CENTER FOR OUTCOMES RESEARCH AND EVALUATION

MEMORANDUM

TO: NQF Cost and Resource Use Standing Committee
FROM: Nancy Kim and Susannah Bernheim, Yale New Haven Health Services Corporation - Center for Outcomes Research and Evaluation (CORE)
THROUGH: Lein Han, CMS
DATE: Monday, October 5, 2015
SUBJECT: Empiric analyses for payment measures in the sociodemographic status (SDS) trial period

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The National Quality Forum (NQF) endorsed three payment measures, developed by the Center for Outcomes Research and Evaluation (CORE) under contract with the Centers for Medicare & Medicaid (CMS), in 2014 with the consideration that additional testing and analyses, focusing on sociodemographic status (SDS) risk factors, is performed and considered under an ad hoc review process by the NQF Cost and Resource Use Standing Committee (hereinafter "Standing Committee"). Consequently, NQF staff proposed, evaluated, and finalized a two-staged process that includes the following: Webinar #1 conceptual analysis and determination of SDS variables to be used in empiric analysis and Webinar #2 empiric analysis.

Webinar #1 took place on May, 21, 2015. During this meeting Yale presented an initial conceptual framework for the causal pathways by which SDS may influence episode payments and presented the variables that we planned to use in the empiric analysis. In response to Webinar #1, the Standing Committee recommended that Yale broaden the conceptual model and literature review to determine if there were other variables that would merit consideration in risk-adjustment. They further suggested that Yale consider a number of variables including race and Medicaid status. With regard to race, the Standing Committee specifically felt that further literature review was necessary "to determine the within and between effects of race on hospital performance."[i]

In this memo, we provide:

1) A revised conceptual model;
2) A summary of the expanded literature review with a particular focus on within and between effects of race on health outcomes; and
3) Empiric analyses that examine the effect of adjustment for race (black/non-black) and Medicaid status on hospital-level risk-standardized payments for the three payment measure conditions (acute myocardial infarction [AMI], heart failure [HF], and pneumonia [PN]).

[i] "Meeting Summary: Cost and Resource Use Standing Committee Webinar: Discussion of Conceptual Relationships between SDS Variables and Payment Outcomes: May 21, 2015 (2-4pm ERT)" via correspondence with Ashlie Wilbon, NQF, June 2015.

This memo and conceptual model pertain to the following three measures:

- NQF #2431: Hospital-level, risk-standardized payment associated with a 30-day episode-of-care for Acute Myocardial Infarction (AMI) (CMS/Yale)
- NQF #2436: Hospital-level, risk-standardized payment associated with a 30-day episode-of-care for Heart Failure (HF) (CMS/Yale)
- NQF #2579: Hospital-level, risk-standardized payment associated with a 30-day episode of care pneumonia (CMS/Yale)

SECTION 1. UPDATED CONCEPTUAL APPROACH TO RISK-ADJUSTMENT

For Webinar #1, we presented a conceptual framework with which we approached risk-adjustment. The conceptual model was not intended to be an exhaustive overview of the many ways that SDS factors can affect population health but rather a focused view of the hospital experience guided by a narrow question of whether or not to risk adjust our payment measures. The Standing Committee provided feedback on the conceptual model and felt that the model should be broadened to account for more public health variables. Specifically, they felt the model should: 1) more explicitly include community, environmental, or patient factors, 2) differentiate lack of patient resources from lack of community resources, 3) reflect resources available for care within individual hospitals, and 4) change "patient behavior" title as it seemed to blame patients for poor outcomes.

In response to the above recommendations, we have made a number of modifications to highlight the context of the patient's community and larger environment both before and after admission to the hospital (Appendix 1). We have changed the titles within pre-admission and post-discharge to capture the many patient and community factors that reflect differential SDS and can impact episode of care payments. We have changed the title "patient behavior" to patient factors in the post-discharge setting. Additionally, given the chance to revisit the model, we chose to reorient the model to emphasize the potential pathways by which low SDS may be exerting influence on care provided by hospitals that may be captured in the episode of care payments.

SECTION 2. UPDATED LITERATURE REVIEW

For Webinar #1, we performed three focused literature reviews to examine the relationship between socioeconomic status (SES) and/or sociodemographic factors and costs associated with AMI, HF, or pneumonia care. In the course of the discussion of the conceptual model and the potential pathways by which low sociodemographic status (SDS) may exert influence on health outcomes or payments, the Standing Committee asked for an expanded literature review to determine: 1) whether other SDS factors should be considered for risk-adjustment and 2) the within and between effects of race on hospital performance.

In response to NQF Webinar #1, we further examined the medical literature that assessed the association of SDS and health outcomes beyond cost and payment, with a particular focus on the

hospital's role in healthcare outcomes. We reviewed a number of studies shared by Standing Committee member, Dr. Andrew Ryan as well as additional relevant articles.

In total, we evaluated 14 articles (Appendix 2). Based on the Standing Committee's recommendations, we organized the articles conceptually by their focus on the following categories: 1) "within hospital" papers; i.e. those examining differences in quality or outcome between populations of different SDS cared for in the same institution, and 2) "between hospital" differences between populations of different SDS, i.e. papers examining whether minorities or patients of low socioeconomic status are cared for at lower quality hospitals based on outcomes.

Among the four articles that examined only within hospital differences in outcomes, all used race/ethnicity as their independent variable.[1-5] These articles had mixed findings and most focused on cardiovascular diseases and procedures. Gaskin et al. found that whites and minorities received the same quality of care as measured by AHRQ inpatient quality (mortality after certain procedures or conditions) and safety (complications and adverse events following surgeries and procedures) indicators.[1] In contrast, Schulman et al found that race and gender, independent of clinical factors, influenced physician management of chest pain.[2] Similarly Chen et al. and Epstein et al. found that blacks received fewer invasive procedures for AMI that whites.[3-5] Further, Chen et al. exposed the complexity of this relationship demonstrating that despite differences in the receipt of intermediate outcomes such as invasive procedures, mortality between blacks and whites was no different.[4,5] Taken together these papers do not present a conclusive or consistent picture about the role of within hospital differences in treatment of patients based on SDS nor the subsequent impact on outcomes or cost. However they provide some evidence that in certain settings differential care by race could contribute to differences in costs and outcome.

To gain further insights into the interplay between the hospital and SDS variables, we reviewed nine articles that examined between hospital differences in outcomes.[6-14] Among these, several also examined within hospital differences. Two focused specifically on the use of lower quality hospitals by minorities.[9,10] Eight analyzed the effect of race while only one, Reames et al.,[6] used Census derived SES data as their independent variable. In general, these articles consistently found both within and between hospital differences across a breadth of outcomes including inpatient perioperative complications, cardiovascular procedures, readmission rates, and mortality rates. Helland et al. found that black race was associated with reduced spending for heart conditions, but the race effect went away after considering blacks from out of state, suggesting that local care was responsible for disparities.[7] The two articles that examined the use of lower quality hospitals by minorities offered different conclusions. Gaskin et al. examined black, Hispanic, and Asians,[10] while Dimick et al. looked only at blacks versus whites.[9] Gaskin et al. found that minorities do not necessarily use lower quality hospitals and this type of characterization will differ based on the choice of quality indicator.[10] Dimick et al. found a strong relationship between racial segregation and use of low-quality hospitals.[9]

Summary: Taken together, the body of literature reveals an inconsistent and complex association of low SDS and health outcomes. Most studies used race as their independent variable with less attention to income or other measures of poverty (e.g. Medicaid status). The literature demonstrates both within and between hospital differences in outcomes among racial/ethnic groups that can be partially explained by the use of lower quality hospitals by minorities.

SECTION 3. EMPIRIC ANALYSES

To investigate the impact of adding SDS variables to the episode of care payment models for the three conditions, we performed a number of empiric analyses. We used the same strategy for each condition. To facilitate review of our results, we briefly outline our step-wise approach after we selected the SDS variables.

We began by examining the prevalence of SDS variables in each cohort (AMI, HF, pneumonia) and the distribution of SDS variables across hospitals. We then analyzed the bivariate relationship between SDS variables and total payment at the patient level as well the impact on other covariates when SDS variables were added. We then performed a number of model diagnostics to assess model performance when SDS variables were added and further considered the model performance among subgroups (black/non-black and Medicaid/non-Medicaid). We then evaluated the correlation of SDS variables and finally investigated the hospital risk-standardized payment when SDS variables added

3.1 Variable Selection

We selected SDS variables based on our literature review and their availability in national data sources. Few SDS variables are available nationally at a patient-level and can be linked to Medicare data. We settled on race and a variable that would proxy for low-income as the only two feasible patient-level SDS variables to examine directly. This was discussed with the NQF Cost and Resource use Committee during Webinar #1. The Committee was in favor of this approach and did not recommend the use of the 5-digit zip code data as a proxy for low SDS.

3.2 Description of Variables

The two SDS variables we chose to use for race and low-income in the empiric analyses are found in CMS administrative claims data.

For the race variable, we used Beneficiary Race Code. This has been used for CORE disparities analyses in the past and is present in the data used for 2015 production of the payment measures. We considered creating categorizations of black/white/other or black/white/other/Hispanic, but data from CMS suggests that black and white are the only categories with both high sensitivity and specificity in the Beneficiary Race Code variable (Table 1). Therefore, we created an indicator variable for black/non-black for use in our empiric analyses.

Table 1. Medicare Race and Ethnicity Data Validation Results[α]

	Accuracy Measures for CMS EDB				
Racial/Ethnic Classification	Sensitivity	Specificity	PPV	NPV	Kappa
White	99.3	92.9	98.7	96.1	0.93
Black	98.2	99.6	96.8	99.8	0.97
Hispanic	28.6	99.9	96.7	94.2	0.42

[α] Source: Validating Medicare's Race and Ethnicity Data. Kimberly Proctor and Carla Hodge. CMS, Office of Minority Health. (Using 2010 and 2000 Census data and 2011-2009 American Community Survey)

	Accuracy Measures for CMS EDB				
Asian/Pacific Islander	57.4	99.8	91.4	98.6	0.70
American Indian/Alaska Native	54.3	99.9	71.9	99.7	0.62
Other	15.7	98.3	0.6	99.9	0.01

As a proxy for low-income, we chose Medicaid enrollment. After discussion with Committee members who have used a different approach to define low-income status, we performed analyses among potential low-income proxy variables and chose to use Dual Status Code. Specifically, where Dual Status Code equaled 01, 02, 03, 04, 05, 06, or 08 (indicating full or partial Medicaid benefits) we categorized patients as "Medicaid". All other patients were categorized as "Non-Medicaid." The Dual Status Code variable has been used for CORE payment measure disparities analyses in the past. Ultimately, we chose to use the Dual Status Code variable as a marker of poverty because we felt it best reflected those with the lowest income. Additionally, CCW and ResDAC technical guidelines suggest that this variable best captures beneficiaries that are dual eligible (i.e. also receiving Medicaid benefits).

CORE currently has access to the race variable for the full current public reporting periods (July 2011 to June 2014), however we only have access to the Medicaid variable for July 2011 to December 2013. To maintain consistency in these empiric analyses, we chose to use the two and a half year span from July 2011 to December 2013 for all analyses.

3.3 Methods

We began our analyses on the effect of the addition of SDS variables to the payment models at the patient level. This is aligned with our general approach to considering clinical risk-adjustment variables for inclusion during measure development. We examined changes in predicted total episode standardized payments with the addition of the SDS variables at the patient level and computed summary statistics to assess model performance: predictive ratios by deciles and top 1% of predicted payment and quasi-R^2.[y] We compared residuals for subgroups of patients (i.e. black/non-black; Medicaid/non-Medicaid) to discern whether the addition of SDS variables produced a better model fit for those subgroups. We also investigated whether the SDS variables were strongly correlated (i.e. collinear) with one another or with any other risk-adjustment variables.

We then conducted analyses to examine whether hospital-level RSPs were affected by the inclusion of SDS variables in the payment model. We compared the distributions of RSPs calculated with and without the addition of each SDS variable. We used a Spearman rank correlation coefficient to examine whether the ranking of hospitals' RSP estimates shifted with the addition of the SDS variables. We also examined the percent change in same-hospital RSPs with the addition of the SDS variables.

[y] A predictive ratio is an estimator's ratio of predicted outcome to observed outcome. A predictive ratio of 1.0 indicates an accurate prediction. A ratio greater than 1.0 indicates overprediction, and a ratio less than 1.0 indicates underprediction. The quasi-R^2 calculated is the R^2 from a regression of observed outcome on the predicted outcome. (Reference: Jones AM. Models for Health Care. Health, Econometrics and Data Group (HEDG) Working Papers. 2010.)

3.4 Summary of Results

To facilitate discussion of the results, we are providing a summary of key findings. We begin with the results of the hospital-level RSP analyses since the question posed by NQF is whether the measure outcome, or RSP, is affected by the addition of SDS variables. We then provide patient-level results. Additional, detailed results are available on request.

Overall we found that there is minimal association between race and/or Medicaid status and the episode of care payment. Specifically, the addition of the race and/or the Medicaid variable to the payment model had little to no effect on hospital RSPs (Tables 4; 13; 22) for all three payment measure conditions. The Spearman rank correlation coefficients showed very little difference between the ranking of RSPs produced by original model and those produced by the model that included the SDS variables. The overall change in RSPs was minimal. The average percent change in same-hospital RSPs for all three of the payment measures was effectively 0 after adding the SDS variable(s) (Tables 5-6; 14-15; 23-24). Thus, the impact of these SDS variables was small to negligible on hospital profiling.

At the patient level, for most variable/condition combinations, we saw little change in predicted total episode payments when the SDS variables were added to the model. However, the relationship between AMI payment and race was slightly more substantial. Though the coefficients for both race and Medicaid were statistically significant for all models, the large sample size should be taken into account when considering significance. Moreover, for some variable/condition combinations, the relationship between the SDS variables and payment is in the opposite direction than what has been the expressed concern of stakeholders interested in adding such adjustment to the models. For example, the relationship between AMI payment and race indicates that an AMI episode of care is significantly less expensive for black patients than for non-black patients.

We also found that the impact of the SDS variables was small to negligible on model performance. There was no appreciable difference in the coefficients of the other risk-adjustment variables after adding race and/or Medicaid or race and Medicaid and an interaction between race and Medicaid to the model. Similarly, the results of the collinearity analyses did not suggest that there is a significant relationship between the race and Medicaid variables or between these variables and any other risk-adjustment variables in the model.

3.5 Conclusion

The addition of race and/or Medicaid status had a negligible impact on hospital RSPs, and are therefore unlikely to affect hospital profiling. Additionally, the direction of the association of race and/or Medicaid status (whether their addition increased or decreased predicted total episode payment) was not consistent across the three conditions (AMI, HF, pneumonia).

3.5 Condition-Specific Results: AMI Payment

3.5.1 Cohort

The AMI payment cohort, based on July 2011-December 2013 data, included 379,923 index admissions (Table 2). Among black patients, 41.86% were also receiving Medicaid benefits and among Medicaid patients, 17.31% were black. 3.33% of the total index admissions were both black and Medicaid patients. This indicates that there is not substantial overlap in the populations captured by these variables.

Table 2. Prevalence of SDS factors in AMI payment measure cohort

Variable category	Number of index admissions (% of total index admissions)
Black	30,249 (7.96%)
Non-Black	349,674 (92.04%)
Medicaid	73,151 (19.25%)
Non-Medicaid	306,772 (80.75%)
Black and Medicaid	12,663 (3.33%)

The prevalence of SDS factors in the AMI payment cohort varies substantially across hospitals (Table 3). For hospitals whose AMI payment measure results are publicly reported (i.e. those with at least twenty-five cases during the measurement period) the percent of index admissions that were black ranged from 0% to 100%, with a mean of 8.6% and a median of 3.4% (IQR 0% to 10.3%). For these hospitals, the percent of index admissions that were receiving Medicaid benefits ranged from 0% to 91.9%, with a mean of 21.5 % and a median of 17.7% (IQR 11.8% to 26.8%).

Table 3. Distribution of percent Black and Medicaid index admissions in AMI payment measure cohort across hospitals

Distribution	% Black index admissions		% Medicaid index admissions	
	All hospitals (N=4,287)	Hospitals with at least 25 cases (N=2,287)	All hospitals (N=4,287)	Hospitals with at least 25 cases (N=2,287)
Minimum	0	0	0	0
10th Percentile	0	0	0	8.1
25th Percentile	0	0.71	10.8	11.8
Median	0.67	3.4	20.0	17.7
Mean	7.5	8.6	25.6	21.5
75th Percentile	7.7	10.3	34.7	26.8
90th Percentile	23.0	22.9	53.8	40.0
99th Percentile	77.8	67.3	100	75.9
Maximum	100	100	100	91.9

3.5.2 Hospital-Level Results

For AMI, the addition of the race variable had virtually no impact on the overall distribution of hospital-level RSPs (Table 4). Moreover, a Spearman rank correlation coefficient[†] (rho) of 0.997 (p<=0.0001) indicated that the ranking of hospital RSPs were virtually unchanged after the addition of the race variable. The findings were similar for both the addition of the Medicaid variable alone as well as the addition of the race and Medicaid variable together. The Spearman rank correlation coefficients were 0.999 (p<=0.0001) and 0.996 (p<=0.0001), respectively.

Roughly 97% of hospitals showed less than a 1% change in RSP when the race variable was added to the risk-adjustment model (Table 5). The maximum change for any hospital was 5% (Table 6). The finding was similar for the addition of the Medicaid variable alone, where nearly all hospitals showed less than a 1% change in RSP and the maximum change was 1% as well as for the addition of the race and Medicaid variable together, where roughly 97% of hospitals showed less than a 1% change in RSP and the maximum change was 5%.

Summary: These analyses indicate that the addition of the race and/or the Medicaid variable to the risk-adjustment model had little to no effect on overall and same-hospital RSPs.

Table 4. AMI RSPs calculated with the current model vs. the current model with the addition of SDS variables

Variables included in model	Number of Hospitals	Minimum	Median	Mean	Standard Deviation	Maximum
Current[*]	4,287	$13,760	$21,635	$21,806	$1,350	$29,594
Current + Black	4,287	$13,688	$21,642	$21,807	$1,359	$29,547
Current + Medicaid	4,287	$13,712	$21,634	$21,806	$1,349	$29,537
Current + Black + Medicaid	4,287	$13,655	$21,641	$21,806	$1,358	$29,507

Table 5. Percent change in AMI RSPs calculated with the addition of SDS variables to the current model

Variables included in model	% Change in RSP	Number of Hospitals	% of Hospitals
Current[*] + Black	- 1[+]	0	0
	- 0-1	3,326	77.6
	0-1	829	19.3
	1[+]	132	3.1
Current + Medicaid	- 1[+]	0	0
	- 0-1	2,441	56.9
	0-1	1,843	43.0
	1[+]	3	0.1
Current + Black + Medicaid	- 1[+]	0	0
	- 0-1	3,043	71.0
	0-1	1,099	25.6
	1[+]	145	3.4

[†] A Spearman correlation coefficient, rho, equal to 1 indicates that the ranking of hospital RSPs were virtually unchanged after the addition of the race variable

[*] Current indicates inclusion of all current risk-adjustment variables (age, comorbidities)

Table 6. Distribution of percent change in AMI RSPs with addition of SDS variables to the current model

Distribution	Current* + Black (% RSP Change)	Current + Medicaid (% RSP Change)	Current + Black + Medicaid (% RSP Change)
Minimum	-0.53	-0.38	-0.76
10th Percentile	-0.31	-0.18	-0.36
25th Percentile	-0.19	-0.087	-0.2
Median	-0.064	-0.013	-0.054
Mean	0.00084	0.00013	0.00093
75th Percentile	-0.0079	0.054	0.021
90th Percentile	0.34	0.17	0.37
99th Percentile	1.91	0.58	1.88
Maximum	5.06	1.11	5.00

3.5.3 Patient-Level Results

While our primary goal was to assess the effect of the addition of SDS variables on hospital RSPs, we began our analyses, as we do when building any outcome measure, at the patient level. The results of these analyses may help to inform the hospital-level results seen above.

We began by assessing the individual relationship between the payment outcome and the SDS variables. A bivariate regression (i.e. a regression of total episode payment on the individual SDS variables) indicated little to no effect on total episode payment (Table 7).

Table 7. Bivariate relationship between total AMI payment and SDS variables[ŧ]

Variables included in model	Estimate	Payment Ratio[r]	p-value
Black	0.0085	1.01	0.0261
Medicaid	0.0048	1.00	0.0657

The bivariate regression between total payment and the race variable estimated that payments were, on average, roughly 1% higher for black index admissions than for non-black index admissions (payment ratio of 1.01). The bivariate regression between total payment and the Medicaid variable estimated that payments were, on average, roughly the same as for non-Medicaid index admissions (payment ratio of 1.00).

We then added the SDS variables to the current risk-adjustment model, both individually and jointly (Table 8). With the sole addition of race to the patient-level model, black index admissions were estimated to be roughly 6% less expensive than non-black index admissions (payment ratio of 0.94). With the sole addition of Medicaid status to the patient-level model, Medicaid index admissions were estimated to be 2% less expensive than non-Medicaid index admissions (payment ratio of 0.98). With the addition of both race and Medicaid status to the model, the same individual results hold. The interpretation of these results is that, holding all other risk-

* Current indicates inclusion of all current risk-adjustment variables (age, comorbidities)
ŧ Used log link and inverse Gaussian distribution as with current AMI payment measure patient-level model
r Payment ratio is equal to exponentiated estimate

adjustment variables constant, both black and Medicaid patients are slightly less expensive for an AMI episode of care than non-black and/or non-Medicaid patients.

Table 8. Relationship between total AMI payment and SDS variables[t]

Variables included in model	Variable	Estimate	Payment Ratio[r]	p-value
Current[*] + Black	Black	-0.062	0.94	<0.0001
Current + Medicaid	Medicaid	-0.023	0.98	<0.0001
Current + Black + Medicaid	Black	-0.058	0.94	<0.0001
	Medicaid	-0.017	0.98	<0.0001

3.5.4 Model Diagnostics

Model Performance

The addition of the SDS variables to the patient-level model did not significantly improve model performance compared the current model as demonstrated by the comparison of predictive ratios and quasi-R^2s (Table 9).

Table 9. AMI payment model performance

Diagnostic[y]	Current[*]	Current + Black	Current + Medicaid	Current + Black + Medicaid
Predictive Ratio, 1st Decile (lowest)	0.9540	0.9546	0.9535	0.9537
Predictive Ratio, 2nd Decile	1.0021	1.0028	1.0031	1.0025
Predictive Ratio, 3rd Decile	1.0098	1.0113	1.0114	1.0128
Predictive Ratio, 4th Decile	1.0290	1.0221	1.0206	1.0207
Predictive Ratio, 5th Decile	1.0492	1.0506	1.0544	1.0525
Predictive Ratio, 6th Decile	1.0521	1.0540	1.0510	1.0555
Predictive Ratio, 7th Decile	1.0302	1.0274	1.0331	1.0258
Predictive Ratio, 8th Decile	0.9907	0.9962	0.9903	0.9951
Predictive Ratio, 9th Decile	0.9590	0.9553	0.9594	0.9584
Predictive Ratio, 10th Decile (highest)	0.9356	0.9363	0.9343	0.9340
Quasi-R^2	0.0717	0.0722	0.0719	0.0724

[t] Used log link and inverse Gaussian distribution as with current AMI payment measure patient-level model
[r] Payment ratio is equal to exponentiated estimate
[*] Current indicates inclusion of all current risk-adjustment variables (age, comorbidities)
[y] A predictive ratio is an estimator's ratio of predicted outcome to observed outcome. A predictive ratio of 1.0 indicates an accurate prediction. A ratio greater than 1.0 indicates overprediction, and a ratio less than 1.0 indicates underprediction. The quasi-R^2 calculated is the R^2 from a regression of observed outcome on the predicted outcome. (Reference: Jones AM. Models for Health Care. Health, Econometrics and Data Group (HEDG) Working Papers. 2010.)

Residual Analysis

To assess whether the addition of the SDS variables produced a better model fit (i.e. improved the predicted total payment) for sub-groups of patients, we compared residuals[Φ] from the current model to the residuals after the SDS variables were added (Table 10). Model fit was improved, on average, for all sub-groups (though the addition of a variable is likely to produce this result for any model). The prediction for black patients improved more than the prediction for non-black patients. The same is true for Medicaid and non-Medicaid patients, though the magnitude of improvement is decreased.

Table 10. Average residual for current model vs. current model with the addition of SDS variables for sub-groups of patients

Variable category	Current[*] ($)[ת]	Current + Black + Medicaid ($)[ת]
Black	-1,233	-8
Non-Black	192	87
Medicaid	-488	-116
Non-Medicaid	214	126

Collinearity Analyses

With respect to assessing collinearity among the variables, the addition of the SDS variables did not increase the standard errors of the current risk-adjustment variables or appreciably alter their estimated coefficients (Appendix 3; full results available upon request). However, formal testing for collinearity among the risk-adjustments variables after the addition of the SDS variables was also performed (analyses available upon request). No indications of collinearity were found.

[Φ] The residual is the difference between the observed total payment and the predicted total payment
[*] Current indicates inclusion of all current risk-adjustment variables (age, comorbidities)
[ת] Values are in standardized dollars

3.6 Condition-Specific Results: HF Payment

3.6.1 Cohort

The HF payment cohort, based on July 2011-December 2013 data, included 736,511 index admissions (Table 11). Among black patients, 45.8% were also receiving Medicaid benefits and among Medicaid patients, 21.81% were black. 5.24% of the total index admissions were both black and Medicaid patients. This indicates that there is not substantial overlap in the populations captured by these variables.

Table 11. Prevalence of SDS factors in HF payment measure cohort

Variable category	Number of index admissions (% of total index admissions)
Black	84,311 (11.45%)
Non-Black	652,200 (88.55%)
Medicaid	176,849 (24.01%)
Non-Medicaid	559,662 (75.99%)
Black and Medicaid	38,579 (5.24%)

The prevalence of SDS factors in the HF payment cohort varies substantially across hospitals (Table 12). For hospitals whose HF payment measure results are publicly reported (i.e. those with at least twenty-five cases during the measurement period) the percent of index admissions that were black ranged from 0% to 98.7%, with a mean of 10.2% and a median of 3.3% (IQR 0% to 12.9%). For these hospitals, the percent of index admissions that were receiving Medicaid benefits ranged from 0% to 95.2%, with a mean of 27.2% and a median of 22.9% (IQR 15.7% to 34.7%).

Table 12. Distribution of percent Black and Medicaid index admissions in HF payment measure cohort across hospitals

Distribution	% Black index admissions		% Medicaid index admissions	
	All hospitals (N=4,629)	Hospitals with at least 25 cases (N=3,536)	All hospitals (N=4,629)	Hospitals with at least 25 cases (N=3,536)
Minimum	0	0	0	0
10th Percentile	0	0	9.1	10.8
25th Percentile	0	0	15.0	15.7
Median	2.0	3.3	23.2	22.9
Mean	9.5	10.2	27.5	27.2
75th Percentile	11.3	12.9	36.4	34.7
90th Percentile	29.4	29.9	51.4	49.3
99th Percentile	80.2	76.8	90.0	81.1
Maximum	100	98.7	100	95.2

3.6.2 Hospital-Level Results

For HF, the addition of the race variable had virtually no impact on the overall distribution of hospital-level RSPs (Table 13). Moreover, a Spearman rank correlation coefficient[†] (rho) of 0.999 (p<=0.0001) indicated that the ranking of hospital RSPs were virtually unchanged after the addition of the race variable. The findings were similar for both the addition of the Medicaid variable alone as well as the addition of the race and Medicaid variable together. The Spearman rank correlation coefficients were 0.999 (p<=0.0001) and 0.996 (p<=0.0001), respectively.

Roughly 97% of hospitals showed less than a 1% change in RSP when the race variable was added to the risk-adjustment model (Table 14). The maximum change for any hospital was 2.6% (Table 15). The finding was similar for the addition of the Medicaid variable alone, where all hospitals showed less than a 1% change in RSP and the maximum change was 0.3% as well as for the addition of the race and Medicaid variable together, where roughly 97% of hospitals showed less than a 1% change in RSP and the maximum change was approximately 2.7%.

Summary: These analyses indicate that the addition of the race and/or the Medicaid variable to the risk-adjustment model had little to no effect on overall and same-hospital RSPs.

Table 13. HF RSPs calculated with the current model vs. the current model with the addition of SDS variables

Variables included in model	Number of Hospitals	Minimum	Median	Mean	Standard Deviation	Maximum
Current[*]	4,629	$11,762	$15,188	$15,346	$1,376	$22,181
Current + Black	4,629	$11,709	$15,193	$15,347	$1,383	$22,178
Current + Medicaid	4,629	$11,722	$15,193	$15,347	$1,379	$22,230
Current + Black + Medicaid	4,629	$11,727	$15,198	$15,347	$1,388	$22,240

Table 14. Percent change in HF RSPs calculated with the addition of SDS variables to the current model

Variables included in model	% Change in RSP	Number of Hospitals	% of Hospitals
Current[*] + Black	- 1^{+}	0	0
	- 0-1	3,319	71.7
	0-1	1,189	25.7
	1^{+}	121	2.6
Current + Medicaid	- 1^{+}	0	0
	- 0-1	2,050	44.3
	0-1	2,579	55.7
	1^{+}	0	0
Current + Black + Medicaid	- 1^{+}	8	0.2
	- 0-1	2,928	63.3
	0-1	1,564	33.8
	1^{+}	129	2.8

[†] A Spearman correlation coefficient, rho, equal to 1 indicates that the ranking of hospital RSPs were virtually unchanged after the addition of the race variable

[*] Current indicates inclusion of all current risk-adjustment variables (age, comorbidities)

Table 15. Distribution of percent change in HF RSPs with addition of SDS variables to the current model

Distribution	Current* + Black (% RSP Change)	Current + Medicaid (% RSP Change)	Current + Black + Medicaid (% RSP Change)
Minimum	-0.45	-0.7	-1.22
10th Percentile	-0.24	-0.16	-0.3
25th Percentile	-0.19	-0.062	-0.18
Median	-0.094	0.014	-0.059
Mean	0.00056	0.000087	0.00067
75th Percentile	0.026	0.089	0.083
90th Percentile	0.36	0.15	0.37
99th Percentile	1.47	0.23	1.47
Maximum	2.59	0.29	2.74

3.5.3 Patient-Level Results

While our primary goal was to assess the effect of the addition of SDS variables on hospital RSPs, we began our analyses, as we do when building any outcome measure, at the patient level. The results of these analyses may help to inform the hospital-level results seen above.

We began by assessing the individual relationship between the payment outcome and the SDS variables. A bivariate regression (i.e. a regression of total episode payment on the individual SDS variables) indicated little to no effect on total episode payment (Table 16).

Table 16. Bivariate relationship between total HF payment and SDS variables[t]

Variables included in model	Estimate	Payment Ratio[r]	p-value
Black	0.0129	1.01	<0.0001
Medicaid	0.0576	1.06	<0.0001

The bivariate regression between total payment and the race variable estimated that payments were, on average, roughly 1% higher for black index admissions than for non-black index admissions (payment ratio of 1.01). The bivariate regression between total payment and the Medicaid variable estimated that payments were, on average, roughly 6% for Medicaid index admissions as for non-Medicaid index admissions (payment ratio of 1.06).

We then added the SDS variables to the current risk-adjustment model, both individually and jointly (Table 17). With the sole addition of race to the patient-level model, black index admissions were estimated to be roughly 3% less expensive than non-black index admissions (payment ratio of 0.97). With the sole addition of Medicaid status to the patient-level model, Medicaid index admissions were estimated to be 1% more expensive than non-Medicaid index admissions (payment ratio of 1.01). With the addition of both race and Medicaid status to the model, the same individual results hold. The interpretation of these results is that, holding all other risk-

* Current indicates inclusion of all current risk-adjustment variables (age, comorbidities)
t Used log link and Gamma distribution as with original HF payment measure patient-level model
r Payment ratio is equal to exponentiated estimate

adjustment variables constant, both black patients are slightly less expensive for an HF episode of care than non-black patients and Medicaid patients are slightly more expensive for an HF episode of care than non-Medicaid patients.

Table 17. Relationship between total HF payment and SDS variables[t]

Variables included in model	Variable	Estimate	Payment Ratio[r]	p-value
Current[*] + Black	Black	-0.028	0.97	<0.0001
Current + Medicaid	Medicaid	0.0080	1.01	<0.0001
Current + Black + Medicaid	Black	-0.030	0.97	<0.0001
	Medicaid	0.012	1.01	<0.0001

3.5.4 Model Diagnostics

Model Performance

The addition of the SDS variables to the patient-level model did not significantly improve model performance compared the current model as demonstrated by the comparison of predictive ratios and quasi-R^2s (Table 18).

Table 18. HF payment model performance

Diagnostic[y]	Current[*]	Current + Black	Current + Medicaid	Current + Black + Medicaid
Predictive Ratio, 1st Decile (lowest)	1.0273	1.0307	1.0271	1.0299
Predictive Ratio, 2nd Decile	1.0184	1.0182	1.0184	1.0175
Predictive Ratio, 3rd Decile	1.0062	1.0020	1.0061	1.0017
Predictive Ratio, 4th Decile	0.9903	0.9895	0.9903	0.9939
Predictive Ratio, 5th Decile	0.9918	0.9939	0.9920	0.9908
Predictive Ratio, 6th Decile	0.9868	0.9858	0.9873	0.9852
Predictive Ratio, 7th Decile	0.9834	0.9826	0.9848	0.9859
Predictive Ratio, 8th Decile	0.9840	0.9838	0.9813	0.9811
Predictive Ratio, 9th Decile	0.9871	0.9886	0.9879	0.9891
Predictive Ratio, 10th Decile (highest)	1.0300	1.0304	1.0301	1.0303
Quasi-R^2	0.0399	0.0400	0.0399	0.0401

[t] Used log link and Gamma distribution as with original HF payment measure patient-level model
[r] Payment ratio is equal to exponentiated estimate
[*] Current indicates inclusion of all current risk-adjustment variables (age, comorbidities)
[y] A predictive ratio is an estimator's ratio of predicted outcome to observed outcome. A predictive ratio of 1.0 indicates an accurate prediction. A ratio greater than 1.0 indicates overprediction, and a ratio less than 1.0 indicates underprediction. The quasi-R^2 calculated is the R^2 from a regression of observed outcome on the predicted outcome. (Reference: Jones AM. Models for Health Care. Health, Econometrics and Data Group (HEDG) Working Papers. 2010.)

Residual Analysis

To assess whether the addition of the SDS variables produced a better model fit (i.e. improved the predicted total payment) for sub-groups of patients, we compared residuals[Φ] from the current model to the residuals after the SDS variables were added (Table 19). Model fit was improved, on average, for all sub-groups (though the addition of a variable is likely to produce this result for any model). The prediction for black patients improved more than the prediction for non-black patients. The same is true for Medicaid and non-Medicaid patients, though the magnitude of improvement is decreased.

Table 19. Average residual for current model vs. current model with the addition of SDS variables for sub-groups of patients

Variable category	Current[*] ($)[Λ]	Current + Black + Medicaid ($)[Λ]
Black	-330	33
Non-Black	38	-9
Medicaid	85	-4
Non-Medicaid	-33	-4

Collinearity Analyses

With respect to assessing collinearity among the variables, the addition of the SDS variables did not increase the standard errors of the current risk-adjustment variables or appreciably alter their estimated coefficients (Appendix 4; full results available upon request). However, formal testing for collinearity among the risk-adjustments variables after the addition of the SDS variables was also performed (analyses available upon request). No indications of collinearity were found.

[Φ] The residual is the difference between the observed total payment and the predicted total payment
[*] Current indicates inclusion of all current risk-adjustment variables (age, comorbidities)
[Λ] Values are in standardized dollars

3.7 Condition-Specific Results: PN Payment

3.7.1 Cohort

The PN payment cohort, based on July 2011-December 2013 data, included 740,244 index admissions (Table 20). Among black patients, 51.66% were also receiving Medicaid benefits and among Medicaid patients, 13.61% were black. 3.63% of the total index admissions were both black and Medicaid patients. This indicates that there is not substantial overlap in the populations captured by these variables.

Table 20. Prevalence of SDS factors in PN payment measure cohort

Variable category	Number of index admissions (% of total index admissions)
Black	51,966 (7.02%)
Non-Black	688,278 (92.98%)
Medicaid	197,142 (26.63%)
Non-Medicaid	543,102 (73.37%)
Black and Medicaid	26,844 (3.63%)

The prevalence of SDS factors in the PN payment cohort varies substantially across hospitals (Table 21). For hospitals whose PN payment measure results are publicly reported (i.e. those with at least twenty-five cases during the measurement period) the percent of index admissions that were black ranged from 0% to 100%, with a mean of 6.9% and a median of 2.0% (IQR 0% to 8.0%). For these hospitals, the percent of index admissions that were receiving Medicaid benefits ranged from 0% to 100%, with a mean of 29.3 % and a median of 25.9% (IQR 18.4% to 36.7%).

Table 21. Distribution of percent Black and Medicaid index admissions in PN payment measure cohort across hospitals

Distribution	% Black index admissions		% Medicaid index admissions	
	All hospitals (N=4,670)	Hospitals with at least 25 cases (N=4,094)	All hospitals (N=4,670)	Hospitals with at least 25 cases (N=4,094)
Minimum	0	0	0	0
10th Percentile	0	0	11.1	12.2
25th Percentile	0	0	17.8	18.4
Median	1.5	2.0	25.9	25.9
Mean	6.9	6.9	29.4	29.3
75th Percentile	7.6	8.0	37.5	36.7
90th Percentile	20.1	19.6	52.6	51.1
99th Percentile	71.4	64.7	87.3	83.5
Maximum	100	100	100	100

3.5.2 Hospital-Level Results

For PN, the addition of the race variable had virtually no impact on the overall distribution of hospital-level RSPs (Table 22). Moreover, a Spearman rank correlation coefficient[†] (rho) of 0.999 (p<=0.0001) indicated that the ranking of hospital RSPs were virtually unchanged after the addition of the race variable. The findings were similar for both the addition of the Medicaid variable alone as well as the addition of the race and Medicaid variable together. The Spearman rank correlation coefficients were 0.999 (p<=0.0001) and 0.999 (p<=0.0001), respectively.

Roughly 99.9% of hospitals showed less than a 1% change in RSP when the race variable was added to the risk-adjustment model (Table 23). The maximum change for any hospital was 0.2% (Table 24). The finding was similar for the addition of the Medicaid variable alone, where roughly 96% of all hospitals showed less than a 1% change in RSP and the maximum change was approximately 1% as well as for the addition of the race and Medicaid variable together, where roughly 97% of hospitals showed less than a 1% change in RSP and the maximum change was approximately 1%.

Summary: These analyses indicate that the addition of the race and/or the Medicaid variable to the risk-adjustment model had little to no effect on overall and same-hospital RSPs.

Table 22. PN RSPs calculated with the current model vs. the current model with the addition of SDS variables

Variables included in model	Number of Hospitals	Minimum	Median	Mean	Standard Deviation	Maximum
Current[*]	4,670	$9,171	$14,249	$14,299	$1,396	$23,661
Current + Black	4,670	$9,182	$14,245	$14,299	$1,392	$23,647
Current + Medicaid	4,670	$8,985	$14,247	$14,300	$1,398	$23,769
Current + Black + Medicaid	4,670	$8,882	$14,244	$14,300	$1,396	$23,761

Table 23. Percent change in PN RSPs calculated with the addition of SDS variables to the current model

Variables included in model	% Change in RSP	Number of Hospitals	% of Hospitals
Current[*] + Black	- 1[+]	2	0.04
	- 0-1	1,211	25.9
	0-1	3,457	74.0
	1[+]	0	0
Current + Medicaid	- 1[+]	153	3.3
	- 0-1	1,777	38.1
	0-1	2,740	58.7
	1[+]	0	0
Current + Black + Medicaid	- 1[+]	175	3.8
	- 0-1	1,714	36.7
	0-1	2,781	59.6
	1[+]	0	0

[†] A Spearman correlation coefficient, rho, equal to 1 indicates that the ranking of hospital RSPs were virtually unchanged after the addition of the race variable

[*] Current indicates inclusion of all current risk-adjustment variables (age, comorbidities)

Table 24. Distribution of percent change in PN RSPs with addition of SDS variables to the current model

Distribution	Current* + Black (% RSP Change)	Current + Medicaid (% RSP Change)	Current + Black + Medicaid (% RSP Change)
Minimum	-1.09	-2.49	-2.42
10th Percentile	-0.14	-0.58	-0.6
25th Percentile	-0.004	-0.22	-0.23
Median	0.048	0.088	0.094
Mean	0.0031	0.0059	0.0073
75th Percentile	0.075	0.32	0.33
90th Percentile	0.089	0.48	0.49
99th Percentile	0.11	0.7	0.71
Maximum	0.19	0.95	0.98

3.5.3 Patient-Level Results

While our primary goal was to assess the effect of the addition of SDS variables on hospital RSPs, we began our analyses, as we do when building any outcome measure, at the patient level. The results of these analyses may help to inform the hospital-level results seen above.

We began by assessing the individual relationship between the payment outcome and the SDS variables. A bivariate regression (i.e. a regression of total episode payment on the individual SDS variables) indicated little to no effect on total episode payment (Table 25).

Table 25. Bivariate relationship between total PN payment and SDS variables‡

Variables included in model	Estimate	Payment Ratio	p-value
Black	$1,708	N/A	<0.0001
Medicaid	$1,600	N/A	<0.0001

The bivariate regression between total payment and the race variable estimated that payments were, on average, roughly $1,708 higher for black index admissions than for non-black index admissions. The bivariate regression between total payment and the Medicaid variable estimated that payments were, on average, roughly $1,600 higher for Medicaid index admissions as for non-Medicaid index admissions.

We then added the SDS variables to the current risk-adjustment model, both individually and jointly (Table 26). With the sole addition of race to the patient-level model, black index admissions were estimated to be roughly $391 more expensive than non-black index admissions. With the sole addition of Medicaid status to the patient-level model, Medicaid index admissions were estimated to be $516 more expensive than non-Medicaid index admissions. With the addition of both race and Medicaid status to the model, black index admissions were estimated to be roughly $287 more expensive than non-black index admission and Medicaid index admissions were

* Current indicates inclusion of all current risk-adjustment variables (age, comorbidities)

‡ Used identity link and Gamma distribution as with original PN payment measure patient-level model. Estimates can be directly interpreted as standardized dollars.

estimated to be $496 more expensive than non-Medicaid index admissions. The interpretation of these results is that, holding all other risk-adjustment variables constant, both black and Medicaid patients are slightly more expensive for a PN episode of care than non-black and/or non-Medicaid patients.

Table 26. Relationship between total PN payment and SDS variables[t]

Variables included in model	Variable	Estimate	Payment Ratio[r]	p-value
Current[*] + Black	Black	$391	N/A	<0.0001
Current + Medicaid	Medicaid	$516	N/A	<0.0001
Current + Black + Medicaid	Black	$287	N/A	<0.0001
	Medicaid	$496	N/A	<0.0001

3.7.4 Model Diagnostics

Model Performance

The addition of the SDS variables to the patient-level model did not significantly improve model performance compared the current model as demonstrated by the comparison of predictive ratios and quasi-R^2s (Table 27).

Table 27. HF payment model performance

Diagnostic[y]	Current[*]	Current + Black	Current + Medicaid	Current + Black + Medicaid
Predictive Ratio, 1st Decile (lowest)	1.0567	1.0565	1.0593	1.0567
Predictive Ratio, 2nd Decile	1.0026	1.0021	0.9978	1.0026
Predictive Ratio, 3rd Decile	0.9832	0.9827	0.9843	0.9832
Predictive Ratio, 4th Decile	0.9729	0.9740	0.9747	0.9729
Predictive Ratio, 5th Decile	0.9698	0.9706	0.9704	0.9698
Predictive Ratio, 6th Decile	0.9728	0.9726	0.9731	0.9728
Predictive Ratio, 7th Decile	0.9818	0.9824	0.9823	0.9818
Predictive Ratio, 8th Decile	0.9943	0.9935	0.9925	0.9943
Predictive Ratio, 9th Decile	1.0173	1.0180	1.0181	1.0173
Predictive Ratio, 10th Decile (highest)	1.0580	1.0568	1.0571	1.0580
Quasi-R^2	0.0893	0.0895	0.0898	0.0893

[t] Used identity link and Gamma distribution as with original PN payment measure patient-level model.
[r] Payment ratio is equal to exponentiated estimate
[*] Current indicates inclusion of all current risk-adjustment variables (age, comorbidities)
[y] A predictive ratio is an estimator's ratio of predicted outcome to observed outcome. A predictive ratio of 1.0 indicates an accurate prediction. A ratio greater than 1.0 indicates overprediction, and a ratio less than 1.0 indicates underprediction. The quasi-R^2 calculated is the R^2 from a regression of observed outcome on the predicted outcome. (Reference: Jones AM. Models for Health Care. Health, Econometrics and Data Group (HEDG) Working Papers. 2010.)

Residual Analysis

To assess whether the addition of the SDS variables produced a better model fit (i.e. improved the predicted total payment) for sub-groups of patients, we compared residuals[Φ] from the current model to the residuals after the SDS variables were added (Table 28). Model fit was improved, on average, for all sub-groups (though the addition of a variable is likely to produce this result for any model). The prediction for black patients improved more than the prediction for non-black patients. The same is true for Medicaid and non-Medicaid patients.

Table 28. Average residual for current model vs. current model with the addition of SDS variables for sub-groups of patients

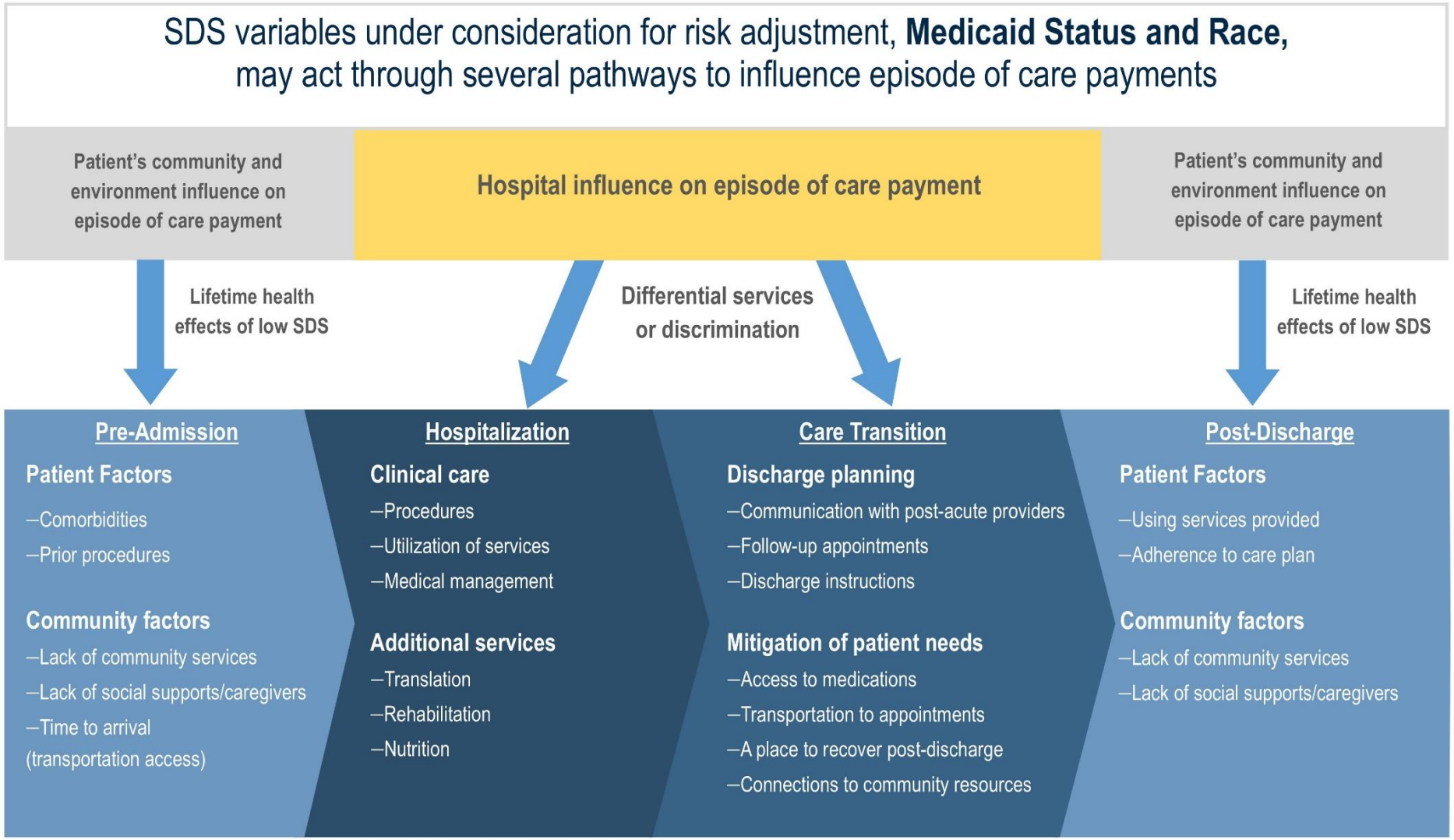
Variable category	Current[*] ($)[Л]	Current + Black + Medicaid ($)[Л]
Black	533	187
Non-Black	-72	-46
Medicaid	289	-51
Non-Medicaid	-145	-21

Collinearity Analyses

With respect to assessing collinearity among the variables, the addition of the SDS variables did not increase the standard errors of the current risk-adjustment variables or appreciably alter their estimated coefficients (Appendix 5; full results available upon request). However, formal testing for collinearity among the risk-adjustments variables after the addition of the SDS variables was also performed (analyses available upon request). No indications of collinearity were found.

[Φ] The residual is the difference between the observed total payment and the predicted total payment
[*] Current indicates inclusion of all current risk-adjustment variables (age, comorbidities)
[Л] Values are in standardized dollars

APPENDIX 1.
UPDATED CONCEPTUAL MODEL


SDS variables under consideration for risk adjustment, Medicaid Status and Race, may act through several pathways to influence episode of care payments
Patient's community and environment influence on episode of care payment
Hospital influence on episode of care payment
Patient's community and environment influence on episode of care payment
Lifetime health effects of low SDS
Differential services or discrimination
Lifetime health effects of low SDS
Pre-Admission
Patient Factors
–Comorbidities
–Prior procedures
Community factors
–Lack of community services
–Lack of social supports/caregivers
–Time to arrival (transportation access)
Hospitalization
Clinical care
–Procedures
–Utilization of services
–Medical management
Additional services
–Translation
–Rehabilitation
–Nutrition
Care Transition
Discharge planning
–Communication with post-acute providers
–Follow-up appointments
–Discharge instructions
Mitigation of patient needs
–Access to medications
–Transportation to appointments
–A place to recover post-discharge
–Connections to community resources
Post-Discharge
Patient Factors
–Using services provided
–Adherence to care plan
Community factors
–Lack of community services
–Lack of social supports/caregivers

APPENDIX 2
ARTICLES INCLUDED IN UPDATED LITERATURE REVIEW

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APPENDIX 3
AMI PAYMENT PATIENT-LEVEL SDS ANALYSES

Patient-level risk-adjustment model results for the current model and with the addition of the SDS variables[t]

Variable	Current[*] Model		Current Model + Race + Medicaid	
	Estimate	p-value	Estimate	p-value
Intercept	9.78	-	9.78	
Age (65 – 74)	0.184	<.0001	0.187	<.0001
Age (75 – 84)	0.172	<.0001	0.173	<.0001
Age (>=85) (reference group)	0.000	-	0.000	-
History of Percutaneous Transluminal Coronary Angioplasty (PTCA) (ICD, 9 codes V45.82, 00.66, 36.06, 36.07)	-0.057	<.0001	-0.058	<.0001
History of Coronary Artery Bypass Graft (CABG) (ICD, 9 codes V45.81, 36.10, 36.16)	-0.187	<.0001	-0.189	<.0001
Metastatic cancer, acute leukemia and other severe cancers (CC 7, 8)	-0.092	<.0001	-0.092	<.0001
Diabetes mellitus (DM) or DM complications (CC 15, 19, 119, 120)	0.079	<.0001	0.082	<.0001
Protein, calorie malnutrition (CC 21)	0.205	<.0001	0.207	<.0001
Other significant endocrine and metabolic disorders (CC 22)	0.062	<.0001	0.063	<.0001
Other endocrine/metabolic/ nutritional disorders (CC 24)	-0.017	<.0001	-0.019	<.0001
Other gastrointestinal disorders (CC 36)	-0.029	<.0001	-0.029	<.0001
Osteoporosis and other bone/cartilage disorders (CC 41)	-0.045	<.0001	-0.046	<.0001
Iron deficiency or other unspecified anemias and blood disease (CC 47)	0.199	<.0001	0.201	<.0001
Delirium and encephalopathy (CC 48)	-0.027	<.0001	-0.025	<.0001
Dementia (CC 49)	-0.074	<.0001	-0.070	<.0001
Drug/alcohol psychosis (CC 51)	0.0096	0.5220	0.0076	0.6100
Drug/alcohol abuse/dependence (CC 52, 53)	0.014	<.0001	0.015	<.0001
Severe mental illness (CC 54, 55)	0.030	<.0001	0.033	<.0001
Reactive and unspecified psychosis (CC 56)	0.0029	0.6271	0.0030	0.6139
Depression/anxiety (CC 58, 59)	-0.025	<.0001	-0.027	<.0001
Congestive heart failure (CC 80)	-0.052	<.0001	-0.049	<.0001
Angina pectoris/old myocardial Infarction (CC 83)	-0.035	<.0001	-0.036	<.0001
Heart infection/inflammation, except rheumatic (CC 85)	0.210	<.0001	0.209	<.0001
Valvular or rheumatic heart disease (CC 86)	0.068	<.0001	0.067	<.0001
Congenital cardiac/circulatory defect (CC 87, 88)	0.113	<.0001	0.112	<.0001
Hypertension and hypertension complications (CC 89, 91)	-0.028	<.0001	-0.025	<.0001
Precerebral arterial occlusion and transient cerebral ischemia (CC 97)	0.014	<.0001	0.012	0.0002

[t] Used log/inverse Gaussian as with original AMI Payment patient-level model
[*] Current indicates inclusion of all current risk-adjustment variables (age, comorbidities)

Variable	Current* Model		Current Model + Race + Medicaid	
	Estimate	p-value	Estimate	p-value
Vascular disease and complications (CC 104, 105)	-0.0004	0.8872	0.0010	0.6963
Other lung disorders (CC 115)	0.057	<.0001	0.057	<.0001
Legally blind (CC 116)	-0.035	0.0005	-0.031	0.0021
Dialysis status (CC 130)	0.113	<.0001	0.122	<.0001
Internal injuries (CC 160)	0.148	<.0001	0.148	<.0001
Black	-	-	-0.058	<.0001
Medicaid	-	-	-0.017	<.0001

APPENDIX 4.
HF PAYMENT PATIENT-LEVEL SDS ANALYSES

Patient-level risk-adjustment model results for the current model and with the addition of the SDS variables[ŧ]

Variable	Current[*] Model		Current Model + Race + Medicaid	
	Estimate	p-value	Estimate	p-value
Intercept	9.50	<.0001	9.50	<.0001
Age (65 – 74)	0.054	<.0001	0.056	<.0001
Age (75 – 84)	0.044	<.0001	0.045	<.0001
Age (>=85) (reference group)	0.000		0.000	
History of infection (CC 1, 3-5)	0.065	<.0001	0.066	<.0001
Other infectious diseases (CC 6)	0.024	<.0001	0.023	<.0001
Protein-calorie malnutrition (CC 21)	0.156	<.0001	0.156	<.0001
Other significant endocrine and metabolic disorders (CC 22)	0.074	<.0001	0.075	<.0001
Other endocrine/metabolic/ nutritional disorders (CC 24)	0.0002	0.9221	-0.0002	0.9235
Other gastrointestinal disorders (CC 36)	0.0003	0.8565	-0.0001	0.9550
Bone/joint/muscle infections/necrosis (CC 37)	0.046	<.0001	0.046	<.0001
Other musculoskeletal and connective tissue disorders (CC 43)	0.0064	0.0002	0.0066	0.0001
Delirium and encephalopathy (CC 48)	0.024	<.0001	0.024	<.0001
Dementia and senility (CC 49, 50)	0.050	<.0001	0.049	<.0001
Schizophrenia/major depressive/ bipolar disorders (CC 54-55)	0.062	<.0001	0.060	<.0001
Other psychiatric disorders (CC 60)	0.0060	0.0011	0.0045	0.0144
Respiratory arrest/ cardiorespiratory failure/respirator dependence (CC 77-79)	0.025	<.0001	0.025	<.0001
Angina pectoris/old myocardial infarction (CC 83)	-0.015	<.0001	-0.016	<.0001
Heart infection/inflammation, except rheumatic (CC 85)	0.092	<.0001	0.093	<.0001
Major congenital cardiac/circulatory defect (CC 87)	0.042	<.0001	0.042	<.0001
Hypertension (CC 91)	-0.055	<.0001	-0.054	<.0001
Arrhythmias (CC 92, 93)	-0.025	<.0001	-0.025	<.0001
Cerebrovascular disease (CC 97-99)	0.018	<.0001	0.017	<.0001
Vascular or circulatory disease (CC 104-106)	0.017	<.0001	0.018	<.0001
History of pneumonia (CC 111-113)	0.112	<.0001	0.112	<.0001
Other ear, nose, throat, and mouth disorders (CC 127)	-0.019	<.0001	-0.019	<.0001
Dialysis status (CC 130)	0.155	<.0001	0.157	<.0001

[ŧ] Used log link and Gamma distribution as with original HF payment measure patient-level model
[*] Current indicates inclusion of all current risk-adjustment variables (age, comorbidities)

Variable	Current* Model		Current Model + Race + Medicaid	
	Estimate	p-value	Estimate	p-value
Renal failure (CC 131)	0.030	<.0001	0.031	<.0001
Decubitus ulcer of skin (CC 148)	0.039	<.0001	0.039	<.0001
Chronic ulcer of skin, except decubitus (CC 149)	0.067	<.0001	0.067	<.0001
Cellulitis, local skin infection (CC 152)	0.011	<.0001	0.010	<.0001
Hip fracture/dislocation (CC 158)	0.033	<.0001	0.032	<.0001
Internal injuries (CC 160)	0.084	<.0001	0.085	<.0001
Black	-	-	-0.030	<.0001
Medicaid	-	-	0.012	<.0001

APPENDIX 5.
PN PAYMENT PATIENT-LEVEL SDS ANALYSES

Patient-level risk-adjustment model results for the current model and with the addition of the SDS variables[ŧ]

Variable	Current[*] Model		Current Model + Race + Medicaid	
	Estimate ($)	p-value	Estimate ($)	p-value
Intercept	10,141	<.0001	10,095	<.0001
Age (65 – 74)	-1,164	<.0001	-1,208	<.0001
Age (75 – 84)	-683	<.0001	-694	<.0001
Age (>=85; reference group)	0	--	0	--
History of infection (CC 1, 3-5)	2,246	<.0001	2,252	<.0001
Other infectious diseases (CC 6)	434	<.0001	398	<.0001
Metastatic cancer and acute leukemia (CC 7)	1,405	<.0001	1,422	<.0001
Lung, upper digestive tract, and other severe cancers (CC 8)	813	<.0001	830	<.0001
Lymphatic, head and neck, brain, and other major cancers (CC 9)	872	<.0001	909	<.0001
Diabetes mellitus (DM) or DM complications (CC 15-19, 119, 120)	472	<.0001	427	<.0001
Protein-calorie malnutrition (CC 21)	3,593	<.0001	3,575	<.0001
Other significant endocrine and metabolic disorders (CC 22)	1,237	<.0001	1,246	<.0001
Other endocrine/metabolic/ nutritional disorders (CC 24)	-105	<.0001	-75	0.0012
Other gastrointestinal disorders (CC 36)	-134	<.0001	-142	<.0001
Bone/joint/muscle infections/necrosis (CC 37)	890	<.0001	887	<.0001
Osteoporosis and other bone/cartilage disorders (CC 41)	-187	<.0001	-185	<.0001
Severe hematological disorders (CC 44)	1,106	<.0001	1,140	<.0001
Iron deficiency or other unspecified anemias and blood disease (CC 47)	1,356	<.0001	1,336	<.0001
Delirium and encephalopathy (CC 48)	486	<.0001	491	<.0001
Dementia and senility (CC 49-50)	1,253	<.0001	1,183	<.0001
Drug/alcohol dependence/psychosis (CC 51-52)	-87	0.2352	-89	0.2228
Drug/alcohol abuse, without dependence (CC 53)	-8	0.7688	-34	0.2349
Major psychiatric disorders (CC 54-56)	1,052	<.0001	985	<.0001
Plegia, paralysis, spinal cord disorder and amputation (CC 67-69, 100-101, 177-178)	1,358	<.0001	1,296	<.0001
Muscular dystrophy and/or polyneuropathy (CC 70-71)	602	<.0001	622	<.0001
Multiple sclerosis and Parkinson's (CC 72-73)	1,237	<.0001	1,238	<.0001
Coma, brain compression/anoxic damage	1,289	<.0001	1,287	<.0001

[ŧ] Used identity link and Gamma distribution as with original PN payment measure patient-level model
[*] Current indicates inclusion of all current risk-adjustment variables (age, comorbidities)

Variable	Current* Model		Current Model + Race + Medicaid	
	Estimate ($)	p-value	Estimate ($)	p-value
(CC 75)				
Respirator dependence/respiratory arrest/cardiorespiratory failure (CC 77-79)	949	<.0001	946	<.0001
Congestive heart failure (CC 80)	644	<.0001	609	<.0001
Angina pectoris/old myocardial infarction (CC 83)	-299	<.0001	-291	<.0001
Heart infection/inflammation, except rheumatic (CC 85)	1,255	<.0001	1,249	<.0001
Valvular and rheumatic heart disease (CC 86)	492	<.0001	519	<.0001
Hypertension (CC 91)	-57	0.0196	-81	0.0010
Arrhythmias (CC 92-93)	201	<.0001	229	<.0001
Stroke (CC 95-96)	416	<.0001	400	<.0001
Vascular or circulatory disease (CC 104-106)	156	<.0001	155	<.0001
Chronic Obstructive Pulmonary Disease (COPD) (CC 108)	813	<.0001	799	<.0001
Fibrosis of lung or other chronic lung disorder (CC 109)	406	<.0001	430	<.0001
Asthma (CC 110)	-694	<.0001	-708	<.0001
Aspiration and specified bacterial pneumonias (CC 111)	461	<.0001	442	<.0001
Pleural effusion/pneumothorax (CC 114)	548	<.0001	567	<.0001
Other ear, nose, throat, and mouth disorders (CC 127)	-484	<.0001	-472	<.0001
Dialysis status (CC 130)	3,239	<.0001	3,161	<.0001
Renal failure (CC 131)	473	<.0001	462	<.0001
Decubitus ulcer or chronic skin ulcer (CC 148-149)	1,159	<.0001	1,142	<.0001
Head injury (CC 154-156)	327	<.0001	343	<.0001
Vertebral fractures (CC 157)	1,017	<.0001	1,044	<.0001
Hip fracture/dislocation (CC 158)	584	<.0001	593	<.0001
Major fracture, except of skull, vertebrae, or hip (CC 159)	770	<.0001	780	<.0001
Internal injuries (CC 160)	1,512	<.0001	1,530	<.0001
Major symptoms, abnormalities (CC 166)	689	<.0001	669	<.0001
Black	-	-	287	<.0001
Medicaid	-	-	496	<.0001