County socioeconomic characteristics and heart transplant outcomes in the United States

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Background Geographic disparities in survival after heart transplantation have received mixed support in prior studies, and specific geographic characteristics that might be responsible for these differences are unclear. We tested for differences in heart transplant outcomes across United States (US) counties after adjustment for individual-level covariates. Our secondary aim was to evaluate whether specific county-level socioeconomic characteristics explained geographic disparities in survival.

Methods Data on patients aged ≥18 years undergoing a first-time heart transplant between July 2006 and December 2014 were obtained from the United Network for Organ Sharing. Residents of counties represented by <5 patients were excluded. Patient survival (censored in March 2016) was analyzed using multivariable Cox regression. Shared frailty models were used to test for residual differences in overall all-cause mortality across counties after adjusting for recipient and donor characteristics. Measures of county economic disadvantage, inequality, and racial segregation were obtained from US Census data and coded into quintiles. A likelihood ratio test determined whether adjusting for each county measure improved the fit of the Cox model.

Results Multivariable analysis of 10,879 heart transplant recipients found that, adjusting for individual-level characteristics, there remained statistically significant variation in mortality hazard across US counties ($P = .004$). Adjusting for quintiles of community disadvantage, economic inequality, or racial segregation did not significantly improve model fit (likelihood ratio test $P = .092$, $P = .273$, and $P = .107$, respectively) and did not explain residual differences in patient survival across counties.

Conclusions Heart transplantation outcomes vary by county, but this difference is not attributable to county-level socioeconomic disadvantage. (Am Heart J 2017;190:104-112.)

Risk-adjusted patient survival is a key quality metric used for evaluating heart transplant programs in the United States (US).[1,2] However, established methods of risk adjustment do not take into account geographic characteristics that may improve prediction of patient survival.[3] This may be an important omission, as surgical outcomes have been shown to vary geographically across the US.[4,5] Community socioeconomic disadvantage may limit access to care and social support available to transplant recipients, whereas individual socioeconomic status may influence patients' morbidity burden and likelihood of treatment nonadherence. Despite evidence suggesting that geographic disparities may exist in some groups of patients undergoing heart transplantation,[6,7] it remains unclear at what geographic level (eg, US Census tract, ZIP code, or county) these disparities should be evaluated and which geographic characteristics accurately distinguish between locales with better or worse patient outcomes.

To overcome a lack of data on transplant recipients' individual socioeconomic status (SES), several studies have incorporated geographic measures of socioeconomic disadvantage in multivariable analysis of heart transplantation

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outcomes.[8-11] Most commonly, the median household income (MHI) of patients' US Postal Service ZIP code has been used to supplement data available in the United Network for Organ Sharing (UNOS) patient registry, such as patient insurance status.[8,11] Research in kidney and liver transplantation has demonstrated the value of this approach to improve prediction of posttransplant survival.[12-14] However, analyses of US adult heart transplant recipients have found local MHI to be uncorrelated with survival or allograft rejection.[9,14] Furthermore, adjusting surgical quality measures for socioeconomic characteristics may inadvertently adjust for differences in the quality of care provided at different institutions. Therefore, the rationale for adjusting models of heart transplant outcomes for local socioeconomic characteristics remains in question. To disambiguate the role of local socioeconomic characteristics in predicting heart transplant outcomes among US adults, we linked UNOS registry data to US Census Bureau data on county socioeconomic disadvantage, income inequality, and racial segregation. Our primary aim was to determine whether significant geographic variability in heart transplant recipients' survival existed after adjusting for individual characteristics. Our secondary aim was to determine which, if any, local socioeconomic characteristics adequately explained this geographic variation.

Methods

Following Institutional Review Board approval, data were obtained from the UNOS registry, which tracks candidates and recipients of solid organ transplants in the US.[15] Patients 18 years or older undergoing first-time heart transplantation since July 2006 (corresponding to the implementation of broader regional sharing of donor organs) were evaluated for inclusion if they had been transplanted no later than 2014, when the US Census Bureau released the most recent available data on socioeconomic characteristics of small geographic areas. Patients' residence was defined using ZIP codes, but there were too few patients in each ZIP code to evaluate clustering of transplant outcomes at that geographic level.[16] Therefore, ZIP codes were linked to US counties according to the county that contained the majority of each ZIP code's population. Patients were excluded from the analysis if they were missing data on ZIP code of residence and if they were missing data on local socioeconomic measures, described below. Heart transplant recipients residing in counties represented by ≥5 patients (to assure a sufficient number of patients in each geographic unit for multilevel modeling) and with complete data on study covariates were included in the final multivariable analysis. Patients with incomplete data on 1 or more covariates were excluded from this group. The characteristics of this group were compared with 2 groups of excluded patients: those who were excluded because of residence in a county with <5 patients and those who were excluded solely because of missing data on covariates.

The primary outcome was overall, all-cause patient mortality (using all available follow-up data) ascertained from transplant center reports and linkage to the Social Security Death Master file. Whereas 1-year survival outcomes are currently used for transplant program evaluation,[1] we examined overall survival duration because of the potential for socioeconomic disparities in survival to emerge later than 1 year posttransplant.[17] A secondary composite outcome was examined to account for possible disparities in nonfatal complications of heart transplant. The composite outcome was defined as experiencing death, graft failure, acute rejection, rehospitalization, or listing for retransplant; and the time elapsed until the earliest of these events was used for survival analysis. Results for this secondary outcome are presented in the Appendix. The primary exposure variables were measures of county characteristics obtained from US Census Bureau data and matched to patient records in the UNOS registry by the county of residence at the time of the transplant.

Data on county socioeconomic characteristics were obtained from the 2011-2014 5-year file of the American Community Survey.[18] The first measure was a composite index of socioeconomic advantage indicators (MHI; median value of owner-occupied housing units; percentage of households with interest, dividend, or net rental income; percentage of workers employed in management, business, science, and arts occupations; and percentage of residents >25 years of age with a high school diploma [α = .81]).[19] Positive values indicated relative socioeconomic advantage, whereas negative values indicated disadvantage. The second measure was the Index of Concentration at the Extremes, measuring the local concentration of wealthy families (incomes >$75,000) and poor families (incomes below the Federal poverty line).[20] Index of Concentration at the Extremes scores were expressed in the range of −1 to 1, with −1 indicating that all families were poor and 1 indicating that all families were affluent. Lastly, we used the county index of dissimilarity to measure residential racial segregation, indicating the percentage of white or black households that would have to change neighborhoods to achieve integration.[21] The index of dissimilarity was calculated using Census tracts as the neighborhood unit, and scores ranged from 0 to 1, where 0 indicated that the county was completely integrated and 1 indicated that the county was completely segregated. Each of these 3 measures was recoded into quintiles among the counties represented in the analytic data set.

Study outcomes were analyzed using multivariable Cox proportional hazards regression. The primary model included individual-level covariates (described below) and a shared frailty parameter at the county level. “Shared frailty” refers to an unobserved county characteristic that