



RESEARCH LETTER

Imbalance in Heart Transplant to Heart Failure Mortality Ratio by Sex

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Allocation of heart transplants may be inequitable by sex. For over a decade, women have received <25% of heart transplants.¹ Women have similar prevalence of heart failure (HF) as men, but higher HF mortality.² Women also have higher prevalence of HF with preserved ejection fraction, which has limited benefit with heart transplant, than men.³ However, among the highest risk population that has recurrent heart failure hospitalizations, women have similar prevalence of HF with preserved ejection fraction and HF with reduced ejection fraction (HFrEF).³ Adding the intersection of race results in higher prevalence of HFrEF among subgroups such as Black women.³ In comparison, the majority of men with recurrent HF hospitalizations have HFrEF.³ Since HFrEF can be treated with heart transplants, this suggests a heart transplant sex disparity.

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Geographic and center culture may contribute to disparities in heart transplant allocation.⁴ Given observed sex bias in the allocation of heart transplants,⁴ we sought to determine whether heart transplant rate to HF mortality rate varied geographically across the United States for women compared with men.

It is important to identify geographic areas with the greatest disparities so that interventions can be appropriately tailored to achieve equity.

Using data from the United Network for Organ Sharing and Centers for Disease Control and Prevention Wide-Ranging Online Data for Epidemiological Research we examined heart transplant and HF mortality (underlying

cause of death *International Classification of Diseases, Tenth Revision (ICD-10: I50 [I50.0, I50.1, I50.9])* ratio by sex from 2016 to 2018 nationally and by state among adults aged 35 to 64 years since this age group receives the majority of heart transplants. All 50 states plus D.C. were included for the national analysis. Among state analyses, states were excluded for missing HF mortality (9 states+D.C.), which was either suppressed or marked unreliable by Centers for Disease Control and Prevention Wide-Ranging Online Data for Epidemiological Research for <20 HF deaths or risk of identifying individuals. The national cohort included 19 784 HF deaths and 5800 heart transplants; the final state cohort included 19 497 HF deaths and 5641 heart transplants (n=41 states). The University of Arizona Institutional Review Board exempted this study from review. Data are publicly available from United Network for Organ Sharing and Centers for Disease Control and Prevention Wide-Ranging Online Data for Epidemiological Research.

The primary outcome was heart transplant rate to HF mortality rate ratio. Ratios were calculated for each sex nationally and by state as the number of transplants per 100 000 population per year divided by the age-adjusted HF mortality rate per 100 000 population per year. Heart transplant to HF mortality ratios were compared between women and men, with the ratio for men as the control. Calculations were completed using R version 3.6.3 (Vienna, Austria).

In national analyses, women received 0.789 heart transplants per 100 000 per year, and men received 2.330 heart transplants per 100 000 per year. The heart transplant to HF mortality ratio was 0.263 for women and 0.424 for men, resulting in lower ratio for women versus men at 0.620. In the state analyses, 98% (40 of 41 states)

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Table. Ratio of Heart Transplantation to Heart Failure Mortality by Sex 2016 to 2018

State	Region	Transplant Rate Women	HF Mortality Rate Women	Transplant Rate Men	HF Mortality Rate Men	Transplant to Mortality Ratio Women	Transplant to Mortality Ratio Men	Ratio Women to Men
All		0.789	3.00	2.330	5.50	0.263	0.424	0.620
West Virginia	South	0.367	4.08	2.518	5.39	0.090	0.467	0.193
New Jersey	Northeast	0.413	2.13	2.410	3.65	0.194	0.660	0.294
Tennessee	South	0.947	4.34	4.008	7.11	0.218	0.564	0.387
Alabama	South	0.308	7.91	1.508	15.97	0.039	0.094	0.413
Delaware	South	0.866	2.70	2.646	3.46	0.321	0.765	0.419
Kentucky	South	0.832	6.41	2.895	9.49	0.130	0.305	0.426
Idaho	West	0.320	1.98	1.286	3.67	0.162	0.350	0.461
Wisconsin	Midwest	0.618	1.54	2.232	2.57	0.401	0.869	0.462
Arkansas	South	0.583	4.93	2.303	9.50	0.118	0.242	0.488
New Mexico	West	0.256	2.16	0.977	4.06	0.118	0.241	0.492
Nevada	West	0.461	2.11	1.660	3.81	0.219	0.436	0.502
Georgia	South	0.445	6.42	1.609	11.66	0.069	0.138	0.502
New York	Northeast	0.742	1.32	2.709	2.50	0.562	1.084	0.519
Mississippi	South	0.800	11.13	2.533	18.29	0.072	0.138	0.519
Ohio	Midwest	0.784	3.53	2.331	5.49	0.222	0.425	0.523
Minnesota	Midwest	0.622	1.23	2.162	2.33	0.505	0.928	0.545
Massachusetts	Northeast	0.982	2.06	2.667	3.05	0.477	0.874	0.545
Florida	South	0.804	2.10	2.500	3.63	0.383	0.689	0.556
Utah	West	0.711	2.47	2.048	4.02	0.288	0.509	0.565
Oklahoma	South	0.503	3.94	1.447	6.43	0.128	0.225	0.567
Hawaii	West	0.372	1.89	1.494	4.36	0.197	0.343	0.575
North Carolina	South	0.984	4.25	2.762	7.03	0.232	0.393	0.589
California	West	0.626	2.03	2.110	4.33	0.309	0.487	0.633
Oregon	West	0.575	3.04	1.339	4.51	0.189	0.297	0.638
Missouri	Midwest	0.730	4.49	1.893	7.46	0.163	0.254	0.641
Illinois	Midwest	0.963	3.40	2.851	6.50	0.283	0.439	0.645
Michigan	Midwest	0.642	3.26	1.731	5.68	0.197	0.305	0.647
Iowa	Midwest	0.914	1.93	1.986	2.88	0.473	0.690	0.686
South Carolina	South	0.632	5.52	1.665	10.04	0.115	0.166	0.691
Virginia	South	0.999	3.95	2.797	7.82	0.253	0.358	0.707
Kansas	Midwest	1.303	2.51	3.314	4.56	0.519	0.727	0.714

(Continued)

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State	Region	Transplant Rate Women	HF Mortality Rate Women	Transplant Rate Men	HF Mortality Rate Men	Transplant to Mortality Ratio Women	Transplant to Mortality Ratio Men	Ratio Women to Men
Pennsylvania	Northeast	0.907	2.51	2.443	4.84	0.361	0.505	0.716
Nebraska	Midwest	1.431	2.50	3.403	4.38	0.572	0.777	0.737
Texas	South	0.908	3.43	2.390	6.65	0.265	0.359	0.737
Washington	West	1.114	1.16	2.768	2.15	0.961	1.287	0.746
Maryland	South	1.170	1.66	2.818	3.03	0.705	0.930	0.758
Indiana	Midwest	1.220	3.82	2.654	6.64	0.319	0.400	0.799
Louisiana	South	0.737	8.87	1.556	15.45	0.083	0.101	0.825
Colorado	West	0.645	1.36	1.460	2.73	0.474	0.535	0.887
Arizona	West	0.796	0.81	2.224	2.07	0.982	1.074	0.914
Connecticut	Northeast	1.393	1.20	3.046	3.25	1.161	0.937	1.238

Rates are per 100 000 per year among patients aged 35 to 64 years. HF indicates heart failure.

had lower ratios for women compared with men (Table). Ratios were higher for women compared with men only in Connecticut. The lowest median heart transplant to HF mortality ratio was observed in the Southern region at 0.537 (interquartile range, 0.424–0.695) followed by Northeast at 0.545 (interquartile range, 0.519–0.716), West at 0.604 (interquartile range, 0.517–0.719), and Midwest at 0.646 (interquartile range, 0.569–0.707).

Multiple factors contribute to low allocation of heart transplant to women. This study was not able to adjust for clinical factors, patients' preferences, social determinants of health, or sex bias. Rather a general overview of transplant disparities is provided at a geographic level. Given known sex inequities in pharmacological and non-pharmacological management of heart failure,⁵ this study provides fuel to explore cultural decision-making contributing to low transplant rates among women.

As crude analyses, we were unable to stratify results by phenotype contributing to HF mortality and are at risk for unmeasured confounding variables as with any observational study. However, among the highest risk group with recurrent HF hospitalizations, HF with preserved ejection fraction was a greater cause of annual mortality than HF with preserved ejection fraction among White men in 1 national study.³ Conversely HF with preserved ejection fraction was a greater cause of annual mortality than HF with preserved ejection fraction among women.³ This suggests that sex disparities in transplant to mortality ratio may be underestimated. In addition, taking ratios of ratios may amplify small differences. For this reason, we included a table of individual rates and ratios by sex to surmise sex differences among and across states.

Among the United States, women had lower heart transplant to HF mortality rate ratios than men. Disparities were widespread but were the worst in the US South. Implementation of strategies to achieve sex equity in allocation of heart transplants should be investigated across the United States.

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