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Excess Readmission-Based Penalty: *Is arthroplasty different from the other outcomes?*

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Abstract

Whether factors not under hospital's control affect readmissions remains intensely debated in the context of the Centers for Medicare & Medicaid Services' Hospital Readmission Reduction Program. We aimed to evaluate the potential effects of poverty, race and hospital volume on excess readmissions, with >3000 hospitals participating in "Hospital Compare". We assessed correlations between 'Excess Readmission Ratio' for five eligible outcomes (including hip-knee arthroplasty) with the three area/hospital-level factors: poverty, race (percent of Black population), and hospital volume (number of discharges). Correlation coefficients of the ratios with race were approximately r=0.2; consistently larger than those with poverty, r=0–0.1. Volume showed r=0 to −0.5. Hip-knee arthroplasty showed unique findings: null correlation with poverty (r≈0); largest variability; and strong monotonicity with volume (r≈−0.5). Percent of Hispanic showed negligible correlations in secondary analysis. Penalty assessment and hospital profiling should consider areas with high percentages of Black population and small volume hospitals/providers of hip-knee surgery.

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Keywords

Black; CMS; Hip; Hospital Readmission Reduction Program; Knee

INTRODUCTION

Reducing hospital readmissions has become an important but controversial health policy priority in the US. The Hospital Readmissions Reduction Program (HRRP), administered since 2012 by the Centers for Medicare & Medicaid Services (CMS), requests hospitals report on 30-day readmission, and assesses penalties for poorly performing hospitals. Payment reduction up to 3% annually occurs for hospitals demonstrating a high rate of readmission under the rationale that the outcome is both preventable and determined primarily by the quality of hospital care.(1, 2)

Other potential factors influencing readmissions—sociodemographics, community infrastructure, patient and area-level poverty—are explicitly excluded from adjustment of the HRRP metric.(3–6) While previous data have been mixed about the effects of these characteristics on readmission, debate continues regarding whether they may explain substantial differences in readmission rates between high vs. low-performing hospitals. There is growing concern that hospitals serving populations with a high burden of poverty and/or patient illness severity (e.g., safety-net hospitals) may be penalized unfairly based on the patients they serve.(7–10) Furthermore, key stakeholders have queried the validity, accuracy, and mutability of the metric, with some calling for legislative reform.(3, 10–12)

Recently, independent studies, examining the relationship of socioeconomic status (SES) with readmission based on patient-level claims or discharge data, have added new information to the debate. Bernheim et al. and Martsolf et al. investigated the effect of adjustment of SES (e.g., neighborhood median income and Medicaid status) on hospital profiling and penalty assessment for the 3 medical conditions originally selected in HRRP and total hip and knee arthroplasty (HK); they concluded that accounting for patient-level SES does not change hospital readmission rates in meaningful ways.(3, 13) Martsolf et al. also reported that adding race/ethnicity and SES had a nontrivial effect on the size of the penalty on safety-net and rural hospitals, yet total effect is still small.(14) On the other hand, Manickam et al. examined the correlation of area-level poverty and excess readmission ratio (ERR) for the 5 current conditions, using hospital-level data.(15) While overall these groups reached qualitatively similar results, interesting or tantalizing nuances emerged; for example, while the observed effect sizes were small, all conditions showed statistically significant correlations ($p \leq 0.001$), except for HK ($r \approx 0$, $p=0.62$) which uniquely showed the largest variability in ERR.

In this paper, we examined the relationship of area-level poverty on excess hospital readmission, by adding the two community and hospital-related factors outside of a provider’s control: percentage of black population and hospital size.(15, 16) We hypothesized that: 1) percent of Black residents is positively correlated with ERRs, and 2) hospital volume is negatively correlated with ERRs, for *all* 5 medical conditions. We further hypothesized that 3) area-level poverty is the most appropriate among the 3 covariates—

poverty, race and hospital size—that capture different aspects of area and hospital. If it is true, the current focus on poverty as a primary SES measure is a right direction.

MATERIALS AND METHODS

Data Sources

The standardized morbidity ratio of observed vs. expected cases was adapted by CMS: the risk-standardized readmission rate for each hospital is computed as the ratio of the number of 'predicted' readmissions to the number of 'expected' readmissions at a given hospital, multiplied by the national observed readmission rate. Predicted and expected numbers of readmissions were derived from a two-level hierarchical logistic regression model.(1, 3, 6, 17) The HRRP determines payment penalties on the basis of this ratio, ERR, with hospitals having a value greater than 1 facing a financial penalty.

Our study outcomes are the 5 applicable conditions selected by CMS as the most common causes of hospitalizations: acute myocardial infarction, heart failure, pneumonia, chronic obstructive pulmonary disease, and HK. For hospital or area-level characteristics, we selected poverty level, race composition and hospital volume. Specifically, poverty level was ascertained as percent of population below the federal poverty level, race as percent of Black residents (who identified themselves as single race of 'Black' or 'African American'), both in the census tract of the hospital,(15, 18) and hospital size as the volume or number of discharges/procedures for each of the 5 conditions in eligible hospitals. The ERR values computed by CMS and the associated number of discharges in 2011–2014 were publicly available https://www.medicare.gov/hospitalcompare/. Data on poverty and race were retrieved from the American Community Survey by the US Census Bureau, 5-year estimates 2010–2014. We used data from the Dartmouth Atlas that defines the Hospital Service Area, along with corresponding US Postal Zip codes. Subsequently, geographical mapping was performed with Census Bureau Zip Code Tabulation Areas from the Uniform Data System Mapper, http://udsmapper.org/zcta-crosswalk.cfm. The institutional review board determined no IRB review is needed.

Statistical Analyses

Descriptive statistics (including mean, standard deviation and interquartile range) were used to summarize covariates and outcomes. Spearman correlation coefficients were computed to test if the correlation between the ERR and each covariate is 0, the *null* hypothesis (which is expected for a fair model in theory), and to describe the overall pattern. Rank correlation was adopted to address skewness and potential nonlinearity. To visualize the association and trend, box plot was drawn using quintiles-based categorization for each covariate. All analyses were based on non-missing data, i.e., no imputation was employed. We used simple (bivariate) correlation, unadjusted for other covariates as we were interested in the correlations with "final, publicly available" outcomes as they are that *already adjusted* for case-mix and other factors in the CMS models. We did not aim to address the performance and different aspects of the models that require raw, detailed data on the patient and hospital-levels (e.g., in terms of included or excluded variables). Also, the covariates are perceived to be inter-dependent, so some degree of multi-collinearity is natural; some caution should be exercised.

We conducted the following ancillary/sensitivity analyses: 1) for race, we repeated the analyses a) allowing multi-race selection in the survey, b) replacing Black by non-White, and c) replacing Black by Hispanic; 2) for poverty, we used "median income" in order to compare findings to previous studies on the subject; 3) we replaced Spearman by Pearson linear correlation; and 4) we fitted exploratory multiple regression with 2 (poverty vs. race) or 3 covariates (poverty vs. race vs. log(volume)) jointly, in order to assess relative importance.(19) Finally, 5) we computed the correlations between predicted readmission rates (which is the numerator in ERR, outcome before standardization) and covariates; non-zero correlations are expected here as different SES markers are well known to be associated with various health outcomes.(20) We used SAS 9.4 (SAS Institute, Cary, NC, USA) for analyses. P-values were unadjusted for multiple comparisons.

RESULTS

Demographics and covariates were available for over 3000 hospitals (Table 1). The number of complete cases was varied in ERR and discharge count, depending on the condition. The mean and median of the ERRs were essentially 1 (range in 0.997–1.007), as anticipated due to standardization.(15)

The ERRs and poverty were positively correlated, but relatively small in magnitude (r=0.01–0.13), with a null value for HK (~0; p=0.6) (Table 2). Correlations of the ERRs with race were approximately r=0.2 (in 0.18–0.24; all p's<0.0001), consistently larger than those with poverty, for all 5 outcomes. Positive, monotonic associations between race and ERRs were demonstrated in the corresponding box plots (Figure 1). Those with volumes were more varied or pronounced, r ranged in 0 to −0.5; ~0 for pneumonia, −0.2 for myocardial infarction, and −0.5 for HK. In the presence of the highest variability for HK in the already standardized measure that conveys the properties of shrinkage and attenuation,(10, 17) r≈ −0.5 for HK is striking. A strong, nonlinear relationship in HK, in contrast with the 4 other conditions, is elucidated in the box plots (Figure 2); the upper quartile (75%tile) of the ERR in the largest hospitals was lower than the lower quartile (25%tile) in the smallest hospitals.

Ancillary and sensitivity analyses yielded qualitatively similar results. When we used a slightly different definition of Black (single to multi-races), correlation coefficients were virtually unchanged. Notably, median income and percent of Hispanic population showed low correlations (e.g., largest absolute value of r=0.07 and 0.02, respectively), mostly lack of statistical significance. Hispanic population must be the main driver of the diluted correlations observed for non-White, and non-significance of Hispanic has been observed in a similar context.(14) The largest correlation with poverty on heart failure previously reported was also validated when we used median income(15) (Table A1). Pearson's correlation showed attenuated values, while the hierarchical ordering of poverty vs. race was preserved: for example, the largest r=−0.48 (p<0.0001) became −0.35 (p<0.0001) and the lowest r=0.01 (p=0.62) became 0.002 (p=0.90)—both observed for HK—when Spearman was replaced by Pearson. When we fitted multiple regression with 2 or 3 competing covariates, race uniformly showed stronger associations than poverty, as reflected in the regression coefficient as well as p-value, confirming the results from our primary analyses (Results not shown).

Finally, when “(predicted) readmission rate” instead of ratio was used as the outcome, all covariates showed results in expected directions. These analyses confirmed weak associations with median income and percent of Hispanic (Table A2). Overall, analyses imply that our findings on race are robust and less subject to influence by adjustment, outcome metric and medical condition.

DISCUSSION

Excess readmission has been identified as one of the key metrics of quality of care and has implications for reimbursement. Understanding the variation in factors—particularly those not under hospital’s control—associated with ERR and its implications on quality of care issues is crucial for healthcare policy.

In this national sample of US hospitals, we found that correlations of ERRs with varied definitions of area-level disadvantage for the 5 primary outcomes seem to differ in meaningful ways. First and foremost, ERR correlated with percent of Black population for all 5 conditions, more strongly than with poverty level, either based on percent of poor population or median income, i.e., ~0.2 for race vs. ≤0.1 for poverty. Correlation of ERR with hospital volume, furthermore, demonstrated the *largest* absolute value, 0.5, for HK. Except for volume in chronic obstructive pulmonary disease (r=0.07; p=0.0007), all other coefficients showed expected directions. Overall, the larger the proportion of residents identified as Black in the census tract, the larger the excess risk, and the larger the hospital size, the lower the excess risk, where the outcome is “excess” or “residual” in risk even after comprehensive, principled standardization and adjustment.

Our group, as well as others, chose federal poverty line as the SES measure of interest with ample evidence in the literature and policy.(20–22) We were quite surprised by weak signal conveyed in median income. Based on our findings, area-level race/ethnicity composition may need to be considered in penalty assessment. It might be necessary to re-evaluate the findings of previous studies demonstrating no or minimal impact of patient or hospital-related SES on ERRs in the light of our findings. For example, it would be informative to see whether previous analyses of financial impacts (3, 13, 14) would change if repeated with community-level race and SES variables. An interpretation is given as risk adjustment for SES reduces the proportion of low SES hospitals facing penalties by <5% on any given measure. However, 5% may be of practical importance on a “population” basis or disadvantaged subgroups, and even higher proportions could be resulted if different SES markers are used.(13, 23, 24)

To date, sociodemographic and SES variables in development and calculation of the readmission metrics have been excluded. The major argument has been that it would hold some hospitals to lower standards of quality, ultimately resulting in lower quality care for patients.(6, 8, 25) Another argument is that there should be no biological differences in survival or patient preferences that impacted survival among different racial/ethnic groups.(6) Studies have demonstrated marked difference in healthcare utilization and outcomes when examining the racial concordance of patient and physician.(26–30) Also, it has been reported that racial disparity could be greater than income disparity in HK(31). Interestingly for HK, correlation was highest for volume, lower for race and virtually null for poverty (r=0.5 vs. 0.2 vs. 0.0). Thus, CMS may pay attention to small hospitals performing HK surgery, and reassess how to best handle hospital/provider volume or size in model and policy decision.(17, 32, 33)

There is no single definition of a safety-net hospital, but typically based on income, poverty or deprivation indexes.(9, 10) Race composition may provide incremental information.(34) It is not fully clear, however, why percent of Black population showed stronger associations with 'excess' risk than percent of poor population, and why median income showed weak associations. Weak signals were also confirmed in our ancillary analyses with a crude, unstandardized outcome, readmission rate; thus standardization or not is not a sufficient explanation. One reason may be that percent of Black population might be more objective with less measurement error/misclassification, compared with economic attributes. The widely used poverty measures generally do not reflect geographical differences in cost of living, particularly, cost of healthcare.(18) Alternatively, the list of comorbidities adjusted for in the CMS models might not fully capture the underlying, time-varying health and condition of a patient, before/during/after hospitalization, including racial differences in biology, health and environment.(35) Further, differences in hospital infrastructure and resources and in relationship between patients and healthcare providers might contribute.(16, 35, 36) Perhaps, our study along with previous reports teaches us a reassuring lesson that development of very fair "expected" or "predicted" values in these statistical standardizations is an inherently difficult task.

The findings on ERR for HK, quite different from the 4 other conditions, warrant further investigation with respect to r≈0 with poverty, highest variability, and the role of hospital volume/size. Firstly, HK represents a surgical intervention, whereas the other conditions are of medical nature. Hence, outcomes can be more dependent on a select group of physicians and surgeons. Second, HK represents in the majority of cases an elective scenario, thus allowing patients the opportunity to wait and have more time to compare hospitals. Third, larger variability for HK may imply that there are explanatory variables that could be more relevant to surgery, such as the length of stay and surgeon's volume and experience.(19) Although the notion of *"Is bigger better?"* is frequently asked, the associated disparity/gap between large vs. small groups may be larger for HK or surgery in general, compared to medical conditions.(24, 37) Here, readers may say they anticipated the role of volume in HK (thus, no news here), but they should recall that study outcome is the "ratio", not rate or event (0/1), where a number of factors were already adjusted in the CMS models so that presumably a significant portion of disparity in the outcome should have been captured.

The limitations of our study should be noted. First, we conducted simple analyses on a small number of variables. However, our approach based on publicly available, hospital-level data (not patient-level data) could be appropriate for our purpose, because they represent an evaluation of already implemented policy, models and outcomes. Additionally, hospitals represent a study unit since they are directly affected by the penalties imposed. Second, we did not study a combination of covariates via interaction or subgroup. For example, we did not address who are the most disadvantaged (e.g., disadvantaged within the disadvantaged), and outcomes of the poor vs. the rich within the same medical center. This along with more sophisticated analyses for complex issues (e.g., race vs. SES, unmeasured bias, exposure vs. confounder vs. mediator) can be important topics in future. Third, our study addresses numerical correlation or association, not causation, which is a common limitation in most observational studies. Yet, it is widely perceived that SES is almost causal even though most evidence is destined to be observational or qualitative, not experimental. We could not elucidate a causal pathway from race to ERRs, nor assess modifiable, intermediate factors between them.(35) Finally, we did not adjust for multiple comparisons but presented or summarized all analyses conducted. Thus, some observations could be random so that validation is needed. Yet, p-value<0.0001 would be statistically significant even with conservative adjustment (e.g., Bonferroni), and we focused on the overall pattern and consistency of the findings, rather than hypothesis testing.

The strengths of our study include: a large, representative sample of hospitals and the use of publicly available and free-of-charge data of a "policy in place". Patients would use essentially the same set of *limited* variables to understand the quality of hospitals at the CMS websites, similar to other aggregate ranking or rating statistics for consumers (e.g., Gini index, GDP, college ranking). Our study could be timely (related to active, ongoing discussions and gathering of evidence for national forums and legislative proposals, that entail revisiting models and methods) and easily reproduced by interested parties. Further, the nature of the data in the public domain, coupled with widely used, easily understood variables, statistical tools and presentation, would enhance transparency, communication, understanding and consensus among different stakeholders in public policy.

Our study suggests that race and hospital volume can matter in the ERR context, independently and in addition to poverty. Hospitals face direct financial penalties, as well as the negative image consequences, among future patients who choose hospitals based on quality as presented by the published metrics. Based on measures available to CMS for the purposes of HRRP policy, we should discuss: why does race show larger correlation than poverty; what is the best SES measure(s); and what is the best approach to handling race, poverty and volume (and other factors not modifiable).

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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References

1. Readmissions Reduction Program (HRRP). https://www.cms.gov/Medicare/Medicare-Fee-for-Service-Payment/AcuteInpatientPPS/Readmissions-Reduction-Program.html.
2. Frishman WH, Alpert JS. Reducing hospital readmissions for cardiovascular disease: is it feasible? The American Journal of Medicine. 2013;126(9):753–4. [PubMed: 23968898]
3. Bernheim SM, Parzynski CS, Horwitz L, Lin Z, Araas MJ, Ross JS, et al. Accounting for patients' socioeconomic status does not change hospital readmission rates. Health Affairs. 2016;8:1461–70.
4. Demkowicz P The Blame Game of Hospital Readmissions http://www.yalescientific.org/2015/03/the-blame-game-of-hospital-readmissions/. 2015.
5. Keyhani S, Myers LJ, Chen R, Hebert P, Williams LS, Bravata DM. Effect of clinical and social risk factors on hospital profiling for stroke readmission. Annals of Internal Medicine. 2014;161:775–84. [PubMed: 25437405]
6. Normand S-LT, Shahian DM. Statistical and clinical aspects of hospital outcomes profiling. Statistical Science. 2007;22(2):206–26.
7. Barnett M, Hsu J, McWilliams J. Patient characteristics and differences in hospital readmission rates. JAMA Internal Medicine. 2015;175(11):1803–12. [PubMed: 26368317]
8. Gillespie L Missouri hospitals seek to focus readmission penalties on patient poverty. Kaiser Health News http://khn.org/news/missouri-hospitals-seek-to-focus-readmission-penalties-on-patient-poverty/. 2016.
9. Kind AJH, Jencks S, Brock J, Yu M, Bartels C, Ehlenbach W, et al. Neighborhood socioeconomic disadvantage and 30-day rehospitalization: A retrospective cohort study. Annals of Internal Medicine. 2014;161:765–74. [PubMed: 25437404]
10. Sheingold SH, Zuckerman R, Shartzer A. Understanding Medicare hospital readmission rates and differing penalties between safety-net and other hospitals. Health Affairs. 2016;1:124–31.
11. van Walraren C The utility of unplanned early hospital readmissions as a health care quality indicator. JAMA Internal Medicine. 2015;175(11):1812–4. [PubMed: 26367518]
12. Chin DL, Bang H, Manickam RN, Romano PS. Rethinking thirty-day hospital readmissions: shorter intervals might be better indicators of quality of care. Health Affairs. 2016;35(10):1867–75. [PubMed: 27702961]
13. Martsolf GR, Barrett ML, Weiss AJ, Kandrack R, Washington R, Steiner CA, et al. Impact of race/ethnicity and socioeconomic status on risk-adjusted hospital readmission rates following hip and knee arthroplasty. J Bone Joint Surg Am. 2016;98:1385–91. [PubMed: 27535441]
14. Martsolf GR, Barrett ML, Weiss AJ, Washington R, Steiner CA, Mehrotra A, et al. Impact of race/ethnicity and socioeconomic status on risk-adjusted readmission rates: implications for the Hospital Readmissions Reduction Program. Inquiry. 2016;53:1–9.
15. Manickam RN, Mu Y, Kshirsagar A, Bang H. Area-level poverty and excess hospital readmission ratio. American Journal of Medicine. 2017;130(4):e153–5. [PubMed: 28325228]
16. O'Brien JJM,. Why is it always about race with you Americans? Crit Care Med. 2009;37(1):324–5. [PubMed: 19112283]
17. Ash A, Fienberg S, Louis T, Normand S, Stukel T, Utts J. Statistical issues in assessing hospital performance. Commissioned by the Committee of Presidents of Statistical Societies. The COPSS-CMS White Paper Committee. 2012:1–70.
18. http://www.census.gov/topics/income-poverty/poverty/about/history-of-the-poverty-measure.html.
19. Gu AG, McAlister FA, Bakal JA, Ezekowitz JE, Kaul P, van Walraren C. Predicting the risk of unplanned readmission or death within 30 days of discharge after a heart failure hospitalization. American Heart Journal. 2012;164:365–72. [PubMed: 22980303]
20. Williams DR, Mohammed SA, Leavell J, Collins C. Race, socioeconomic status, and health: Complexities, ongoing challenges, and research opportunities. Ann N.Y. Acad. Sci 2010;1186:69–101. [PubMed: 20201869]
21. Chetty R, Stepner M, Abraham S, Lin S, Scuderi B, Turner N, et al. The association between income and life expectancy in the United States, 2001–2014 JAMA. 2016;15(16):1750–66.

22. Hahn RA, Eaker E, Baker ND, Teutsch SM, Sosniak W, Krieger N. Poverty and death in the United States: 1973 and 1991. Epidemiology. 1995;6(5):490–7. [PubMed: 8562624]

23. Rose G Sick individuals and sick populations. International Journal of Epidemiology. 1985;14(1): 32–8. [PubMed: 3872850]

24. Weinberg C, Zaykin D. Is bad luck the main cause of cancer? J National Cancer Institute. 2015;107(7):pii: djv125.

25. The hospital readmission penalty: How well is it working?. http://www.medpac.gov/-blog-/medpacblog/2015/03/24/the-hospital-readmission-penalty-how-well-is-it-working.

26. Sweeney CF, Zinner D, Rust G, Fryer GE. Race/Ethnicity and Health Care Communication: Does Patient-Provider Concordance Matter? Medical Care. 2016;54:1005–9. [PubMed: 27213546]

27. Chen J, Rathore SS, Radford MJ, Wang Y, Krumholz HM. Racial differences in the use of cardiac catheterization after acute myocardial infarction. NEJM. 2001;344:1443–9. [PubMed: 11346810]

28. Powe NR, Cooper LA. Diversifying the racial and ethnic composition of the physician workforce. Annals of Internal Medicine. 2004;141(3):223–4. [PubMed: 15289221]

29. Freedman RA, Kouri EM, West DW, Keating NL. Racial/ethnic differences in patients' selection of surgeons and hospitals for breast cancer surgery JAMA Oncology. 2015;1(2):222–30. [PubMed: 26181027]

30. Schulman KA, Berlin JA, Harless W, Kerner JF, Sistrunk S, Gersh BJ, et al. The effect of race and sex on physicians' recommendations for cardiac catheterization. NEJM. 1999;340(8):618–26. [PubMed: 10029647]

31. Bang H, Chiu YL, Memtsoudis SG, Mandl LA, Della Valle AG, Mushlin AI, et al. Hip and knee arthroplasties: trends and disparities revisited. American Journal of Orthopedics. 2010;39(9):E95–102. [PubMed: 21290031]

32. He K, Kalbfleisch J, Li Y, Li Y. Evaluating hospital readmission rates in dialysis facilities; adjusting for hospital effects. Lifetime Data Analysis. 2013;19(4):490–512. [PubMed: 23709309]

33. Normand S-LT, Glickman ME, Gatsonis CA. Statistical methods for profiling providers of medical care: issues and applications. JASA. 1997;92(439):803–14.

34. Joynt K, Orva E, Jha A. Thirty-day readmission rates for Medicare beneficiaries by race and site of care. JAMA. 2011;305(7):675–81. [PubMed: 21325183]

35. Howard G, Moy CS, Howard VJ, McClure LA, Kleindorfer DO, Kissela BM, et al. Where to focus efforts to reduce the Black–White disparity in stroke mortality: Incidence Versus Case Fatality? Stroke. 2016.

36. Corbie-Smith G, Thomas SB, St. George MM. Distrust, race and research. Archives of Internal Medicine. 2002;162:2458–63. [PubMed: 12437405]

37. Posnett J Is bigger better? Concentration in the provision of secondary care. BMJ. 1999;319(7216): 1063–5. [PubMed: 10521207]

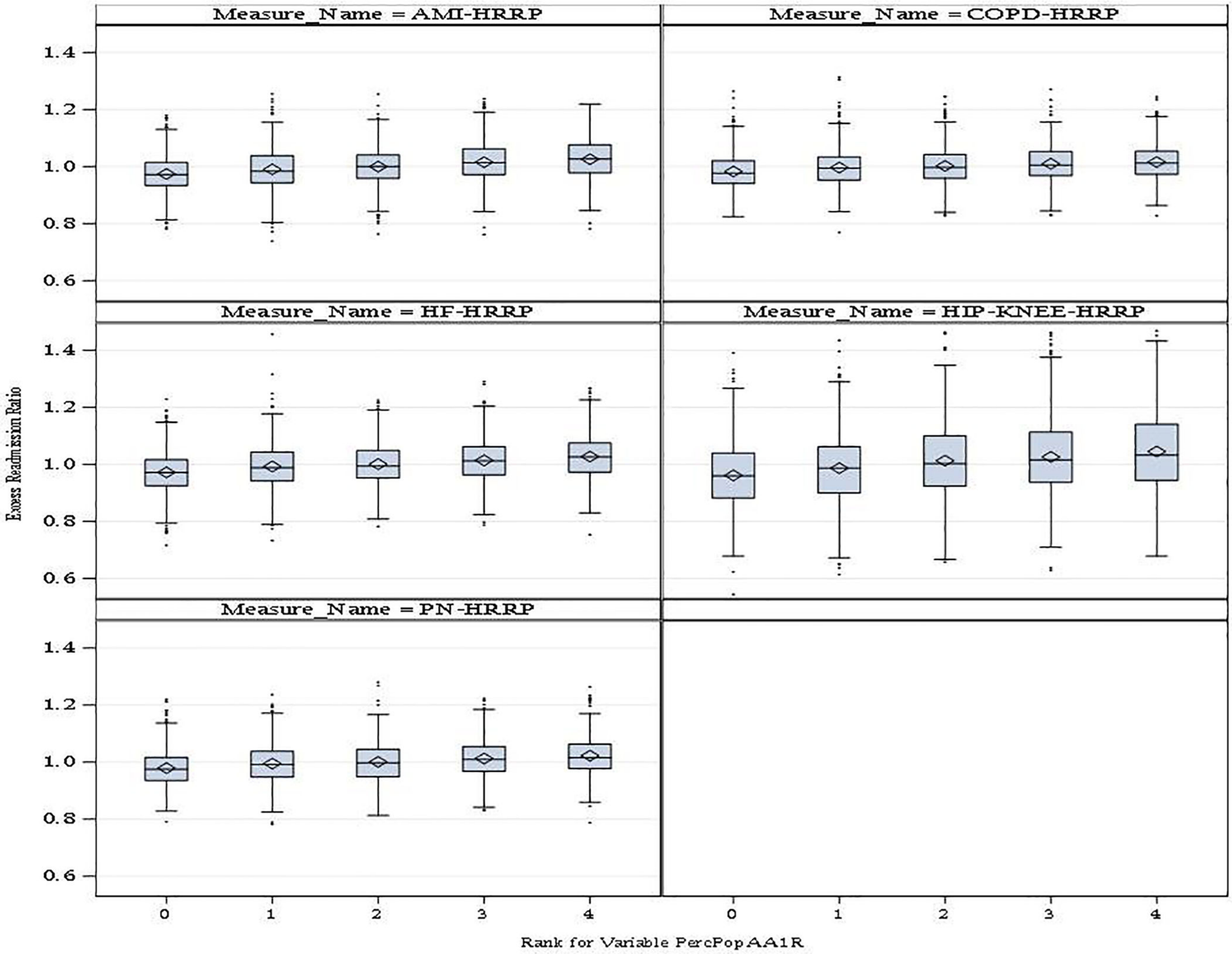

Figure 1. Box Plots for Excess Readmission Ratios by Percent of Black residents for 5 Conditions

The horizontal lines of the box represent the first, second and third quartiles, with the diamond indicating the mean. The whiskers are drawn to the most extreme points in the group that lie within the fences, where the upper/lower fence is defined as the third/first quartile plus/minus 1.5 times the interquartile range. Five conditions are: myocardial infarction, heart failure, pneumonia, chronic obstructive pulmonary disease, and total hip and knee arthroplasty.

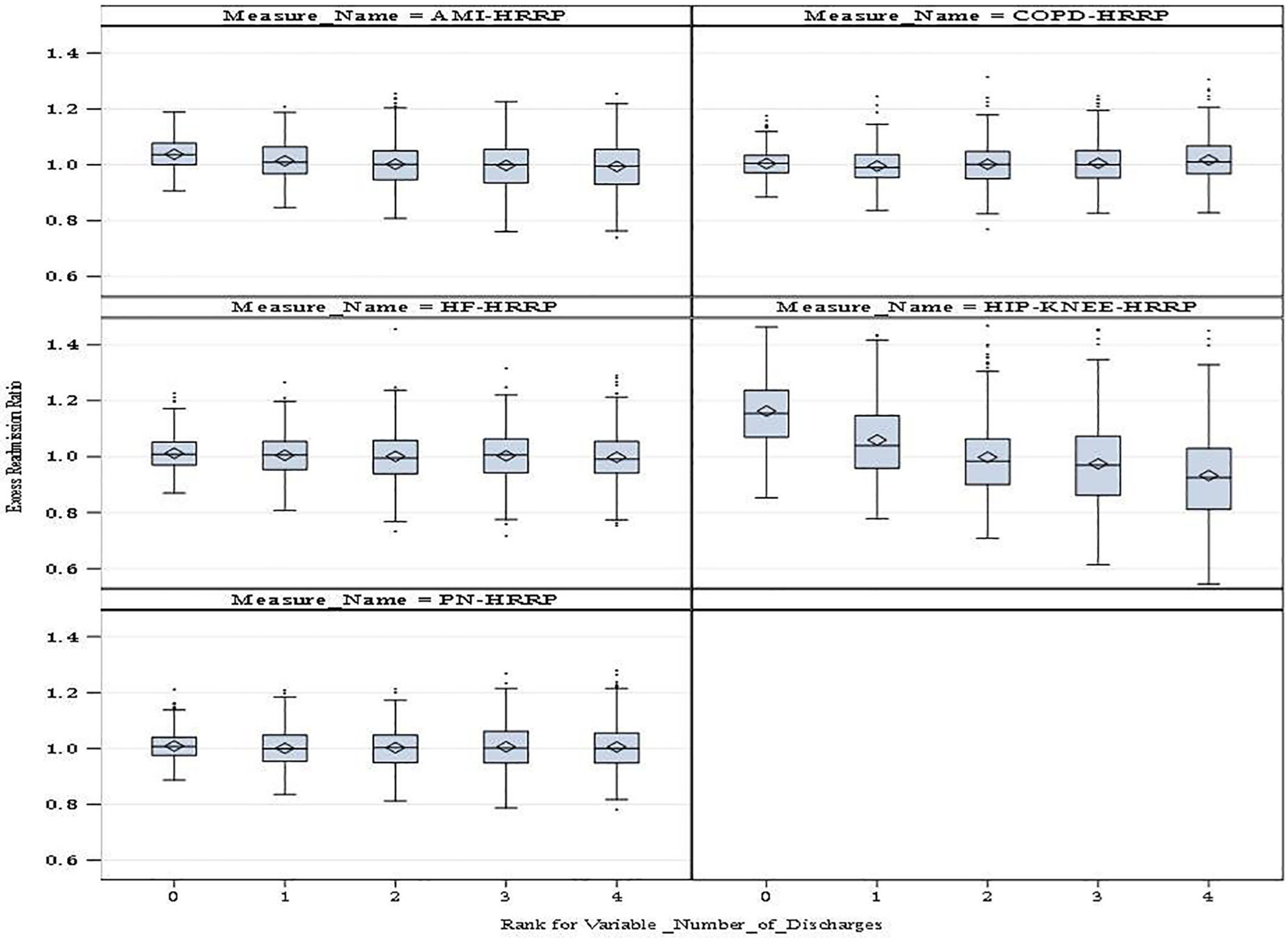

Figure 2. Box Plots for Excess Readmission Ratios by Hospital Volume for 5 Conditions

Hospital volume was measured by the number of discharges for each medical condition. See the footnote of Figure 1.

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Table 1.

Descriptive Statistics for Poverty, Race and Hospital Volume

Three primary measures are boldfaced. COPD denotes chronic obstructive pulmonary disease.

Variables	N of Hospitals	Mean (Standard deviation)	Median (Interquartile range)
Area-level characteristic	3309		
% of Poverty		17.1 (6.4)	16.8 (13.1–20.5)
Median income		$53966 (16973)	$50292 (42984–60115)
% of Black (one race)		12.6 (14.0)	7.2 (2.3–19.0)
% of Black (multi races)		13.7 (14.1)	8.3 (3.1–20.4)
% of Hispanic		14.6 (16.7)	7.8 (3.3–19.8)
% of White (one race)		75.4 (17.2)	79.1 (64.8–89.3)
Hospital volume (number of discharges)			
Myocardial infarction	1754	265 (221)	203 (113–344)
COPD	2687	314 (235)	252 (149–414)
Heart failure	2757	398 (344)	300 (154–535)
Hip-Knee	1339	559 (463)	428 (290–686)
Pneumonia	2728	326 (233)	264 (162–416)

Table 2.

Correlation of ERR with Poverty, Race and Hospital Volume for 5 Conditions

Bold when correlation is ≥0.15 in absolute value (so 0.20 after rounding). P-values are unadjusted for multiple comparisons. ERR denotes excess readmission ratio. COPD denotes chronic obstructive pulmonary disease.

	Correlation of ERR (p-value)		
Medical Condition	**With Poverty**	**With Race**	**With Volume**
Myocardial infarction	0.08 (0.0001)	**0.24** (<0.0001)	**−0.19** (<0.0001)
COPD	0.06 (0.001)	**0.18** (<0.0001)	0.07 (0.0007)
Heart failure	0.13 (<0.0001)	**0.23** (<0.0001)	−0.06 (0.003)
Hip-Knee	0.01 (0.62)	**0.20** (<0.0001)	**−0.48** (<0.0001)
Pneumonia	0.09 (<0.0001)	**0.22** (<0.0001)	−0.02 (0.36)