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Identification of Racial Inequities in Access to Specialized Inpatient Heart Failure Care at an Academic Medical Center

Lauren A. Eberly, MD[1,*], Aaron Richterman, MD[1,*], Anne G. Beckett, MD[1], Bram Wispelwey, MD, MPH[1], Regan H. Marsh, MD, MPH[2], Emily C. Cleveland Manchanda, MD, MPH[2], Cindy Y Chang, MD, MPH[2,3], Robert J. Glynn, ScD, PhD[4,5], Katherine C. Brooks, MD[1], Robert Boxer, MD, PhD[1,6], Rose Kakoza, MD[1], Jennifer Goldsmith, MEd[7], Joseph Loscalzo, MD, PhD[1,3], Michelle Morse, MD, MPH[3,7,^], Eldrin F. Lewis, MD, MPH[8,^] Brigham and Women's Internal Medicine Housestaff[**]

[1]Department of Medicine, Brigham and Women's Hospital, Boston, MA

[2]Department of Emergency Medicine, Brigham and Women's Hospital, Boston, MA

[3]Harvard Medical School, Boston, MA

[4]Division of Preventive Medicine, Department of Medicine, Brigham and Women's Hospital, Boston, MA

[5]Department of Biostatistics, Harvard T.H. Chan School of Public Health, Boston, MA

[6]Division of General Internal Medicine, Department of Medicine, Brigham and Women's Hospital, Boston, MA

[7]Division of Global Health Equity, Department of Medicine, Brigham and Women's Hospital, Boston, MA

[8]Division of Cardiovascular Medicine, Department of Medicine, Brigham and Women's Hospital, Boston, MA

Abstract

Background: Racial inequities for patients with heart failure (HF) have been widely documented. HF patients who receive cardiology care during a hospital admission have better outcomes. It is unknown whether there are differences in admission to a cardiology or general medicine service by race. This study examined the relationship between race and admission service, and its effect on 30-day readmission and mortality

Methods: We performed a retrospective cohort study from 9/2008 to 11/2017 at a single large urban large urban academic referral center of all patients self-referred to the emergency department (ED) and admitted to either the cardiology or general medicine service with a principal diagnosis of HF, who self-identified as white, black, or Latinx. We used multivariable generalized

Corresponding Author: Michelle Morse, MD, MPH, Brigham and Women's Hospital, memorse@bwh.harvard.edu; Address: 80 Parker Hill Ave, Boston, MA, 02120, Phone: (215) 260-2848.
*Contributed equally to this work
^Contributed equally to this work
**Please see Appendix for full list of contributors

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estimating equation models to assess the relationship between race and admission to the cardiology service. We used Cox regression to assess the association between race, admission service and 30-day readmission and mortality.

Results: Among 1,967 unique patients (66.7% white, 23.6% black, and 9.7% Latinx), black and Latinx patients had lower rates of admission to the cardiology service than white patients (adjusted rate ratio [ARR] 0.91, 95% CI 0.84-0.98, for black; ARR 0.83, 95% CI 0.72-0.97 for Latinx). Female sex and age>75 years were also independently associated with lower rates of admission to the cardiology service. Admission to the cardiology service was independently associated with decreased readmission within 30 days, independent of race.

Conclusions: Black and Latinx patients were less likely to be admitted to cardiology for HF care. This inequity may, in part, drive racial inequities in HF outcomes.

Inequitable quality of healthcare and access to healthcare by race is a well-documented phenomenon in the United States (US).[1] This is, in part, driven by the differential access to the goods, services, and opportunities of society by race, which has been termed structural racism.[2] Structural racism in the US is a major impediment to achieving health equity - the opportunity for all people to achieve their full health potential.[3] Health disparities are differences in health outcomes between groups within a population, whereas health inequities are differences in health outcomes that are systematic, avoidable, and unjust.[4] Racial inequities in mortality and readmission rates for patients with heart failure (HF) have been widely documented.[5-10] Some studies suggest that racial inequities in HF care are driven by between-hospital quality differences in the setting of *de facto* health facility segregation for minority patients,[11-16] although there is recent evidence that these differences are derived from a systemic, rather than hospital-specific, effect.[17]

At our institution, patients admitted with HF may be primarily cared for by a hospitalist (on the general medicine service [GMS]) or cardiologist (on the cardiology service). Patients on GMS may receive a cardiology consult, but this is uncommon at our institution. Observational studies have found that patients receiving specialty cardiology care during an admission for HF have superior outcomes, including lower readmission rates and mortality.[18-23] This beneficial outcome may result from a combination of access to cardiology expertise and improved care, and additional supports found on cardiology services (e.g. specialty nursing, pharmacy, post-discharge services). We hypothesized that at our institution there was inequitable access to the cardiology service for patients admitted with HF, and that this inequity could contribute to the previously-mentioned racial inequities in HF outcomes. To address this hypothesis, we performed a single-center retrospective cohort study of patients admitted with a principal diagnosis of HF over a ten-year period to evaluate the relationship between race and admission service assignment, as well as the subsequent relationship between admission service and outcomes.

Methods

Datasets and statistical analysis code are available from the corresponding author upon reasonable request.

Approach

This analysis was one of the first projects undertaken by our institution's Department of Medicine Health Equity Committee, a multidisciplinary group formed in 2017 to identify and address health equity concerns. The committee chose to focus on patients admitted with HF because this is the most frequent medical admission diagnosis at our institution, the second most common reason for hospital admission in the US among older adults,[24] and a condition for which there are known racial inequities in outcomes. The committee also wished to test a hypothesis that leading with a racial equity analysis would uncover additional structural inequities, which could be addressed intersectionally.[25] This study was guided by Public Health Critical Race Praxis (PHCRP), an approach utilized by researchers to study and ameliorate instances of structural racism and resultant health inequities and developed out of the legal framework of Critical Race Theory. [26, 27] We considered race to be a social construct that captures the impacts of racism rather than innate biological differences, and, therefore, hypothesized that differences in HF outcomes were due to structural drivers rather than biological causes.[2]

Study Population and Data Source

We conducted a retrospective cohort study at an urban tertiary care academic hospital with large general medicine and cardiology services. We identified all patients self-referred to the emergency department and admitted with a principal diagnosis of HF to either the general medicine or cardiology service from September 2008 to November 2017.

Self-reported racial identity was our primary exposure and was extracted from the electronic medical record (EMR). We included all black, white, and Latinx patients. Latinx is a gender-neutral term describing a person of Latin American origin or descent. [28] Our EMR did not allow us to distinguish comprehensively between Latinx white and Latinx non-white patients. We excluded patients with other racial identifiers owing to limited numbers (N=131).

We extracted additional covariates from the EMR at the time of admission: sex, age, date of admission, Medicaid beneficiary/insurance status, address, primary language, number of days since the last outpatient appointment with a cardiologist or primary care physician (PCP) at our institution, whether the patient was seen in follow-up at a cardiology clinic at our institution within thirty days of discharge (EMR encounter during which the patient attended a visit at one the institution's cardiology clinics), most recent prior admitting service, and readmission and mortality within 30 days after discharge. Post-discharge deaths were identified from a combination of our institutional EMR and the Massachusetts Death Registry. We used ICD codes recorded in the EMR at the time of admission to determine the presence of the following conditions: HF with preserved ejection fraction (HFpEF), chronic pulmonary disease, valvular heart disease, cardiac arrhythmia, hypertension, diabetes, cancer, chronic kidney disease (CKD), end-stage renal disease (ESRD), liver disease, history of substance use, and psychiatric illness. As an overall measure of comorbidity, we calculated the Elixhauser Comorbidity Index (ECI), considering both overall ECI as well as ECI divided into two components - cardiovascular and non-cardiovascular. As a measure of socioeconomic disadvantage, we determined the 2013 Area Deprivation Index (ADI) for each patient's census block group.[29] The ADI is a validated composite index (reported as a national percentile) that uses 17 neighborhood-level indicators for poverty, education, housing, and employment. We considered patients to be Boston Metro residents if they resided in one of 510 zip codes as defined by the US Census Bureau.[30] We abstracted the chief complaints of the patients upon arrival to the ED from the EMR, which were only available for admissions from 2010–2015.

Ethical approval was obtained from the Partner's Healthcare Institutional Review Board.

Statistical Analysis

We presented categorical data using proportions and continuous data using medians (interquartile range). We made statistical comparisons of proportional variables using Chi-squared tests and continuous variables using Student's t-tests. To assess the relationship between race and admission to the cardiology service, we used generalized estimating equations (GEE) models with an exchangeable correlation structure to account for multiple HF admissions by patients during the study period. We used a Poisson regression approach with robust standard errors to calculate unadjusted rate ratios (RR) with 95% confidence intervals (CI) for admission to the cardiology service by race.[31] We developed a multivariable model for admission to the cardiology service, including race and all covariates correlated with admission to cardiology with $p<0.2$ in univariable models. We again used a Poisson regression approach with robust standard errors to calculate adjusted rate ratios (ARR) with 95% CI.[31] We chose a more lenient p-value of 0.2 for model inclusion to ensure identification and incorporation of variables that could be important confounders.[32]

If continuous variables met criteria for inclusion in our final model, we evaluated the linearity assumption by dividing them into deciles or quartiles and visually inspecting a plot of log (Odds Ratio) of cardiology admission against category. If the resulting plot was not linear, we considered transformation or categorization, yielding categorization for age, ADI, and date of admission.

We calculated the variance inflation factor (VIF) to assess for multicollinearity among model covariates, with a VIF greater than 2.50 considered indicative of multicollinearity. We tested admission date, sex, and age as interaction terms with race in the final model.

As a secondary analysis, we compared presenting chief complaint by race among the sub-cohort with available chief complaint, and whether the addition of chief complaints correlating with cardiology admission with $p<0.2$ to the final multivariable model changed our primary findings.

Missing Data

We performed a complete case analysis because there were no missing data for any covariate except ADI (331/3133 admissions, 11%). Rates of missing ADI did not differ by race. As a sensitivity analysis, we performed multiple imputation (N=25) by covariate and outcome data using the fully conditional specification method, and generated pooled effect estimates across datasets.

Propensity Score Matched Cohort Analysis

In addition to our primary analysis we performed a propensity score analysis using each admission as the unit of analysis. We built two multivariable logistic regression models to determine the propensity for a patient to be black and Latinx, each with white race as reference. We included covariates that correlated with race with $p<0.25$ (c statistics: black 0.85; Latinx 0.88). We excluded English as primary language from the Latinx model because of very high collinearity with Latinx identity. Using a five-to-one-digit "greedy matching" approach with the relevant propensity score,[33] we formed two cohorts of matched patients: black patients matched to white patients, and Latinx patients matched to white patients. For each cohort, we calculated RR with 95% CI of admission to cardiology using the McNemar's test. Using a similar method, we generated a propensity score-matched cohort based on sex (c statistic: 0.70).

Outcomes

We calculated rates of the death and readmission within 30 days of discharge by admission service. We evaluated for differences in the outcome between admission services using Cumulative Incidence Function (CIF) plots and the Gray's tests, with death considered to be a competing risk for readmission. CIF plots were generated using days from discharge as the unit of time. We repeated this process by race and for admission service stratified by race.

We built multivariable Cox proportional hazards models to determine predictors of (1) readmission and (2) mortality within 30 days. We included race, admission to cardiology service, and all covariates that correlated with the outcome with $p<0.2$ in univariable models. The proportional hazards assumption was tested by Schoenfeld residuals and inspection of hazard ratio plots. We generated cause-specific hazard ratios (HR) for the models, with death considered to be a competing risk for readmission.

We performed statistical analysis using SAS version 9.4 (SAS Institute Inc., Cary, North Carolina). CIF plots were generated using R version 3.5.2 (R Foundation for Statistical Computing, Vienna, Austria).

Results

There were 7,629 total admissions with a principal diagnosis of HF during the study period. Of these, 3,133 admissions (1,967 unique patients) met criteria for inclusion in our analysis (Figure 1). Table 1 shows the characteristics of the included patients at the time of their first admission during the study period. Nearly three-quarters of included patients were white. White patients were older, more likely to be male, more likely to have been seen in a cardiology clinic within the past year, and lived in neighborhoods with higher percentile ADI. Black and Latinx patients were more likely to have been seen by a PCP at our institution, live in the Boston Metro Area, and be Medicaid beneficiaries. There was no difference in percentage of patients with HFpEF or ECI by race, although white patients were more likely to have valvular heart disease and cancer and black and Latinx patients were more likely to have CKD or ESRD. Of the patients' first admission during the time period, 874 (67%) of the white patients were admitted to cardiology as compared to 247 (53%) of the black patients and 100 (53%) of the Latinx patients (p<0.0001).

In univariable analysis, black patients had an RR 0.84 (95% CI 0.77–0.91, p<0.0001) and Latinx patients had an RR 0.81 (95% CI 0.72–0.91, p=0.0006) for admission to the cardiology service compared to white patients. Table 2 shows the final multivariable model with all included covariates. Compared to white patients, black patients had an ARR 0.91 (95% CI 0.84–0.98, p=0.019) and Latinx patients had an ARR of 0.83 (95% CI 0.72–0.97, p=0.017) for admission to the cardiology service. Female sex, age over 75 years, chronic pulmonary disease, ESRD, and being seen by a PCP at our institution within the past year were independently associated with admission to GMS. Cardiac valvular disease, arrhythmia, and being seen in a cardiology clinic at our institution within the past year were independently associated with admission to the cardiology service. Results were similar using multiply imputed datasets.

There was no evidence of multicollinearity in the final model, and no significant interaction between race and admission date, age, or sex.

Chief Complaint Analysis

Data for chief complaint at presentation were available for 1,983 (63%) admissions. There were no differences in chief complaint by race with the exception of chest pain, which was more prevalent in Latinx patients (Supplementary Table 10). Shortness of breath and chest pain correlated with admission to GMS in univariable analyses; adding these to our primary model did not alter our findings (Supplementary Table 11).

Propensity Score Matched Cohorts

Details about the development of the propensity scores are not shown (Supplementary Tables 1-6). All covariates are balanced between the cohort matched by propensity to be black (N=782), propensity to be Latinx (N=336), and propensity to be female (N=1558) with the exception of primary language for the cohort matched by propensity to be Latinx (Supplementary Tables 7-9). ORs for admission to cardiology were consistent with our primary analysis for all matched cohorts (Table 3).

Outcomes

Figure 2 shows unadjusted CIF plots of readmission and mortality within 30 days by service - overall and stratified by race. There were 38/1092 (3%) patients with HF who died within 30 days of discharge from GMS and 67/2041 (3%) from cardiology (p=0.68). There were 299/1092 (27%) patients with HF readmitted within 30 days from GMS and 507/2041 (25%) from cardiology (p=0.13). After stratification by race, black patients discharged after admission to GMS had higher risk of death within 30 days compared to black patients discharged after admission to cardiology (3% vs <1%, p=0.01), but there were no differences for white (4% vs 4%, p=0.82) or Latinx patients (3% vs 3%, p=0.85). There were no unadjusted differences in readmissions within 30 days for patients discharged after admission to medicine compared to cardiology: overall (27% vs 25%,p=0.13), white (25% vs 23%, p=0.32), black (30% vs 28%, p=0.34), and Latinx (28% vs 30%, p=0.78).

There were 78/192 (4%) white patients who died within 30 days of discharge compared to 17/872 (2%) black patients and 10/330 (3%) Latinx patients (p=0.0076). There were 452/1921 (26%) white patients who were readmitted within 30 days after discharge compared to 254/872 (29%) black patients and 100/340 (29%) Latinx patients (p=0.0043).

Multivariable cox regression models including admission service, race, and other covariates with p<0.2 in univariate analyses are shown in Supplementary Table 12 for mortality within 30 days and Table 4 for readmission within 30 days. After adjustment, black race was independently associated with a reduced risk of death within 30 days (HR 0.52, 95% CI 0.30–0.91, p=0.02), while there was no significant difference for Latinx patients compared to white patients (HR 0.89, 95% CI 0.46–1.73, p=0.73). Admission to cardiology was not associated with death within 30 days (HR 0.83, 95% CI 0.55–1.24, p=0.36). Admission to cardiology was independently associated with readmission within 30 days (HR 0.84, 95% CI 0.72–0.97, p=0.018), whereas race was not (black vs white HR 1.09, 95% CI 0.92–1.29, p=0.31; Latinx vs white HR 1.14, 95% CI 0.91–1.42,p=0.27)(Table 4).

Of patients admitted to GMS for their first admission during the study period, 189 (25%) were seen in follow up at a cardiology clinic within thirty days compared to 557 (46%) on the cardiology service (p<.0001). Of 1312 white patients admitted for the first time during the study period, 502 (38%) white patients, were seen in follow up at a cardiology clinic within 30 days compared to 159/465 (34%) black patients and 85/190 (45%) Latinx patients (p=0.04).

Discussion

This retrospective single-center study is one of the first to demonstrate that admission service for patients admitted with HF is an intra-hospital driver of racial inequities in HF outcomes. Despite adjustment for neighborhood disadvantage, comorbidity, diagnosis of HFpEF, and having seen a cardiologist or PCP at our institution within the past year, black and Latinx patients admitted with HF remained significantly more likely to be admitted to GMS compared to white patients. Admission to GMS was independently associated with higher rates of readmission within 30 days, and there was no difference in mortality by admission service after multivariable adjustment. Taken together, our findings suggest that racial inequities in admission patterns may contribute, in part, to the well-documented racial inequities in heart failure readmissions in the U.S.[11-16]

Across the US, HF readmission rates are higher for black and Latinx patients compared to white patients.[11-16] Specialty cardiology care for patients admitted to the hospital with HF is associated with better outcomes, including lower readmission rates and improved mortality.[18-23, 34] In this study, black and Latinx patients admitted with HF were less likely than white patients to be admitted to the cardiology service. This pattern—decreased likelihood of receiving specialty care in the hospital with lower rates of subsequent outpatient follow up and higher 30-day readmission rates on GMS—precipitates a cycle in which inequities are compounded. Our findings are consistent with a recent study of patients with HF admitted to an intensive care unit, which found that black patients were less likely than whites to receive cardiology consultation.[35] The higher readmission rates for HF patients on GMS identified in this study suggest that inequities in admission service could be one driver for higher admissions among black patients in the US.[10] We also found that black race was independently associated with lower 30-day mortality, a finding noted in other US settings and of unclear significance.[5] Regardless, more focus should be given to differences in access to specialized care within institutions as a potential root cause of racial inequities in HF readmissions.

We found that having seen an outpatient cardiologist at our institution was the strongest positive predictor of admission to cardiology, and there were significant differences in the proportion of patients who had seen a cardiologist within the past year by race. It is possible that our outpatient facilities are less accessible to black and Latinx patients. Prior studies have shown racial differences in referral patterns to outpatient specialty cardiology care for patients with HF.[36] We found that patients with HF admitted to GMS were less likely to be seen by a cardiologist for outpatient follow-up than those admitted to the cardiology service, consistent with a prior study.[34] While we did not identify differential rates of outpatient cardiology follow up by race, large differences in cardiology follow up by admission service combined with a greater probability of black and Latinx patients being admitted to GMS are likely to perpetuate inequities. Because patients with HF tend to be admitted repeatedly, improving rates of cardiology referral and designing programs to reduce barriers for patients to see a cardiologist after discharge from GMS may both improve care for these patients and reduce inequities in subsequent admission service assignment for HF.

At our institution, the admission service for a patient with HF is determined in collaboration between the attending emergency medicine physician and the on-call cardiologist and/or general medicine hospitalist. We hypothesize that a number of factors could influence admission service decisions for patients with HF, including perceived clinical uncertainty or complexity; active co-morbid conditions; bed availability; prior admission service; whether the patient has been followed previously by a cardiologist at our hospital; advocacy by outpatient provider(s); patient preference and self-advocacy; and provider bias.

Provider bias against minority patients is pervasive,[37-40] and may have been a factor in admission decisions for patients with HF at our institution. For example, while complex social or psychiatric histories are often thought of as reasons to admit to GMS preferentially, we found no difference in alcohol, drug use, or psychiatric disease by race. A perceived importance of these factors for admission service may reflect providers' beliefs that patients of color have higher likelihood of risky behavior and worse adherence to medical advice.[41] Patient self-advocacy might also impact admission decisions if white patients more frequently advocate for admission to the cardiology service. Racial differences in self-advocacy have been previously observed, and can be understood in the context of historical and ongoing discrimination against black and brown people in the US healthcare system, with patient-provider interactions involving patients of color frequently characterized by fewer requests for patient input about treatment decisions and less patient-centered care.[38, 42]

Our institution frequently operates at near-maximal census, pressuring the admission service decision. Depending on the distribution of available hospital beds, patients with uncomplicated HF exacerbations are sometimes preferentially admitted to general medicine. This may exacerbate racial inequities in admission service, particularly if there is a racial difference in prior admitting service or perceived medical complexity.[40, 43]

While our objective was to explore the presence of racial inequities in HF admission decisions, we also found evidence of differential admission decisions based on age and sex. Implicit gender bias has been shown to affect clinical decision-making in cardiovascular disease, with providers rating cardiovascular testing of higher utility for males versus females.[44] Similarly, a recent study found that while women and men have similar symptoms when presenting with acute myocardial infarction, providers are less likely to attribute women's symptoms to heart disease compared to men.[45] It is plausible that gender bias similarly explains decreased access to inpatient cardiology care for patients with heart failure.

Our study is limited by its observational nature, and unmeasured confounders are likely present. For example, we could not account specifically for the severity of heart failure or variability in clinician practice – these should be addressed in future work. Given that the ECI is derived from ICD coding, it is possible that this measure is less accurate for patients with less engagement with our healthcare system, or in general, because of undercoding. The ECI also might not accurately reflect secondary active admission diagnoses that could drive admission to GMS. While there is integration between our inpatient and outpatient EMR, we were unable to evaluate the impact of having a cardiologist or PCP outside of our system on admission decisions, and our readmission rates only reflect readmissions to our institution. Follow-up rates only reflect cardiology-specific visits as data regarding overall rates of post-discharge follow-up were unavailable. There were few deaths overall within our cohort, and, thus, findings around 30-day mortality should be interpreted with caution. We were unable to evaluate for differential cardiology consultation on the medical service based on race, which has been previously demonstrated to play an important role in the intensive care setting.[35] Although this is a single-center study at a high-volume quaternary referral center, we suspect the identified inequities are not unique to our institution.

This analysis reflects our institution's strong tradition of self-reflection and transparency to make care better for all our patients. We are using these findings to inform further studies, including detailed chart reviews and surveys of patients' and providers' experience of the admission decision process to better understand better the observed inequities and their consequences. We are utilizing a PHCRP framework to devise appropriate interventions to address these findings.[27] By assuming the existence of institutional racism across all American institutions, we can turn from research focused on documenting disparities and inequities to implementation research directed towards correcting them whilst ensuring that institutions like ours are accountable to the communities they serve. Strategies under discussion include strengthened standardized admission guidelines or decision tools, racial equity training for clinicians, standardization of HF care on GMS to ensure high-quality treatment, and methods to ensure higher rates of cardiology follow-up after discharge. It is likely that these interventions and more will be needed to address the inequities described in this study. Ongoing institutional insistence on self-critique and recognition of the pervasiveness of structural racism and bias will increase the likelihood of success in achieving health equity at all US institutions.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Appendix:

2017-2018 Brigham and Women's Hospital Internal Medicine Housestaff include the following contributors: Abel, Samantha; Adams, Ayrenne; Anaya, Joseph; Andrews, Erik H; Atkinson, Benjamin; Avutu, Viswatej; Bachorik, Alexandra; Badri, Omar; Bailey, Mariel; Baird, Katie; Bakshi, Salina; Balaban, Denis; Barshop, Kenneth; Baumrin, Emily; Bayomy, Omar; Beamesderfer, Julia; Becker, Nora; Berg, David D., Berman, Adam N.; Blum, Steven M.; Boardman, Alexander P.; Boden, Kaeleen; Bonacci, Robert A; Brown, Sarah; Campbell, Kirsti; Case, Siobhan; Cetrone, Emily; Charrow, Alexandra; Chiang, David; Clark, Devin; Cohen, Aaron J.; Cooper, Alissa; Cordova, Tomas; Cuneo, C. Nicholas; de Feria Alsina Alejandro; Deffenbacher, Karen; DeFilippis, Ersilia M.; DeGregorio, Geneva; Deutsch, Aaron J.; Diephuis, Bradford; Divakaran, Sanjay; Dorschner, Peter; Downing, Nicholas; Drescher, Caitlin; D'Silva, Kristin M.; Dunbar, Peter; Duong, David; Earp, Sarah; Eckhardt, Christine; Elman, Scott A.; England, Ross; Everett, Kay; Fedotova, Natalie; Feingold-Link, Tamara; Ferreira, Mark; Fisher, Herrick; Foo, Patricia; Foote, Michael; Franco, Idalid; Gilliland, Thomas; Greb, Jacqueline; Greco, Katherine; Grewal, Sungat; Grin, Benjamin; Growdon, Matthew E.; Guercio, Brendan; Hahn, Cynthia K.; Hasselfeld, Brian; Haydu, Erika J; Hermes, Zachary; Hildick-Smith, Gordon; Holcomb, Zachary; Holroyd, Kathryn; Horton, Laura; Huang, George; Jablonski, Stanley; Jacobs, Douglas; Jain, Nina; Japa, Sohan; Joseph, Richard; Kalashnikova, Mariya; Kalwani, Neil; Kang, Daniel; Karan, Abraar; Katz, Joel T; Kellner, Daniel; Kidia, Khameer; Kim, June-Ho; Knowles, Scott M; Kolbe, Laura; Kore, Idil; Koullias, Yiannis; Kuye, Ifedayo; Lang, Joshua; Lawlor, Matthew; Lechner, Melissa G.; Lee, Ken; Lee, Scott; Lee, Zachary; Limaye, Neha; Lin-Beckford, Stephanie; Lipsyc, Marla; Little, Jessica; Loewenthal, Julia; Logaraj, Ranjani; Lopez, Diana M; Loriaux, Daniel; Lu, Yi; Ma, Kevin; Marukian, Nareh; Matias, Wilfredo; Mayers, Jared R.; McConnell, Ian; McLaughlin, Michael; Meade, Christina; Meador, Catherine; Mehta, Anish; Messenger, Elizabeth; Michaelidis, Constantinos; Mirsky, Jacob; Mitten, Emilie; Mueller, Alisa; Mullur, Jyotsna; Munir, Amir; Murphy, Emily; Nagami, Ellen; Natarajan, Abirami; Nsahlai, Michelle; Nze, Chijioke; Okwara, Noreen; Olds, Peter; Paez, Rafael; Pardo, Michael; Patel, Siddharth; Petersen, Alec; Phelan, Laura; Pimenta, Erica; Pipilas, Daniel; Plovanich, Molly; Pong, Denise; Powers, Brian W.; Rao, Anita; Ramirez Batlle Haiyan; Ramsis, Mattheus; Reichardt, Anna; Reiger, Sheridan; Rengarajan, Michelle; Rico, Stephanie; Rome, Benjamin N.; Rosales, Rachael; Rotenstein, Lisa; Roy, Alexis; Royston, Sarah; Rozansky, Hallie; Rudder, Meghan; Ryan, Christine E.; Salgado, Sanjay; Sanchez, Pablo;Schulte, Jennifer; Sekar, Aswin; Semenkovich, Nicholas; Shannon, Evan; Shaw, Neil; Shorten, Andrew Ben; Shrauner, William; Sinnenberg, Lauren; Smithy, James W.; Snyder, Gregory; Sreekrishnan, Anirudh; Stabenau, Hans; Stavrou, Eleni; Stergachis, Andrew; Stern, Robert; Stone, Alexander; Tabrizi, Shervin; Tanyos, Sam; Thomas, Cristina; Thun, Haley; Torres-Lockhart Kristine; Tran, An; Treasure, Carolyn; Tsai, Frederick D.; Tsaur, Stephen; Tschirhart, Evan; Tuwatananurak, Justin; Venkateswaran, Ramkumar V.; Vishnevetsky, Anastasia; Wahl, Lindsay; Wall, April; Wallace, Frances; Walsh, Elisa; Wang, Priscilla; Ward, Heather B.; Warner, Lindsay N.; Weeks, Lachelle D.; Weiskopf, Kipp; Wengrod, Jordan; Williams, Jessica N.; Winkler, Marisa; Wong, Jeffrey L.; Worster, Devin; Wright, Aileen; Wunsch, Caroline; Wynter, Jamila S.; Yarbrough, Chase; Yau, Wai-Ying; Yazdi, Daniel; Yeh, Jennifer; Yialamas, Maria A.; Yozamp, Nicholas; Zambrotta, Marina; Zon, Rebecca.

Non-standard Abbreviations and Acronyms

ADI	Area Deprivation Index
CIF	Cumulative Incidence Function
ECI	Elixhauser Comorbidity Index
EMR	electronic medical record
GEE	generalized estimating equations
GMS	general medicine service
PCP	Primary care physician
PHCRP	Public Health Critical Race Praxis
VIF	Variance inflation factor

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WHAT IS NEW?

- We retrospectively analyzed 10 years of HF admissions using multivariable models. We demonstrated that black or Latinx race were independently associated with decreased likelihood of admission to the cardiology service for HF care.
- Female gender and older age were also independently associated with lower likelihood of admission to the cardiology service.
- Admission to the cardiology service was independently associated with lower readmission rates.

WHAT ARE THE CLINICAL IMPLICATIONS?

- Our analysis demonstrates the presence of structural racism in admission service for HF patients, as well as important inequities based on gender and age. Differential access to cardiology for admission service is an important driver of inequities in readmission rates.
- Our findings suggest that differential access to specialty care within institutions may be an important driver of health inequities. Future disparities research in other clinical realms should explore inequities in access to subspecialty care as a causal driver.

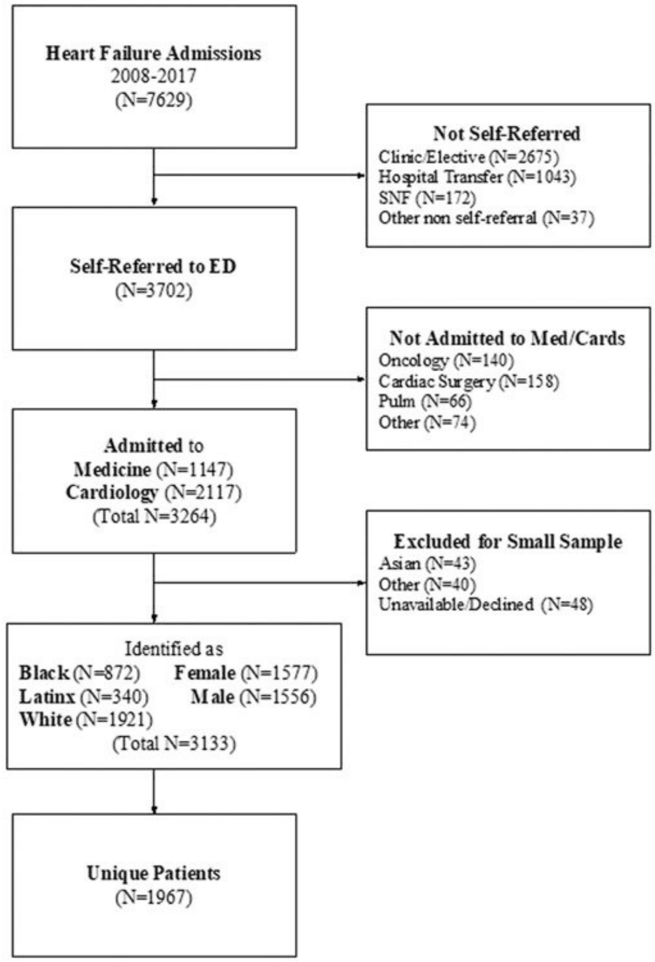

Figure 1.

Flow diagram showing selection of study cohort.

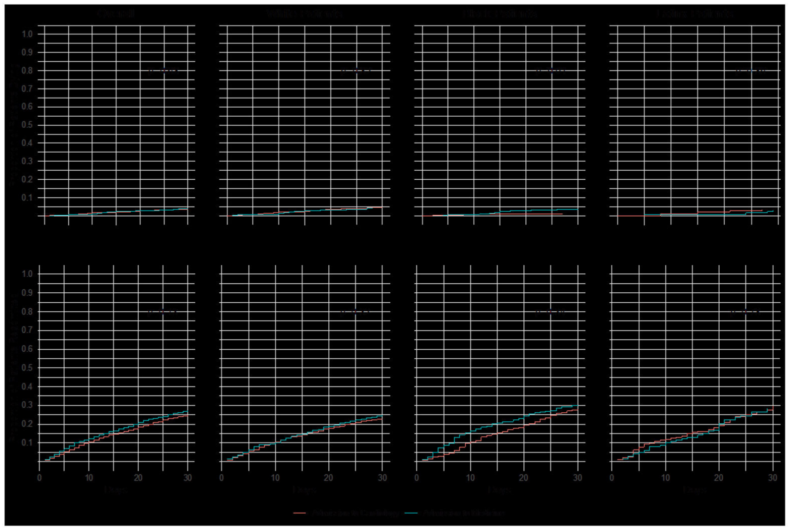

Figure 2.

Unadjusted Cumulative Incident Function (CIF) plots with Gray's tests comparing rates of readmission and death within 30 days after discharge for (A) all patients (B) white patients (C) black patients and (D) Latinx patients.

Table 1.

Characteristics of people admitted with a principal admission diagnosis of HF for the first time to the general medicine or cardiology service after self-referral to the Emergency Department of the Brigham and Women's Hospital from 2008-2017 (N=1967[*])

	White	Black	Latinx	p-value
	n=1312	**n=465**	**n=190**	
Age at first admission	77 (66-84)	66 (56-76)	71 (58-79)	<.0001
Female	601 (46)	264 (57)	114 (60)	<.0001
Boston Metro Resident [†]	1031 (79)	440 (95)	176 (93)	<.0001
English as Primary Language	1239 (94)	437 (94)	54 (28)	<.0001
Medicaid	54 (4)	61 (13)	53 (28)	<.0001
Area Deprivation Index National Percentile, (N=1754)	13 (7-23)	30 (21-40)	36 (22-98)	<.0001
Seen in institutional cardiology clinic in last year	672 (51)	188 (40)	93 (49)	0.0003
Seen by institutional PCP in last year	407 (31)	210 (45)	95 (50)	<.0001
HFpEF	464 (35)	156 (34)	63 (33)	0.70
Specific Comorbidity				
Arrhythmia	178 (14)	63 (14)	15 (8)	0.088
Valvular Disease	468 (36)	111 (24)	45 (24)	<.0001
Chronic Pulmonary Disease	363 (28)	138 (30)	59 (31)	0.50
Diabetes	25 (2)	7 (2)	3 (2)	0.83
Psychiatric disease	195 (15)	67 (14)	30 (16)	0.90
Cancer	138 (11)	39 (8)	10 (5)	0.04
Drug Use Disorder	14 (1)	10 (2)	1 (1)	0.13
Alcohol Use Disorder	8 (1)	5 (1)	2 (1)	0.54
Hypertension	940 (72)	373 (80)	153 (81)	0.0002
Chronic Kidney Disease	523 (40)	222 (48)	76 (40)	0.01
End-Stage Renal Disease	37 (3)	47 (10)	15 (8)	<.0001
Chronic Liver Disease	56 (4)	25 (5)	15 (8)	0.08
Elixhauser Comorbidity Index				
Overall	12 (8-17)	12 (9-16)	12 (8-15)	0.10
Cardiovascular	7 (7-10)	7 (7-10)	7 (7-7)	0.0005
Non-cardiovascular	5 (0-8)	5 (0-8)	3 (1-6)	0.78
Year of first admission				
2008-2010	506 (39)	177 (38)	73 (38)	0.97
2011-2013	479 (36)	167 (36)	72 (38)	
2014-2017	336 (26)	121 (26)	45 (24)	
Admitted to cardiology service	874 (67)	247 (53)	100 (53)	<.0001

Data are presented as N (%) unless otherwise specified. For continuous variables, median (IQR) are shown.

[*] Unless otherwise noted

†Per US Census Bureau

Abbreviations: HF, heart failure; HFpEF, heart failure with preserved ejection fraction; PCP, primary care provider

Table 2.

Multivariable Generalized Estimating Equations (GEE) analysis* showing factors associated with admission to the cardiology service for people admitted with a principal diagnosis of HF after self-referral to the Emergency Department of the Brigham and Women's Hospital from 2008-2017. (Complete case analysis, N=2802; multiply imputed analysis, N=3133).

	Complete Case Analysis			*Multiply Imputed Analysis*		
Characteristic	**Adjusted RR**	**95% CI**	**p-value**	**Adjusted RR**	**95% CI**	**p-value**
Race						
White	ref			ref		
Black	0.91	0.84, 0.98	0.019	0.91	0.84, 0.98	0.015
Latinx	0.83	0.72, 0.97	0.017	0.84	0.73, 0.96	0.012
Age						
<50	ref			ref		
50-75	0.98	0.89, 1.08	0.71	0.98	0.89, 1.08	0.66
>75	0.85	0.77, 0.95	0.003	0.87	0.78, 0.96	0.0056
Female	0.91	0.86, 0.97	0.003	0.90	0.85, 0.95	0.0003
Boston Metro Resident†	0.93	0.87, 1.00	0.056	0.95	0.89, 1.01	0.11
English as primary language	0.91	0.81, 1.01	0.085	0.93	0.84, 1.03	0.16
Area Deprivation Index National Percentile‡	0.99	0.97, 1.01	0.48	1.00	0.98, 1.02	0.98
Seen in institutional cardiology clinic in last year	1.31	1.23, 1.39	<.0001	1.32	1.25, 1.41	<.0001
Seen by institutional PCP in last year	0.88	0.82, 0.93	<.0001	0.87	0.82, 0.92	<.0001
HFpEF	0.93	0.87, 0.99	0.029	0.93	0.87, 0.99	0.017
Comorbidity						
Chronic Pulmonary Disease	0.85	0.80, 0.91	<.0001	0.85	0.80, 0.91	<.0001
Valvular Disease	1.11	1.05, 1.18	0.0002	1.11	1.05, 1.17	0.0001
Arrhythmia	1.14	1.03, 1.27	0.014	1.15	1.04, 1.27	0.0053
Hypertension	0.95	0.90, 1.01	0.08	0.95	0.90, 1.00	0.051
End-Stage Renal Disease	0.47	0.36, 0.61	<.0001	0.47	0.37, 0.60	<.0001
Diabetes	1.08	0.92, 1.27	0.34	1.05	0.90, 1.24	0.53
Psychiatric Disease	0.96	0.88, 1.04	0.33	0.95	0.88, 1.03	0.20
Elixhauser Index, cardiovascular	1.00	0.98, 1.01	0.81	1.00	0.98, 1.01	0.67
Admission Year						
2008-2010	ref			ref		
2011-2013	1.17	1.09, 1.25	<.0001	1.16	1.09, 1.24	<.0001
2014-2017	1.19	1.11, 1.28	<.0001	1.19	1.11, 1.28	<.0001

*The multivariable model includes race, age, sex, Boston metro residence, primary language, year of admission, being seen in a primary care clinic at our institution within the last year, being seen in cardiology clinic at our institution within the last year, ADI, HFpEF, history of chronic pulmonary disease, cardiac valvular disease, cardiac arrhythmia, hypertension, ESRD, diabetes, psychiatric disease, and the ECI (cardiovascular component)

†Per US Census Bureau

‡Per increase in 10%

Abbreviations: GEE, generalized estimating equations; HF, heart failure; HFpEF, heart failure with preserved ejection fraction; PCP, primary care provider; RR, rate ratio

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Table 3.

Rate ratios for admission to cardiology for propensity-matched cohorts.

	Rate Ratio of Admission to Cardiology	95% CI	p-value
Black vs White	0.74	0.63, 0.87	0.0001
Latinx vs White	0.75	0.60, 0.95	0.014
Female vs Male	0.86	0.77-0.96	0.0055

Abbreviations: CI, confidence interval

Table 4.

Multivariable Cox Regression analysis[*] showing factors associated with readmission within 30 days after discharge for people admitted to the general medical or cardiology services with a principal diagnosis of HF after self-referral to the Emergency Department of the Brigham and Women's Hospital from 2008-2017. (N=3133)

Characteristic	Hazard Ratio	95% CI	p-value
Admission to Cardiology	0.84	0.72, 0.97	0.018
Race			
White	ref		
Black	1.09	0.92, 1.29	0.31
Latinx	1.14	0.91, 1.42	0.27
Age			
<50	ref		
50-75	0.61	0.49, 0.76	<.0001
>75	0.54	0.43, 0.69	<.0001
Boston Metro Resident[†]	1.09	0.88, 1.35	0.43
Seen in institutional cardiology clinic in last year	1.27	1.09, 1.49	0.003
Seen by institutional PCP in last year	1.17	1.01, 1.36	0.041
HFpEF	0.81	0.70, 0.94	0.007
Comorbidity			
Valvular Disease	1.24	1.07, 1.44	0.005
Psychiatric Disease	1.15	0.96, 1.38	0.14
Chronic Kidney Disease	1.36	1.15, 1.60	0.0003
Chronic Liver Disease	1.11	0.80, 1.54	0.55
Elixhauser Index	1.01	0.99, 1.02	0.33

[*]Multivariable model includes admission to cardiology, race, age, Boston metro resident, whether the patient was seen in institutional cardiology clinic in last year, whether the patient was seen by institutional PCP in last year, diagnosis of HFpEF, valvular disease, psychiatric disease, chronic kidney disease, chronic liver disease, and Elixhauser Comorbidity Index.

[†]Per US Census Bureau