Health & Place 78 (2022) 102911

Contents lists available at ScienceDirect

Health and Place

journal homepage: www.elsevier.com/locate/healthplace

Does hospital location matter? Association of neighborhood socioeconomic disadvantage with hospital quality in US metropolitan settings

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ARTICLE INFO

Keywords:
Neighborhood socioeconomic disadvantage
Area deprivation index
Hospital ratings
Hospital quality
Hospital location

ABSTRACT

An aspect of a hospital's location, such as its degree of socioeconomic disadvantage, could potentially affect quality ratings of the hospital; yet, few studies have granularly explored this relationship in United States (US) metropolitan areas characterized by a wide breadth of socioeconomic disparities across neighborhoods. An understanding of the effect of neighborhood socioeconomic disadvantage on hospital quality of care is informative for targeting resources in poor neighborhoods. We assessed the association of neighborhood socioeconomic disadvantage with hospital quality of care across several areas of quality (including mortality, readmission, safety, patient experience, effectiveness of care, summary and overall star rating) in US metropolitan areas. Hospitals in the most disadvantaged neighborhoods, compared to hospitals in the least disadvantaged neighborhoods, had worse mortality scores, readmission scores, safety of care scores, patient experience of care scores, effectiveness of care scores, summary scores and overall star rating. Timeliness of care and efficient use of imaging scores were not strongly associated with neighborhood socioeconomic disadvantage; although, future studies are needed to validate this finding. Policymakers could target innovative strategies for improving neighborhood socioeconomic conditions in more disadvantaged areas, as this may improve hospital quality.

1. Introduction

Healthcare quality is an important topic in hospitals and other healthcare settings. In 2004, the Centers for Medicare and Medicaid Services (CMS) began disseminating performance data from hospitals participating in the Hospital Quality Alliance Program. This was done as a way to increase transparency, accountability, and quality improvement activities, as well as influence consumer decisions on where to source for healthcare (Marshall et al., 2000; Ryan et al., 2012). Given curiosity to understand factors contributing to hospital quality, research in this field took flight with the availability of healthcare quality measures data. Preliminary findings reveal significant variation in hospital quality of care (Woodard, 2005; Sheetz et al., 2019; van Sluisveld et al., 2017). Understanding the causes of hospital quality variation is critical to improving the results of the quality measures in hospitals.

Many studies have ascertained that factors such as patient-level socio-demographic and hospital-level characteristics may affect quality of care (Arbaje et al., 2008; Hawkins et al., 2012; Hu et al., 2018; Kind and Buckingham, 2018a; Joynt Maddox et al., 2019; Krumholz et al., 2009; Joynt and Jha, 2013; Woodard, 1096; Landon et al., 2006). In particular, studies have attributed patient-level socio-demographic factors including race, health literacy and social support to be associated with variation in hospital rates of readmission (Arbaje et al., 2008; Hawkins et al., 2012; Hu et al., 2018; Kind and Buckingham, 2018a; Joynt Maddox et al., 2019). Hospital-level characteristics including teaching status, bed size, volume, staffing quality, ownership type, and the number of physicians per capita have also been linked to hospital performance variation (Krumholz et al., 2009; Joynt and Jha, 2013; Woodard, 1096; Landon et al., 2006).

Neighborhood-level characteristics in the form of physical and social environments play a critical role in understanding the distribution of health outcomes (Fisher and Wennberg, 2003). Despite progress in investigating variability in hospital quality, few studies have explored how location is related to hospital quality (Rosenberg et al., 2016). Past location-based studies have often focused on the relationship between a patient's residential location and hospital health outcomes, and even fewer studies have considered hospital location as a predictor of hospital quality. Yet, Herrin and colleagues have shown that hospital location

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https://doi.org/10.1016/j.healthplace.2022.102911
Received 8 April 2022; Received in revised form 3 August 2022; Accepted 11 September 2022
Available online 12 November 2022
1353-8292/

accounts for about 58% of the variation in hospital quality measures such as readmission rates (Herrin et al., 2015). Second, the few studies that explored hospital location as a predictor of hospital quality of care considered hospital location from a larger geographical unit like state, county, and Health Service Areas (HSAs) (Jencks et al.,; Chen et al., 1998). HSAs have relatively large boundaries in metropolitan settings; a specific example is seen in Chicago where a single HSA includes 10 unique hospitals in widely different regions of the city (Fahrenbach et al., 2019). Larger geographical analyses may mask the true extent of variation due to "over-averaging", a phenomenon resulting from using a less granular geographical area unit of measurement (Rosenberg et al., 2016; Heijink et al., 2015).

An aspect of a hospital's location such as its degree of socioeconomic disadvantage could be an important predictor of variation in hospital quality (Fahrenbach et al., 2019). For example, rural areas in the United States (US) tend to be pervasively poor (Pugh, 2019), and hospitals in these areas frequently report less than stellar hospital quality as a result of financial and human resource constraints (Murphy et al., 2018). Similarly, some US metropolitan areas are also characterized by a disproportionate burden of poor neighborhoods in inner-city areas. Nonetheless, little is known if the same phenomenon of lower hospital quality of care will be observed among hospitals in more socioeconomically disadvantaged neighborhoods.

Thus, employing the Area Deprivation Index (ADI) at the census block group level to approximate neighborhood socioeconomic disadvantage as granularly as possible, this study aimed to capture the effect of neighborhood socioeconomic disadvantage on hospital quality in US metropolitan areas. We defined hospital quality using CMS quality measures (mortality, readmission, safety of care, patient experience of care, effectiveness of care, efficient use of medical imaging, timeliness of care, summary of care, and overall hospital star rating).

2. Methods

2.1. Study design

This study was a retrospective observational study using secondary data from 2017, the most recent publicly available data at the time of the study. In situations where the year 2017 data is not available, the available data closest to year 2017 was used.

2.2. Study sample

We included all short-term acute care adult hospitals across US metropolitan areas. The study excluded Maryland hospitals (because this state is granted special permission from Congress to set its own rules regarding Medicare expenditures and how to handle readmissions), specialty hospitals (e.g., psychiatric hospitals), critical access hospitals, cancer hospitals, children's hospitals and veteran's administration hospitals.

This study's sample, according to Hospital Compare data, is a national cohort of approximately 2655 hospitals.

2.3. Data collection and management plan

The 2017 AHA Annual Survey provided the following hospital characteristics: hospital ownership type, teaching status, bed size, number of Medicaid inpatient days (for defining safety-net status), core-based statistical area (CBSA) type (for limiting the data to only metropolitan area hospitals), hospital county information (for deriving hospital metropolitan status), and hospital geographic coordinate points (latitude and longitude points: for deriving hospital census block group federal information processing standards [FIPS] code).

To correctly classify the hospital's metropolitan status into either large central, large fringe, or medium metro, the AHA database was linked to the publicly available *2013* NCHS Urban-Rural Classification Scheme for Counties dataset via the hospital county FIPS code.

The Block group is the smallest geographical unit for which the US government provides decennial data on households, and typically has a population of 600–3000 people (United States Census Bureau, 2022). Unfortunately, the AHA dataset did not readily come with the census block group FIPS code. Nevertheless, the 2010 US Census geographic information, which contains this information, was available through the ESRI US census block spatial layer on ArcMap 10.8 (2019 ESRI, Redlands, CA). A spatial layer containing hospital location was created by geocoding each hospital's latitude (X) and longitude (Y) data points (from the AHA data) using ArcGIS world geocoding service. To determine the census block group FIPS code based on hospital location, the geocoded layer of hospital location was spatially joined to the ESRI US census block spatial layer in ArcMap 10.8. The resulting AHA dataset from the spatial join was exported into an excel spreadsheet.

The ADI data, which measures the neighborhood socioeconomic status (SES) at the block group level, was downloaded from the neighborhood atlas website (University of Wisconsin School of Medicine and Public Health, 2015). ADI data uses the census block group as the geographic unit of construction because it is the closest approximation to neighborhood, and thus this data provides information on the rankings of neighborhoods by socioeconomic disadvantage (Kind and Buckingham, 2018b). The ADI dataset was subsequently linked to the AHA dataset via the hospital's 12-digit Census Block Group FIPS code to get the ADI national rank information corresponding to the Hospital's census block group. This merge was done using SAS 9.4 analytical software. The resultant dataset containing hospital characteristics, metropolitan status, and ADI information was subsequently merged with the publicly available CMS overall star rating 2017 data to get each hospital's corresponding quality group scores, summary scores, and star rating. Please, see Linking Matrix in Appendix for diagrammatic details.

The final dataset was stored on a personal computer, and all files were password-protected to preserve the integrity of the data. Before analyses, data were cleaned, and a codebook was created in SAS 9.4 software. Statistical analyses were performed using STATA version 16.0 (StataCorp LP, College Station, TX) and SAS 9.4 analytical software (SAS Institute Inc, Cary, NC).

2.4. Study variables

2.4.1. Independent Variable: Area Deprivation Index (ADI)

In 2003, Singh et al. created the Area Deprivation Index (ADI), using neighborhood socioeconomic attributes to characterize neighborhood socioeconomic disadvantage from the 1990 census data by zip code service areas (Singh, 2003). The ADI is a composite measure of 17 indicators of socioeconomic status across four theoretical domains of employment, income, education, and housing quality, weighted by factor score coefficients. (See Appendix 2 for the 17 indicators which make up the ADI). In 2013, Kind et al. adapted Singh's methodology by summing the same 17 census indicators multiplied by Singh's factor score coefficients for each US census-block group using the 2000 US Census data (Kind et al., 2014). A composite index rather than a single measure is much preferred for characterizing a community's socioeconomic position because it possesses greater validity, robustness, and explanatory power (Singh, 2003; Singh and Siahpush, 2002). For this study, the 2015 ADI which uses the 2015 American Community Survey (ACS) five-year average data from 2011-2015, was employed in the analyses. These ADI scores were publicly available on the neighborhood atlas website. The national ADI percentiles range from 1 to 100, where higher scores represent higher levels of socioeconomic disadvantage. ADI percentile scores were categorized into quintiles (Q): Q1 (1–20), Q2 (21–40), Q3 (41–60), Q4 (61–80) and Q5 (81–100)), and then each hospital was assigned into their corresponding ADI quintile based on their ADI score. This method of sub-dividing the ADI into quintile groups had been utilized in previous studies (Joynt Maddox et al., 2019).

2.4.2. Co-variates: Hospital-level characteristics

Hospital-level characteristics were classified as categorical variables as follows: ownership type (public, private not for profit, and private for-profit) (Eggleston et al., 2008; Horwitz et al., 2017), teaching status (major teaching program: having a council of teaching hospitals and health systems [COTH] designation due to having an affiliation with an accredited medical/osteopathic school and an accredited residency program, minor teaching program: non-COTH members with a medical school affiliation under the American Medical Association, and no teaching program: all other institutions) (Allison et al., 2000; Burke et al., 2017), bed size (small: 0–99 beds, medium: 100–399, large: 400 or more beds) (Mohan et al., 2013; Desai et al., 2018; Popescu et al., 2019), safety-net status (assigned to hospitals treating more socioeconomically challenged patients; with hospitals classified as "safety net" if the total inpatient Medicaid days was in the top quartile) (Mohan et al., 2013; Joynt and Jha, 2011; Ross et al., 2007), and metropolitan status (assigned to hospitals located in metropolitan statistical areas containing a large population nucleus with adjacent communities having strong economic and social ties with that core (Centers for Disease Control and Prevention, 2013); hospitals were classified based on their location in a large central, large fringe or medium metro area) (Horwitz et al., 2017).

2.4.3. Dependent Variable: Hospital quality measures

Overall hospital star rating is a quality outcome measure that is reported on *Hospital Compare*; it includes information on roughly 57 quality measures (see Appendix 3 for list of individual measures) and more than 4000 hospitals. The star rating summarizes different measures across seven groups of quality (mortality, safety of care, readmission, patient experience, effectiveness of care, timeliness of care, and efficient use of medical imaging) into a single star rating for each hospital. The hospital summary score is calculated from the weighted average of all seven group scores, which is then used to calculate the final overall hospital rating.

The methodology for the star rating was developed by the Yale New Haven Health Services Corporation- Center for Outcomes Research and Evaluation (CORE) under contract with the Centers for Medicare & Medicaid Services (CMS). The development of the star rating followed a six-step approach (see appendix 4), alongside accomplishing a secondary objective of classifying hospital performance on groups or domains of measures.

Each of the seven quality groups (mortality, safety of care, readmission, efficiency of care, effectiveness of care, timeliness of care, patient experience of care), summary score, and overall hospital star rating was used as a proxy for quality and represented the quality measures. Group and summary scores were treated as continuous variables, while the overall star rating was treated as an ordinal variable (Fahrenbach et al., 2019). Higher quality scores indicate better quality.

2.5. Statistical analyses

Standard descriptive statistics, such as frequencies, means and standard deviations, were conducted to describe each quality measure (mortality, readmission, safety of care, patient experience, effectiveness of care, efficient use of medical imaging, timeliness of care, summary of care, and overall star rating) by neighborhood socioeconomic disadvantage (ADI). T-test, chi-square, and ANOVA was used to explore differences between groups of independent variables. Univariate and multivariable regression models were also performed to investigate unadjusted and adjusted associations between neighborhood socioeconomic disadvantage and hospital quality measures. Generalized mixed linear regression models were used for all measures of hospital quality except the overall star rating which used an ordinal mixed regression model. Significance testing was assessed at the level of alpha = 0.05.

Regression Equation: $Y_{ij} = a + BX_{ADI} + \text{covariates} + R_j + \varepsilon_{ij}$

where Y_{ij} represents the quality theme score for *i* hospital within census track *j*, X_{ADI} represents ADI, a is the intercept, B is the fixed effect, covariates represent hospital characteristics, ε_{ii} represents the error term and Rj represents the random component for addressing correlation of hospitals within the same census tract.

2.6. Reliability and validity of data

All data sources were publicly available and have been academically well-cited in previous literature.

2.7. Human subjects and safety consideration

This study was deemed non-human subjects research by the UTHealth School of Public Health Internal Review Board (IRB) since no human subjects, protected health information or personal information was used for this study.

3. Results

The starting AHA data set for the year 2017 contained roughly 6832 hospitals. However, after limiting to only US metropolitan short-term acute care hospitals with a primary service type of general medical or surgical, the final number of hospitals reduced to 2655. Of these 2655 hospitals, only 2502 could be assigned an ADI value. Thus, the total denominator for our study comprised 2502 hospitals.

3.1. Neighborhood socioeconomic disadvantage (ADI)

ADI rank scores for the study cohort ranged from 1 to 100, with a mean of 52.83 (SD = 28.47) and a median of 53 (IQR = 29, 78). ADI was categorically grouped into quintile levels. The range of scores for the least disadvantaged group was 1–20. The ADI scores for the fourth most disadvantaged group ranged from 21 to 40. The third most disadvantaged group had ADI scores between 41 and 60. The second most disadvantaged group had ADI scores between 61 and 80. The most disadvantaged group had scores between 81 and 100. The majority of hospitals (22.54%, n = 564) were in the most disadvantaged neighborhood. Table 1; Fig. 1.

3.2. Hospital characteristics

Of the 2502 hospitals, the majority of the hospitals in the study cohort were not-for-profit (65.11%, n = 1629), non-teaching (46.64%, n = 1167), medium bed-size of 100–399 beds (54.64%, n = 1367), located in a large central metro area (54.04%, n = 1352) and classified as a non-safety-net hospital (59.67%, n = 1493). Table 2.

3.3. Neighborhood socioeconomic disadvantage (ADI) groupings and quality measures

Table 3 summarizes the descriptive statistics of each quality score by ADI quintile levels. Table 4 summarizes the associations between each hospital quality score and ADI quintile levels. There was an association between neighborhood socioeconomic disadvantage and all quality

Table 1
Descriptive statistics of neighborhood socioeconomic disadvantage groups (ADI).

ADI Group	n (%)	Mean	Std. Dev	Min, Max
Overall ADI	2502 (100)	52.83	28.47	1, 100
Least Disadvantaged	421 (16.83)	10.71	5.73	1, 20
Fourth Most Disadvantaged	486 (19.42)	30.50	5.76	21, 40
Third Most Disadvantaged	537 (21.46)	50.52	5.70	41, 60
Second Most Disadvantaged	494 (19.74)	70.14	5.77	61, 80
Most Disadvantaged	564 (22.54)	90.55	6.03	81, 100

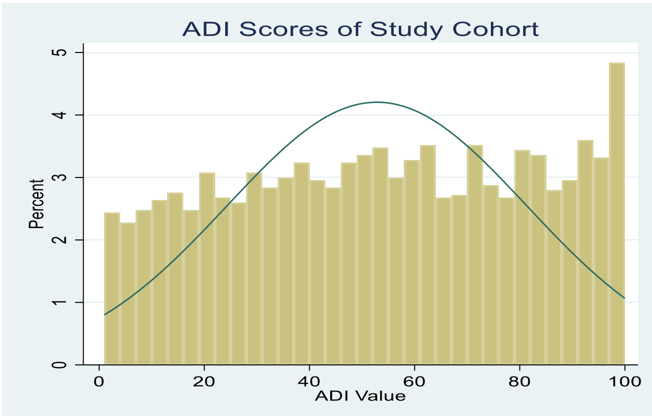

Fig. 1. Distribution of ADI scores.

Table 2
Descriptive statistics by hospital characteristics.

Hospital Characteristics	N = 2502 n (%)	ADI Mean (Std. Dev)	p-value
Safety net status			p<0.001
Yes	1009 (40.33)	53.57 (30.47)	
No	1493 (59.67)	52.33 (27.03)	
Ownership Type			p = 0.359
For Profit	585 (23.38)	56.16 (28.41)	
Non-Profit	1629 (65.11)	50.64 (28.55)	
Government/Public	288 (11.51)	58.44 (26.74)	
Teaching status			p<0.001
Major teaching	178 (7.11)	50.42 (33.54)	
Non-teaching	1167 (46.64)	54.44 (26.59)	
Minor teaching	1157 (46.24)	51.58 (29.37)	
Metropolitan status			p<0.001
Large Fringe Metro	695 (27.78)	58.43 (25.52)	
Large central metropolitan	1352 (54.04)	46.31 (29.78)	
Medium metropolitan	455 (18.19)	63.67 (23.19)	
Bed size			p<0.001
Small: 0-99	765 (30.58)	55.56 (25.88)	
Medium: 100-399	1367 (54.64)	50.92 (28.60)	
Large: 400 or more	370 (14.79)	54.26 (32.36)	

measures (except efficient use of medical imaging and timeliness of care). After adjusting for hospital-level characteristics, hospitals in the most disadvantaged neighborhoods, compared to hospitals in the least disadvantaged neighborhoods, had worse mortality scores (β: -0.41; 95% CI, −0.52, −0.29), readmission scores (β: -0.28; 95% CI, −0.42, −0.14), safety of care scores (β: -0.27; 95% CI, −0.42, −0.12), patient experience of care scores (β: -0.28; 95% CI, −0.40, −0.16), effectiveness of care scores (β: -0.15; 95% CI, −0.25, - 0.05), summary scores (β: -0.29; 95% CI, - 0.35, −0.22) and overall star rating (β: -1.10; 95% CI, - 1.43, −0.78). Table 4. Fig. 2. Fig. 3.

As neighborhood socioeconomic disadvantage increased from low-to high ADI quintiles, mortality scores, overall summary scores and hospital overall star ratings tended to progressively decrease. Hospitals in the most disadvantaged neighborhood had the worst mortality, summary and overall hospital star rating, while hospitals in the least disadvantaged neighborhood had the best mortality score, summary score and overall hospital star rating. Table 4. Fig. 2. Fig. 3.

4. Discussion

This study was an exploratory analysis of the relationship between neighborhood socioeconomic disadvantage and hospital quality. Specifically, we sought to examine the relationship between neighborhood socioeconomic disadvantage and measures of hospital quality (including mortality, readmission, safety, patient experience, efficient use of medical imaging, effectiveness, timeliness, and overall hospital star rating). Collectively, this study's findings demonstrate that neighborhood socioeconomic disadvantage was associated with hospital quality.

In synopsis, an observed pattern in the findings revealed that higher ADI quintiles (most disadvantaged and second most disadvantaged hospital neighborhoods) were more often associated with lower (worse) hospital quality (mortality, readmission, safety, patient experience, effectiveness, efficiency, timeliness, summary) scores and overall hospital star rating. Also, the study revealed that the strength of this association varied across quality groups and hospital neighborhood groups. For example, timeliness and efficient use of medical imaging were least associated with neighborhood socioeconomic disadvantage; While mortality, summary score, and overall hospital star rating had the strongest relationship with neighborhood socioeconomic disadvantage. The association of neighborhood socioeconomic disadvantage with timeliness of care and efficient use of medical imaging was significant in only higher ADI quintile levels (most-disadvantaged and second-most disadvantaged neighborhoods), and this relationship surprisingly lost its significance after adjusting for hospital characteristics. On the other hand, all ADI (neighborhood socioeconomic) quintile groups were associated with the hospital's mortality, summary of care, and overall hospital star rating; with more socioeconomically disadvantaged neighborhoods having lower mortality, summary scores, and overall hospital star rating even after adjusting for hospital characteristics.

Comprehensively, hospitals in the most-disadvantaged, and second-most disadvantaged neighborhoods, compared to the least disadvantaged neighborhood, had lower overall quality in unadjusted analysis. After adjusting for hospital characteristics, the relationship between neighborhood socioeconomic disadvantage and star rating extended to other neighborhood groups including the most-disadvantaged, second-most disadvantaged, third-most disadvantaged, and fourth-most disadvantaged groups compared to hospitals in the least disadvantaged groups.

The finding of this relationship between neighborhood socioeconomic disadvantage and star rating is consistent with the study published by Hu and Nerenz (2017) which revealed that about 20% of the variance in CMS star rating can be explained by a set of city-level characteristics, such as poverty, employment, and crime (Hu et al., 2018).

Of notable mention is the relationship between higher ADI quintile levels (the most socioeconomically disadvantaged neighborhoods) and all quality measures (except timeliness of care and efficient use of medical imaging) after adjusting for hospital characteristics. This study provided substantive evidence of the progressive inverse relationship between higher ADI (more socioeconomically disadvantaged neighborhoods) and lower hospital quality, even after adjusting for safety-net and teaching hospitals known to treat the sickest, most vulnerable, and socioeconomically challenged patients. In general, this study's findings suggest that the most challenging hospital neighborhoods have lower hospital quality. Additionally, the study's findings of lower quality in existing hospital systems in poor neighborhoods further highlights the inadequacies of our health systems in meeting the enormous health needs of low-SES patients.

This study, indeed, contributes novel information to the scientific community, in that, it adds to our collective understanding of how neighborhood disadvantage may be contributing to the widening inequities in the provision of- and access to quality healthcare. Few empirical studies have investigated the regional variation of hospital-level quality metric outcomes. Herrin et al. have looked at community quality of healthcare using HSAs to define community (Herrin et al., 2016). Other studies have looked at how community factors, such as demographics and socioeconomic factors, have influenced hospital quality at the county level (Herrin et al., 2015). This study was novel in that it used block group which is a strong approximation of neighborhood to understand, granularly, the relationship of neighborhood

Table 3
Mean quality group scores by neighborhood socioeconomic disadvantage groups (ADI).

Characteristics		Quality Group Scores							
		Mortality Scores	Readmission Scores	Safety of Care Scores	Patient Experience Scores	Effectiveness of Care Scores	Efficiency Scores	Timeliness Scores	Summary Scores
ADI Group									
Least Disadvantaged	n (%)	377 (17)	402 (17)	404 (18)	394 (18)	411 (17)	373 (17)	399 (17)	411 (17)
	Mean (SD)	0.5 (0.9)	−0.01 (1.16)	0.05 (1.02)	−0.25 (0.97)	0.12 (0.66)	0.17 (0.73)	−0.53 (0.99)	0.06 (0.55)
Fourth-Most Disadvantaged	n (%)	431 (19)	470 (19)	469 (21)	457 (21)	480 (20)	443 (20)	453 (20)	481 (20)
	Mean (SD)	0.06 (0.82)	0.06 (1.07)	0.01 (1.07)	−0.06 (0.1)	0.09 (0.7)	0.17 (0.75)	−0.27 (0.92)	0.03 (0.56)
Third-Most Disadvantaged	n (%)	489 (22)	521 (22)	485 (22)	477 (22)	526 (22)	481 (22)	493 (21)	531 (22)
	Mean (SD)	0.05 (0.8)	0.02 (1.05)	0.05 (0.96)	−0.07 (0.94)	0.11 (0.69)	0.05 (0.91)	−0.13 (0.89)	0.02 (0.49)
Second-Most Disadvantaged	n (%)	458 (20)	483 (20)	413 (18)	407 (19)	479 (20)	436 (20)	464 (20)	487 (20)
	Mean (SD)	−0.05 (0.85)	−0.1 (1.06)	−0.07 (0.98)	−0.2 (0.91)	0.03 (0.75)	0.05 (0.87)	−0.11 (0.91)	−0.08 (0.49)
Most Disadvantaged	n (%)	501 (22)	535 (22)	484 (21)	460 (21)	533 (22)	479 (22)	504 (22)	548 (22)
	Mean (SD)	−0.07 (0.85)	−0.23 (1.1)	−0.18 (1.18)	−0.34 (0.98)	−0.06 (0.82)	−0.02 (0.95)	−0.45 (1.08)	−0.19 (0.55)
Total	n (%)	2256 (100)	2411 (100)	2255 (100)	2195 (100)	2429 (100)	2212 (100)	2313 (100)	2458 (100)
	Mean (SD)	0.08 (0.86)	−0.06 (1.09)	−0.03 (1.05)	−0.18 (0.97)	0.05 (0.73)	0.08 (0.86)	−0.29 (0.97)	−0.04 (0.54)

SD indicates Standard Deviation.

disadvantage status with hospital quality. Block group-level data illuminates the wide breadth of socioeconomic disparities across metropolitan neighborhoods. Although variation in hospital quality had been explained by hospital characteristics (Krumholz et al., 2009; Joynt and Jha, 2013; Horwitz et al., 2017) (such as ownership, bed size, volume, teaching status, and staffing level), no study had used the more granular block group level to assess the impact of neighborhood socioeconomic disadvantage status on hospital quality in metropolitan settings.

The findings from our study is consistent with Fahrenbach's study which also reported associations between neighborhood characteristics (at the block group level) and hospital quality metrics (Fahrenbach et al., 2019). However, unlike our study, the Fahrenbach study reported that timeliness of care had the strongest association with neighborhood conditions. It is important to note that comparisons between the Fahrenbach study and this study need to be interpreted with caution as there are inherent differences in the methodologies adopted by both studies. For instance, in the Fahrenbach study, the researchers defined the hospital's neighborhood using the hospital's catchment area (collection of population-weighted block group centroids within the geographical circumference that captures the hospital's target population) as a proxy for the socioeconomic profile of the patient population seen at the hospital. On the other hand, our study used hospital neighborhood in the context of the socioeconomic condition of the immediate surrounding of the hospital, rather than as a proxy for defining the hospital's target population. In actuality, the goal of our study was to understand whether the socioeconomic context of a hospital's neighborhood was related to its quality regardless of its patient profile. For this reason, we adjusted for hospital characteristics, like hospital safety-net status and teaching status (which served as a proxy for the patient profile of the hospital) when we assessed the relationship between neighborhood socioeconomic disadvantage and hospital quality (Herrin et al., 2015).

Our finding of low hospital quality in poor neighborhoods is unsurprising given the lack of financial and human resources (McLafferty, 1986) (poor credit ratings, lack of access to capital markets, physician/health workforce staffing shortages, low revenue, poor advanced medical technology) often found in these neighborhoods. Socioeconomically disadvantaged neighborhoods are often laced with unfavorable characteristics (such as low household income, limited education, (Kind et al., 2014) social disorganization, high unemployment, increased welfare dependency, limited access to medical services, increased crime, constrained social networks, inadequate housing, malaise, segregation, and isolation (Barnes, 2012)), which make them unattractive labor markets for healthcare professionals. Other studies have reported that the financial and resource constraints of poor neighborhoods have resulted in hospitals pulling out, leaving fewer hospitals in poor neighborhoods. (McLafferty, 1986) As implied by our findings, the cascade of limited resources in these neighborhoods may have inadvertently affected the quality of care hospitals had the capacity to provide.

Collectively, results from this study corroborate the predictive power of the ADI for hospital quality. The findings from this study suggest that external factors like the socioeconomic gradient of a hospital's neighborhood at the block group level can influence hospital quality through causal pathways that warrant further investigation in future studies. A proper understanding of the mechanism by which neighborhood socioeconomic disadvantage affects hospital quality could help policymakers incorporate strategies and target resources for stirring socioeconomic development in these disadvantaged neighborhoods, as this may have a catalytic positive effect on the quality of hospital care in these neighborhoods. Such policies could include neighborhood renewal and gentrification projects that focus on improving measures of neighborhood socioeconomic disadvantage (median family income, percentage of population below poverty, education, and employment rates), that make communities more attractive to capital markets and healthcare workforce, which in turn could drive quality. Several European studies have also published the use of composite measures of

Table 4
Association between neighborhood socioeconomic disadvantage (ADI) groups and quality group scores.

Characteristics	Type of Model	Quality Group Scores						
		Mortality Scores	Readmission Scores	Safety of Care Scores	Patient Experience Scores	Effectiveness of Care Scores	Efficiency Scores	Timeliness Scores
ADI Group		β- Coefficient (95% CI)						
LeastDisadvantaged		Ref	Ref	Ref	Ref	Ref	Ref	Ref
Fourth-MostDisadvantaged	Unadjusted	−0.44 (−0.56, −0.32)*	0.06 (−0.08, 0.21)	−0.04 (−0.18, 0.10)	0.19 (0.06, 0.32)*	−0.03 (−01, 0.07)	−0.00 (−0.12, 0.12)	0.25 (0.12, 0.38)*
	Adjusted	−0.35 (−0.47, −0.24)*	−0.02 (−0.15, 0.12)	−0.07 (−0.21, 0.07)	0.03 (−0.08, 0.15)	−0.07 (0.03, −0.16)	0.06 (−0.06, 0.18)	0.06 (−0.04, 0.17)
Third-MostDisadvantaged	Unadjusted	−0.46 (−0.57, −0.34)*	0.03 (−0.11, 0.17)	−0.0027 (−0.14, 0.14)	0.18 (0.05, 0.31)*	−0.01 (−0.10, 0.09)	−0.13 (−0.24, −0.01)	0.40 (0.03, 0.53)*
	Adjusted	−0.31 (−0.42, −0.19)*	−0.10 (−0.24, 0.04)	−0.06 (−0.20, 0.09)	−0.10 (−0.22, 0.02)	−0.05 (−0.14, 0.05)	−0.01 (−0.13, 0.11)	0.05 (−0.05, 0.16)
Second-MostDisadvantaged	Unadjusted	−0.55 (−0.66, −0.43)*	−0.085 (−0.23, 0.06)	−0.12 (−0.27, 0.02)	0.05 (−0.08, 0.19)	−0.09 (−0.19, 0.03)	−0.12 (−0.24, −0.01)	0.42 (0.29, 0.55)*
	Adjusted	−0.37 (−0.48, −0.25)*	−0.21 (−0.35, −0.07)*	−0.18 (−0.34, −0.03)*	−0.24 (−0.36, −0.11)*	−0.11 (−0.21, - 0.01)	0.02 (−0.10, 0.15)	0.02 (−0.09, 0.13)
MostDisadvantaged	Unadjusted	−0.58 (−0.69, −0.46)*	−0.22 (−0.36, −0.08)*	−0.24 (−0.37, −0.10)*	−0.08 (−0.21, 0.05)*	−0.18 (−0.27, −0.08)*	−0.20 (−0.32, −0.08)*	0.09 (−0.04, 0.22)
	Adjusted	−0.41 (−0.52, −0.29)*	−0.28 (−0.42, −0.14)*	−0.27 (−0.42, −0.12)*	−0.28 (−0.40, −0.16)*	−0.15 (−0.25, −0.05)*	−0.07 (−0.19, 0.05)	−0.10 (−0.21, 0.01)

All scores are on a 0–100 percentile scale; Higher scores = Better scores.
Generalized linear models adjusted for hospital characteristics (ownership status, teaching status, bed size, safety-net status, and metropolitan status).
CI indicates confidence interval.
* indicates P<0.05 and statistical significance.

neighborhood socioeconomic disadvantage similar to the ADI to allocate services and funding to ensure increased support in high-risk regions (Singh, 2003; Sundquist et al., 2003). Analogous to these studies, the ADI can be used to guide and inform policymakers on testing innovative strategies for improving socioeconomic conditions in severely disadvantaged neighborhoods.

The findings from this study also has important implications to the research community and other critical stakeholders including physicians, hospital systems, insurance companies, pharmaceutical companies, and medical technology companies. As we know, people residing in poor neighborhoods disproportionately experience more chronic conditions such as heart disease, diabetes and obesity (Durfey et al., 2019). Additionally, impoverished older adults experience more disability and poorer health than their more affluent peers (Wight et al., 2008; Grafova et al., 2008; Freedman et al., 2011). The increased health needs of residents from poor neighborhoods further validates the urgency for improving hospital quality of care in these neighborhoods. Given that low socioeconomic status (SES) patients living in poor neighborhoods may be accessing healthcare from hospitals in their neighborhood, it is important to optimize the quality of healthcare in these communities so as not to exacerbate the widening health-related disparities experienced by low SES patients. When the quality of hospitals in poor neighborhoods is improved, they can better serve the needs of patients in these disadvantaged communities that are historically known to be sicker in profile. All in all, the study's findings should be an awakening call to policymakers to hasten the targeting of resources to these deprived neighborhoods.

Despite utilizing a large nationwide sample (which can be generalized across the country) in examining the relationship between neighborhood socioeconomic disadvantage and hospital quality, our study did have some limitations. First, it is an observational cross-sectional study and so associations cannot be interpreted as causal. Causality cannot be attributed to observational studies because their non-randomized nature makes them unable to control for all inevitable, and sometime unmeasurable, exposure or factors that may be causing the results. Despite adjusting for hospital-level characteristics in our study, residual confounding may persist due to its observational nature.

Second, given the absence of patient-level data, we could not control for population effects, such as patient socioeconomic status and patient health status, that may confound our results. Nonetheless, the study attempted to control for this limitation by adjusting the model by hospital safety-net status and hospital teaching status given that these hospitals are known to treat highly vulnerable and low-income populations. Still, it would be remiss not to warn that these variables were not completely perfect for incorporating all the individual-level characteristics associated with health quality, and so residual confounding may still play in our findings. Nonetheless, this study illustrates a feasible way of assessing the relationship between hospital neighborhood disadvantage and hospital quality, despite not having access to patient-level data.

Third, CMS quality ratings which was used in this study has been reported to carry inherent flaws such as a lack of transparency around what gets measured, susceptibility to chance variation and the fact that the underlying measures may not be valid measures of quality (Barclay et al., 2019; Bilimoria and Barnard, 2016). For example, despite neighborhood disadvantage having associations with group quality measures, such associations may not persist with specific quality measures (e.g., 30 days mortality due to pneumonia or time spent in an ED room).

Last, the inherent limitations of using the 2015 version of the ADI (created using ACS 2011–2015 data) may not fully reflect neighborhood conditions in the year 2017. However, the study years for the data were close enough and should not adversely affect the integrity of the research findings. Regardless of these limitations, this study is sound, novel, and does elucidate understanding of the relationship between neighborhood factors and hospital quality. Future studies should focus

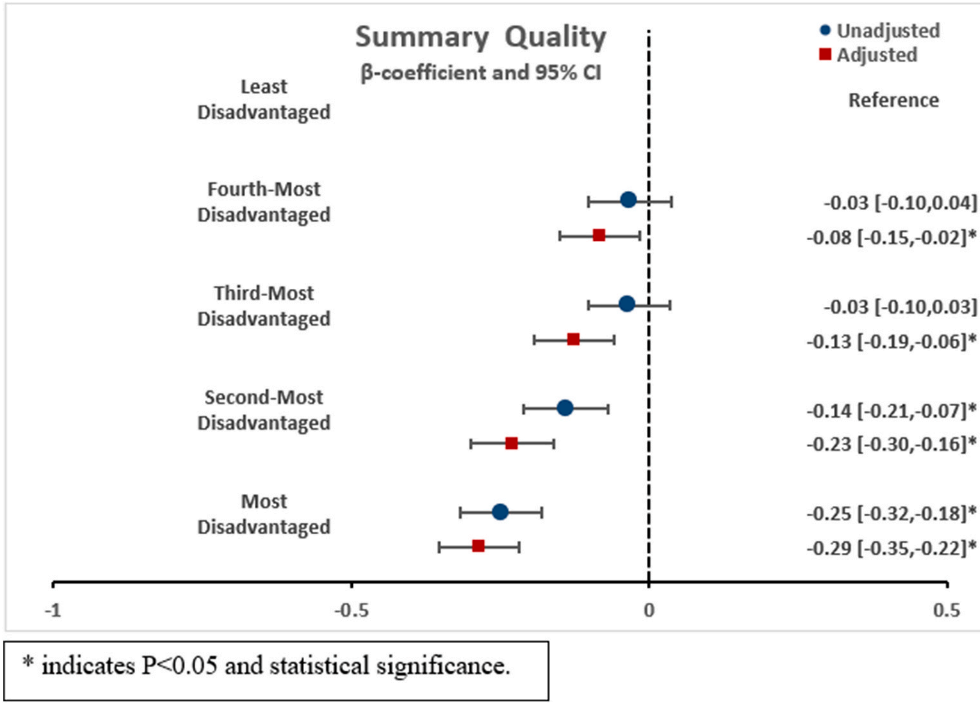

Fig. 2. Association between Neighborhood Socioeconomic disadvantage (ADI Group) and Summary Score*P<0.05 and statistical significance.

on understanding the mechanism by which neighborhood socioeconomic factors affect hospital quality measures. A better understanding of this mechanism is requisite for effective intervention.

5. Conclusion

Neighborhood socioeconomic disadvantage may affect hospital quality. Hospitals in more socioeconomically disadvantaged neighborhoods have lower quality in terms of mortality, readmission, safety, patient experience, effectiveness, efficiency, timeliness, summary of care, and overall hospital star rating. Interventions and policies tailored to improving neighborhood socioeconomic factors may improve hospital quality of care.

Declaration of competing interest

No conflicts of interest relevant to the content of this manuscript were reported by the authors.

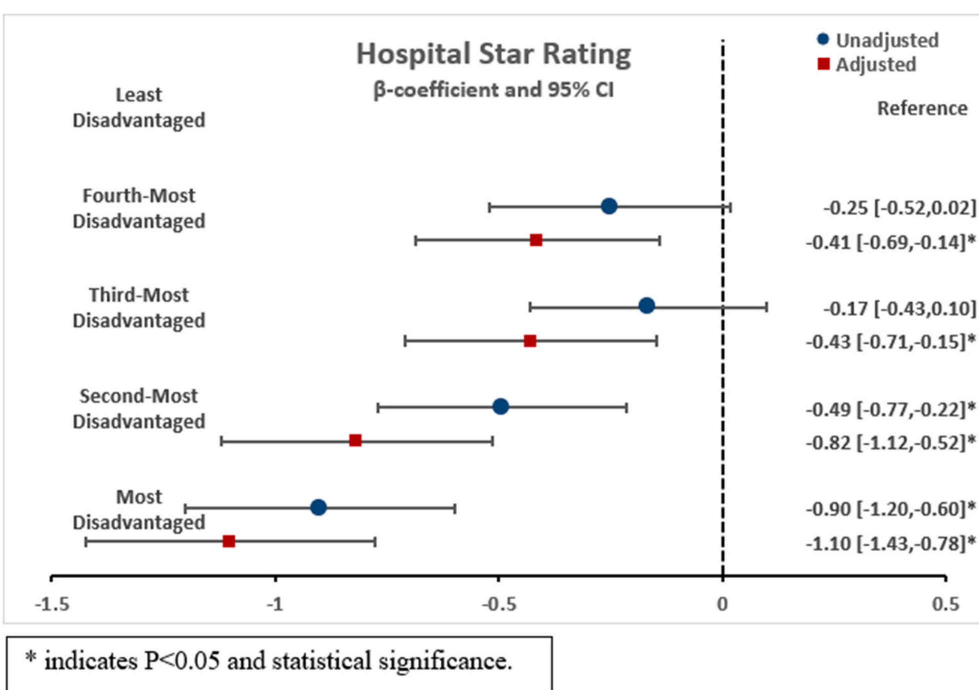

Fig. 3. Association between Neighborhood Socioeconomic (ADI Group) and Hospital Star Rating*P<0.05 and statistical significance.

Data availability

Data will be made available on request.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.healthplace.2022.102911.

References

Allison, J.J., Kiefe, C.I., Weissman, N.W., et al., 2000. Relationship of hospital teaching status with quality of care and mortality for Medicare patients with acute MI. JAMA 284 (10), 1256–1262.

Arbaje, A.I., Wolff, J.L., Yu, Q., Powe, N.R., Anderson, G.F., Boult, C., 2008. Postdischarge environmental and socioeconomic factors and the likelihood of early hospital readmission among community-dwelling Medicare beneficiaries. Gerontol. 48 (4), 495–504.

Barclay, M., Dixon-Woods, M., Lyratzopoulos, G., 2019. The problem with composite indicators. BMJ Qual. Saf. 28 (4), 338–344.

Barnes, S.L., 2012. Cost of Being Poor, the: A Comparative Study of Life in Poor Urban Neighborhoods in Gary, Indiana. SUNY Press.

Bilimoria, K.Y., Barnard, C., 2016. The New CMS hospital quality star ratings: the stars are not aligned. JAMA 316 (17), 1761–1762.

Burke, L.G., Frakt, A.B., Khullar, D., Orav, E.J., Jha, A.K., 2017. Association between teaching status and mortality in US hospitals. JAMA 317 (20), 2105–2113. https://doi.org/10.1001/jama.2017.5702.

Centers for Disease Control and Prevention, 2013. NCHS Urban-Rural Classification Scheme for Counties. https://www.cdc.gov/nchs/data/series/sr_02/sr02_166.pdf. (Accessed 11 March 2020).

Chen J, Normand Sl Fau - Wang Y, Wang Y, Fau - Krumholz HM, Krumholz HM. National and Regional Trends in Heart Failure Hospitalization and Mortality Rates for Medicare Beneficiaries, 1998-2008. (1538-3598 (Electronic)).

Desai, N.R., Ott, L.S., George, E.J., et al., 2018. Variation in and hospital characteristics associated with the value of care for Medicare beneficiaries with acute myocardial infarction, heart failure, and pneumonia. JAMA Netw. Open 1 (6), e183519.

Durfey, S.N.M., Kind, A.J.H., Buckingham, W.R., DuGoff, E.H., Trivedi, A.N., 2019. Neighborhood disadvantage and chronic disease management. Health Serv. Res. 54 (Suppl. 1), 206–216.

Eggleston, K., Shen, Y.-C., Lau, J., Schmid, C.H., Chan, J., 2008. Hospital ownership and quality of care: what explains the different results in the literature? Health Econ. 17 (12), 1345–1362.

Fahrenbach, J., Chin, M.H., Huang, E.S., Springman, M.K., Weber, S.G., Tung, E.L., 2019. Neighborhood disadvantage and hospital quality ratings in the Medicare hospital Compare program. Med. Care.

Fisher, E.S., Wennberg, J.E., 2003. Health care quality, geographic variations, and the challenge of supply-sensitive care. Perspect. Biol. Med. 46 (1), 69–79.

Freedman, V.A., Grafova, I.B., Rogowski, J., 2011. Neighborhoods and chronic disease onset in later life. Am. J. Publ. Health 101 (1), 79–86.

Grafova, I.B., Freedman, V.A., Kumar, R., Rogowski, J., 2008. Neighborhoods and obesity in later life. Am. J. Publ. Health 98 (11), 2065–2071.

Hawkins, N.M., Jhund, P.S., McMurray, J.J., Capewell, S., 2012. Heart failure and socioeconomic status: accumulating evidence of inequality. Eur. J. Heart Fail. 14 (2), 138–146.

Herrin, J., Andre J, St, Kenward, K., Joshi, M.S., Audet, A.-M.J., Hines, S.C., 2015. Community factors and hospital readmission rates. Health Serv. Res. 50 (1), 20–39.

Herrin, J., Kenward, K., Joshi, M.S., Audet, A.-M.J., Hines, S.J., 2016. Assessing community quality of health care. Health Serv. Res. 51 (1), 98–116.

Horwitz, L.I., Bernheim, S.M., Ross, J.S., et al., 2017. Hospital characteristics associated with risk-standardized readmission rates. Med. Care 55 (5), 528–534.

Hu, J., Nerenz, D., 2017. Relationship between stress rankings and the overall hospital star ratings: an analysis of 150 cities in the United States. JAMA Intern. Med. 177 (1), 136–137.

Hu, J., Kind, A.J.H., Nerenz, D., 2018. Area deprivation index predicts readmission risk at an urban teaching hospital. Am. J. Med. Qual. 33 (5), 493–501.

Heijink, R., Engelfriet, P., Rehnberg, C., Kittelsen, S.A.C., Häkkinen, U., and on behalf of the EuroHOPE study group, 2015. A window on geographic variation in health care: insights from EuroHOPE. Health Econ. 24, 164–177. https://doi.org/10.1002/hec.3287.

Jencks SF, Cuerdon T, Fau - Burwen DR, Burwen Dr, Fau - Fleming B, et al. Quality of Medical Care Delivered to Medicare Beneficiaries: A Profile at State and National Levels. (0098-7484 (Print)).

Joynt, K.E., Jha, A.K., 2011. Who has higher readmission rates for heart failure, and why? Implications for efforts to improve care using financial incentives. Circulat. Cardiovascular Qual. Outcomes 4 (1), 53–59.

Joynt, K.E., Jha, A.K., 2013. Characteristics of hospitals receiving penalties under the hospital readmissions reduction program. JAMA 309 (4), 342–343.

Joynt Maddox, K.E., Reidhead, M., Hu, J., et al., 2019. Adjusting for social risk factors impacts performance and penalties in the hospital readmissions reduction program. Health Serv. Res. 54 (2), 327–336.

Kind, A., Buckingham, W.R., 2018a. Visualizing socioeconomic disadvantage to inform programs and policy: the neighborhood atlas. J. Am. Geriatr. Soc. 66 (Suppl. 2), S163–S164.

Kind, A.J.H., Buckingham, W.R., 2018b. Making neighborhood-disadvantage metrics accessible — the neighborhood atlas. N. Engl. J. Med. 378 (26), 2456–2458.

Kind, A.J., Jencks, S., Brock, J., et al., 2014. Neighborhood socioeconomic disadvantage and 30-day rehospitalization: a retrospective cohort study. Ann. Intern. Med. 161 (11), 765–774.

Krumholz, H.M., Merrill, A.R., Schone, E.M., et al., 2009. Patterns of hospital performance in acute myocardial infarction and heart failure 30-day mortality and readmission. Circ Cardiovasc Qual Outcomes 2 (5), 407–413.

Landon, B.E., Normand, S.-L.T., Lessler, A., et al., 2006. Quality of care for the treatment of acute medical conditions in US hospitals. Arch. Intern. Med. 166 (22), 2511–2517.

Marshall, M.N., Shekelle, P.G., Leatherman, S., Brook, R.H., 2000. The public release of performance DataWhat do we expect to gain? A Review of the evidence. JAMA 283 (14), 1866–1874.

McLafferty, S., 1986. The geographical restructuring of urban hospitals: spatial dimensions of corporate strategy. Soc. Sci. Med. 23 (10), 1079–1086.

Mohan, A., Grant, J., Batalden, M., McCormick, D., 2013. The health of safety net hospitals following Massachusetts health care reform: changes in volume, revenue, costs, and operating margins from 2006 to 2009. Int. J. Health Serv. 43 (2), 321–335.

Murphy, K.M., Hughes, L.S., Conway, P., 2018. A path to sustain rural hospitals. JAMA 319 (12), 1193–1194.

Popescu, I., Fingar, K.R., Cutler, E., Guo, J., Jiang, H.J., 2019. Comparison of 3 safety-net hospital definitions and association with hospital characteristics. JAMA Netw. Open 2 (8) e198577-e198577.

Pugh, R., 2019. Rural poverty in the United States Ann R Tickamyer, Jennifer Sherman and Jennifer Warlick (eds). J. Soc. Work 19 (6), 837–838. https://doi.org/10.1177/1468017319837420.

Rosenberg, B.L., Kellar, J.A., Labno, A., et al., 2016. Quantifying geographic variation in health care outcomes in the United States before and after risk-adjustment. PLoS One 11 (12) e0166762-e0166762.

Ross, J.S., Cha, S.S., Epstein, A.J., et al., 2007. Quality of care for acute myocardial infarction at urban safety-net hospitals. Health Aff. 26 (1), 238–248.

Ryan, A.M., Nallamothu, B.K., Dimick, J.B., 2012. Medicare's public reporting initiative on hospital quality had modest or No impact on mortality from three key conditions. Health Aff. 31 (3), 585–592.

Sheetz, K.H., Ibrahim, A.M., Nathan, H., Dimick, J.B., 2019. Variation in surgical outcomes across networks of the highest-rated US hospitals. JAMA Surg. 154 (6), 510–515.

Singh, G.K., 2003. Area deprivation and widening inequalities in US mortality, 1969–1998. Am. J. Publ. Health 93 (7), 1137–1143.

Singh, G.K., Siahpush, M., 2002. Increasing inequalities in all-cause and cardiovascular mortality among US adults aged 25–64 years by area socioeconomic status, 1969–1998. Int. J. Epidemiol. 31 (3), 600–613.

Sundquist, K., Malmström, M., Johansson, S.E., Sundquist, J., 2003. Care Need Index, a useful tool for the distribution of primary health care resources. J. Epidemiol. Community 57 (5), 347–352.

United States Census Bureau, 2022. https://www.census.gov/programs-surveys/geography/about/glossary.html#par_textimage_4. (Accessed 10 July 2022).

University of Wisconsin School of Medicine and Public Health, 2015. Area Deprivation Index v2.0. https://www.neighborhoodatlas.medicine.wisc.edu.

van Sluisveld, N., Bakhshi-Raiez, F., de Keizer, N., et al., 2017. Variation in rates of ICU readmissions and post-ICU in-hospital mortality and their association with ICU discharge practices. BMC Health Serv. Res. 17 (1), 281.

Wight, R.G., Cummings, J.R., Miller-Martinez, D., Karlamangla, A.S., Seeman, T.E., Aneshensel, C.S., 2008. A multilevel analysis of urban neighborhood socioeconomic disadvantage and health in late life. Soc. Sci. Med. 66 (4), 862–872.

Woodard TD. Addressing Variation in Hospital Quality: Is Six Sigma the Answer? (1096-9012 (Print)).

Woodard, T.D., 2005. Addressing variation in hospital quality: is six sigma the answer? J. Healthc. Manag. 50 (4), 226–236.