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Community-level Economic Distress, Race, and Risk of Adverse Outcomes Following Heart Failure Hospitalization among Medicare Beneficiaries

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Abstract

Background: Socioeconomic disadvantage is a strong determinant of adverse outcomes in patients with heart failure (HF). However, the contribution of community-level economic distress to adverse outcomes in HF may differ across races.

Methods: Patients of self-reported Black, White, and Hispanic race/ethnicity hospitalized with HF between 2014 and 2019 were identified from the 100% CMS MedPAR database. We used

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patient-level residential zip code to quantify community-level economic distress based on the distressed community index (DCI, Quintile 5: economically distressed vs. Quintiles 1–4: non-distressed). The association of continuous and categorical measures (distressed vs. non-distressed) of DCI with 30-day, 6-month, and 1-year risk-adjusted mortality, readmission burden, and home time were assessed separately by race/ethnicity groups.

Results: The study included 1,611,586 White (13.2% economically distressed), and 205,840 Black (50.6% economically distressed) and 89,199 Hispanic (27.3% economically distressed) patients. Among White patients, living in economically distressed (vs. non-distressed) communities was significantly associated with a higher risk of adverse outcomes at 30-days and 1-year follow-up. Among Black and Hispanic patients, the risk of adverse outcomes associated with living in distressed vs. non-distressed communities was not meaningfully different at 30-days and became more prominent by 1-year follow-up. Similarly, in the restricted cubic spline analysis, a stronger and more graded association was observed between DCI score and risk of adverse outcomes in White patients (vs. Black and Hispanic patients). Furthermore, the association between community-level economic distress and risk of adverse outcomes for Black patients differed in rural vs. urban areas. Living in economically distressed communities was significantly associated with a higher risk of mortality and lower home time at 1-year follow-up in rural areas but not urban areas.

Conclusion: The association between community-level economic distress and risk of adverse outcomes differs across race-ethnic groups, with a stronger association noted in White patients at short- and long-term follow-up. Among Black patients, the association of community-level economic distress with a higher risk of adverse outcomes is less evident in the short term and is more robust and significant in the long-term follow-up and rural areas.

Keywords

Heart failure; racial disparity; economic distress; mortality; readmission

INTRODUCTION

It is estimated that more than six million patients had prevalent heart failure (HF) in the US in 2018, and this number is projected to increase by 46% by 2030, adding more than eight million newly diagnosed HF patients.[1] HF is the most common cause of hospitalization among older adults and accounting for 1 million hospitalizations annually.[2] As a result, improvement in care quality and outcomes of patients hospitalized with HF has been one of the key targets of the current healthcare policies.

In addition to the in-hospital care quality, community-level socioeconomic distress has been identified as a key driver of outcomes following HF hospitalization. One-fifth of U.S. zip codes currently demonstrate social and economic distress, including high poverty rates, joblessness, and economic recession.[3] Measures of community distress such as low education levels, low median household income, high rates of poverty, and unemployment are important determinants of the overall health and well-being of its residents.[4, 5] Patients with HF living in neighborhoods with higher socioeconomic deprivation and economic distress have a higher risk of adverse clinical outcomes.[6] However, the contribution of community-level socioeconomic distress to adverse outcomes in HF may differ across race and ethnic groups, and to our knowledge, has not been evaluated comprehensively using nation-level datasets.[6] This represents an important knowledge gap in our understanding of the drivers of racial disparities in outcomes among HF patients. Accordingly, in this study, we examined the association of community distress with the short and long-term risk of mortality, readmission, and home time after a HF hospitalization among Black, Hispanic, and White patients.

METHODS

The authors will not make the data, methods used in the analysis, and materials used to conduct the research available to any researcher for purposes of reproducing the results or replicating the procedure.

Study cohort

We identified Medicare beneficiaries who were admitted with a primary diagnosis of HF from 01/01/2014 to 12/01/2019 utilizing International Classification of Diseases (ICD) diagnosis version-9 codes (428. *, 402.01, 402.11, 402.91, 404.01, 404.11, 404.91, 404.03, 404.13, 404.93) and version-10 codes (I50. *, I11.0, I13.0, I13.2) from the Medicare Provider Analysis and Review (MedPar) Part A 100% Files. Figure I in supplement shows the flowchart of the study cohort. Among patients admitted to the hospital more than once during the study period, we included only the first admission. We excluded patients younger than 65 years at HF admission and patients enrolled for <1 year in Fee-for-Service before the HF admission date. We also excluded patients discharged on the admission day and those who left against medical advice, were discharged to hospice, or received palliative care within 30 days from HF admission date. We excluded patients with residence ZIP codes outside the contiguous 48 U.S. states. We also excluded a ZIP code from a specific race analysis if that ZIP code had <30 patients of that race during the study period. We used the Medicare Beneficiary Summary Files to extract patient age, sex, race/ethnicity, residence ZIP code, and Medicare enrollment dates. A lookback period of one year was used to ascertain the patient's comorbidities from all ICD diagnosis and procedure codes submitted in any admission claim in the year before the HF admission date. The Cleveland Clinic Institutional Review Board approved the study with waived informed consent.

Race-Ethnicity and Distressed Community Index Score

The primary exposures of interest were race-ethnicity and neighborhood economic disadvantage measured by the Distressed Community Index (DCI) score. Race-ethnicity was identified using the Research Triangle Institute's Race variable in Medicare Beneficiaries Summary Files. This variable was validated in prior studies and had high sensitivity and specificity (>97%) against self-reported race/ethnicity in Medicare beneficiaries.[7] The race variable in Medicare Beneficiary Summary files classifies patients into the following race-ethnicity groups: non-Hispanic White, non-Hispanic Black, Hispanic, Asian/Pacific Islander, American Indian/Alaskan Native, and others, and it is a mutually exclusive variable. The DCI is a metric that measures the economic disadvantage of different US communities based on residential ZIP codes.[8–10] There are seven components to the metric:

Percent of individuals older than 25 years without a high school diploma, percent of unoccupied habitable housing units, percent of the prime-age population not working, percent of the population with household income below the poverty line, median Zip Code income compared with state's median income, percent change in the number of business establishment and change in the number of jobs. Based on these components, a continuous score is assigned from 0 to 100, where higher numbers indicate higher levels of community distress. Communities were then divided into five quintiles (Q1: "prosperous"; Q2 "comfortable"; Q3: "mid-tier"; Q4: "at-risk", and Q5:"distressed").[9, 11]

Study Outcomes

Study outcomes included all-cause mortality, readmission burden calculated as the admissions rate per 100-person months, and home-time.[12–14] Mortality outcomes were estimated from the date of HF admission. Readmission burden and home time were calculated from the discharge date and only included patients discharged alive from the hospital. Home time— an increasingly recognized patient-centered outcome—is defined as the number of days the patient spends alive and at home [out of the hospital, skilled nursing facility (SNF), or long-term acute care center (LTAC)].[13] Home time is associated with patient-centered outcomes such as self-reported health and functional status and clinical outcomes such as readmission and mortality.[13–16] Our study outcomes were assessed at three different time points after the HF index admission; 30 days, 6 months, and 1-year follow-up. Data on mortality were available through 8/2020, and clinical outcomes were available through 12/2019.

Statistical analysis

The cohort was stratified by race-ethnicity and DCI-based distress status for the residential Zip-code [distressed (Q5) vs. non-distressed (Q1-Q4)]. Within each race-ethnic group, patient characteristics were presented for the distressed vs. non-distressed strata as the median (25th – 75th Percentile) of Zip code-level proportions (for categorical patient characteristics), and the median (25th – 75th Percentile) of Zip code-level means (for continuous patient characteristics) and compared using Mann-Whitney test. For risk-adjusted outcomes, we used generalized linear mixed models to calculate risk-adjusted rates of home time and readmission burden rates with a random intercept for the patient Zip code and fixed effects for patient-level variables. Variables used in risk adjustment models were derived from a prior validated model in HF patients using Medicare data (Table I in supplement).[17] The risk adjustment models were constructed using a log link and Poisson distribution (or logit link and binomial distribution in mortality models). The models included an offset term of log of the time patient was alive during follow up for rate of readmission outcome and estimated using maximum likelihood with patient Zip code as a random effect and patient variables as fixed effects. We first tested whether the association of community-level economic distress with adverse outcomes is different across race-ethnic groups by conducting an interaction analysis by race-ethnicity and DCI score in the overall cohort. Then risk-adjusted models were constructed for each race-ethnic group separately and were used to calculate expected and predicted outcomes with and without linear unbiased prediction modeling respectively. The predicted to expected outcome ratio was multiplied with the overall unadjusted rates of the outcome (mortality, readmission

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burden, and home time) to calculate the risk-adjusted rates for each outcome. The risk-adjusted outcomes of mortality, readmission, and home time at 30 days, 6 months, and 1-year follow-up were compared across distressed vs. non-distressed groups within each race-ethnic group using Mann–Whitney U test. Additional analyses were also conducted to compare the risk-adjusted mortality, readmission burden, and home time at each time point between prosperous (Quintile 1) vs. non-prosperous groups (Quintile 2–5) within each race-ethnic group.

The association between continuous measures of DCI and risk of the outcomes of interest was also assessed using hierarchical logistic regression for mortality and generalized linear mixed models for other outcomes. Separate models were constructed for each race-ethnic group, outcome (mortality, readmission, and home time), and time points (30 days, 6 months, and 12 months). The models were adjusted for the same variables from the risk adjustment model published in prior studies using ICD-9 and ICD-10 codes mapped to each condition, using published CMS risk models (Table I in supplement).[17] To assess and visualize the potential non-linear association between community distress and study outcomes, we modeled the DCI against the risk-adjusted outcomes with a restricted cubic spline method using a priori-defined 5 knots located in the 5th, 27.5th, 50th, 77.5th, and 95th percentiles.

Stratified analysis by rural-urban designation of patients' residential zip code was also performed to understand better the association between community-level economic distress and risk of adverse outcomes for Black and White patients differ in rural vs. urban areas. Patient was considered to live in rural area if the Zip code is designated rural by the Federal Office of Rural Health Policy.[18] The rural-urban stratified analysis was not performed for Hispanic patients due to the small sample size of Zip codes with rural Hispanic HF patients (N = 66 Zip codes in rural areas with >30 HF patients of Hispanic race-ethnicity during the study period).

Sensitivity Analysis

Several sensitivity and subgroup analyses were performed to assess the robustness of our study findings. First, the association between community-level economic distress (distressed vs. not distressed) and adverse outcomes was evaluated within each race-ethnic group using a lower cut-off for inclusion of zip codes (>10 patients of a specific race-ethnic group during the study period). Second, the association of community-level economic distress (distressed vs. not distressed) with rates of skilled nursing facilities (SNF) or long-term acute care [LTAC] use was also assessed at 30-day and 1-year follow-up. The risk-adjusted SNF/LTAC utilization rates were evaluated using generalized linear mixed models as detailed above with a random intercept for the zip code and fixed effects for patient-level variables. Finally, to account for the imbalance between the White and Black race-ethnic groups in the number of patients and the gradient in mean DCI score across the community-level distress-based strata, sensitivity analysis was performed matching Black and White patients in a 1:1 fashion at the zip code-level DCI and comparing the risk of adverse outcomes among distressed vs. non-distressed strata within each race-ethnic group. For this, a propensity matching approach was used with the greedy method on the DCI with a caliper of 0.1 and exact method on the distressed group to create two matched groups of White and Black race-ethnicity patients balanced on the degree of community distress. The analysis was performed using SAS version 9.4 (SAS Institute, Inc., Cary, North Carolina), R version 4.0.2 (R Foundation for Statistical Computing, Vienna, Austria), and GraphPad Prism version 8. A 2-sided p-value <0.05 was considered statistically significant. P values presented in the primary analysis are corrected using the fixed discovery rate approach.

RESULTS

Baseline characteristics of the study cohort

The study cohort included 1,906,625 patients with HF. The race-ethnicity distribution in the study cohort was as follows: 84.5% (N =1,611,586 from 13381 zip codes) White patients, 10.8% (N = 205,840 from 2307 zip codes) Black patients, and 4.7% (N = 89,199 from 1118 zip codes) Hispanic patients. Table 1 shows the baseline characteristics of the study cohort stratified by community-level economic distress within each race-ethnic group. Overall, 17.9% of patients (N = 341,976) lived in distressed communities, with substantial variation according to race-ethnic groups. The proportion of patients living in economically distressed communities was significantly higher for Black (50.6% living in 958 economically distressed zip codes) and Hispanic (27.3% living in 300 economically distressed zip codes) patients compared with White patients (13.2% living in 2233 economically distressed zip codes) (P value<0.001). The difference in mean DCI between distressed vs. non-distressed communities was greater for White patients (88.8±5.4 vs. 36.6±22.6) than Black (91.5±5.7 vs. 52.9±19.5) and Hispanic patients (88.9±5.5 vs. 54.0±19.1). At the zip code level, patients living in distressed (vs. non-distressed communities) had a higher prevalence of COPD but lower rates of pacemaker use and valve disease diagnosis across race-ethnic groups. The prevalence of coronary artery disease and diabetes was significantly higher in distressed (vs. non-distressed communities) for the White and Hispanic patients but not for the Black patients.

Community-level economic distress and all-cause mortality

Community-level economic distress was associated with a higher risk of 30-day mortality following HF hospitalization in the overall cohort, and the association differed across race-ethnic groups at all study time points ($P_{interaction}$ <0.001 for all). Among White patients, the risk-adjusted 30-day mortality for those living in distressed communities was 7.0% vs. 6.2% for those living in non-distressed communities (p-value <0.001). A similar pattern was noted in the association of community distress with mortality at longer follow-up (1-year: 36.1% vs. 34.5% respectively, p-value <0.001) (Table 2). In contrast, risk-adjusted 30-day mortality was not significantly different among Black patients living in distressed vs. non-distressed communities (4.0% vs. 3.7%, p-value = 0.052). The association between community-level economic distress and mortality was statistically significant among Black patients at longer follow-up (1-year: 28.0% vs. 27.2% respectively, p-value <0.001) (Table 2). Similar findings were observed when DCI score was analyzed as a continuous variable with a stronger association between higher DCI and risk of mortality among White vs. Black patients at each follow-up time point (30 days, 6 months, and 1 year; $P_{interaction}$ <0.001 for all, Table II in supplement, Figure 1 A&B). There was no association between community-level economic distress and mortality among Hispanic patients at any time point (Table 2, Figure 1 C&D).

Community-level economic distress and readmission burden

Community-level economic distress was associated with higher rates of 30-day readmission following HF hospitalization in the overall cohort, with meaningful differences in the association across race-ethnic groups ($P_{interaction}$ <0.001). Among White patients, the risk-adjusted 30-day readmission rate for those living in distressed communities was 29.5 vs. 27.4 per 100 person-months for those residing in non-distressed communities (p-value <0.001). A similar pattern was noted in the association of community-level economic distress with readmission rate at longer follow up (1-year: 25.2 vs. 21.7 per 100 person-months, p-value <0.001) (Table 2). In contrast, the 30-day risk-adjusted readmission rates were comparable among Black patients living in distressed vs. non-distressed communities on short-term follow-up (30-day: 26.7 vs. 26.7 per 100 person-months, p-value 0.6). A significantly higher burden of readmission among Black patients living in distressed (vs. non-distressed) communities was only noted in the extended follow-up period (1-year: 23.3 vs. 21.3 per 100 person-months, p-value < 0.001) (Table 2). Similar patterns of association were noted between the continuous measure of DCI and readmission burden among White and Black patients (Table II in supplement, Figure 2 A&B).

Among Hispanic patients, the association between community-level economic distress and readmission burden was similar to that observed for Black patients with no difference in the short-term (30-days; 28.3 per 100 person-months vs. 28.2 admissions per 100 person-months, P=0.4) and a more pronounced but statistically insignificant difference at 1 year follow up (23.0 vs. 21.7 per 100 person-months, P=0.1). (Table 2, Figure 2 C&D)

Community-level economic distress and home time

There was evidence of an interaction between race-ethnicity and community-level economic distress for the risk-adjusted home time in each follow-up time point ($P_{interaction}$ <0.001 for all). Among White patients, the risk-adjusted 30-day home time was lower among those living in distressed vs. non-distressed communities (23.4 days vs. 24.1 days, p-value <0.001). A similar pattern was noted in the association of community distress with home time at longer follow-up (1-year home time: 261 days vs. 273 days, p-value <0.001). In contrast, risk-adjusted 30-day home time was not different among Black patients living in distressed vs. non-distressed communities (25.4 vs. 25.2 days, p=0.3). Higher community distress was associated with significantly lower home time only at more extended follow-up periods (1-year: 286 vs. 289 days; p-value=0.006) (Table 2). Similar patterns of association were noted between continuous measures of DCI and risk-adjusted home time at different time points post-discharge among White and Black patients (Table II in supplement, Figure 3 A&B). Among Hispanic patients, the risk-adjusted home time was not different living in the distressed vs. non-distressed communities at every follow-up time point (Table 2, Figure 3 C&D).

Additional analyses were also performed evaluating the association of community-level economic distress with the risk-adjusted utilization rates of SNF/LTAC—a key contributor to time spent away from home— at 30-day and 1-year follow-up across different race-ethnic groups. Among White patients, the risk-adjusted SNF/LTAC utilization rate was higher among those living in distressed vs. non-distressed communities at both time points (Table III in supplement). In contrast, the risk-adjusted SNF/LTAC utilization rate among Black and Hispanic patients was not significantly different among those living in distressed (vs. non-distressed) communities (Table III in supplement).

Community-level prosperous vs. non-prosperous status and risk of adverse outcomes

The association of socioeconomic prosperity — assessed by the DCI (Q1- prosperous vs. Quintile 2–5: non-prosperous) —with the risk of adverse outcomes differed across races/ethnic groups. Among White patients, living in a prosperous community (vs. non-prosperous, Q1 vs. Q2-Q5) was significantly associated with lower risk of all-cause mortality, readmission burden, and higher home time in short-term and longer-term follow-up (Table 3). In contrast, the differences in the risk of mortality and home time among Black patients living in prosperous vs. non-prosperous communities were not statistically significant at 30-day or longer follow up time points. For readmission burden, Black patients living in prosperous (vs. non-prosperous) communities had significantly lower readmission burden only at 6 month and 1-year follow up but not at 30-days follow up (Table 3). Among Hispanic patients, the risk of mortality at any time point and readmission burden and home time at 30-day and 6-month follow-up were not significantly different among those living in prosperous vs. non-prosperous communities. In contrast, Hispanic patients living in prosperous communities had significantly lower readmission burden was higher home time at 1-year follow up (Table 3).

Rural vs. urban location, community-level economic distress, and risk of adverse outcomes

Among White patients, living in distressed (vs. non-distressed) communities was significantly associated with a higher risk of mortality, readmission, and worse home time in rural as well as urban locations (Table IV in supplement). Furthermore, White patients living in distressed rural communities had a significantly higher mortality rate and lower home time at 1-year than those living in distressed urban communities (mortality: 36.5% vs. 35.7%, $p<0.001$; home time = 258 vs. 267 days, $p <0.001$). Among Black patients, living in distressed communities was significantly associated with a higher risk of mortality and lower home time at 1-year follow-up in rural but not urban locations (Table IV in supplement). Furthermore, Black patients living in distressed rural communities had a significantly higher risk of mortality (31.7% vs. 27.1%, $p<0.001$) and lower home time (269 vs. 290 days, $p <0.001$) than those living in distressed urban communities. Finally, the risk of mortality and home time among patients living in non-distressed rural communities was comparable with those living in distressed urban communities across both race-ethnic groups.

Sensitivity analysis

In sensitivity analysis using a relaxed inclusion threshold for the race-specific analysis zip codes (excluding zip codes with <10 patients of that race during the study period), the pattern of association between community-level economic distress (distressed vs. non-distressed) and risk of adverse outcomes was similar to that observed in the primary analysis (Table V in supplement).

In the sensitivity analysis using 1:1 DCI-matched Black and White race-ethnic groups (N = 104,230 in distressed vs. n = 101,610 in non-distressed communities for both race-ethnic groups), the gradient in the mean DCI scores between distressed vs. non-distressed communities was comparable across both race-ethnic groups (mean DCI in distressed vs. non-distressed, Black patients = 91.5 ± 5.6 vs. 52.9 ± 19l White patients = 88.9 ± 5.4 vs. 50.1 ± 19.5). The pattern of association between community-level economic distress and risk of adverse outcomes in the short-term (30-days) and long-term (1-year) follow-up in the matched cohort analysis was similar to that observed for the primary analysis (Table VI in supplement).

DISCUSSION

In the present study of Medicare beneficiaries hospitalized with HF, we observed that the association of community-level economic distress with adverse outcomes after HF hospitalization differed across race-ethnic groups. Among White patients, living in distressed (vs. non-distressed) communities was significantly associated with higher mortality rate, higher readmission burden, and lower home time in the short-term (30-day) as well as longer-term follow up (6-month and 1-year). In contrast, the risk of adverse outcomes among Black patients living in distressed vs. non-distressed communities was comparable in the short-term follow-up; it became significant and more meaningfully different only at extended follow-up periods.

Prior studies have evaluated and compared race-ethnic disparities in the short- and intermediate-term readmission and mortality rates in patients with HF. In the Organized Program to Initiate Lifesaving Treatment in Hospitalized Patients with Heart Failure (OPTIMIZE-HF) registry, the Black (vs. White) race was an independent predictor of lower in-hospital mortality risk.[19] Similarly, in the Get With The Guidelines-HF registry, Black (vs. White) patients had lower mortality and higher readmission risk.[20, 21] Consistent with these prior observations, we also observed lower mortality and higher readmission rates among Black Medicare beneficiaries following HF hospitalization. The potential reasons for the observed lower mortality but higher readmission rates among Black patients are not well understood but may be driven by individual and community-level socioeconomic factors. Black patients with HF were significantly younger and had a higher burden of non-ischemic cardiomyopathy— factors associated with lower short-term mortality. Furthermore, differences in overall HF care patterns in the outpatient setting for Black patients with HF could also explain these outcome differences. Black patients may have lower access to outpatient care and depend predominantly on emergency department visits for HF care, even for medication refills or slight outpatient worsening symptoms.[22, 23] In contrast, White patients have better access to outpatient care and may be hospitalized for more severe decompensation. Future studies with better characterization of outpatient care patterns in Black vs. White patients are needed to understand better the drivers of the observed differences in post-discharge outcomes.

The present study adds to our understanding of racial disparities in outcomes following HF hospitalization by evaluating the association of neighborhood economic distress and prosperity — assessed based on the residential zip-code—with the risk of adverse clinical outcomes. We observed that a significantly higher proportion of Black and Hispanic patients resided in the most distressed communities (50.6% and 27.3%, respectively) than White patients (13.2%). Among patients with established HF, higher levels of neighborhood socioeconomic deprivation have been associated with higher mortality and readmission.[6, 24] We observed that the association of community-level economic distress with risk of adverse outcomes following a HF hospitalization differed by race-ethnicity. Higher levels of economic distress were more consistently and strongly associated with greater mortality and readmission in White patients than Black and Hispanic patients. Among White patients, the overall burden of economic disadvantage is low, and for those living in distressed communities, economic disadvantage may be the primary hardship that determines short- and long-term outcomes. In contrast, the relative burden of socioeconomic distress among Black patients – even among those living in non-distressed communities—is high, making it more challenging to identify meaningful differences in clinical outcomes between distressed vs. non-distressed groups. Furthermore, the sample size of Black vs. White race-ethnic group was smaller, which may have also contributed to the observed modest to no association between economic distress and risk of adverse outcomes. However, in matched cohort analysis with a balanced number of Black and White patients and comparable gradient in mean DCI across the community-level distress-based strata score across the two races, we observed a consistent pattern of results to the primary analysis. This suggests that the modest association between economic distress and risk of adverse outcomes in Black patients may not be all driven by smaller sample size and less substantive gradient in DCI among distressed vs. non-distressed communities.

Economic distress is just one of the several societal/structural disadvantages Black patients face as part of their lived experience. Other societal challenges may also play an important role in predisposing Black patients to increased risk of adverse outcomes in economically distressed and prosperous communities. [25, 26] Consistent with this notion, in the analysis comparing results among patients living in prosperous vs. non-prosperous communities, we observed similar patterns of race-ethnic difference. Living in prosperous communities was associated with a significantly lower risk of mortality and higher home time in White patients but not among Black or Hispanic patients. Factors such as geographical proximity to resources (urban vs. rural) may be an important determinant of outcomes in patients with HF who require frequent access to care. We observed that patients living in distressed rural communities had the highest mortality rates across both race groups, significantly higher than patients living in distressed urban communities. Moreover, the mortality rates in non-distressed rural communities were comparable to that of distressed urban communities. These findings suggest that geographical proximity to resources (rural vs. urban) may be an important and upstream determinant of adverse outcomes in patients with HF. Living in a rural vs. urban area also modified the association of community-level economic distress with mortality in Black patients. Among Black patients, the association of community distress with mortality was significant in rural but not urban areas. In contrast, among White patients, community distress was significantly associated with worse outcomes in urban and rural areas. These findings highlight the complex interplay of different societal factors and social determinants factors in predicting outcomes of Black patients with HF.

The present study also included over 89,000 Hispanic patients hospitalized with HF and evaluated the association of community distress and outcomes in this subgroup separately. The association of community distress with the risk of adverse outcomes in Hispanic patients with HF was not significant in short- and long-term follow-up. This may be related to several factors. First, similar to the Black patients, the smaller sample size of the Hispanic race-ethnic group and the relative higher burden of economic distress even among Hispanic patients living in non-distressed communities may have biased the associations toward null. Second, the zip code level economic distress parameters used in the present study may not be sensitive enough to capture the individual level social determinants of health meaningfully. This is particularly relevant for Hispanic patients who have substantial heterogeneity in the social determinants of health, health behaviors, and cardiovascular risk based on their backgrounds (Mexican American vs. Cuban American, Puerto Rican vs. Guatemalan).[27] Future studies that better capture Hispanic patients' background and individual-level data on social determinants of health across multiple domains may advance our understanding of the drivers of adverse outcomes in this patient population.

Our study findings may be important in directing future health policies. Racial disparities in CV outcomes are among the key public health issues in our society requiring urgent attention.[28, 29] Understanding the contribution of specific patient- and societal-level factors to adverse outcomes across races is critical to devising and implementing successful policies and initiatives to reduce racial disparities in HF. Our study findings provide important insights into how community-level economic distress and rural vs. urban location of the community may differentially modify the risk of adverse outcomes across races.

Our study has several limitations. First, we classified the study cohort based on the race-ethnicity variable in Medicare data which has three mutually exclusive categories. However, many patients might self-identify in more than one race-ethnicity, which could not be accounted for in the present analysis.[30] We also lacked information on census tracts, which allows more granular geospatial analysis for clinical outcomes. Second, we lacked data about care processes and quality during the hospitalization, specialized cardiology care post-discharge, and the use of guideline-directed therapy on follow-up, which may differ by economic distress status and affect downstream adverse events. Third, we also lacked information on societal factors such as neighborhood violence, housing stability, access to transportation, etc., which may influence the risk of adverse outcomes differently across race-ethnic subgroups. Fourth, the risk-adjustment was based on claims data which may be prone to coding error or missingness from lack of capture of events before Medicare enrollment. However, the use of claims-based data for risk adjustment is standard for the Center for Medicare and Medicaid and most health policy and health services research. Finally, most associations in our study appear modest as these are zip code level factors, but considering the population being studied (at zip code level), a small magnitude of association has large absolute effects on event rates.

In conclusion, community-level economic distress is strongly associated with the risk of adverse outcomes in White patients with HF. Among Black and Hispanic patients, the burden of community-level economic distress is high; however, its association with a higher risk of adverse outcomes is less evident in the short term and is more robust and significant in the long-term follow-up. Future studies with a more granular assessment of individual-level social determinants of health are needed to understand better the drivers of adverse outcomes among Black and Hispanic patients with HF.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Non-standard Abbreviations and Acronyms

DCI	Distressed Community Index
HF	Heart failure
ICD	International classification of diseases
LTAC	Long-term acute care
Q	Quintile
SNF	Skilled nursing facility

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Clinical perspective:

What is new?

- The burden of community-level economic distress is lower in HF patients of white vs. Black and Hispanic race/ethnicity
- Association of community-level economic distress with adverse outcomes after HF hospitalization differs across race-ethnic groups.
- Among Black patients, the association of community-level economic distress with a higher risk of adverse outcomes is less evident in the short term and is more robust and significant in the long-term follow-up and rural areas.

What are the clinical implications?

- Community-level economic distress and rural vs. urban location of the community may differentially modify the risk of adverse outcomes across races.
- Health policies targeting improvements in community-level social determinants of health are needed to improve long-term outcomes in patients with HF.

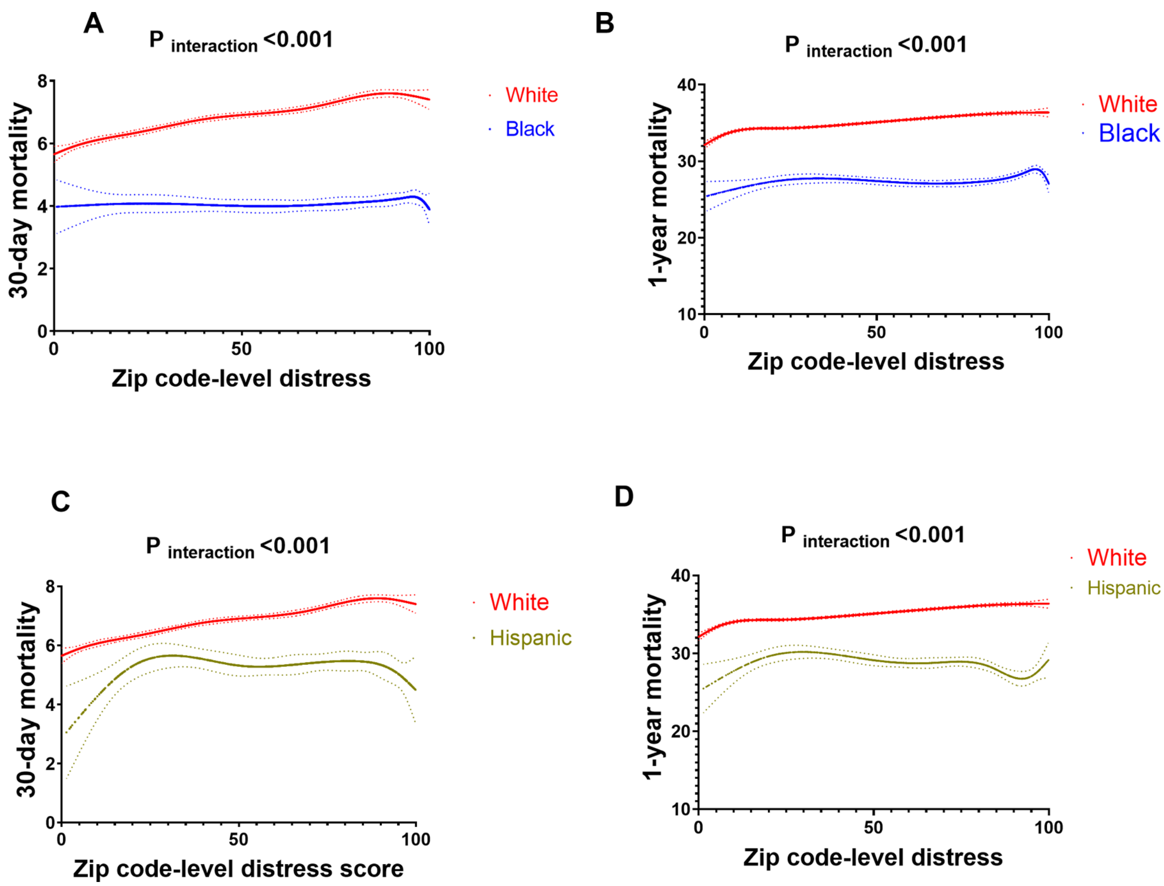

Figure 1:

Restricted cubic spline curves for the relation between Zip Code-level economic distress score and risk-adjusted mortality. Restricted cubic spline curves with 5 knots at 5^{th}, 27.5^{th}, 50^{th}, 77.5^{th} and 95^{th} percentiles to show relation between Zip-code level distress score and A) thirty-day mortality in White versus Black patients, B) one-year mortality in White versus Black patients, C) thirty-day mortality in White versus Hispanic patients, and D) one-year mortality in White versus Hispanic patients.

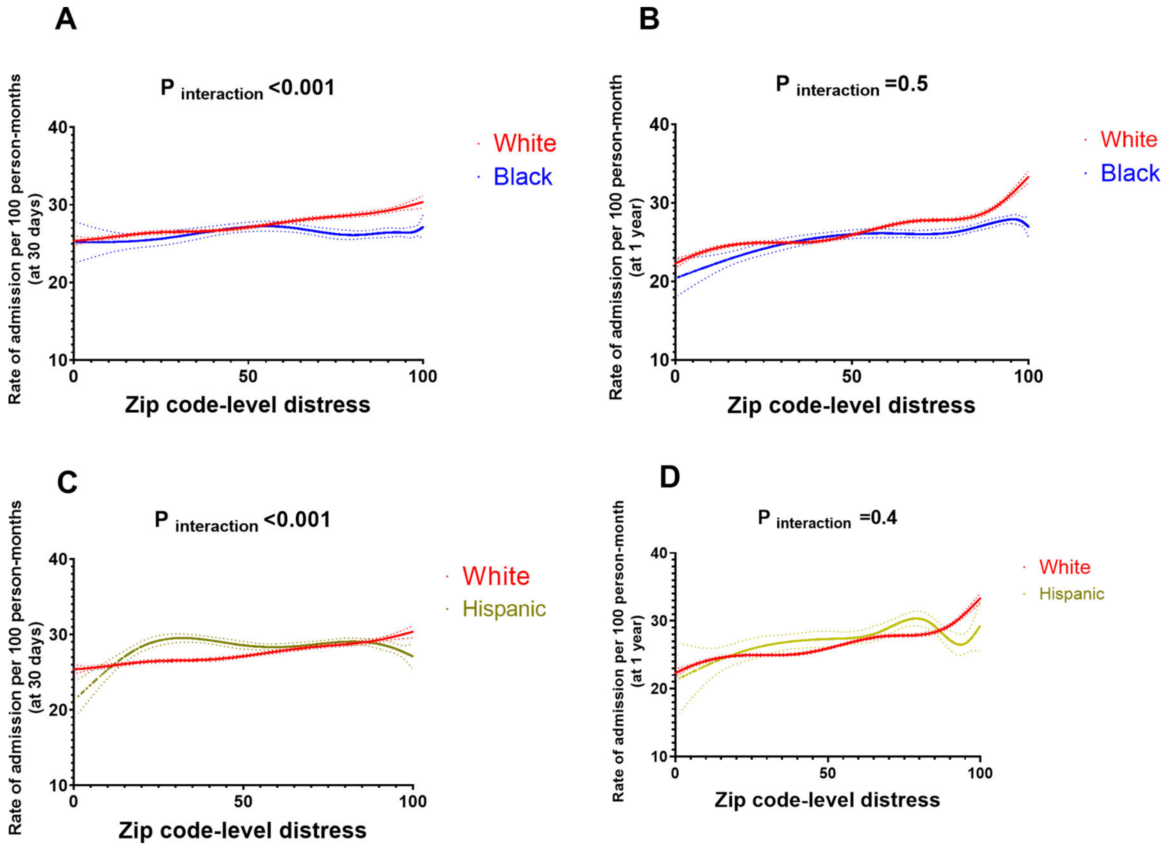

Figure 2:

Restricted cubic spline curves for the relation between Zip Code-level economic distress score and risk-adjusted readmission burden. Restricted cubic spline curves with 5 knots at 5th, 27.5th, 50th, 77.5th and 95th percentiles to show relation between Zip-code level distress score and A) readmission burden at 30-days in White versus Black, B) readmission burden at 1-year in White versus Black patients, C) readmission burden at 30-days in White versus Hispanic patients, and D) readmission burden at 1-year in White versus Hispanic patients. Readmission burden is presented as rate of admission per 100 person-month.

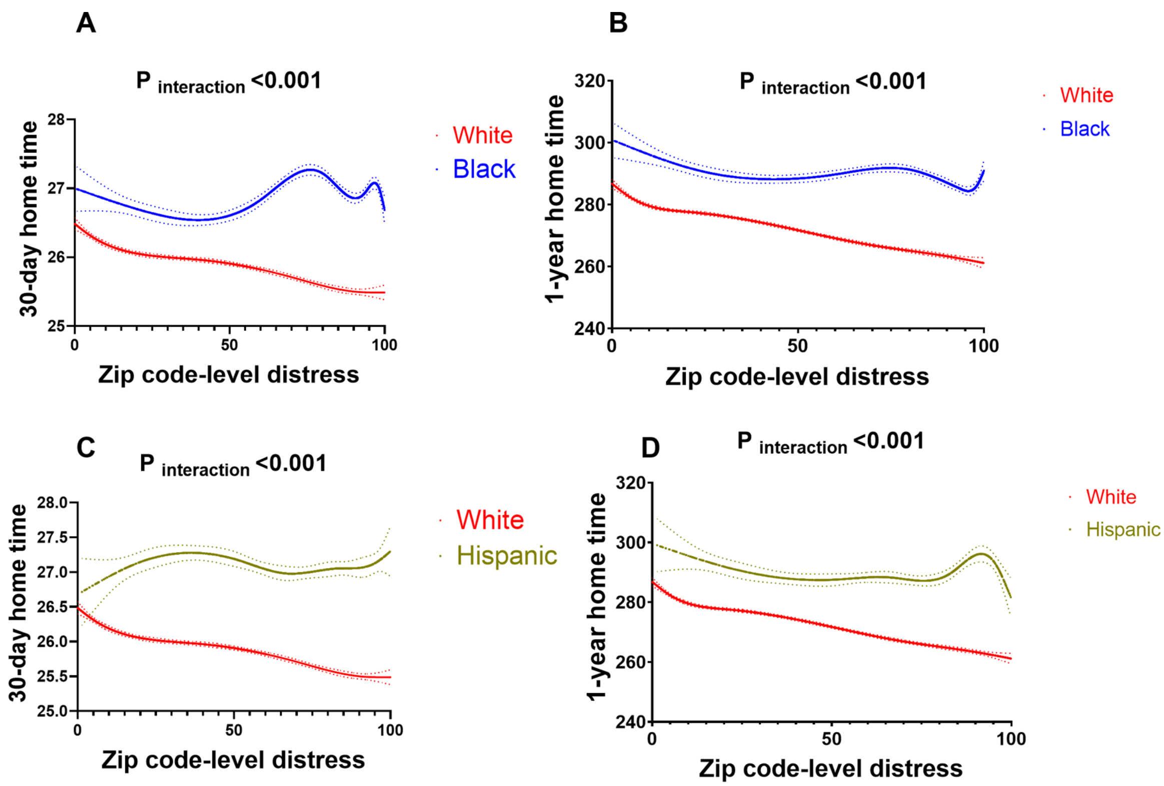

Figure 3:

Restricted cubic spline curves for the relation between Zip Code-level economic distress score and risk-adjusted home time. Restricted cubic spline curves with 5 knots at 5th, 27.5th, 50th, 77.5th and 95th percentiles to show relation between Zip-code level distress score and A) thirty-day home time in White versus Black patients, B) one-year home time in White versus Black patients, C) thirty-day home time in White versus Hispanic patients, and D) one-year home time in White versus Hispanic patients.

Table 1:

Baseline characteristics of study participants at the zip code level, stratified by zip code-level economic distress score and race-ethnicity.

Characteristics	White patients			Black patients			Hispanic patients		
	Distressed (13.2%) N=213,421 Zip codes=2233 DCI 89.5±37.0	**Non-distressed N=1,398,165 Zip codes=11148 DCI 36.7±23.2**	**P value**	**Distressed (50.6%) N=104,230 Zip codes=958 DCI 91.2±5.6**	**Non-distressed N=101,610 Zip codes=1349 DCI 50.4±20.7**	**P value**	**Distressed (27.3%) N=24,325 Zip codes=300 DCI 89.2±5.5**	**Non-distressed N=64,874 Zip codes=818 DCI 50.6±20.0**	**P value**
Age (mean, SD)	79.4 (78.2–80.5)	80.8 (79.4–82.3)	<0.001	76.4 (75.4–77.4)	76.5 (75.4–77.6)	0.1	77 (75.8–78.1)	78.1 (76.9–79.5)	<0.001
Male Sex	45.9 (41.7–50.8)	48.2 (44.3–52.4)	<0.001	40.1 (36.3–44.4)	41.2 (36.5–46.1)	0.003	46.7 (41.9–52.3)	46.8 (42–51.3)	0.7
Prevalence of Comorbidities									
Asthma, (%)	7.7 (5.4–10.5)	8.4 (6.2–10.9)	<0.001	12.1 (8.7–15.6)	12.5 (9.1–16.1)	0.04	11.5 (7.5–17.1)	12.1 (8.3–16.7)	0.6
Anemia, (%)	43.2 (38–48.7)	42.4 (37.6–47.3)	<0.001	51.5 (46.4–56.5)	51.5 (46.4–57.4)	0.4	51.9 (46.6–57.3)	50 (44.9–56.4)	0.008
Chronic kidney disease stage 3–5, (%)	49.4 (43.8–54.8)	50 (45.2–55)	<0.001	60.5 (55.4–65.5)	61.8 (56.6–66.7)	<0.001	56.8 (50.8–62.5)	56.1 (50–61.7)	0.2
Cancer, (%)	3.7 (2.3–5.4)	4.4 (2.9–5.9)	<0.001	3.8 (2.4–5.4)	3.8 (2.3–5.9)	0.6	3 (1.6–4.7)	3 (1.7–4.8)	0.9
COPD, (%)	45.8 (40–52.4)	39.5 (33.3–45.5)	<0.001	37 (31.7–42.9)	33.3 (28.2–39.5)	<0.001	31.3 (25.2–37)	29.7 (24.3–36.4)	0.04
Coronary artery disease, (%)	66.4 (60.7–71.4)	64.5 (59.5–69.4)	<0.001	58.1 (53–63.3)	57.5 (52.3–63.4)	0.5	66 (59.3–71.7)	63.3 (57.1–69.4)	<0.001
Diabetes mellitus, (%)	48.8 (43.9–53.7)	44.1 (38.6–49.2)	<0.001	58.9 (54.6–63.3)	60 (55.1–64.7)	0.004	70.6 (65.8–75)	66.4 (59.7–71.7)	<0.001
Hypertension, (%)	93.3 (90.6–95.5)	93.1 (90.5–95.1)	0.04	97.5 (96.2–98.7)	97.6 (96–99.5)	0.2	96.8 (94.8–98.3)	96.4 (94.3–97.7)	0.04
Liver disease, (%)	3.5 (2.2–5.3)	3.3 (2.2–4.9)	0.001	3.6 (2.2–5.7)	3.7 (2.2–5.9)	0.6	6.3 (4.3–8.9)	5.9 (3.5–8.2)	0.03
Morbid obesity, (%)	6.5 (4.4–9.0)	5.8 (3.8–8.0)	<0.001	7.4 (5.3–9.6)	7.4 (5–10)	0.9	6.5 (4.6–9.1)	5.6 (3.2–7.7)	<0.001
Prior stroke, (%)	6.8 (4.8–9.1)	6.6 (4.8–8.8)	0.02	5.6 (3.6–7.3)	5.7 (3.4–8.3)	0.1	5.5 (3.1–7.8)	5.3 (3.2–7.2)	0.3
Prior CABG, (%)	21.4 (17.6–25.5)	20.3 (16.8–23.9)	<0.001	12.5 (9.9–15.6)	12.5 (9.4–15.6)	0.9	18.8 (14.5–22.8)	18.2 (14.3–22.6)	0.2
Prior PCI, (%)	20 (16.1–25)	19.3 (15.6–23.3)	<0.001	14.7 (11.5–18.2)	14.5 (11.1–18.2)	0.3	18 (13.7–22.3)	17.2 (13.3–21.7)	0.2
Prior pacemaker, (%)	14.3 (11.1–17.5)	15 (12.1–18.3)	<0.001	8.6 (6.4–11.5)	9.2 (6.7–12)	0.004	11.5 (8.9–14.7)	12.5 (9.2–15.7)	0.003
Prior ICD, (%)	7.8 (5.6–10.22)	7.9 (5.7–10.1)	0.8	9.3 (6.8–11.7)	9.1 (6.4–12.1)	0.6	8 (5.4–10.4)	7.5 (5–10.6)	0.3
PVD, (%)	19 (15.4–22.9)	19.5 (16.2–23.2)	<0.001	17.6 (14.4–21.1)	17.2 (13.7–21.7)	0.7	18.9 (14.7–22.5)	19.7 (15–25)	0.02
Valve disease	36.4 (29.8–42.9)	42.1 (35.8–48.9)	<0.001	29.9 (24.1–35.9)	31.6 (26.1–38.7)	<0.001	30.7 (25–36.1)	33.3 (27.3–40.2)	<0.001
Zip-code level socioeconomic parameters									
% prime age adults not working	31.5 (27.1–37.1)	19.5 (16–23.6)	<0.001	32.5 (28.1–37.9)	21.1 (17.8–25.1)	<0.001	31.1 (27.3–34.4)	22.5 (19.6–26.1)	<0.001
% Adults without high school degree	18.9 (14.9–23.1)	8.5 (5.4–12.7)	<0.001	19.8 (15.9–24.2)	11.9 (8.3–16.4)	<0.001	30.6 (24.7–39.3)	18.8 (12.4–26.7)	<0.001

Characteristics	White patients			Black patients			Hispanic patients		
	Distressed (13.2%) N=213,421 Zip codes=2233 DCI 89.5±37.0	**Non-distressed N=1,398,165 Zip codes=11148 DCI 36.7±23.2**	**P value**	**Distressed (50.6%) N=104,230 Zip codes=958 DCI 91.2±5.6**	**Non-distressed N=101,610 Zip codes=1349 DCI 50.4±20.7**	**P value**	**Distressed (27.3%) N=24,325 Zip codes=300 DCI 89.2±5.5**	**Non-distressed N=64,874 Zip codes=818 DCI 50.6±20.0**	**P value**
% Change in business establishments	-2.5 (−6.5–1.3)	4.5 (0–10.1)	<0.001	-0.9 (−4.6–2.9)	5.4 (1.3–10.3)	<0.001	1 (−2.2–4.4)	7.7 (4.2–12.9)	<0.001
% Change in employment	-2 (−9.4–4.7)	7.8 (0.4–16.7)	<0.001	-0.5 (−7.6–6.3)	8.8 (2.3–16.7)	<0.001	0.9 (−7–7.3)	9.9 (3.7–18.1)	<0.001
median income ratio (in relation to state)	70.9 (62.2–80)	105 (88.7–126.7)	<0.001	60.9 (49.7–70.8)	90.2 (77.5–106)	<0.001	60.6 (50.3–71.3)	89.9 (76.7–107)	<0.001
Poverty rate	23 (19.2–28.2)	10 (6.4–14.5)	<0.001	28.3 (23.1–33.9)	15 (10.5–19.5)	<0.001	29 (23.7–34.2)	15.2 (11.4–20.7)	<0.001
Vacancy rate	13.5 (11.1–16.7)	6.4 (4.4–8.9)	<0.001	14.9 (11.8–19)	7.8 (5.7–10.3)	<0.001	10.8 (8.3–13.3)	5.8 (4.1–7.6)	<0.001
DCI	89.3 (84.6–94.1)	35.2 (16.5–56.9)	<0.001	91.9 (86.4–96.1)	53.9 (35–68.1)	<0.001	88.8 (84.4–93.9)	54.2 (36.2–67.3)	<0.001

The patient characteristics are presented as the median (25th – 75th Percentile) of Zip code-level proportions (for categorical patient characteristics) and the median (25th – 75th Percentile) of Zip code-level means (for continuous patient characteristics)

COPD: Chronic obstructive pulmonary disease; CAD: coronary artery disease; CABG: coronary artery bypass graft; PCI: percutaneous coronary intervention; ICD: implantable cardioverter defibrillator; IQR: interquartile range; PVD: peripheral vascular disease, DCI: Distressed community index

Table 2:

Risk adjusted outcomes following discharge among study participants stratified by ZIP code-level economic distress status and race/ethnicity. Risk adjustment done using validated risk model in Medicare patients with HF[1].

Outcomes	White patients			Black patients			Hispanic patients		
	Distressed 213,421 Patients 2233 Zip codes	**Non-distressed 1,398,165 Patients 11,148 Zip codes**	**P-value**	**Distressed 104,230 Patients 1349 Zip codes**	**Non-distressed 101,610 Patients 958 Zip codes**	**P-value**	**Distressed 24,325 Patients 300 Zip codes**	**Non-distressed 64,874 Patients 818 Zip codes**	**P-value**
	Median (25^{th}-75^{th} Percentile)	**Median (25^{th}-75^{th}Percentile)**		**Median (25^{th}-75^{th} Percentile)**	**Median (25^{th}-75^{th}Percentile)**		**Median (25^{th}-75^{th} Percentile)**	**Median (25^{th}-75^{th}Percentile)**	
30-days outcomes									
Mortality, %	7.0 (4.7–9.7)	6.2 (4.2–8.7)	<0.001	4.0 (2.5–6.0)	3.7 (2.3–5.7)	0.052	4.7 (2.5–7.5)	4.7 (2.7–6.9)	0.7
Readmission, / 100 person months	29.5 (23.6–36.5)	27.4 (22.4–33.3)	<0.001	26.7 (22.1–32.6)	26.7 (21.1–33.1)	0.6	28.3 (22.9–35.1)	28.2 (22.1–33.8)	0.4
Home time, days	23.4 (21.2–25.6)	24.1 (22.0–26.0)	<0.001	25.4 (23.4–27.0)	25.2 (23.1–27.0)	0.3	26.0 (24.0–27.7)	25.9 (24.4–27.4)	0.7
6-months outcomes									
Mortality, %	24.9 (20.8–29.3)	23.3 (19.5–27.3)	<0.001	17.9 (14.2–21.6)	16.9 (13.6–20.6)	<0.001	18.0 (13.2–22.5)	18.5 (14.3–23.0)	0.1
Readmission, / 100 person months	26.0 (20.3–32.7)	23.4 (18.7–29.2)	<0.001	24.1 (19.2–30.6)	22.7 (18.3–28.6)	0.002	24.8 (19.5–31.1)	23.8 (18.2–30.3)	0.3
Home time, days	140 (129–150)	145 (136–155)	<0.001	151 (141–160)	152 (142–161)	0.1	153 (143–163)	152(143–162)	0.8
1-year outcomes									
Mortality, %	36.1 (31.2–40.8)	34.5 (30.1–38.9)	<0.001	28.0 (24.3–33.0)	27.2 (22.9–31.5)	<0.001	27.7 (22.1–32.7)	28.3 (23.3–33.7)	0.1
Readmission, / 100 person months	25.2 (18.5–34.6)	21.7 (16.4–29.0)	<0.001	23.3 (16.8–32.4)	21.3 (15.3–29.6)	<0.001	23.0 (16.3–34.0)	21.7 (15.4–31.0)	0.1
Home time, days	261(239–284)	273 (253–293)	<0.001	286 (265–305)	289 (268–311)	0.006	292 (266–313)	290 (268–311)	0.7

Risk adjustment done using validated risk model in Medicare patients with heart failure [7].

P-values are corrected for multiple testing using fixed discovery rate approach.

Table 3:

Risk adjusted short and long-term outcomes following discharge among study participants living in prosperous (quintile 1) vs. non-prosperous (quintile 2–5) in different races/ethnicity.

Outcomes	White patients			Black patients			Hispanic patients		
	Prosperous 416,459 Patients 3356 Zip codes DCI 9.9±5.7	Non-prosperous 1,195127 Patients 10,025 Zip codes DCI 57.7±23.1	P-value	Prosperous 7404 Patients 139 Zip codes DCI 11.4±5.2	Non-prosperous 198,436 Patients 2168 Zip codes DCI 70.9±22.3	P-value	Prosperous 4261Patients 79 Zip codes DCI 12.5±5.0	Non-prosperous 24,325 Patients 1039 Zip codes DCI 64.7±21.1	P-value
	Median (25th-75th Percentile)	Median (25th-75th Percentile)		Median (25th-75th Percentile)	Median (25th-75th Percentile)		Median (25th-75th Percentile)	Median (25th-75th Percentile)	
30-days outcomes									
Mortality, %	5.7 (3.8–7.9)	6.5 (4.4–9.1)	<0.001	3.4 (2.2–6.1)	3.9 (2.4–5.8)	0.9	3.9 (2.3–6.5)	4.7 (2.7–7.2)	0.09
Readmission, per 100 person months	26.5 (21,8–32,1)	28.2 (22.8–34.4)	<0.001	25.0 (19.6–33.2)	27.2 (21.9–33.5)	0.08	27.3 (20.0–32.8)	28.2 (22.4–34.5)	0.4
Home time, days	24.3 (22.2–26.3)	23.8 (21.7–25.9)	<0.001	25.1 (22.7–27.0)	25.2 (23.2–27.0)	0.5	25.5 (24.0–27.1)	25.9 (24.3–27.5)	0.4
6-months outcomes									
Mortality, %	22.4 (18.8–26.3)	23.9 (20.0–28.3)	<0.001	16.9 (13.2–20.9)	17.4 (13.8–21.1)	0.4	17..1 (12.4–22.9)	18.5 (14.2–22.8)	0.3
Readmission, per 100 person months	22.2 (17.9–27.6)	24.4 (19.3–30.5)	<0.001	20.9 (16.2–26.7)	23.4 (18.8–29.7)	<0.001	21.6 (16.1–29.4)	24.2 (18.5–30.5)	0.08
Home time, days	148 (139–157)	143 (133–153)	<0.001	150 (142–162)	151(141–160)	0.6	156 (143–167)	152 (143–162)	0.1
1-year outcomes									
Mortality, %	33.7 (29.3–37.8)	35.1 (30.5–39.7)	<0.001	27.0 (21.2–31.4)	27.6 (23.5–32.0)	0.1	27.8 (21.7–33.1)	28.2 (23.2–33.6)	0.7
Readmission, per 100 person months	20.3 (15.5–26.7)	23.0 (17.0–31.0)	<0.001	17.5 (12.6–25.8)	22.4 (15.9–31.3)	<0.001	19.1 (13.2–28.1)	22.5 (15.8–32.2)	<0.001
Home time, days	279 (260–298)	268 (248–289)	<0.001	293 (265–313)	285 (263–306)	0.08	297 (272–325)	290 (268–311)	0.04

Risk adjustment done using validated risk model in Medicare patients heart failure [7].

P-values are corrected for multiple testing using fixed discovery rate approach.