ORIGINAL RESEARCH

Regional Variation in the Association of Poverty and Heart Failure Mortality in the 3135 Counties of the United States

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***Background*—**There is significant geographical variation in heart failure (HF) mortality across the United States. County socioeconomic factors that influence these outcomes are unknown. We studied the association between county socioeconomic factors and HF mortality and compared it with coronary heart disease (CHD) mortality.

***Methods and Results*—**This is a cross-sectional analysis of socioeconomic factors and mortality in HF and CHD across 3135 US counties from 2010 to 2015. County-level poverty, education, income, unemployment, health insurance status, and cause-specific mortality rates were collected from the Centers for Disease Control and Prevention and US Census Bureau databases. Poverty had the strongest correlation with both HF and CHD mortality, disproportionately higher for HF (r=0.48) than CHD (r=0.24). HF mortality increased by 5.2 deaths/100 000 for each percentage increase in county poverty prevalence in a frequency-weighted, demographic-adjusted, multivariate regression model. The greatest attenuation in the poverty regression coefficient (66.4%) was seen after adjustment for prevalence of diabetes mellitus and obesity. Subgroup analysis by census region showed that this relationship was the strongest in the South and weakest in the Northeast (6.1 versus 1.4 deaths/100 000 per 1% increase in county poverty in a demographics-adjusted model).

***Conclusions*—**County poverty is the strongest socioeconomic factor associated with HF and CHD mortality, an association that is stronger with HF than with CHD and varied by census region. Over half of the association was explained by differences in the prevalence of diabetes mellitus and obesity across the counties. Health policies targeting improvement in these risk factors may address and possibly minimize health disparities caused by socioeconomic factors. **(*J Am Heart Assoc*. 2019;8:e012422. DOI: 10.1161/JAHA.119.012422.)**

Key Words: disparities • heart failure • mortality • socioeconomic position

Cardiovascular disease (CVD) is the leading cause of death in the United States. Heart failure (HF) afflicts ≈5.7 million people in the country and is projected to affect 8 million by 2030.[1] Despite improvement in overall survival after diagnosis of HF, there is significant geographical variation in HF mortality across the United States, which is associated with prevalence of obesity, physical inactivity, diabetes mellitus, and hypertension.[2,3] Understanding the sources of these geographical variations in HF outcomes can help to identify potential targets that could be studied for intervention to improve disparities in outcomes. Although the correlation between regional socioeconomic factors and coronary heart disease (CHD) has been well documented,[4–6] the relation of socioeconomic deprivation with regional variations in HF mortality has not been studied.[7] Accordingly, we aimed to study the association between socioeconomic factors and HF mortality and compare it with CHD mortality at a regional level.

Given that various multifaceted efforts for identifying areas of need and addressing allocation of resources to improve health outcomes and eliminate health disparities are already underway,[8] the objectives of this study were as follows: (1) to determine the association between county socioeconomic factors and HF mortality, (2) to contrast and compare it with CHD mortality, and (3) to understand the county characteristics that may explain this association, to identify potential targets for health policy reform. Because HF is a chronic disease process that is highly sensitive to variation in lifestyle factors and health behaviors,[9–11] which are related to socioeconomic deprivation,[12–14] we

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Clinical Perspective

What Is New?

- There is an association between heart failure mortality and poverty, which is stronger than and independent of the association of coronary heart disease mortality with poverty, is variable across the census regions, and can be mostly explained by the prevalence of diabetes mellitus and obesity.

What Are the Clinical Implications?

- Health policies that intend to mitigate heart failure mortality could target diabetes mellitus and obesity in areas of high poverty.

hypothesized that county variation in HF mortality has a stronger association with socioeconomic deprivation compared with CHD mortality.

Methods

This is a cross-sectional analysis of data from 3141 US counties from 2010 to 2015. We excluded 6 counties with missing HF mortality data, for a final analytic sample of 3135 counties. All data used in this study are aggregate data and publicly available by the Centers for Disease Control and Prevention and US Census Bureau for researchers; therefore, the data met the criteria for exemption by the Providence Veterans Affairs Medical Center Institutional Review Board.

Demographics

We adjusted for demographics, such as age, sex, and race, to ensure that the observed relationship was not purely caused by differences in the demographic structure of the population. County data on median age (2010 census), percentage men (2010 census), and percentage white (2015 census) were collected from the US Census Bureau.[15]

Metropolitan Status

We also adjusted for metropolitan status to potentially account for difference in HF mortality that can be related to rurality.[16,17] County metropolitan status was identified as large central metropolitan, fringe metropolitan, medium/small metropolitan, and nonmetropolitan region, per definitions set forth by the Office of Management and Budget 2013.[18]

Exposure of Interest

Data for 5 socioeconomic factors at the county level were collected. These variables included percentage of people living in poverty (2014), median household income (2014), unemployment rate for population aged >16 years (2015), percentage population aged >25 years without high school diploma (2010–2014), and percentage population aged <65 years without health insurance (2014). In 2014, the poverty threshold was $11 670 per annum for 1-person household, plus $4060 for each additional person, as reported by the US Census Bureau and the Bureau of Labor Statistics.[19]

Prevalence of CVD Risk Factors

We adjusted for diabetes mellitus and obesity, as these are established risk factors for HF mortality.[20] Information on risk factor prevalence for all US counties was obtained from the Centers for Disease Control and Prevention.[15] This included percentage of the population aged >20 years diagnosed with diabetes mellitus (2013) and percentage of the population aged >20 years with obesity (2013).

Prevalence of Healthcare-Associated Behavior

We adjusted for smoking, physical inactivity, and medication adherence patterns, as literature suggests that these risk factors can increase the risk of HF mortality.[11,21–23] Data for prevalence of behavior patterns pertaining to CVD risk factors were obtained from the Centers for Disease Control and Prevention.[15] These were composed of percentage population who reported smoking (2015 American Community Survey), percentage population aged >20 years with leisure-time physical inactivity (2014), and antihypertensive medication nonadherence percentage in Part D Medicare beneficiaries (2014).

HF Hospitalization

Data for HF hospitalizations/1000 Medicare beneficiaries (2012–2014) were obtained from the Centers for Disease Control and Prevention,[15] as a representative variable for disease burden in the counties and to ensure that the observed relationship is not purely accounted for by a higher disease burden of the specific geographic location.

Outcome Measures

Mortality data for 2012 to 2014 for both CHD deaths/100 000 and HF deaths/100 000 were derived from death certificates, published by the National Center for Health Statistics. The sensitivity of death certificate for cardiovascular causes was reported to be 82%.[24]

Statistical Analyses

County-level data were described using median and range for continuous and number and percentage for discrete variables.

Counties were stratified by US Census regions, and linear regression was used to compare the county characteristics across the 4 US Census regions (ie, Northeast, Midwest, South, and West), using the Northeast as reference.

Pearson's correlation coefficient was used to assess the strength of association of individual socioeconomic factors with HF and CHD mortality. We used the bootstrapping technique to generate 95% CIs . We conducted a standard test for equality of correlation coefficients using Fisher's *Z* test to compare the strength of the correlation coefficients. To confirm the association of poverty with HF mortality independent of CHD mortality, we also adjusted for CHD mortality in a population-weighted regression model of HF mortality and poverty.

Given that poverty had the strongest correlation with mortality among the socioeconomic factors, we assessed the association between poverty and the baseline county characteristics, stratified by census region. Frequency-weighted, multivariate, linear regression analyses were used to assess the relationship between county poverty prevalence and HF mortality, after adjustment for the following groups of county-level variables: (1) demographics, (2) metropolitan status, (3) CVD risk factor prevalence, (4) healthcare-associated behavior prevalence, and (5) HF hospitalization. The percentage change in poverty regression coefficient, with adjustment for each category of variables, was calculated to assess the variables that could potentially explain or confound the association. We also tested for statistical interaction between county-level poverty prevalence and US Census regions on HF mortality, which was significant ($P<0.001$). Thus, subgroup multivariate regression analysis by census region was conducted to understand the regional differences in this association between county-level poverty prevalence and HF mortality.

All analyses were population weighted, where applicable, and performed in STATA SE v15.0. A 2-sided $P<0.05$ was considered significant.

Results

Of 3135 counties in the United States included in the study sample, the median poverty percentage was 15.8% (range, 3.2%–52.2%), median HF mortality was 189.5 deaths/100 000 (range, 18–708.3 deaths/100 000), and median CHD mortality was 208 deaths/100 000 (range, 14.3–576.2 deaths/100 000) across counties. Overall mortality significantly varied by the census region, being highest in the South for both HF and CHD ($P<0.001$). Prevalence of poverty and CVD risk factors, such as obesity and diabetes mellitus, and number of HF hospitalizations were also significantly higher in the South compared with the Northeast ($P<0.001$) (Table 1).

County-level poverty prevalence correlated with both HF mortality ($r=0.48$; 95% CI, 0.45–0.51) and CHD mortality ($r=0.24$; 95% CI, 0.20–0.27) ($P<0.001$) (Table 2). The correlation of county poverty with HF mortality was significantly stronger than the correlation with CHD mortality ($P<0.001$) (Figure). Poverty was independently associated with HF mortality in a frequency-weighted regression model with adjustment for CHD mortality ($P<0.001$) (Table 3). We also found significant correlation between county poverty and CVD risk factor prevalence (namely, diabetes mellitus [$r=0.69$; 95% CI, 0.67–0.72] and obesity [$r=0.55$; 95% CI, 0.52–0.58]), as well as number of HF hospitalizations/1000 Medicare beneficiaries per county ($r=0.21$; 95% CI, 0.18–0.25) and healthcare-associated behavior prevalence, including smoking ($r=0.34$; 95% CI, 0.31–0.38), physical inactivity during leisure time ($r=0.26$; 95% CI, 0.22–0.29), and antihypertensive medication nonadherence ($r=0.46$; 95% CI, 0.43–0.49) ($P<0.001$). When stratified by census region, the correlation of poverty with diabetes mellitus and obesity was highest in the South and lowest in the West, whereas sedentary lifestyle and HF hospitalization had the strongest association with poverty in the Northeast (Table 4).

The demographic-adjusted model showed an increase of 5.2 HF deaths/100 000 for each percentage increase in county poverty. This represents a difference of 254.8 deaths/100 000 from the county with lowest poverty prevalence (3.2%) to the county with highest poverty prevalence (52.2%). Overall, percentage poverty statistically explained ≈30% of the observed between-county variation in HF mortality rates. County poverty prevalence remained independently associated with HF mortality, after adjustment for other county socioeconomic factors, demographics, CVD risk factor prevalence, metropolitan status, healthcare-associated behavior prevalence, and HF hospitalization, with an increase of 1.76 deaths/100 000 for each percentage increase in poverty. This represents a difference of 86.2 deaths/100 000 from the county with the lowest poverty to the county with the highest poverty (Table 3). Among the categories of variables included in the multivariate regression model, the prevalence of diabetes mellitus and obesity had the greatest attenuating effect (66.4% change in the regression coefficient) on the association between poverty and HF mortality.

The correlation for poverty and HF mortality was $r=0.63$ in the South, $r=0.57$ in the Midwest, $r=0.34$ in the West, and $r=0.09$ in the Northeast. The demographics-adjusted model showed that the association of poverty and HF mortality varied significantly by census region ($P<0.001$ for additive interaction), being greatest in the South and smallest in the Northeast. In the final model, with adjustment for all county-level covariates, there was a 2.31 deaths/100 000 increase with each percentage increase in poverty in the South, which represents a difference of 102.1 HF deaths/100 000 from the southern county with the highest poverty percentage (47.4%) to the southern county with the lowest poverty

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Table 1. Demographic Characteristics, Cardiovascular Risk Factor Prevalence, and Mortality of US Counties, by US Census Region, 2010 to 2015

Variable	Overall Median (Range) (n=3135)	Northeast Median (Range) (n=217)	Midwest Median (Range) (n=1055)	South Median (Range) (n=1358)	West Median (Range) (n=505)
Population (2010–2014)	25 893 (73–9 974 203)	60 864 (1947–2 280 602)	20 947 (426–3 086 331)	28 506 (89–5 227 827)	22 500 (73–9 974 203)
Median age (2010 census), y	41.0 (21.5–66.0)	42.4 (30.3–53.5)	41.0 (24.3–59.5)	40.6 (21.5–66)	39.2 (23.3–61.2)
Men (2010 census), %	49.5 (43.2–72.1)	49.1 (46.2–66.9)	49.7 (44.8–64.1)	49.3 (43.2–68.3)	50.2 (46.7–72.1)
White (2015 census), %	84.6 (0.7–100)	88.0 (8.7–97.5)	90.8 (9.0–100.0)	76.3 (0.7–99.5)	79.0 (9.0–99.2)
Population living in poverty (2014), %	15.8 (3.2–52.2)	13.5 (4.7–34.5)	13.9 (4.3–52.2)	18.6 (3.2–47.4)	15.6 (3.7–43.0)
Annual household income (2014), $1000	45.2 (21.6–125.6)	50.0 (33.6–103.8)	46.4 (21.6–107.2)	42.2 (22.6–125.6)	46.3 (25.4–108.4)
Unemployment rate (2015)	5.3 (1.8–24.0)	5.3 (2.7–10.9)	4.4 (1.8–11.5)	5.8 (2.1–16.9)	5.7 (2.1–24.0)
Population without high school diploma, aged >25 y (2010–2014), %	13.5 (1.2–53.2)	10.8 (5.0–29.7)	10.6 (1.2–44.2)	18.6 (3.2–53.2)	12.1 (1.8–34.8)
Population without health insurance, aged <65 y (2014), %	13.9 (0.0–39.3)	9.4 (1.0–22.2)	10.8 (4.3–25.5)	16.5 (4.6–35.4)	15.6 (0.0–39.3)
Age-adjusted population with diabetes mellitus, aged >20 y (2013), %	9.3 (3.8–20.8)	8.9 (5.3–14.5)	8.5 (4.5–17.3)	10.6 (5.1–20.8)	7.9 (3.8–15.5)
Age-adjusted population with obesity, aged >20 y (2013), %	31.0 (11.8–47.9)	28.6 (14.8–42.4)	31.2 (19.2–42.5)	32.1 (16.7–47.9)	27.7 (11.8–46.3)
Population with reported smoking (2015), %	20.8 (3.1–51.1)	18.6 (8.4–35.0)	20.0 (6.6–47.1)	22.8 (7.5–51.1)	18.4 (3.1–48.2)
Population with leisure-time physical inactivity, aged >20 y (2014), %	25.7 (10.0–42.1)	24.3 (14.5–37.5)	25.3 (10.0–41.3)	27.1 (10.1–42.1)	23 (10.0–37.4)
Antihypertensive medication nonadherence in Part D Medicare beneficiaries (2014), %	26.1 (1.0–56.2)	22.1 (1.0–36.4)	22 (1.0–56.2)	29.4 (1.0–41.8)	26.9 (1.0–50.5)
Heart failure hospitalizations/1000 Medicare beneficiaries (2012–2014)	13.5 (0.5–48.4)	15.4 (1.6–26.6)	12 (1.2–41.6)	15.1 (0.5–48.4)	9.7 (0.8–42.6)
Heart failure mortality (2012–2014), deaths/100 000	189.5 (18.0–708.3)	168.2 (85.7–264.1)	187.8 (72.5–431.3)	202.5 (20.7–708.3)	174.9 (18.0–362.0)
Coronary heart disease mortality (2012–2014), deaths/100 000	207.8 (14.3–576.2)	206.6 (108.9–438.0)	209.7 (76.1–462.2)	218.5 (65.8–576.2)	180.1 (14.3–416.1)

P value for interregional difference was <0.001 for all variables.

Table 2. Correlation of Socioeconomic Factors and Mortality

Variable	Heart Failure Mortality Correlation Coefficient (95% CI)	Coronary Heart Disease Mortality Correlation Coefficient (95% CI)
Poverty %	0.48 (0.45 to 0.51)	0.24 (0.20 to 0.27)
Uninsured %	0.18 (0.14 to 0.22)	0.07 (0.03 to 0.10)
Median household income	−0.23 (−0.26 to −0.19)	−0.17 (−0.20 to −0.13)
Unemployment rate	0.19 (0.15 to 0.23)	0.16 (0.12 to 0.20)
Lack of high school education %	0.32 (0.28 to 0.35)	0.22 (0.19 to 0.26)

P value was <0.001 for comparison of all correlations between the above socioeconomic factors and heart failure and coronary heart disease mortalities based on Fisher's *Z* test.

percentage (3.2%), in contrast to 0.76 deaths/100 000 increase with each percentage increase in poverty in the Northeast, which denotes a difference of 22.6 deaths/100 000 from the county with the lowest poverty percentage (4.7%) to the county with the highest poverty percentage (34.5%) in the Northeast (Table 5).

Discussion

We investigated potential regional socioeconomic contributors of disparity in HF outcomes in the United States and established county poverty as having the strongest correlation with county HF mortality and CHD mortality. Furthermore, poverty had a significantly stronger correlation with mortality in HF compared with CHD. Percentage poverty statistically explained >30% of the variation in HF mortality at the county level. This association between county-level poverty prevalence and HF mortality was largely explained by differences in the prevalence of CVD risk factors across the counties, which were closely correlated with county poverty.

Our study builds on previous findings of socioeconomic deprivation being related with higher incidence or worse outcomes of asthma, stroke, and myocardial ischemia.[25–27] A systematic review found that the incidence, prevalence, and readmission rates for HF were worse in patients with lower socioeconomic status.[7] There were 5

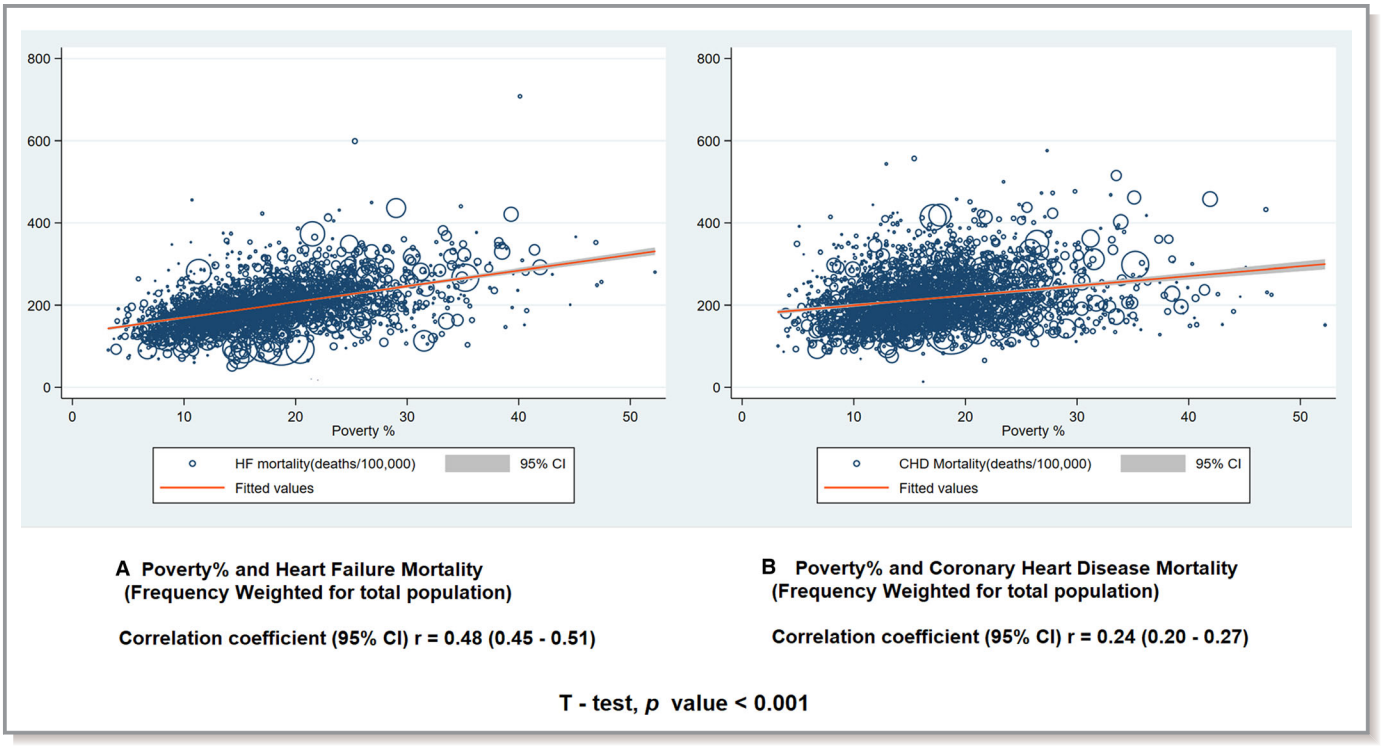

Figure. Correlation of poverty percentage and mortality and disproportionate association of poverty percentage with heart failure (HF) mortality. Frequency-weighted scatterplots showing correlation of poverty percentage with HF mortality (**A**) and coronary heart disease (CHD) mortality (**B**), across 3135 counties of the United States.

Table 3. Population-Weighted Multivariate Linear Regression Modeling

Model	Adjusted Poverty Regression Coefficient (95% CI)*	% Change in Poverty Regression Coefficient	R^2 Value, %
Unadjusted mortality and poverty	5.21 (5.21–5.21)	···	30.6
Adjusted for coronary heart disease mortality	4.97 (4.97–4.97)	0.5	31.0
Adjusted for demographics†	5.20 (5.20–5.20)	0.2	37.2
Adjusted for other socioeconomic factors‡	5.25 (5.25–5.26)	0.8	31.4
Adjusted for risk factors§	1.75 (1.75–1.75)	66.4	55.3
Adjusted for healthcare-associated behaviors‖	4.40 (4.40–4.40)	15.5	45.7
Adjusted for metropolitan status	3.18 (3.18–3.18)	39.0	50.9
Adjusted for heart failure hospitalization	5.14 (5.14–5.14)	1.3	32.8
Adjusted for socioeconomic factors, demographics, metropolitan status, risk factor prevalence, healthcare-associated behavior prevalence, and heart failure hospitalization¶	1.76 (1.76–1.76)	66.2	63.4

P value was <0.001 for all models.
*Change in mortality associated with each percentage increase in poverty.
†Median age/county, male percentage, and white percentage.
‡Unemployment rate, median household income, uninsured percentage, and lack of high school diploma percentage.
§Diabetes mellitus percentage, obesity percentage, smoking percentage, antihypertensive medication nonadherence percentage, and physical inactivity during leisure time percentage.
‖Number of heart failure hospitalizations/1000 Medicare beneficiaries.
¶Unemployment rate, median household income, uninsured percentage, lack of high school diploma percentage, median age/county, men percentage, white percentage, diabetes mellitus percentage, obesity percentage, smoking percentage, antihypertensive medication nonadherence percentage, and physical inactivity during leisure time percentage.

studies that explored different aspects of socioeconomic deprivation and mortality in HF,[28–32] with 3 showing varying degrees of worse survival with different indicators of socioeconomic deprivation.[7] Our study not only confirmed these findings but also established regional poverty as an indicator that can be used to identify areas of need and potential targets for intervention at the county level. For example, a study by Philbin et al[33] showed a decrease in hospital readmissions after HF hospitalization with increasing income.

Another innovative finding is that poverty has a differential effect in CVD, where we showed that poverty has a stronger correlation with HF mortality compared with CHD mortality. Furthermore, the association of poverty with HF mortality was independent of CHD mortality. It is possible that the much improved prognosis of acute myocardial infarction and unstable angina in the recent years has made CHD mortality less sensitive to lifestyle activities related to poverty.[34] On the contrary, HF represents the final stage of many CVDs, with high 30-day and 1-year mortality rates after each hospitalization.[35] In fact, it is distinctly sensitive to daily activities and habits, such as salt intake, adherence to medication, and fluid restriction,[9–11,23] which have been shown to have a strong correlation with mortality.[36,37]

The established risk factors for HF can also be influenced by the socioeconomic factors.[12–14,38] As shown in our study, the prevalence of obesity and diabetes mellitus was highly correlated with poverty and can partially explain the association between county poverty and HF mortality. This finding may indicate potential opportunity to address disparities in HF outcomes by targeting diabetes mellitus and obesity at the regional level.

We found that the relationship between poverty and HF mortality was not uniform across the United States, but varied between different census regions, with the greatest magnitude in the South and the smallest in the Northeast. This indicates that there may be other unidentified aspects that contribute to this association. These may be, in part, influenced by intrinsic regional characteristics, like differences in access to health care, antipoverty programs, availability of fruits and vegetables, or environmental exposures that relate to obesity, diabetes mellitus, and HF mortality in the region. Factors such as access to care, pollution, and living in “food deserts” have been associated with HF morbidity[39–41] and need to be investigated in the context of regional socioeconomic disparity and HF mortality, to target and reform healthcare policy and achieve uniform health outcomes despite economic disproportions.

The strength of our study is that we used nationwide data with a large sample size (3135 US counties) that allows for greater generalizability. Second, this is the first study to investigate regional socioeconomic characteristics to understand health disparities pertaining to HF mortality. There are also limitations to consider while reviewing these results.

Table 4. Correlation of Poverty With County Characteristics

Variable	Correlation With Poverty (95% CI)				
	Overall	Northeast	Midwest	South	West
Population	0.07 (0.03 to 0.10)	0.22 (0.06 to 0.37)	0.17 (0.10 to 0.23)	0.05 (0.00 to 0.10)	0.03 (−0.02 to 0.08)*
Median age (2010 census), y	−0.14 (−0.17 to −0.11)	−0.08 (−0.25 to 0.09)*	−0.07 (−0.14 to 0.00)*	−0.12 (−0.17 to −0.07)	−0.14 (−0.23 to −0.06)
Men % (2010 census)	0.04 (−0.01 to 0.09)*	0.07 (−0.12 to 0.26)*	−0.02 (−0.07 to 0.03)*	0.09 (0.02–0.16)	0.02 (−0.13 to 0.17)*
White % (2015 census)	−0.19 (−0.23 to −0.15)	−0.08 (−0.28 to 0.11)*	−0.11 (−0.19 to −0.04)	−0.11 (−0.17 to −0.06)	−0.18 (−0.26 to −0.10)
Median annual household income (in $1000)	−0.48 (−0.51 to −0.45)	−0.39 (−0.50 to −0.28)	−0.43 (−0.48 to −0.38)	−0.48 (−0.53 to −0.43)	−0.55 (−0.62 to −0.49)
Unemployment rate	0.51 (0.47 to 0.54)	0.34 (0.24 to 0.45)	0.38 (0.33 to 0.43)	0.54 (0.50 to 0.58)	0.45 (0.36 to 0.53)
Population without high school diploma, aged >25 y, % (2010–2014)	0.58 (0.55 to 0.61)	0.47 (0.33 to 0.61)	0.41 (0.34 to 0.47)	0.55 (0.51 to 0.59)	0.54 (0.47 to 0.61)
Population without health insurance, aged <65 y, % (2014)	0.34 (0.31 to 0.38)	0.22 (0.09 to 0.34)	0.36 (0.29 to 0.43)	0.15 (0.10 to 0.20)	0.30 (0.21 to 0.39)
Age-adjusted population with diabetes mellitus, aged >20 y, % (2013)	0.69 (0.67 to 0.72)	0.70 (0.62 to 0.78)	0.71 (0.67 to 0.74)	0.70 (0.67 to 0.74)	0.53 (0.45 to 0.61)
Age-adjusted population with obesity, aged >20 y, % (2013)	0.55 (0.53 to 0.58)	0.57 (0.46 to 0.68)	0.57 (0.52 to 0.62)	0.62 (0.58 to 0.65)	0.44 (0.36 to 0.51)
Heart failure hospitalizations/1000 Medicare beneficiaries (2012–2014)	0.21 (0.18 to 0.25)	0.23 (0.10 to 0.36)	0.11 (0.05 to 0.16)	0.18 (0.12 to 0.23)	0.19 (0.11 to 0.27)
Population with reported smoking % (2015)	0.34 (0.31 to 0.38)	0.35 (0.20 to 0.50)	0.37 (0.30 to 0.43)	0.26 (0.20 to 0.32)	0.29 (0.18 to 0.40)
Population with leisure-time physical inactivity, aged >20 y, % (2014)	0.26 (0.22 to 0.29)	0.28 (0.16 to 0.39)	0.11 (0.06 to 0.17)	0.27 (0.21 to 0.32)	0.19 (0.10 to 0.27)
Antihypertensive medication nonadherence in Part D Medicare beneficiaries % (2014)	0.46 (0.43 to 0.49)	0.10 (−0.05 to 0.25)*	0.27 (0.20 to 0.34)	0.45 (0.40 to 0.50)	0.38 (0.30 to 0.46)
Heart failure mortality (deaths/100 000)	0.48 (0.45 to 0.51)	0.43 (0.27 to 0.60)	0.47 (0.41 to 0.52)	0.49 (0.44 to 0.53)	0.31 (0.22 to 0.41)
Coronary heart disease mortality (deaths/100 000)	0.24 (0.20 to 0.28)	0.30 (0.15 to 0.45)	0.22 (0.15 to 0.29)	0.22 (0.16 to 0.27)	0.20 (0.12 to 0.28)

*P value not statistically significant.

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Table 5. Population-Weighted Multivariate Regression Modeling, According to Census Region

Model	Census Region	Poverty Regression Coefficient (95% CI)*	R^2 Value, %
Unadjusted heart failure mortality and poverty %	Northeast	0.56 (0.56–0.56)	0.9
	Midwest	4.85 (4.85–4.86)	32.0
	South	6.23 (6.22–6.23)	40.2
	West	2.92 (2.92–2.92)	11.7
Adjusted for demographics†	Northeast	1.44 (1.44–1.44)	34.8
	Midwest	4.82 (4.82–4.82)	39.4
	South	6.09 (6.09–6.09)	43.6
	West	2.59 (2.59–2.60)	19.6
Adjusted for socioeconomic factors, metropolitan status, demographics, risk factor prevalence, healthcare-associated behavior prevalence, and heart failure hospitalization‡	Northeast	0.76 (0.76–0.76)	80.8
	Midwest	1.78 (1.77–1.78)	54.9
	South	2.31 (2.30–2.31)	69.5
	West	0.98 (0.97–0.98)	52.9

P value was <0.001 for all models.
*Change in mortality associated with each percentage increase in poverty.
†Median age/county, men percentage, and white percentage.
‡Unemployment rate, median household income, uninsured percentage, lack of high school diploma percentage, median age/county, men percentage, white percentage, diabetes mellitus percentage, obesity percentage, smoking percentage, antihypertensive medication nonadherence percentage, and physical inactivity during leisure time percentage.

Although the sensitivity of death certificates for CVD is higher compared with other disease processes, misclassification of cause of death on death certificates is possible. Given the format of death certificates, a person could have both CHD and HF as causes of death, being captured as both HF and CHD mortality in our county-level analysis. As such, it could potentially attenuate the true difference in the correlation of poverty with HF mortality versus with CHD mortality in our first objective and bias toward the null hypothesis. This study used aggregate data and not individual-level data; therefore, individual exclusion criteria were not used. We were also unable to account for nonarteriosclerotic pathways of HF that have been shown to be associated with socioeconomic deprivation, such as peripartum cardiomyopathy, drug-induced cardiomyopathy, and myocarditis, which may contribute to the potential mechanisms of the association between poverty and HF mortality.[42,43] Furthermore, an ecological study does not lend itself for causal inference. This study is also cross-sectional and, therefore, temporality cannot be established. We tried to assess for mediators and confounders by using multivariate modeling, but residual confounding and unmeasured mediators may still remain.

Conclusions

County poverty is more strongly associated with HF mortality compared with CHD mortality. The association between poverty and HF mortality varied by census region. Over half of the association was explained by differences in CVD risk factor prevalence across the counties. These findings have relevance for future policy-oriented studies.

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Disclosures

None.

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