Supplemental Online Content

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This supplemental material has been provided by the authors to give readers additional information about their work.
eAppendix 1. Selection of SDoH Variables

We used the National Academy of Medicine (NAM) conceptual framework as the basis for selecting SDoH measures. The NAM conceptual framework specifies five categories of SDoH associated with Medicare spending, including (1) socioeconomic position, (2) race and ethnicity composition, (3) social relationships, (4) overall residential and community context, and (5) gender. We identified 87 publicly available county-level SDoH measures from literature and web searches (eTable 1). SDoH measures identified in our searches, but not publicly available were excluded from this study (e.g., walking score, transit score, self-reported financial burden, and self-reported financial barriers to medication). After we identified publicly available SDoH measures, we mapped each of the 87 SDoH measures to one of the four NAM’s conceptual framework categories and the subcategories therein (e.g., income, insurance etc. under socioeconomic position). We made two changes to the conceptual framework after this step. First, we did not use gender as one of the SDoH measures as we considered gender as part of demographics. Second, NAM’s conceptual framework considered healthcare resources to be part of the Residential and Community Context category; however, we used healthcare resources separately to be consistent with previous literature, which emphasized the importance of the supply of healthcare resources to regional spending variation.

After mapping of SDoH measures to the NAM conceptual framework, we qualitatively screened SDoH measures that were conceptually similar under the same category or across subcategories. For example, % receiving public assistance income, % receiving supplement security income, and % receiving food stamp/snap in the “Income” subcategory all capture poverty. We therefore only included % residents in poverty (based on federal poverty threshold). We selected up to two SDoH variables for each conceptually similar measure for further consideration.

The qualitative screening generated a total of 13 SDoH measures, generally with one measure in each subcategory (except for marital status and living alone which we did not include in any measure as they conceptually overlap with social relationships), including six for socioeconomic position (median household income, % of residents in poverty, % of residents who are uninsured, unemployment rate, % of residents without a high school degree, and food environment index), three for race and ethnicity composition (% of residents who are non-white, % of residents who are non-citizen, and % residents with limited English proficiency), one for social relationships (number of membership associations per 1,000 population), and three for overall residential and community context (% of households with severe housing problems, % of residents with access to exercise opportunities, and % of housing units in rural areas). Finally, we tested the correlation between SDoH measures within each category (eTables 2-4). For each group of measures that captured similar concepts and were highly correlated (i.e., correlation coefficient over 0.7), we selected the variable that was most commonly used in the literature. Therefore, we dropped % of residents in poverty given its high correlation with median household income (eTable 2). We also dropped % residents with limited English proficiency as it
is highly correlated with % of residents who are non-citizen (eTable 3). We tested the correlation between the remaining 11 SDoH measures and included them in the analysis (eTable 5). We subsequently adopted a more detailed race/ethnicity classification and replaced the % resident who are non-White with % Hispanic, % non-Hispanic Black and % non-Hispanic with another race. Therefore, our final analyses include 13 SDoH measures.
eTable 1 List of social determinants of health variables considered in the study

| ID  | Categories and Subcategories          | Measures                                      | Sources                              |
|-----|--------------------------------------|-----------------------------------------------|--------------------------------------|
|     | Socioeconomic Position               |                                               |                                      |
| 1.  | Income                               | Median Household Income                       | ACS 2017 5-year Estimates            |
| 2.  | % in poverty                         | % in poverty                                  | ACS 2017 5-year Estimates            |
| 3.  | % receiving public assistance income | % receiving public assistance income          | ACS 2017 5-year Estimates            |
| 4.  | % receiving supplement security income| % receiving supplement security income        | ACS 2017 5-year Estimates            |
| 5.  | % receiving food stamp/snap           | % receiving food stamp/snap                   | ACS 2017 5-year Estimates            |
| 6.  | % Uninsured                          | % Uninsured                                   | ACS 2017 5-year Estimates            |
| 7.  | % Uninsured, <18                     | % Uninsured, <18                              | ACS 2017 5-year Estimates            |
| 8.  | % Uninsured, 18-64                   | % Uninsured, 18-64                            | ACS 2017 5-year Estimates            |
| 9.  | % Uninsured, over 65                 | % Uninsured, over 65                          | ACS 2017 5-year Estimates            |
| 10. | % Any private insurance, all ages    | % Any private insurance, all ages             | ACS 2017 5-year Estimates            |
| 11. | % Any public insurance, all ages     | % Any public insurance, all ages              | ACS 2017 5-year Estimates            |
| 12. | % Insured                            | % Insured                                     | ACS 2017 5-year Estimates            |
| 13. | % Medicare                           | % Medicare                                    | ACS 2017 5-year Estimates            |
| 14. | % Medicare only                      | % Medicare only                               | ACS 2017 5-year Estimates            |
| 15. | % Medicaid                           | % Medicaid                                    | ACS 2017 5-year Estimates            |
| 16. | % Medicaid only                      | % Medicaid only                               | ACS 2017 5-year Estimates            |
| 17. | % Medicaid, over 65                  | % Medicaid, over 65                           | ACS 2017 5-year Estimates            |
| 18. | % No schooling                       | % No schooling                                | ACS 2017 5-year Estimates            |
| 19. | % Completed high school, no degree   | % Completed high school, no degree            | ACS 2017 5-year Estimates            |
| 20. | % High school or GED degree          | % High school or GED degree                   | ACS 2017 5-year Estimates            |
| 21. | % Some college, no degree            | % Some college, no degree                     | ACS 2017 5-year Estimates            |
| 22. | % College Degree                     | % College Degree                              | ACS 2017 5-year Estimates            |
| 23. | % Masters, professional, doctorate   | % Masters, professional, doctorate           | ACS 2017 5-year Estimates            |
| 24. | % Other level of schooling (< High school) | % Other level of schooling (< High school) | ACS 2017 5-year Estimates            |
| 25. | Occupation                           | Unemployment rate                             | BLS, 2017 / ACS 2017 5-year Estimates|
| 26. | White collar occupation*             | White collar occupation*                     | ACS 2017 5-year Estimates            |
| 27. | Food                                 | Food insecurity                               | County Health Ranking, 2019/Map the Meal Gap |
| 28. | Food environment                     | Food environment                              | County Health Ranking, 2019/USDA Food Environment Atlas |
| 29. | Race and Ethnicity                   | % White                                       | ACS 2017 5-year Estimates            |
| 30. |                                      | % African American                            | ACS 2017 5-year Estimates            |
| 31. |                                      | % American Indian                             | ACS 2017 5-year Estimates            |
| 32. |                                      | % Asian                                       | ACS 2017 5-year Estimates            |
|   |   |   |
|---|---|---|
| 33. | % Native Hawaiian/Pacific Islander | ACS 2017 5-year Estimates |
| 34. | % Other Race | ACS 2017 5-year Estimates |
| 35. | % 2 or more Races | ACS 2017 5-year Estimates |
| 36. | % Latino/Hispanic Ethnicity | ACS 2017 5-year Estimates |
| 37. | Language | % Limited English proficiency | ACS 2017 5-year Estimates |
| 38. |   | % Language other than English | ACS 2017 5-year Estimates |
| 39. | Nativity | % Non-citizen | ACS 2017 5-year Estimates |
| 40. |   | % Foreign born | ACS 2017 5-year Estimates |
| 41. |   | % US citizen | ACS 2017 5-year Estimates |
| 42. |   | % Native born in US | ACS 2017 5-year Estimates |
| 43. | Gender | % Male | ACS 2017 5-year Estimates |
| 44. |   | % Female | ACS 2017 5-year Estimates |
|   | Social Relationships |   |
| 45. | Marital Status | % Now married | ACS 2017 5-year Estimates |
| 46. |   | % Widowed | ACS 2017 5-year Estimates |
| 47. |   | % Divorced | ACS 2017 5-year Estimates |
| 48. |   | % Separated | ACS 2017 5-year Estimates |
| 49. |   | % Never married | ACS 2017 5-year Estimates |
| 50. | Living Alone | % Lives alone | ACS 2017 5-year Estimates |
| 51. |   | % Householder living with spouse or spouse of householder | ACS 2017 5-year Estimates |
| 52. |   | % Householder living with unmarried partner or unmarried partner of householders | ACS 2017 5-year Estimates |
| 53. |   | % Child of householder | ACS 2017 5-year Estimates |
| 54. |   | % Other relatives | ACS 2017 5-year Estimates |
| 55. |   | % Other nonrelatives | ACS 2017 5-year Estimates |
| 56. | Social Support | Social associations | County Health Ranking, 2019/County Business Patterns |
| 57. |   | Children in single-parent households | ACS 2017 5-year Estimates |
|   | Residential and Community Context |   |
|   | Built environment |   |
| 58. | Housing | Median home value | ACS 2017 5-year Estimates |
| 59. |   | Median gross rent | ACS 2017 5-year Estimates |
| 60. |   | Median monthly mortgage | ACS 2017 5-year Estimates |
| 61. |   | Percentage of owner-occupied housing units (home ownership rate) | ACS 2017 5-year Estimates |
| 62. |   | Percentage of occupied housing units without a motor vehicle | ACS 2017 5-year Estimates |
| 63. |   | Percentage of occupied housing units without a telephone | ACS 2017 5-year Estimates |
| 64. |   | Percentage of occupied housing units without complete plumbing | ACS 2017 5-year Estimates |
| 65. | Percentage of occupied housing units with >1 person per room (crowding) | ACS 2017 5-year Estimates |
| 66. | Total vacant addresses | USPS |
| 67. | % of households with severe housing problems | County Health Ranking, 2019 Comprehensive Housing Affordability Strategy (CHAS) data |
| 68. | Low-vacancy areas | HUD, data collected annually through 2019 |
| 69. | Monthly housing costs as a percentage of household income in the past 12 months | ACS 2017 5-year Estimates |
| 70. | Number of total physicians (MD+DO) per 1,000 population | Area Health Resource File |
| 71. | Number of primary care physician per 1,000 population | Area Health Resource File |
| 72. | Number of hospital beds per 1,000 population | Area Health Resource File |
| 73. | Number of SNF beds per 1,000 population | Area Health Resource File |
| 74. | Number of HHA per 1,000 population | Area Health Resource File |
| 75. | Number of hospices per 1,000 population | Area Health Resource File |
| 76. | Number of ambulatory surgery center per 1,000 population | Area Health Resource File |
| 77. | GINI inequality index | ACS 2017 5-year Estimates |
| 78. | Urban/Rural | ACS 2017 5-year Estimates |
| 79. | Violent crime | County Health Ranking, 2019/Uniform Crime Reporting – FBI |
| 80. | Injury deaths | County Health Ranking, 2019 |
| 81. | Access to exercise opportunities | County Health Ranking, 2019 |

**Composite Indices**

| 82. | SVI-total themes percentile | Centers for Disease Control and Prevention |
| 83. | SVI-Socioeconomic Status percentile | Centers for Disease Control and Prevention |
| 84. | SVI-Household Composition & Disability percentile | Centers for Disease Control and Prevention |
| 85. | SVI-Minority Status & Language percentile | Centers for Disease Control and Prevention |
| 86. | SVI-Housing Type & Transportation percentile | Centers for Disease Control and Prevention |
| 87. | Social Deprivation Index | The Robert Graham Center |

Notes: ACS: American Community Survey; BLS: Bureau of Labor Statistics; USDA: United States Department of Agriculture; USPS: United States Postal Service; HUD: United States Department of Housing and Urban Development. SNF: skilled nursing facility; HHA: home health agency. * Definition from https://seer.cancer.gov/seerstat/variables/countyattribs/static.html#14-18
### eTable 2 Correlations between social determinants of health measures of socioeconomic position

|                        | Median household income | % of residents in poverty | % of residents who are uninsured | Unemployment rate | % of residents without a high school degree | Food environment index |
|------------------------|-------------------------|---------------------------|----------------------------------|-------------------|--------------------------------------------|------------------------|
| Median household income| 1.0000                  |                           |                                  |                   |                                            |                        |
| % of residents in poverty| **-0.7600**             | 1.0000                    |                                  |                   |                                            |                        |
| % of residents who are uninsured| -0.3427               | 0.3581                    | 1.0000                           |                   |                                            |                        |
| Unemployment rate      | -0.4422                 | 0.5567                    | 0.0907                           | 1.0000            |                                            |                        |
| % of residents without a high school degree| -0.5558               | 0.6396                    | 0.5691                           | 0.4332            | 1.0000                                     |                        |
| Food environment index | 0.5811                  | **-0.6678**               | **-0.3734**                      | **-0.4135**       | **-0.3536**                               | 1.0000                 |

### eTable 3 Correlations between social determinants of health measures of race and ethnicity composition

|                        | % of residents who are non-white | % of residents who are non-citizen | % residents with limited English proficiency |
|------------------------|----------------------------------|-----------------------------------|---------------------------------------------|
| % of residents who are non-white | 1.0000                           |                                   |                                             |
| % of residents who are non-citizen | 0.1968                           | 1.0000                           |                                             |
| % residents with limited English proficiency| 0.1496                           | **0.8199**                        | 1.0000                                      |
**eTable 4 Correlations between social determinants of health measures of overall residential and community context**

|                      | % of households with severe housing problems | % of residents with access to exercise opportunities | % of housing units in rural areas |
|----------------------|---------------------------------------------|-----------------------------------------------------|----------------------------------|
| % of households with severe housing problems     | 1.0000                                      |                                                     |                                  |
| % of residents with access to exercise opportunities | 0.2209                                     | 1.0000                                               |                                  |
| % of housing units in rural areas                 | -0.3595                                     | -0.6094                                              | 1.0000                           |
eTable 5 Correlations between Social determinants of health measures included in the study

| Correlation Matrix | Median household income | % of residents who are uninsured | Unemployment rate | % of residents without a high school degree | Food environment index | % of residents who are non-white | % of residents who are non-citizen | Number of membership associations per 1,000 population | % of households with severe housing problems | % of residents with access to exercise opportunities | % of housing units in rural areas |
|-------------------|-------------------------|---------------------------------|------------------|------------------------------------------|------------------------|---------------------------------|-------------------------------|-----------------------------------|----------------------------------------|----------------------------------------|----------------------------------------|
| Median household income | 1.0000 | | | | | | | | | | | |
| % of residents who are uninsured | -0.3427 | 1.0000 | | | | | | | | | | |
| Unemployment rate | -0.4422 | 0.0907 | 1.0000 | | | | | | | | | |
| % of residents without a high school degree | -0.5558 | 0.5691 | 0.4332 | 1.0000 | | | | | | | | |
| Food environment index | 0.5811 | -0.3734 | -0.4135 | -0.3536 | 1.0000 | | | | | | | |
| % of residents who are non-white | -0.1626 | 0.2943 | 0.3128 | 0.3318 | -0.5025 | 1.0000 | | | | | | |
| % of residents who are non-citizen | 0.2396 | 0.3398 | -0.0503 | 0.3161 | 0.1092 | 0.1968 | 1.0000 | | | | | |
| Number of membership associations per 1,000 population | -0.0635 | -0.0533 | -0.2409 | -0.1955 | 0.0857 | -0.2240 | -0.2042 | 1.0000 | | | | |
| % of households with severe housing problems | -0.0748 | 0.1649 | 0.2691 | 0.2192 | -0.2488 | 0.4838 | 0.4002 | -0.4056 | 1.0000 | | | |
| % of residents with access to exercise opportunities | 0.4109 | -0.2906 | -0.1420 | -0.3582 | 0.3126 | -0.0797 | 0.2550 | -0.0751 | 0.2209 | 1.0000 |
|---|---|---|---|---|---|---|---|---|---|---|
| % of housing units in rural areas | -0.3897 | 0.1693 | 0.0897 | 0.1788 | -0.1159 | -0.2009 | -0.4042 | 0.2663 | -0.3595 | -0.6094 | 1.0000 |
## cTable 6. Sources of social determinants of health measures used in this study

| Measures                                           | Source                                           | Year of Data |
|----------------------------------------------------|--------------------------------------------------|--------------|
| Median household income                            | American Community Survey                        | 2017         |
| Uninsured rate                                     | American Community Survey                        | 2017         |
| Unemployment rate                                  | American Community Survey                        | 2017         |
| % without high school degree                       | American Community Survey                        | 2017         |
| Food environment index                             | 2019 County Health Rankings and Roadmaps        | 2015 & 2016  |
| % of Hispanic                                      | American Community Survey                        | 2017         |
| % of non-Hispanic black                            | American Community Survey                        | 2017         |
| % of non-Hispanic with another race                | American Community Survey                        | 2017         |
| % of residents who are non-citizen                 | American Community Survey                        | 2017         |
| Social associations per 1,000 population            | 2019 County Health Rankings and Roadmaps        | 2016         |
| % of households with severe housing problems       | 2019 County Health Rankings and Roadmaps        | 2011-2015    |
| % of residents with access to exercise opportunities| 2019 County Health Rankings and Roadmaps        | 2010 & 2018  |
| % of housing units in rural areas                  | Decennial Census                                 | 2010         |

Notes:  
1. Food environment index equally weights two indicators of the food environment: (1) Limited access to healthy foods, which estimates the percentage of the population that is low income and does not live close to a grocery store. (2) Food insecurity, which estimates the percentage of the population that did not have access to a reliable source of food.  
2. Other races include American Indian and Alaska Native, Asian, Native Hawaiian and Other Pacific Islander, and other races.  
3. Social Associations measures the number of membership associations per 10,000 population.  
4. Severe housing problems is the percentage of households with one or more of the following housing problems: (1) Housing unit lacks complete kitchen facilities; (2) Housing unit lacks complete plumbing facilities; (3) Household is overcrowded; or (4) Household is severely cost burdened.  
5. Access to exercise opportunities measures the percentage of individuals in a county who live reasonably close to a location for physical activity, defined as parks or recreational facilities. Individuals are considered to have access to exercise opportunities if they reside in a census block that is within a half mile of a park, or reside in an urban census block that is within one mile of a recreational facility, or reside in a rural census block that is within three miles of a recreational facility.  
6. More information about these measures could be found at: https://www.countyhealthrankings.org/explore-health-rankings/measures-data-sources/2021-measures
eAppendix 2. Regression models to examine the contribution of patient, supply, and SDoH characteristics to geographic variation in per beneficiary Medicare total spending

We first categorized counties into quintiles based on their price-adjusted per beneficiary Medicare spending in 2017 and calculated the differences in mean price-adjusted per beneficiary Medicare spending between each higher spending quintile (quintiles 2-5) and quintile 1. We then followed previously developed methods to examine the extent to which the variation in price-adjusted per beneficiary Medicare spending across quintiles could be explained by (1) patient demographics, (2) patient clinical risk, (3) supply of health resources, and (4) SDoH.

To assess the total contribution of each group of characteristics to geographic variation in Medicare spending, we first ran a linear regression model where the outcome variable is the price-adjusted per beneficiary spending and explanatory variables are one of the four groups of characteristics above.

\[ Y_i = \alpha + \beta X_i + \varepsilon_i \]  

In this equation, \( Y_i \) represents the price-adjusted per beneficiary Medicare spending in each county \( i \), \( X_i \) is a vector of independent variables (e.g., demographics or clinical risk). \( \beta \) represents the coefficients estimating the relationship between per beneficiary Medicare spending and the independent variables. \( \varepsilon_i \) represents the error term. This model is weighted by the number of fee-for-service patients in each county.

After estimating model (1) using OLS, we estimated the predicted value of the outcome \( \hat{Y}_i \) given the independent variables and estimated coefficients \( \hat{\beta} \) and calculated the residual for each county as \( e_i = Y_i - \hat{Y}_i \). \( e_i \) represents the per beneficiary spending that is not explained by independent variables. We then calculated the mean per beneficiary spending across all counties as \( \bar{Y} = \frac{\sum_{i=1}^{3,038} Y_i}{3,038} \). Finally, the adjusted per beneficiary spending for each county was calculated as \( \hat{Y}_{adj,i} = \bar{Y} + e_i \), which removes variation in \( Y_i \) explained by \( X_i \). The adjusted variation in per beneficiary spending was calculated as the differences in mean \( \bar{Y}_{adj,i} \) among counties in quintiles 2-5 and mean \( \bar{Y}_{adj,i} \) among counties in quintile 1. If the independent variables in the regression model (1) could explain the variation, we would expect a narrowed variation across quintiles. The share of the variation explained by the independent variable was calculated as one minus the ratio of variation in adjusted spending \( \bar{Y}_{adj,i} \) to that in price-adjusted per beneficiary spending \( Y_i \), times 100. This model and the estimation process were repeated for four times to calculate the total contribution of each group of characteristics.

We note that this approach is analogous and yields similar results to the R-squared statistic of the regression with \( Y_i \) as the dependent variable and \( X_i \) as independent variables (Figure 3 and Table 2). The current approach has the benefit of allowing us to flexibly present changes in spending in terms of dollar amounts of counties in different spending quintiles.

To estimate the direct contribution of each group of characteristics, we ran a single model using all characteristics as independent variables.

\[ Y_i = \alpha + \beta_1 \text{demographic}_i + \beta_2 \text{clinical risk}_i + \beta_3 \text{supply}_i + \beta_4 \text{SDoH}_i + \varepsilon_i \]  

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Similar with model 1, we first calculated the residual for each county as \( e_i = Y_i - \hat{Y}_i \) after estimating model (1) using OLS. We then sequentially replaced each group of characteristics using their means across all counties and estimated the predicted per beneficiary spending \( \hat{Y}_i \) given the independent variables and estimated coefficients \( \hat{\beta}_1 - \hat{\beta}_4 \). Finally, the adjusted per beneficiary spending is calculated as \( \hat{Y}_{adj,i} = \hat{Y}_i + e_i \). Similarly, the adjusted variation in per beneficiary spending was calculated as the differences in mean \( \hat{Y}_{adj,i} \) among counties in quintiles 2-5 and mean \( \hat{Y}_{adj,i} \) among counties in quintile 1. The share of the variation explained by the independent variable was calculated as one minus the ratio of variation in adjusted spending \( \hat{Y}_{adj,i} \) to that in price-adjusted per beneficiary spending \( Y_i \), time 100. This process was repeated four times to calculate the direct contribution of each group of characteristics.

**eTable 7. Summary of regression models and their purposes**

| Model | Outcome | Independent Variables | Purposes | Primary or Sensitivity |
|-------|---------|-----------------------|----------|------------------------|
| 1     | Price-adjusted per beneficiary spending | Demographics | Estimating total contribution of demographics | Primary |
| 2     | Price-adjusted per beneficiary spending | Clinical risk | Estimating total contribution of clinical risk | Primary |
| 3     | Price-adjusted per beneficiary spending | Supply | Estimating total contribution of supply of healthcare | Primary |
| 4     | Price-adjusted per beneficiary spending | SDoH | Estimating total contribution of SDoH | Primary |
| 5     | Price-adjusted per beneficiary spending | Demographics, clinical risk, supply, and SDoH | Estimating direct contribution of each set of characteristics | Primary |
| 6     | Price-adjusted per beneficiary spending | Demographics, supply, and SDoH | Estimating direct contribution of demographics, supply, and SDoH | Sensitivity |
| 7     | Price-, age-, gender-, and race-adjusted per beneficiary spending | Supply and SDoH | Estimating direct contribution of supply and SDoH | Sensitivity |
Notes: For each quintile, the share of variation associated with each set of characteristics was estimated when controlling for other characteristics. Demographics include age, age squared, age cubed, and gender; supply characteristics include the following measures per 1,000 population: primary care physicians, specialists, hospital beds, skilled nursing facility beds, home health agency aides, registered nurses employed by hospices, and ambulatory care centers. SDoH include median household income, % who are uninsured, unemployment rate, % without high school degree, food environment index; % who are Hispanic, % of non-Hispanic black, and % of non-Hispanic with another race (i.e., American Indian and Alaska Native, Asian, Native Hawaiian and Other Pacific Islander, and other races), % who are non-citizen, social associations per 1,000 population, % with severe housing problems, % with access to exercise opportunities, and % of housing units in rural areas.
eFigure 2. Contribution to variation in price-, age-, gender-, and race-adjusted per beneficiary spending between quintiles 2-5 and quintile 1, using Dartmouth spending as outcome

Notes: For each quintile, the share of variation associated with each set of characteristics was estimated when controlling for other characteristics. Supply characteristics include the following measures per 1,000 population: primary care physicians, specialists, hospital beds, skilled nursing facility beds, home health agency aides, registered nurses employed by hospices, and ambulatory care centers. SDoH include median household income, % who are uninsured, unemployment rate, % without high school degree, food environment index; % who are Hispanic, % of non-Hispanic black, and % of non-Hispanic with another race (i.e., American Indian and Alaska Native, Asian, Native Hawaiian and Other Pacific Islander, and other races), % who are non-citizen, social associations per 1,000 population, % with severe housing problems, % with access to exercise opportunities, and % of housing units in rural areas.
eTable 8. Full regression output of sensitivity analysis: coefficients and robust standard errors

| Demographics | Using CMS spending measure | Partial F (p value) | Using Dartmouth spending measure | Partial F (p value) |
|--------------|----------------------------|---------------------|----------------------------------|---------------------|
| Age          | -103884.8 * (51690.18)    | 48.6 (<0.001)       | –                                | –                   |
| Age squared  | 1440.14 (734.07)          |                     |                                  |                     |
| Age cubed    | -6.65 (3.47)              |                     |                                  |                     |
| % of female  | 262.87 *** (24.08)        |                     | –                                | –                   |

| Supply of health resources per 1,000 population Mean |
|------------------------------------------------------|
| Number of PCPs                                       | -1122.92 *** (160.14) | 28.7 (<0.001) | -1018.85 *** (165.76) | 30.2 (<0.001) |
| Number of specialists                                 | 93.56 ** (34.92)      |               | 74.86 * (31.47)       |               |
| Number of hospital beds                               | 37.25 *** (9.77)      |               | 38.35 *** (10.96)     |               |
| Number of SNF beds                                    | 89.29 *** (8.01)      |               | 104.14 *** (8.44)     |               |
| Number of HHA aides                                   | 43.46 (28.42)         |               | 34.58 (24.87)         |               |
| Number of hospice RNs                                 | 329.85 (174.74)       |               | 419.48 * (196.50)     |               |
| Number of ASCs                                        | -6738.00 *** (1896.45)|               | -7535.31 *** (2096.51)|               |

| Social determinants of health                         |
|------------------------------------------------------|
| Socioeconomic Position                               |
| Median household income ($$)                          | -0.001 (0.005)        | 53.0 (<0.001) | 0.002 (0.006)        | 43.1 (P<0.001) |
| Uninsured rate                                       | 103.56 *** (13.25)    |               | 95.47 *** (14.29)    |               |
| Unemployment rate                                    | 74.39 * (37.64)       |               | 41.30 (41.46)        |               |
| % without high school degree                         | 20.26 (18.59)         |               | 49.45 * (21.03)      |               |
| Food environment index                               | 135.88 (69.71)        |               | 261.83 ** (89.04)    |               |

| Race & Ethnicity                                     |
|------------------------------------------------------|
| % of residents who are non-citizens                  | -30.49 (20.74)        | -17.44 (23.46) | -17.44 (23.46)       |               |
| % of residents who are Hispanic                      | 1.84 (4.91)           | -14.34 ** (5.32) |               |               |
| % of residents who are non-Hispanic black            | 15.96 *** (3.69)      | 9.65 * (4.82)  |               |               |
| % of residents who are non-Hispanic other races      | -43.27 (3.69)         | -35.43 (4.82)  |               |               |
### Social Relationships

| Social associations per 1,000 population | (169.18) | (188.42) |
|----------------------------------------|----------|----------|
| **Social associations per 1,000 population** | -55.20 *** | -70.77 *** |
|                                         | (9.59)   | (10.47)  |

### Residential and Community Context

| % of households with severe housing problems | 18.78 (22.48) | 3.06 (25.60) |
|--------------------------------------------|---------------|--------------|
| % of residents with access to exercise opportunities | -4.12 (2.24) | -5.57 (2.50) * |
| % of housing units in rural areas | -11.81 *** (2.02) | -17.26 *** (1.89) |

| N                                      | 3,038 | 3,038 |
|----------------------------------------|-------|-------|
| Overall F                               | 67.7  | 38.8  |
| p-value of F                            | <0.001| <0.001|
| R-squared                              | 0.53  | 0.33  |
| Adjusted R-squared                     | 0.54  | 0.33  |

Notes: PCP: primary care physicians; SNF: skilled nursing facility; HHA: home health agency; RN: registered nurses; ASC: ambulatory surgery center. * P<0.05, **P<0.01, ***P<0.001. Results are from the linear regressions using CMS price-adjusted per beneficiary Medicare spending or Dartmouth price-, age-, gender-, and race-adjusted spending as outcome, controlling for variables in each column in the regression models. We reported coefficients and robust standard errors for each variable.
| Social determinants of health | SDoH F tests | SDoH and demographics F tests | Parti al F tests | SDoH, demographics, and supply of health resources F tests | Parti al F tests |
|-------------------------------|--------------|-------------------------------|-----------------|----------------------------------------------------------|-----------------|
| **Socioeconomic Position**    |              |                               |                 |                                                          |                 |
| Median household income ($1,000) | -0.002 ***  | 68.8 (P<0.001) | -0.002 *** (0.0004) | 38.40 (P<0.001) | -0.001 ** (0.0004) |
| Uninsured rate                | -0.0009 (0.0009) | 0.001 (0.0009) | 0.001 (0.001) | 0.007 ** (0.003) | 0.007 ** (0.003) |
| Unemployment rate             | 0.002 (0.003) | 0.007 ** (0.003) | 0.007 ** (0.003) | 0.004 ** (0.001) | 0.004 ** (0.001) |
| % without high school degree  | 0.008 *** (0.001) | 0.005 *** (0.001) | 0.005 *** (0.001) | 0.004 ** (0.001) | 0.004 ** (0.001) |
| Food environment index        | 0.024 *** (0.006) | 0.016 ** (0.005) | 0.016 ** (0.006) | 0.016 ** (0.006) | 0.016 ** (0.006) |
| **Race & Ethnicity**          |              |                               |                 |                                                          |                 |
| % of residents who are non-citizens | -0.0005 (0.002) | -0.001 (0.001) | -0.0003 (0.001) | -0.0003 (0.001) | -0.0003 (0.001) |
| % of residents who are Hispanic | -0.0008 (0.0004) | 0.0001 (0.0004) | 0.0001 (0.0004) | 0.0001 (0.0004) | 0.0001 (0.0004) |
| % of residents who are non-Hispanic black | 0.002 *** (0.0003) | 0.001 *** (0.0003) | 0.001 *** (0.0003) | 0.001 *** (0.0003) | 0.001 *** (0.0003) |
| % of residents who are non-Hispanic with another races | 0.018 (0.010) | 0.013 (0.009) | 0.013 (0.009) | 0.013 (0.009) | 0.013 (0.009) |
| **Social Relationships**      |              |                               |                 |                                                          |                 |
| Social associations per 1,000 population | -0.0005 (0.0006) | -0.002 * (0.0007) | -0.003 *** (0.0007) | -0.003 *** (0.0007) | -0.003 *** (0.0007) |
| **Residential and Community Context** |              |                               |                 |                                                          |                 |
| % of households with severe housing problems | -0.003 * (0.001) | 0.004 ** (0.001) | 0.005 *** (0.001) | 0.005 *** (0.001) | 0.005 *** (0.001) |
| % of residents with access to exercise opportunities | -0.0002 (0.0002) | -0.0002 (0.0002) | -0.0001 (0.0002) | -0.0001 (0.0002) | -0.0001 (0.0002) |
| Demographics |  |  |  |
|--------------|---|---|---|
| % of housing units in rural areas | -0.002 *** (0.0001) | -0.0008 *** (0.0001) | -0.001 *** (0.0001) |
| Age | -3.31 (3.44) | 35.65 (P<0.001) | -2.53 (3.15) |
| Age squared | 0.001 *** (0.0003) | 0.03 (0.04) | -0.0001 (0.0002) |
| Age cubic |  |  |  |
| % of female | 0.016 *** (0.0009) | 0.018 *** (0.002) |  |

| Supply of health resources per 1,000 population Mean |  |  |  |
|----------------------------------------------------|---|---|---|
| Number of PCPs | -0.058 *** (0.012) | 19.79 (P<0.001) |  |
| Number of specialists | 0.006 * (0.003) |  |  |
| Number of hospital beds | 0.002 ** (0.0006) |  |  |
| Number of SNF beds | 0.005 *** (0.0006) |  |  |
| Number of HHA aides | 0.003 (0.002) |  |  |
| Number of hospice RNs | -0.007 (0.013) |  |  |
| Number of ASCs | -0.589 *** (0.140) |  |  |
| N | 3,038 | 3,038 | 3,038 |
| R-squared | 0.55 | 0.63 | 0.65 |
| Adjusted R-squared | 0.54 | 0.61 | 0.64 |

Notes: PCP: primary care physicians; SNF: skilled nursing facility; HHA: home health agency; RN: registered nurses; ASC: ambulatory surgery center. * P<0.05, **P<0.01, ***P<0.001. Results are from the linear regressions using CMS-HCC scores as the outcome. We reported coefficients and robust standard errors for each variable.
Notes: For each quintile, the share of variation associated with each set of characteristics was estimated when controlling for other characteristics. Demographics include age, age squared, age cubed, and gender. Supply characteristics include the following measures per 1,000 population: primary care physicians, specialists, hospital beds, skilled nursing facility beds, home health agency aides, registered nurses employed by hospices, and ambulatory care centers. SDoH include median household income, % who are uninsured, unemployment rate, % without high school degree, food environment index; % who are Hispanic, % of non-Hispanic black, and % of non-Hispanic with another race (i.e., American Indian and Alaska Native, Asian, Native Hawaiian and Other Pacific Islander, and other races), % who are non-citizen, social associations per 1,000 population, % with severe housing problems, % with access to exercise opportunities, and % of housing units in rural areas.

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