrals for obvious transplant contraindications before scheduling)?	Evaluate all patients referred at scheduled visits	40.0	Reference	Reference
	Screen referrals for suitability	58.9	1.00 (0.77–1.28)	1.03 (0.82–1.28)
Do you prioritize potential recipients who state they have a potential living donor for evaluation earlier than those who do not for initial transplant evaluation?	No	52.2	Reference	Reference
	Sometimes	22.2	0.95 (0.69–1.30)	0.93 (0.70–1.22)
	Yes	25.6	1.02 (0.76–1.38)	1.09 (0.83–1.45)
At what eGFR threshold does your center begin evaluation of patients referred for initial transplant evaluation if not yet started on dialysis?	<20 ml/min/1.73m^2	37.8	Reference	Reference
	<25 ml/min/1.73m^2	30.0	1.13 (0.84–1.52)	0.85 (0.63–1.15)
	<30 ml/min/1.73m^2	13.3	0.95 (0.65–1.40)	1.01 (0.71–1.44)
	No set policy	16.7	1.22 (0.86–1.74)	1.37 (0.99–1.91)
What is the BMI threshold for eligibility for receipt of a kidney transplant at your center?	≤35 kg/m^2	12.2	Reference	Reference
	≤40 kg/m^2	54.4	1.52 (1.03–2.23)	1.38 (0.96–1.97)
	Depends on comorbidities	17.8	1.65 (1.05–2.59)	1.36 (0.88–2.11)
	No threshold, transplant at any BMI	5.6	1.67 (0.90–3.10)	1.41 (0.79–2.50)
	Other threshold	8.9	1.84 (1.07–3.14)	1.83 (1.10–3.03)

Multivariable models adjusted for all relevant survey practice patterns as well as age at waitlist registration, sex, race/ethnicity, and UNOS region of the transplant program.

BMI = body mass index; CI= confidence interval; eGFR = estimated glomerular filtration rate.

*Responses excluded from table if fewer than three centers selected any response option.

Table 2B.

Association between program practice patterns (reported January to May 2020) and hazard of deceased donor transplantation using Cox regressions with random effects (shared frailty terms).

Hazard ratio (95% CI) of deceased donor transplantation		**Percentage of transplant programs***	**Cox regression**	
Survey question	**Response options**		**Univariable**	**Multivariable**
Do you see all patients referred to your center for in-person evaluation (versus screen referrals for obvious transplant contraindications before scheduling)?	Evaluate all patients referred at scheduled visits	40.0	Reference	Reference
	Screen referrals for suitability	58.9	1.34 (1.04–1.72)	1.14 (0.91–1.42)
Do you prioritize potential recipients who state they have a potential living donor for evaluation earlier than those who do not for initial transplant evaluation?	No	52.2	Reference	Reference
	Sometimes	22.2	0.73 (0.54–1.00)	0.62 (0.47–0.81)
	Yes	25.56	0.98 (0.73–1.32)	1.19 (0.90–1.56)
At what eGFR threshold does your center begin evaluation of patients referred for initial transplant evaluation if not yet started on dialysis?	<20 ml/min/1.73m^2	37.8	Reference	Reference
	<25 ml/min/1.73m^2	30.0	0.79 (0.59–1.05)	0.81 (0.61–1.07)
	<30 ml/min/1.73m^2	13.3	0.63 (0.43–0.91)	0.58 (0.41–0.82)
	No set policy	16.7	0.81 (0.57–1.14)	0.92 (0.66–1.27)
What is the BMI threshold for eligibility for receipt of a kidney transplant at your center?	≤35 kg/m^2	12.2	Reference	Reference
	≤40 kg/m^2	54.4	1.23 (0.84–1.81)	1.19 (0.83–1.69)
	Depends on comorbidities	17.8	1.06 (0.68–1.67)	1.07 (0.70–1.64)
	No threshold, transplant at any BMI	5.6	1.70 (0.92–3.15)	1.35 (0.76–2.41)
	Other threshold	8.9	1.15 (0.68–1.96)	1.25 (0.74–2.09)

Multivariable models adjusted for all relevant survey practice patterns as well as age at waitlist registration, sex, race/ethnicity, and UNOS region of the transplant program.

BMI = body mass index; CI= confidence interval; eGFR = estimated glomerular filtration rate.

*Responses excluded from table if fewer than three centers selected any response option.

Table 3A.

Association between cardiac evaluation patterns (reported January to May 2020) and hazard of living donor transplantation within two years of waitlist registration using Cox regressions with random effects (shared frailty terms).

Hazard ratio (95% CI) for living donor transplantation		**Percentage of transplant programs***	**Cox regression**	
Survey question	**Response options**		**Univariable**	**Multivariable**
Is cardiac catheterization performed in all potential recipients with diabetes?	No	79.8	Reference	Reference
	Yes	20.2	1.03 (0.76–1.40)	0.94 (0.71–1.24)
In potential recipients who do not need cardiac catheterization, what method is typically performed to screen for coronary disease?	Combination of methods that depends on the individual patient's risk factors	58.4	Reference	Reference
	Stress echocardiography	20.2	1.02 (0.74–1.41)	1.11 (0.83–1.50)
	Nuclear medicine perfusion study	19.1	1.11 (0.81–1.54)	1.02 (0.75–1.40)
If cardiac catheterization is needed as part of the evaluation to be a kidney transplant recipient in a patient who is **not** receiving dialysis therapy, is the cardiac catheterization typically deferred until after initiation of dialysis?	No	15.9	Reference	Reference
	Yes	84.1	0.76 (0.56–1.08)	0.75 (0.55–1.03)
In the absence of a new or suspected cardiac event, is testing to rule out new coronary disease or monitor known coronary disease regularly requested in those active on the kidney transplant wait list?	No re-testing while on wait list	3.37	Reference	Reference
	Yes, regular re-testing in all patients on the wait list	47.2	1.08 (0.54–2.14)	1.28 (0.68–2.40)
	Yes, regular re-testing but only in patients with certain risk factors (such as previously documented CAD or diabetes)	49.4	1.06 (0.54–2.10)	1.27 (0.68–2.38)

Multivariable models adjusted for all relevant survey practice patterns as well as age at waitlist registration, sex, race/ethnicity, and UNOS region of the transplant program. CI= confidence interval; CAD= coronary artery disease.

*Responses excluded from table if fewer than three centers selected any response option.

Table 3B.

Association between cardiac evaluation patterns (reported January to May 2020) and hazard of deceased donor transplantation using Cox regressions with random effects (shared frailty terms).

Hazard ratio (95% CI) for deceased donor transplantation		**Percentage of transplant programs***	**Cox regression**	
Survey question	**Response options**		**Univariable**	**Multivariable**
Is cardiac catheterization performed in all potential recipients with diabetes?	No	79.8	Reference	Reference
	Yes	20.2	1.12 (0.82–1.54)	1.00 (0.75–1.32)
In potential recipients who do not need cardiac catheterization, what method is typically performed to screen for coronary disease?	Combination of methods that depends on the individual patient's risk factors	58.4	Reference	Reference
	Stress echocardiography	20.2	1.59 (1.17–2.15)	1.62 (1.19–2.22)
	Nuclear medicine perfusion study	19.1	1.29 (0.95–1.75)	1.27 (0.94–1.71)
If cardiac catheterization is needed as part of the evaluation to be a kidney transplant recipient in a patient who is **not** receiving dialysis therapy, is the cardiac catheterization typically deferred until after initiation of dialysis?	No	15.9	Reference	Reference
	Yes	84.1	1.03 (0.73–1.46)	0.98 (0.71–1.35)
In the absence of a new or suspected cardiac event, is testing to rule out new coronary disease or monitor known coronary disease regularly requested in those active on the kidney transplant wait list?	No re-testing while on wait list	3.37	Reference	Reference
	Yes, regular re-testing in all patients on the wait list	47.2	1.36 (0.67–2.75)	1.70 (0.86–3.37)
	Yes, regular re-testing but only in patients with certain risk factors (such as previously documented CAD or diabetes)	49.4	1.49 (0.74–3.01)	2.21 (1.13–4.43)

Multivariable models adjusted for all relevant survey practice patterns as well as age at waitlist registration, sex, race/ethnicity, and UNOS region of the transplant program. CI= confidence interval; CAD= coronary artery disease.

*Responses excluded from table if fewer than three centers selected any response option.