Title

Utility of Socioeconomic Status in Predicting 30-Day Outcomes After Heart Failure Hospitalization

Journal

Circulation Heart Failure, 8(3)

ISSN

1941-3289

Authors

Eapen, Zubin J
McCoy, Lisa A
Fonarow, Gregg C
et al.

Publication Date

2015-05-01

DOI

10.1161/circheartfailure.114.001879

Peer reviewed

HHS Public Access
Author manuscript
Circ Heart Fail. Author manuscript; available in PMC 2016 May 01.

Published in final edited form as:
Circ Heart Fail. 2015 May ; 8(3): 473–480. doi:10.1161/CIRCHEARTFAILURE.114.001879.

Utility of Socioeconomic Status in Predicting 30-Day Outcomes After Heart Failure Hospitalization

Zubin J. Eapen, MD, MHS[1], **Lisa A. McCoy, MS**[1], **Gregg C. Fonarow, MD**[2], **Clyde W. Yancy, MD**[3], **Marie Lynn Miranda, PhD**[4], **Eric D. Peterson, MD, MPH**[1], **Robert M. Califf, MD**[1], and **Adrian F. Hernandez, MD, MHS**[1]

[1]Duke Clinical Research Institute, Durham, NC

[2]Ronald Reagan-UCLA Medical Center, Ahmanson-UCLA Cardiomyopathy Center, Division of Cardiology, Los Angeles, CA

[3]Northwestern University Medical Center, Division of Cardiology, Chicago, IL

[4]Departments of Pediatrics and Obstetrics & Gynecology and School of Natural Resources and Environment, University of Michigan, Ann Arbor, MI

Abstract

Background—An individual's socioeconomic status (SES) is associated with health outcomes and mortality, yet it is unknown whether accounting for SES can improve risk-adjustment models for 30-day outcomes among Centers for Medicare & Medicaid Services (CMS) beneficiaries hospitalized with heart failure (HF).

Methods and Results—We linked clinical data on hospitalized HF patients in the Get With The Guidelines®-HF™ database (01/2005–12/2011) with CMS claims and county-level SES data from the 2012 Area Health Resources Files. We compared the discriminatory capabilities of multivariable models that adjusted for SES, patient, and/or hospital characteristics to determine whether county-level SES data improved prediction or changed hospital rankings for 30-day all-cause mortality and rehospitalization. After adjusting for patient and hospital characteristics, median household income (per $5,000 increase) was inversely associated with odds of 30-day mortality (OR 0.97, 95% CI 0.95–1.00, p=0.032), and the percentage of persons with at least a

Correspondence to: Zubin J. Eapen, MD, MHS, Duke Clinical Research Institute, PO Box 17969, Durham, NC 27715, Tel: 919-668-8852, Fax: 919-668-7058, zubin.eapen@duke.edu.

Disclosures: ZJ Eapen: Dr. Eapen reports serving on advisory boards for Novartis and Cytokinetics; honoraria from Janssen.
LA McCoy: Ms. McCoy has no relevant disclosures to report.
GC Fonarow: Dr. Fonarow reports research funding from the NIH and AHRQ; consulting for Amgen, Bayer, Gambro, Janssen, Novartis, and Medtronic.
CW Yancy: Dr. Yancy has no relevant disclosures to report.
ML Miranda: Dr. Miranda has no relevant disclosures to report.
ED Peterson: Dr. Peterson reports research funding for the American College of Cardiology, American Heart Association, Eli Lilly & Company, Janssen Pharmaceuticals, and Society of Thoracic Surgeons (all significant); consulting (including CME) for Merck & Co. (modest), Boehringer Ingelheim, Genentech, Janssen Pharmaceuticals, and Sanofi-Aventis (all significant).
RM Califf: Dr. Califf reports research funding from Amylin, Bristol Myers Squibb, Eli Lilly & company, Janssen Research & Development, LLC, Merck, and Novartis (all significant); consulting or other services (including CME) from Amgen ($5K-$25K), Medscape LLC/heart.org (modest), and Novartis ($5K-$25K); equity in N30 Pharma and Portola (both >$5K).
AF Hernandez: Dr. Hernandez reports research grants from Bristol Myers Squibb; personal fees from Bristol Myers Squibb, Gilead, and Idenix Pharmaceuticals.

high school diploma (per 5 unit increase) was associated with lower odds of 30-day rehospitalization (OR 0.95, 95% CI 0.91–0.99).After adjustment for county-level SES data, relative to whites, Hispanic ethnicity (OR 0.70, 95% CI 0.58, 0.83) and black race (OR 0.57, 95% CI: 0.50–0.65) remained significantly associated with lower 30-day mortality, but had similar 30-day rehospitalization. County-level SES did not improve risk adjustment or change hospital rankings for 30-day mortality or rehospitalization.

Conclusions—County-level SES data are modestly associated with 30-day outcomes for CMS beneficiaries hospitalized with HF, but do not improve risk adjustment models based on patient characteristics alone.

Keywords

heart failure; predictive models; risk stratification

Heart failure (HF) is the top discharge diagnosis for the Centers for Medicare & Medicaid Services (CMS) and the leading cause of rehospitalization within 30 days of an index hospitalization.[1] As a result, CMS has recognized the need to curb excessive rehospitalization and mortality rates, and has initiated public reporting of risk-adjusted rates for hospitals. Additionally, CMS now financially penalizes hospitals with high rehospitalization rates for HF through the Hospital Readmissions Reduction Program, as well as high mortality rates as part of the composite score used in the Hospital Value-Based Purchasing Program.[2-4] The risk-adjustment models currently used by CMS incorporate data exclusively from administrative claims.[5,6] Previous research indicates that adding clinical data to claims data for HF hospitalizations significantly improves prediction of mortality, and shifts mortality performance rankings for a substantial proportion of hospitals.[7] However, incorporating clinical data does not meaningfully improve prediction of rehospitalization and has little effect on performance rankings based on rehospitalization.[7]

Neither claims nor clinical data account for a patient's socioeconomic (SES) environment, which can differ in many aspects potentially related to health.[8-10] The SES context of a community has been shown to be related to health status and mortality,[10-15] as well as to health-related behaviors, including smoking, dietary habits, and physical activity.[16-20] The relationship between the characteristics of a community and health outcomes appears to be independent of the SES position of individual persons. This has been demonstrated in coronary artery disease studies; after controlling for personal income, education, and occupation, living in a disadvantaged neighborhood is associated with an increased incidence of having coronary artery disease.[21]

Differences in hospital-level post-discharge outcomes are partially related to both the SES mix and racial/ethnic backgrounds of the patient population served.[22,23] Nevertheless, the risk-adjustment models currently used by CMS to determine financial penalties for excess readmissions account for neither. Patient risk factors such as age, gender, and selected clinical covariates are considered, but their SES is not. As a result, hospitals that care for vulnerable populations may be disproportionately penalized for post-discharge outcomes independent of the quality of care delivered. An Expert Panel convened by the National Quality Forum concluded that a lack of adjustment for SES factors might unintentionally worsen disparities by penalizing the providers that care for disadvantaged populations.[24] The panel acknowledged the lack of high quality and readily available SES data that could be incorporated into risk adjustment models, and recommended that a standard set of SES variables should be identified and collected. Several standard SES variables have been used to establish the relationship between neighborhood of residence and incidence of coronary artery disease,[21] but their relationship to early outcomes in HF patients is unclear.

Using data from the Get With The Guidelines®-Heart Failure™ (GWTG-HF) Registry linked with the CMS database and county-level census data from Area Health Resource Files, we sought to determine: 1) whether county-level SES variables are associated with 30-day outcomes for older HF patients; 2) whether county-level SES accounts for the association of race with 30-day outcomes; and 3) whether county-level SES data alone, and in concert with, clinical data can improve risk adjustment beyond current CMS models.

Methods

Data Sources

We linked data from GWTG-HF with CMS enrollment files and inpatient claims from January 1, 2005 to December 30, 2011. The design, inclusion criteria, and data collection methods have been previously published.[25] Patients were eligible for inclusion if they were admitted for an episode of worsening HF or developed significant HF symptoms during a hospitalization for which HF was the primary discharge diagnosis. Hospital teams used HF case-ascertainment methods similar to those used by the Joint Commission. Data on demographics (i.e., age, gender, race/ethnicity) medical history, signs and symptoms, medications, contraindications for or intolerance to medications, and diagnostic test results were collected in the GWTG-HF database using the Internet-based Patient Management Tool (Quintiles Real-World & Late Phase Research, Cambridge, MA). Race/ethnicity data were collected in GWTG-HF by patient self-reporting as recorded by admissions or medical staff during registration. Race was recorded as part of a multiple-choice data entry tool (i.e., white, black, Asian, American Indian/Alaska Native, and Native Hawaiian/Pacific Islander). A separate data element for Hispanic ethnicity (i.e., yes vs. no/not documented) was also utilized. All regions of the United States were represented, and a variety of centers participated, from community hospitals to large tertiary centers.

All participating institutions were required to comply with local regulatory and privacy guidelines and, if applicable, to obtain institutional review board approval. Since the data were primarily used at the local site for quality improvement, sites were granted a waiver of informed consent under the Common Rule. The Duke Clinical Research Institute (Durham, NC) served as the data analysis center. The CMS files included data on all fee-for-service CMS beneficiaries age ≥65 years hospitalized with a diagnosis of HF (International Classification of Diseases, Ninth Revision, Clinical Modification [ICD-9-CM] codes 428.x, 402.x1, 404.x1, and 404.x3). We linked patient data in the registry with CMS Part A inpatient claims, matching by admission and discharge dates, hospital, date of birth, and sex.[26] We then linked these clinical data to county-level SES data using Population Characteristics and Economic Data in the 2012 Area Health Resources Files. To link the clinical and SES data, we used the Federal Information Processing Standard county code associated with the patient's zip code from the index claim or the denominator file for the year of the index claim.

End Points and Definitions

Consistent with metrics publicly reported by CMS,[27] the primary endpoints evaluated in this analysis were mortality within 30 days of admission and all-cause rehospitalization within 30 days of discharge. Similar to other studies of CMS beneficiaries, we obtained dates of death from CMS enrollment files and rehospitalization dates from Part A inpatient claims. Patients who died out of hospital before a rehospitalization were counted as "no" for the rehospitalization outcome to match the definition in the CMS 30-day rehospitalization measure.

Statistical Analysis

Patient characteristics, including demographics, history and risk factors, and hospital characteristics were presented by outcomes. Categorical variables were presented as frequencies (percentages) and differences by outcome were assessed using the chi-square test when the sample size was sufficient; otherwise, an exact test was used. Continuous variables were presented as median (Q1, Q3) and were compared using the Wilcoxon rank-sum test. To assess the association of SES with outcomes, we used a logistic regression model with random-intercepts for site. The random hospital intercept is a shrunken estimator and represents the log odds of the outcome for each hospital. To determine whether SES data improved discriminatory power, we fit a series of models for each outcome. First, we fit a model adjusting for only SES environmental characteristics. Second, we added pre-specified patient characteristics. Finally, we added hospital characteristics. C-indexes were used to assess the discriminatory power of the models. We also fit the current/standard adjustment model based on patient- and hospital-level characteristics. For comparison to current models espoused by CMS,[5,6] we fit the adjustment models based on patient characteristics alone.

We adjusted for a pre-specified list of clinical and hospital characteristics including age, gender, medical history (atrial fibrillation/flutter, anemia, chronic obstructive pulmonary disease, depression, diabetes mellitus, heart failure, hypertension, prior implantable cardioverter-defibrillator, ischemic etiology of HF, dyslipidemia, pacemaker, peripheral vascular disease, renal insufficiency, cerebrovascular accident/transient ischemic attack, valvular heart disease, and smoking history), vital signs (systolic blood pressure, heart rate, and respiratory rate), labs (sodium, serum creatinine, blood urea nitrogen, and hemoglobin), and year of index hospitalization. Hospital characteristics included in adjustment were region (Midwest, West, South, vs. Northeast), number of beds, teaching status (academic or residents), and rural (vs. urban). Adapting from the list of variables used by Diez Roux et al. to determine the relationship between neighborhood of residence and incidence of coronary artery disease,[21] we included the following SES characteristics in adjustment: median household income estimate (2006 Census estimate), median home value (2000 and 2006–2010 Census estimates), percentage of persons age ≥25 years with 4 or more years of college education (2006–2010 Census estimates), percentage of persons age ≥25 years with a high school diploma or higher education (2006–2010 Census estimates), and percentage of white collar workers (2000 Census estimate). The plots of observed versus predicted outcomes defined by deciles were used to evaluate model performance on calibration. Spearman's rank correlation coefficient was used to quantify the association between site event rates (i.e., hospital rankings) under different models using the estimated hospital random-intercepts. To assess whether race is a placeholder for SES, we fit two logistic regression models for each outcome. In the first model, we adjusted only for race. In the second model, we adjusted for race and SES variables. If race were significantly associated with the outcomes before and after adjusting for SES variables, then SES variables would not be considered a placeholder for race.

All statistical tests were two-sided and we considered alpha <0.05 to be significant. We used SAS version 9.3 software (SAS Institute, Cary, NC) for all analyses.

Results

Our starting population included 66,090 patients discharged between January 1, 2005 and December 30, 2011 from 292 hospitals fully participating in GWTG-HF with CMS linkage. We obtained a final study population of 48,338 patients from 197 hospitals after excluding patients with different discharge dates in CMS files and registry (n=1058, 0 sites), patients not eligible for fee-for-service CMS at discharge (n=2565, 0 sites), patients who did not have at least 1 admission vital sign (n=4817, 3 sites), patients who did not have at least 1 admission lab (n=8321, 11 sites), and patients from hospitals with <25 patients in the study population (n=991, 81 sites). Among the 48,338 patients who had at least 30 days of follow-up after their index admission, 4391 (9.1%) died within 30 days of admission. Among the 44,217 patients who survived until discharge and were not transferred out, 9107 (20.6%) were readmitted within 30 days of discharge, and 10,515 (23.8%) either died or were readmitted within 30 days of discharge. The median age of the overall cohort was 80 years (25^{th}, 75^{th}: 74, 86), 54.5% were female, and 81.3% were white (Table 1). Hypertension was the most frequent comorbidity, occurring in 77.2% of patients. The median household income was USD $45,902 ($25^{th}$, 75^{th}: $40,780, $53,677), which is lower than the United States 2010–2012 three-year average of $51,771.[27] In zip codes where patients resided, the median percentage of persons with at least a high school diploma was 85.7% (25^{th}, 75^{th}: 82.1, 88.5), and the median percentage of persons with at least 4 years of college was 26.1% (25^{th}, 75^{th}: 17.9, 29.6). These education data are consistent with national statistics.[28]

Table 2 shows the association of county-level SES variables from area resource files after adjusting for: 1) SES variables and patient characteristics; and 2) SES variables, patient characteristics, and hospital characteristics. After adjusting for SES variables and patient and hospital characteristics, median household income per $5,000 increase was modestly but significantly associated with a lower odds of 30-day mortality (odds ratio [OR] 0.97, 95% confidence interval [CI] 0.95–1.00, p=0.032). With the same multivariable adjustment, the proportion of persons with at least a high school diploma was associated with lower odds of 30-day rehospitalization (OR 0.95, 95% CI 0.91–0.99). When adjusting only for race and ethnicity, Hispanic ethnicity and black race are significantly associated with lower 30-day mortality and higher 30-day admission (Table 3). After adjustment for SES environment, Hispanic ethnicity and black race remained significantly associated with 30-day mortality

(Hispanic ethnicity: OR 0.70, 95% CI 0.58–0.83; black race: OR 0.57, 95% CI: 0.50–0.65), but not with 30-day rehospitalization.

Table 4 compares the discriminatory capabilities of models that adjust for SES, patient, and/or hospital characteristics. There was no perceptible improvement in discrimination beyond patient characteristics for SES or hospital characteristics for either 30-day endpoint (c-index for all 30-day mortality models: 0.74, c-index for all 30-day rehospitalization models: 0.62). Model calibration is shown in the plots of observed versus predicted outcomes defined by deciles (Supplemental Figure). Hospital rankings by 30-day mortality and 30-day rehospitalization were highly correlated among all models, but particularly among models that adjusted for patient characteristics (Table 5).

Discussion

Public reporting and financial penalties have made hospitals accountable for 30-day outcomes in select conditions: HF, acute myocardial infarction, and pneumonia. Public, and possibly financial, accountability is extending to hospital-wide rehospitalization rates.[29,30] As a result, there is an increasing focus on the methodology used to risk-adjust for outcomes measures like hospital rehospitalization rates. To date, risk adjustment accounts for the clinical characteristics of patients, but not the SES environment in which they live. Prior studies have demonstrated the relationship of the SES environment with both patient morbidity and mortality. Moreover, the SES environment is associated with a hospital's financial and clinical resources. Hospitals that care for disadvantaged populations often have limited resources and, ultimately, higher rehospitalization rates for HF.[31] Without accounting for the SES environment, financial penalties may disproportionately affect providers who serve disadvantaged populations, which ultimately, will widen disparities in care.

In this analysis of 48,338 patients from 197 hospitals in GWTG-HF linked with the CMS database and census data, we found that a higher community median household income was associated with a patient having a lower odds of 30-day mortality. We also found that the proportion of persons with at least a high school diploma within a community was associated with a lower odds of 30-day rehospitalization. Furthermore, county-level SES data adjusted away the association of black race or Hispanic ethnicity with 30-day rehospitalization. However, census-level data did not improve risk adjustment, nor did it change hospital rankings for 30-day rehospitalization or mortality based on patient-level characteristics alone.

Clinical outcomes such as rehospitalization and mortality are ideal for accountability applications such as public reporting and pay-for-performance, but it is often difficult to place full accountability on one institution (e.g., a hospital). In an effort to account for the differences in patient populations, outcomes are adjusted for patient comorbidities and severity of illness. Current models do not account for race or SES, although these characteristics are shown in our analysis, as well as prior studies, to be associated with early post-discharge outcomes in HF. For example, Nagasako et al. found that including community-level SES characteristics like county median income greatly reduced variation in hospital risk-standardized readmission rates for HF patients in Missouri.[32] Among New York City hospitals, Blum et al. demonstrated that SES was associated with 30-day readmission rates for HF patients, but did not improve the discriminatory capacity of risk adjustment models.[33] To our knowledge, our study is among the first to examine the impact of SES data on risk adjustment models in a large dataset representative of patients and hospitals across the United States.

Similar to previous studies,[23,34,35] we found that black race and Hispanic ethnicity are associated with lower rates of post-discharge mortality and higher rates of readmission for patients with HF. Furthermore, we found that the association of black race and Hispanic ethnicity with lower 30-day mortality remained after adjusting for the SES environment. Despite disparities in care, this relationship has also been identified in other conditions including stroke.[36] The reasons for differences in outcome according to race/ethnicity are varied and include factors at the hospital-level (e.g., quality of care) and patient-level (e.g., preferences of care). Our findings are also concordant with prior studies, which suggest that an individual's health is related to the environment in which he or she lives. Using data from the Atherosclerosis Risk in Communities Study, Diez-Roux et al. showed that living in a disadvantaged neighborhood was associated with an increased incidence of coronary heart disease, as well as an increased prevalence of risk factors, even after adjusting for personal income, education, and occupation.[19,21] Linking data from the National Longitudinal Mortality Study to census tract information, Anderson et al. found that up to one-third of the mortality associated with residence in low-income areas was independent of personal income level.[11] Yen and Kaplan found that mortality risks were significantly higher in neighborhoods with a low social environment, even after accounting for individual income level, education, race/ethnicity, perceived health status, smoking status, body mass index, and alcohol consumption.[13] Among patients hospitalized for HF, a single-center study of a large urban hospital found that community-level factors such as income level for zip code of residence can improve prediction of 30-day rehospitalization.[37] The interrelatedness between SES characteristics of the communities that hospitals serve and patient race/ethnicity has not been fully explored. Our findings suggest that SES at least partially accounts for the relationship of race and ethnicity with early post-discharge outcomes for patients with HF.

Heterogeneity within counties likely dilutes the discriminatory capacity of the SES variables used in this analysis. More granular data will elucidate whether factors unrelated to systems of care, including race/ethnicity and SES, would improve risk adjustment and efforts to incentivize more equitable care. Geographic health information systems, which integrate clinical data with census data and other community-level information, can enable a more precise evaluation of the distribution of SES characteristics within communities and their relation to clinical outcomes. Such systems have been used to identify local predictors of emergency department use and are scalable.[38] Integrating geospatial data with nationwide quality improvement initiatives could not only improve risk adjustment and predictive modeling for clinical outcomes, but could enhance population health management efforts.

Limitations

Our study has several limitations. First, the study population was comprised of CMS fee-for-service beneficiaries enrolled in GWTG-HF and might not be clinically representative of all patients hospitalized with HF. The outcomes are likely conservative given the voluntary participation of hospitals in this quality improvement registry; however, analyses of a similar clinical registry called the Organized Program to Initiate Lifesaving Treatment in Hospitalized Patients with Heart Failure (OPTIMIZE-HF) Registry, indicated that enrolled patients were reasonably representative of the broader CMS population with HF.[39]Second, traditional variables such as median household income and median home value are poorer measures of SES in this older population, many of whom may be retired. As a result, the weak association observed with these SES variables may be further diluted. Nevertheless, it is important to pursue the objective of our paper (i.e., to determine the utility of SES in risk-adjusting outcomes for CMS beneficiaries with HF), given the financial implications of risk-adjusted readmission and mortality rates for this specific population. Third, a stronger relationship between county-level SES data and outcomes may have emerged with longer-term follow-up and with the use of more granular SES data. Fourth, the data in this study are dependent on the quality of medical record documentation and chart abstraction. Fifth, study results can be influenced by differences in assessment, treatment, and documentation patterns at participating hospitals. Finally, residual confounding (measured and unmeasured) may account for some or all of these observations.

Conclusions

Census-level SES data are modestly associated with 30-day outcomes for CMS beneficiaries hospitalized with HF, but do not improve risk adjustment models based on patient characteristics alone. SES data at a more detailed level may improve understanding of the relationship between SES and 30-day outcomes in HF.

Acknowledgments

The authors thank Erin Hanley for editorial contributions. Ms. Hanley did not receive compensation for her assistance, apart from her employment at the institution where the study was conducted.

Sources of Funding: This project was supported in part by grant number U19HS021092 from the Agency for Healthcare Research and Quality and grant number KM1CA156687from the National Cancer Institute/National Institutes of Health. The content is solely the responsibity of the authors and does not represent the official views of the Agency for Healthcare Research and Quality, National Cancer Institute, or theNational Institutes of Health.

References

1. Jencks SF, Williams MV, Coleman EA. Rehospitalizations among patients in the Medicare fee-for-service program. N Engl J Med. 2009; 360:1418–1428. [PubMed: 19339721]
2. Krumholz HM, Merrill AR, Schone EM, Schreiner GC, Chen J, Bradley EH, Wang Y, Wang Y, Lin Z, Straube BM, Rapp MT, Normand SL, Drye EE. Patterns of hospital performance in acute myocardial infarction and heart failure 30-day mortality and readmission. Circ Cardiovasc Qual Outcomes. 2009; 2:407–413. [PubMed: 20031870]
3. Medicare Payment Advisory Commission. [Accessed June 5, 2014] Chapter 4: A path to bundled payment around a hospitalization. Report to the Congress: Reforming the Delivery System. Medpac.gov web site. http://www.medpac.gov/documents/Jun08_EntireReport.pdf. Updated June 13, 2008

4. Fiscal Year 2015 Overview for Beneficiaries, Providers, and Stakeholders. Centers for Medicare & Medicaid Services; National Provider Call: Hospital Value-Based Purchasing. Centers for Medicare & Medicaid Services web site. http://www.cms.gov/Outreach-and-Education/Outreach/NPC/Downloads/HospVBP_FY15_NPC_Final_03052013_508.pdf. Updated March 14, 2013 [Accessed October 21, 2014]
5. Krumholz HM, Wang Y, Mattera JA, Wang Y, Han LF, Ingber MJ, Roman S, Normand SL. An administrative claims model suitable for profiling hospital performance based on 30-day mortality rates among patients with heart failure. Circulation. 2006; 113:1693–1701. [PubMed: 16549636]
6. Keenan PS, Normand SL, Lin Z, Drye EE, Bhat KR, Ross JS, Schuur JD, Stauffer BD, Bernheim SM, Epstein AJ, Wang Y, Herrin J, Chen J, Federer JJ, Mattera JA, Wang Y, Krumholz HM. An administrative claims measure suitable for profiling hospital performance on the basis of 30-day all-cause readmission rates among patients with heart failure. Circ Cardiovasc Qual Outcomes. 2008; 1:29–37. [PubMed: 20031785]
7. Hammill BG, Curtis LH, Fonarow GC, Heidenreich PA, Yancy CW, Peterson ED, Hernandez AF. Incremental value of clinical data beyond claims data in predicting 30-day outcomes after heart failure hospitalization. Circ Cardiovasc Qual Outcomes. 2011; 4:60–67. [PubMed: 21139093]
8. Kaplan GA. People and places: contrasting perspectives on the association between social class and health. Int J Health Serv. 1996; 26:507–519. [PubMed: 8840199]
9. Robert SA. Socioeconomic position and health: the independent contribution of community socioeconomic context. Annu Rev Sociol. 1999; 25:989–998.
10. Macintyre S, MAciver S, Sooman A. Area, class, and health: should we be focusing on places or people? J Soc Pol. 1993; 22:213–234.
11. Anderson RT, Sorlie P, Backlund E, Johnson N, Kaplan GA. Mortality effects of community socioeconomic status. Epidemiology. 1997; 8:42–47. [PubMed: 9116094]
12. Robert SA. Community-level socioeconomic status effects on adult health. J Health Soc Behav. 1998; 39:18–37. [PubMed: 9575702]
13. Yen IH, Kaplan GA. Neighborhood social environment and risk of death: multilevel evidence from the Alameda County Study. Am J Epidemiol. 1999; 149:898–907. [PubMed: 10342798]
14. Smith GD, Hart C, Watt G, Hole D, Hawthorne V. Individual social class, area-based deprivation, cardiovascular disease risk factors, and mortality: the Renfrew and Paisley Study. J Epidemiol Community Health. 1998; 52:399–405. [PubMed: 9764262]
15. Waitzman NJ, Smith KR. Phantom of the area: poverty-area residence and mortality in the United States. Am J Public Health. 1998; 88:973–976. [PubMed: 9618634]
16. Kleinschmidt I, Hills M, Elliott P. Smoking behaviour can be predicted by neighbourhood deprivation measures. J Epidemiol Community Health. 1995; 49:S72–77. [PubMed: 8594138]
17. Yen IH, Kaplan GA. Poverty area residence and changes in physical activity level: evidence from the Alameda County Study. Am J Public Health. 1998; 88:1709–1712. [PubMed: 9807543]
18. Duncan C, Jones K, Moon G. Smoking and deprivation: are there neighbourhood effects? Soc Sci Med. 1999; 48:497–505. [PubMed: 10075175]
19. Diez Roux AV, Nieto FJ, Muntaner C, Tyroler HA, Comstock GW, Shahar E, Cooper LS, Watson RL, Szklo M. Neighborhood environments and coronary heart disease: a multilevel analysis. Am J Epidemiol. 1997; 146:48–63. [PubMed: 9215223]
20. Diez Roux AV, Nieto FJ, Caulfield L, Tyroler HA, Watson RL, Szklo M. Neighbourhood differences in diet: the Atherosclerosis Risk in Communities (ARIC) Study. J Epidemiol Community Health. 1999; 53:55–63. [PubMed: 10326055]
21. Diez Roux AV, Merkin SS, Arnett D, Chambless L, Massing M, Nieto FJ, Sorlie P, Szklo M, Tyroler HA, Watson RL. Neighborhood of residence and incidence of coronary heart disease. New Engl J Med. 2001; 345:99–106. [PubMed: 11450679]
22. Joynt KE, Orav EJ, Jha AK. Thirty-day readmission rates for Medicare beneficiaries by race and site of care. JAMA. 2011; 305:675–681. [PubMed: 21325183]
23. Rathore SS, Foody JM, Wang Y, Smith GL, Herrin J, Masoudi FA, Wolfe P, Havranek EP, Ordin DL, Krumholz HM. Race, quality of care, and outcomes of elderly patients hospitalized with heart failure. JAMA. 2003; 289:2517–2524. [PubMed: 12759323]

24. National Quality Forum. Risk adjustment for socioeconomic status or other sociodemographic factors: draft technical report for review. The Leap frog Group; web site. http://www.leapfroggroup.org/media/file/NQF_SocioDem.pdf. Updated March 18, 2014 [Accessed June 5, 2014]
25. LaBresh KA, Ellrodt AG, Gliklich R, Liljestrand J, Peto R. Get with the guidelines for cardiovascular secondary prevention: pilot results. Arch Intern Med. 2004; 164:203–209. [PubMed: 14744845]
26. Hammill BG, Hernandez AF, Peterson ED, Fonarow GC, Schulman KA, Curtis LH. Linking inpatient clinical registry data to Medicare claims data using indirect identifiers. Am Heart J. 2009; 157:995–1000. [PubMed: 19464409]
27. Medicare.gov Hospital Compare. [Accessed June 5, 2014] 30-day death and readmission measures. Medicare.gov Hospital Compare web site. http://www.medicare.gov/hospitalcompare/Data/30-day-measures.html
28. [Accessed June 5, 2014] Hospital-wide all-cause unplanned readmission (HWR) measure. Quality Net web site. http://www.qualitynet.org/dcs/ContentServer?c=Page&pagename=QnetPublic%2FPage%2FQnetTier4&cid=1228772504318
29. Medicare Payment Advisory Commission. [Accessed June 5, 2014] Chapter 4: Refining the hospital readmissions reduction program. Report to the Congress: Medicare and the Health Care Delivery System. Medpac.gov web site. Updated June 2013
30. MEDPAC: Medicare Payment Advisory Commission. [Accessed July 23, 2014] Chapter 4: Refining the hospital readmissions reduction program. Report to the Congress: Medicare and the Health Care Delivery System. http://www.medpac.gov/chapters/Jun13_Ch04.pdf. Published June 2013
31. Joynt KE, Jha AK. Who has higher readmission rates for heart failure, and why? Implications for efforts to improve care using financial incentives. Circ Cardiovasc Qual Outcomes. 2011; 4:53–59. [PubMed: 21156879]
32. Nagasako EM, Reidhead M, Waterman B, Dunagan WC. Adding socioeconomic data to hospital readmissions calculations may produce more useful results. Health Aff (Millwood). 2014; 33:786–791. [PubMed: 24799575]
33. Blum AB, Egorova NN, Sosunov EA, Gelijns AC, DuPree E, Moskowitz AJ, Federman AD, Ascheim DD, Keyhani S. Impact of socioeconomic status measures on hospital profiling in New York City. Circ Cardiovasc Qual Outcomes. 2014; 7:391–397. [PubMed: 24823956]
34. Chen J, Normand SL, Wang Y, Krumholz HM. National and regional trends in heart failure hospitalization and mortality rates for Medicare beneficiaries, 1998-2008. JAMA. 2011; 306:1669–1678. [PubMed: 22009099]
35. Ross JS, Mulvey GK, Stauffer B, Patlolla V, Bernheim SM, Keenan PS, Krumholz HM. Statistical models and patient predictors of readmission for heart failure: a systematic review. Arch Intern Med. 2008; 168:1371–1386. [PubMed: 18625917]
36. Xian Y, Holloway RG, Smith EE, Schwamm LH, Reeves MJ, Bhatt DL, Schulte PJ, Cox M, Olson DM, Hernandez AF, Lytle BL, Anstrom KJ, Fonarow GC, Peterson ED. Racial/ethnic differences in process of care and outcomes among patients hospitalized with intracerebral hemorrhage. Stroke. 2014; 45:3243–3250. [PubMed: 25213344]
37. Amarasingham R, Moore BJ, Tabak YP, Drazner MH, Clark CA, Zhang S, Reed WG, Swanson TS, Ma Y, Halm EA. An automated model to identify heart failure patients at risk for 30-day readmission or death using electronic medical record data. Med Care. 2010; 48:981–988. [PubMed: 20940649]
38. Miranda ML, Ferranti J, Strauss B, Neelon B, Califf RM. Geographic health information systems: a platform to support the 'triple aim'. Health Aff (Millwood). 2013; 32:1608–1615. [PubMed: 24019366]
39. Curtis LH, Greiner MA, Hammill BG, DiMartino LD, Shea AM, Hernandez AF, Fonarow GC. Representativeness of a national heart failure quality-of-care registry: comparison of OPTIMIZE-HF and non-OPTIMIZE-HF Medicare patients. Circ Cardiovasc Qual Outcomes. 2009; 2:377–384. [PubMed: 20031864]

Table 1

Baseline Characteristics of the Study Population (n=48,338)*

Patient characteristics	
Age, yrs	80 (74, 86)
Female gender	26,347 (54.5)
Race	
Asian	553 (1.15)
Black	4928 (10.26)
Hispanic (any race)	2331 (4.85)
White	39032(81.3)
Other	1187 (2.47)
History of, %	
Atrial fibrillation or flutter	18,521 (38.6)
COPD or asthma	14,024 (29.3)
Diabetes mellitus, insulin-dependent	8,159 (17.0)
Hyperlipidemia	22,299 (46.5)
Hypertension	37,019 (77.2)
Peripheral vascular disease	6,789 (14.2)
Coronary artery disease	24,841 (51.8)
Prior MI	8,579 (17.9)
Ischemic etiology of HF	28,192 (58.8)
Cerebrovascular accident/TIA	7,966 (16.6)
Anemia	9,458 (19.7)
Chronic dialysis	1,501 (3.1)
Chronic renal insufficiency	8,586 (17.9)
Smoking history	4,328 (9.1)
Ejection fraction, %	45 (30, 57)
Hospital characteristics	
Number of beds	392 (243,581)
Teaching hospital	28,571 (59.1)
Primary PTCA performed for acute MI	40,162 (89.2)
Cardiac surgery performed on-site	34,739 (77.5)
Heart transplants performed on-site	5,273 (11.5)
Region	
Midwest	13,600 (28.1)
Northeast	13,622 (28.2)
South	16,002 (33.1)
West	5,114 (10.6)
SES environment characteristics	
Median household income	45,902 (40,780, 53,677)
Median home value	149,700 (111,700, 241,500)
Persons aged ≥25 years with high school diploma or more	85.7 (82.1, 88.5)

Persons aged ≥25 yrs w/4+ yrs of college or more	26.1 (17.9, 29.6)
White collar workers, 2000	58.7 (52.8, 63.7)

COPD indicates chronic obstructive pulmonary disease; HF, heart failure; MI, myocardial infarction; PTCA, percutaneous transluminal coronary angioplasty; SES, socioeconomic status; TIA, transient ischemic attack

*Values are median (25th, 75th interquartile range) or n (%)

Table 2

Odds Ratios Associated with 30-Day Outcomes

		SES + Patient Characteristics		SES + Patient & Hospital Characteristics	
Outcome	Variable	OR (95% CI)	p-value	OR (95% CI)	p-value
30-day mortality	% persons ≥25 yrs with ≥4 yrs college per 5 unit increase	1.00 (0.94, 1.07)	0.939	1.00 (0.94, 1.07)	0.937
	% persons ≥25 yrs with HS diploma or more per 5 unit increase	1.01 (0.97, 1.07)	0.569	1.03 (0.97, 1.09)	0.315
	Median household income per $5,000 increase	0.97 (0.95, 1.00)	0.034	0.97 (0.95, 1.00)	0.032
	Median home value per $10,000 increase	1.00 (1.00, 1.01)	0.529	1.00 (1.00, 1.01)	0.560
	% white collar workers per 5 unit increase	0.98 (0.92, 1.04)	0.518	0.97 (0.91, 1.04)	0.412
30-day rehospitalization	% persons ≥25 yrs with ≥4 yrs college per 5 unit increase	0.98 (0.94, 1.03)	0.499	0.98 (0.94, 1.03)	0.522
	% persons >25 yrs with HS diploma or more per 5 unit increase	0.94 (0.90, 0.98)	0.002	0.95 (0.91, 0.99)	0.019
	Median household income per $5,000 increase	0.99 (0.97, 1.01)	0.391	0.99 (0.97, 1.01)	0.222
	Median home value per $10,000 increase	1.00 (1.00, 1.01)	0.171	1.00 (1.00, 1.01)	0.061
	% white collar workers per 5 unit increase	1.07 (1.01, 1.12)	0.0115	1.05 (1.00, 1.11)	0.0471

CI indicates confidence interval; HS, high school; OR, odds ratio; All other abbreviations can be found in Table 1.

Table 3

Association of Race and SES on Outcomes

		Race Only		Race + SES	
Outcome	**Variable**	**OR (95% CI)**	**p-value**	**OR (95% CI)**	**p-value**
30 day-mortality	Overall race		<0.001		<0.001
	Hispanic vs. white	0.71 (0.60, 0.85)	<0.001	0.70 (0.58, 0.83)	<0.001
	Black vs. white	0.57 (0.50, 0.65)	<0.001	0.57 (0.50, 0.65)	<0.001
	Asian vs. white	0.95 (0.70, 1.29)	0.752	0.96 (0.70, 1.30)	0.780
	Other vs. white	0.83 (0.67, 1.03)	0.091	0.84 (0.68, 1.03)	0.099
	Median household income per $5,000 increase			0.97 (0.94, 0.99)	0.016
	Median home value per $10,000 increase			1.00 (1.00, 1.01)	0.248
	% persons 25+ w/4+ yrs college per 5 unit increase			1.01 (0.95, 1.08)	0.657
	% persons 25+ w/HS diploma or more per 5 unit increase			1.02 (0.97, 1.08)	0.342
	% white collar workers per 5 unit increase			0.98 (0.92, 1.04)	0.429
30-day rehospitalization	Overall race		<0.001		0.002
	Hispanic vs. white	1.14 (1.02, 1.28)	0.023	1.08 (0.96, 1.22)	0.188
	Black vs. white	1.10 (1.01, 1.19)	0.024	1.07 (0.99, 1.16)	0.099
	Asian vs. white	1.11 (0.89, 1.39)	0.343	1.09 (0.87, 1.36)	0.472
	Other vs. white	0.75 (0.64, 0.89)	<0.001	0.74 (0.63, 0.88)	<0.001
	Median household income per $5,000 increase			0.99 (0.97, 1.01)	0.433
	Median home value per $10,000 increase			1.00 (1.00, 1.01)	0.371
	% persons 25+ w/4+ yrs college per 5 unit increase			0.98 (0.94, 1.03)	0.534
	% persons 25+ w/HS diploma or more per 5 unit increase			0.94 (0.91, 0.98)	0.005
	% white collar workers per 5 unit increase			1.06 (1.01, 1.11)	0.022

All abbreviations can be found in Tables 1 and 2.

Table 4

C-indexes for All Models

	Patient Characteristics	Patient + Hospital Characteristics	SES + Patient Characteristics	SES + Patient + Hospital Characteristics
Outcome	C-Index	C-Index	C-Index	C-Index
30-day mortality	0.741	0.741	0.741	0.741
30-day rehospitalization	0.619	0.619	0.619	0.618

All abbreviations can be found Table 1.

Author Manuscript

Author Manuscript

Author Manuscript

Table 5

Spearman's Rho Correlations in Hospital Rankings of Event Rates

Outcome	Correlation between		Rho (p-value)
30-day mortality	SES only model	SES + patient & hospital characteristics	0.866 (<0.001)
	SES + patient characteristics	SES + patient & hospital characteristics	0.985 (<0.001)
	SES only model	Patient & hospital characteristics	0.855 (<0.001)
	SES + patient & hospital characteristics	Patient & hospital characteristics	0.969 (<0.001)
30-day rehospitalization	SES only model	SES + patient & hospital characteristics	0.890 (<0.001)
	SES + patient characteristics	SES + patient & hospital characteristics	0.935 (<0.001)
	SES only model	Patient & hospital characteristics	0.870 (<0.001)
	SES + patient & hospital characteristics	Patient & hospital characteristics	0.966 (<0.001)

All abbreviations can be found in Table 1.