The Association of Social Determinants of Health With Health Outcomes

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ABSTRACT

OBJECTIVES: This study explored the contributions of social determinants of health (SDOH) to measures of population health—specifically cost, hospitalization rates, rate of emergency department utilization, and health status—in Texas.

STUDY DESIGN: The study associated common SDOH metrics from public data sources (county specific) with health plan enrollment data (including demographics, counties, and zip codes) and medical and pharmaceutical annual claims data.

METHODS: Following correlation analyses to reduce variables, the contribution of each SDOH individually and by category to the health outcomes was evaluated. Separate matrices for age populations (under age 19, general population [all ages], and ≥ 65 years) were created with assigned weights of influence for categories and the factors within each category.

RESULTS: The contributions of the categories varied by population, confirming that different SDOH influence populations to varying degrees. This was reflected in each model. The largest contributor to cost for the general population and for the group 65 years and older was factors grouped as health outcomes (such as perceived health), at 43.5% contribution and 37.7% contribution, respectively. Yet for the population younger than 19 years, the largest contributor to cost was socioeconomic factors (such as unemployment rate), at 40.2%. The other performance measures also varied by population and the mix and weight of determinants.

CONCLUSIONS: This study and the developed population-based matrices can provide a valuable framework for reporting the impact of SDOH on health care quality. The variation suggests the need for further research on how age groups react to the social environment.

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A growing recognition is occurring of the role of "place," which is defined as various environments and settings (eg, school, church, workplace, neighborhood).[1] Place has been found to affect health outcomes and provider quality-of-care scores across the United States.[2-5] However, most research on health care quality to date has focused on select quality measures and reported on a health plan or provider level using claims or medical record data collected at the individual patient level. This methodology often overlooks the role of place and social determinants of health (SDOH) characteristics.[2,6] Little is known about whether, or how, population-level care quality scores differ by county-level demographic characteristics and, in particular, community SDOH factors.[5] The integration of health care quality data and SDOH data is particularly important to support the transition to value-based care and to inform health plans and providers on how to target interventions, programs, and funding into communities to improve health outcomes.[7]

Multiple metrics, indices, and rankings exist for assessing community health, including county-level, community, and neighborhood indicators; well-being indices; deprivation indices; and health indicators and rankings.[8-12] A recognized ranking in the United States is the County Health Rankings (CHRs), created by the University of Wisconsin Population Health Institute.[13,14] The CHRs provide a set of rankings that are simple to interpret and use for public health policy decision makers to spur population health action. The conceptual framework for the index includes modifiable health factors—health behaviors, clinical care (access), health outcomes, social and economic factors, and physical environment. Previous studies of the CHRs found that some factors are more closely associated with health outcomes than others.[15] Henning-Smith et al extended the CHRs by assessing differences between rural and urban counties modeled in Medicare. They found inconsistent associations across 3 quality measures used (preventable hospitalization[2] and diabetic and mammography screening) and the direction of association varied, indicating that risk adjustment for sociodemographic data alone is not sufficient to address the role of place.[2]

The CDC created the social vulnerability index, which focuses on community preparedness, resilience, and planning for natural hazards.[16] The index contains data in 4 themes: (1) socioeconomic status (SES), (2) household composition, (3) minority status and language, and (4) housing and transportation. The index was created for natural hazards; however, utility has been suggested for access-to-care studies, particularly given the inclusion of social factors (transportation, housing).[16]

TAKEAWAY POINTS

The study proposed a conceptual framework useful for the integration of social and behavioral data into population health strategies at the patient, health system, and community levels. This study:

- validates the association between social determinants of health and health outcomes,
- provides a framework for program design,
- enhances the field through statistical validation,
- supports policy decisions related to value-based approaches, and
- provides strategic information for population health.

To date, there are no methods for integrated assessment of social and behavioral determinants of health and for statistical assessment of how these factors contribute to key health metrics. In addition, there are no methods available that focus specifically on health care quality data for age-specific populations or that are designed to support health plans in health care quality reporting. This study seeks to fill that gap and to build on existing CHRs and indices. Using county-level data on SDOH, health care performance and outcomes measures, and population characteristics, SDOH indices for health care quality were created and validated. The results from this study will help to illuminate the role of place-based influences on population health and quality-of-care measures. These results may also help health plans and health care providers to better identify and improve the health of their populations by accounting for the nontreatment factors affecting risk and variation. Additionally, the findings are valuable to policy makers to inform care delivery and health care policy.

METHODS

Study Area

The state of Texas and its 254 counties served as the study area for index creation. "Place" for this analysis was the county in which the insured member resided.

Creation of the Aggregated Index

The study started by using the CHRs,[13,14] which provided data compiled from a variety of national and state data sources. The CHRs group more than 30 measures by general category: health outcomes, health behaviors, clinical care, social and economic factors, and physical environment. Each category contains subcategories, which are defined as 1 or more measures from data sources. Each measure stands alone and is distinguished by a specific unit of measure, such as percentage, rate per 1000, and air particulate matter density.

To compare the overall SDOH across counties, the disparate measures were converted into determinant-specific scores for each. Ranking was converted from a metric value into an indicator between the values of 1 and 5, with 1 being a favorable or reasonable level of social or behavioral conditions and 5 being undesirable. This allowed the summation of a total score for each component, using the scores of each contributing factor.

CHRs were supplemented by additional factors supported by previous studies, which contributed to the robustness of the models (eg, access to primary care and mental health professionals).[17-19] Furthermore, social and behavioral determinants were hypothesized to vary by age and population group, which resulted in different matrices for children and adolescents younger than 19 years, persons 65 years and older, and the general population (all ages). The categories used for measurement were health outcomes (child and infant mortality, life expectancy, and residents' perception of their health), health behaviors (eg, smoking, alcohol use, sexually transmitted diseases, teen pregnancy), access (access to primary care physicians and behavioral health professionals), social and economic environment (eg, education, income, community safety, violence), and physical environment (eg, water quality, air quality, housing, food environment). Specific metrics within each category are identified in the tables and **eAppendix** (available at **ajmc.com**).

Statistical analyses were conducted to identify measures that were highly correlated for subcomponent reduction. Once relevant measures were identified, they were analyzed to assess the contribution of each measure to select health performance indicators: total cost per member per year, rate of acute inpatient hospitalization, rate of emergency department (ED) utilization, and 2 measures of health status: 3M Clinical Risk Groups (CRGs) and corresponding patient severity scores. CRGs are derived from standard claims data and pharmaceutical data to assign a level associated with severity of disease to each enrollee in a population.[14]

Health care outcomes were derived from health care claims and enrollment data from 2016. Data sources included Texas Medicaid and Children's Health Insurance Program managed care claims, Optum Clinformatics DataMart claims data (commercial health plans and Medicare Advantage plans), and Medicare claims data. Member ages were derived from the enrollment files for each data source. Cost was computed as the allowed amount, inclusive of patient pay portions and coordination of benefit amounts. Acute inpatient admissions and ED visits were identified by type of bill codes, revenue codes, and place of service codes. CRG severity scores were derived by the 3M software using the full claims history per member. Results were computed for more than 10 million insured members within the 3 population groups in each of the 254 counties in Texas and reported as a per-member per-year amount for cost,

TABLE 1. Conceptual Framework Matrix for Group Younger Than 19 Years

Health outcomes (20%)			
Focus area	**Measure**	**Weight**	**Source**
Health care status	Child mortality rate	20%	CDC WONDER mortality data
	Infant mortality rate	20%	Compressed Mortality File
	Percentage of uninsured children	25%	Small Area Health Insurance Estimates
	Low birthweight	35%	National Center for Health Statistics natality files
Health behaviors (15%)			
Focus area	**Measure**	**Weight**	**Source**
Health focus	Food environment index	35%	US Department of Agriculture Food Environment Atlas, Map the Meal Gap
	Access to exercise opportunities	15%	Business Analyst, Delorme map data, ESRI, and US Census files
Sexual activity	Sexually transmitted infections	25%	National Center for HIV/AIDS, Viral Hepatitis, STD, and TB Prevention
	Teen births	25%	National Center for Health Statistics natality files
Access (15%)			
Focus area	**Measure**	**Weight**	**Source**
Access to care	Primary care physicians	45%	Area Health Resources Files/American Medical Association
	Mental health providers	55%	CMS, National Provider Identification file
Social and economic environment (30%)			
Focus area	**Measure**	**Weight**	**Source**
Education	High school graduation	10%	State-specific sources and EDFacts
Employment	Unemployment	25%	Bureau of Labor Statistics
Home environment	Children in poverty	10%	Small Area Income and Poverty Estimates
	Food insecurity	10%	Feeding America Data Map
	Children in single-parent households	15%	American Community Survey
Community safety	Violent crime	5%	Uniform Crime Reporting (Federal Bureau of Investigation)
	Injury deaths	15%	CDC WONDER mortality data
	Disconnected youth	10%	US Census data and Measure of America
Physical environment (20%)			
Focus area	**Measure**	**Weight**	**Source**
Air and water quality	Air pollution: particulate matter	20%	Environmental Public Health Tracking Network
	Drinking water violations	10%	Safe Drinking Water Information System
Housing	Severe housing problems	30%	Comprehensive Housing Affordability Strategy data
	Food desert	40%	US Department of Agriculture Economic Research Service

EDFacts, US Department of Education Facts; ESRI, Environmental Systems Research Institute; STD, sexually transmitted disease; TB, tuberculosis.

a rate per year for acute inpatient admissions and ED visits, and a CRG and severity for the risk value.

Validation of the Aggregated Index

Pearson correlation coefficients were calculated to identify possible collinearity between SDOH categories. Regression models of various types were developed to assess weights for the impact of SDOH categories on the 5 outcomes. For medical cost, acute inpatient admissions, and ED visits, linear regression models were used. For 3M CRGs and CRG severity level, proportional odds models were employed to assess the odds of each CRG level and corresponding severity. Statistical analyses were performed using SAS 9.4 (SAS Institute). Models were developed separately for each age group and included sex, age, and insurance types (Medicare, Medicaid, Medicare Advantage, and commercial) as covariates along with SDOH variables. Race and income could not be included in the models because that information was not available in all data sources. Akaike information criterion values of full models and reduced models (intercept only) were compared to determine the value of SDOH variables to the model.

The final resulting percentages of impact for each category are displayed in the conceptual frameworks shown in **Table 1**, **Table 2**, and **Table 3**. The tables identify the percentage of overall contribution by category, as well as the independent SDOH variables within each category. For each outcome and age group model, the percentage of variance explained by each SDOH was calculated from the model results (**Table 4** and **Table 5**). Percentages were derived by dividing the coefficient of interest for a social determinant over the sum of the absolute values of all social determinant coefficients. These percentages were then averaged across the outcomes for the age group, giving an overall value to be used as the weighting system (Table 4). For the 3M CRG severity outcome, additional steps were taken to account for the highest possible severity score differing between CRGs. For example, CRGs of 1 and 2 have no severity score; a CRG of 3 has a maximum severity score of 2; CRGs of 4, 5, 8, and 9 have a maximum severity score of 4; and for CRGs 6 and 7, the severity score can go up to 6. For this, the weight for all variables was

TABLE 2. Conceptual Framework Matrix for General Population

Health outcomes (30%)			
Focus area	**Measure**	**Weight**	**Source**
Health outcomes	Life expectancy	25%	National Center for Health Statistics mortality files
	Perceived poor or fair health	40%	Behavioral Risk Factor Surveillance System
	Perceived poor physical health days	15%	Behavioral Risk Factor Surveillance System
	Perceived poor mental health days	20%	Behavioral Risk Factor Surveillance System
Health behaviors (25%)			
Focus area	**Measure**	**Weight**	**Source**
Tobacco use (10%)	Adult smoking	10%	Behavioral Risk Factor Surveillance System
Diet and exercise (35%)	Adult obesity	5%	CDC Diabetes Interactive Atlas
	Food environment index	10%	US Department of Agriculture Food Environment Atlas, Map the Meal Gap
	Physical inactivity	10%	CDC Diabetes Interactive Atlas
	Access to exercise opportunities	5%	Business Analyst, Delorme map data, ESRI, and US Census Files
	Insufficient sleep	5%	Behavioral Risk Factor Surveillance System
Race and ethnicity (30%)	Race	15%	US Census Bureau American Community Survey, 5-year estimates
	Language factor	15%	American Community Survey, 5-year estimates
Alcohol and drug use (10%)	Excessive drinking	5%	Behavioral Risk Factor Surveillance System
	Alcohol-impaired driving deaths	5%	Fatality Analysis Reporting System
Sexual activity (15%)	Sexually transmitted infections	5%	National Center for HIV/AIDS, Viral Hepatitis, STD, and TB Prevention
	Teen births	10%	National Center for Health Statistics natality files
Access (10%)			
Focus area	**Measure**	**Weight**	**Source**
Access to care	Primary care physicians	15%	Area Health Resources Files/American Medical Association
	Mental health providers	25%	CMS, National Provider Identification file
	Rural as indicator of access to specialists	30%	The Texas Demographic Center (US Bureau of the Census State Data Center Program)
	Uninsured adults	30%	Small Area Health Insurance Estimates
Social and economic environment (25%)			
Focus area	**Measure**	**Weight**	**Source**
Education (15%)	High school graduation	5%	State-specific sources and EDFacts
	Some college	10%	American Community Survey
Income (25%)	Median household income	10%	American Community Survey
	Average household size	15%	US Census Bureau, American Community Survey, 5-year estimates
Employment (15%)	Unemployment	15%	Bureau of Labor Statistics
Family and social support (25%)	Food insecurity	10%	Feeding America Data Map
	Social associations	5%	County Business Patterns
	Children in single-parent households	10%	American Community Survey
Community safety (20%)	Violent crime	10%	Uniform Crime Reporting (Federal Bureau of Investigation)
	Injury deaths	10%	CDC WONDER mortality data
Physical environment (10%)			
Focus area	**Measure**	**Weight**	**Source**
Air and water quality	Air pollution: particulate matter	30%	Environmental Public Health Tracking Network
	Drinking water violations	5%	Safe Drinking Water Information System
Housing	Severe housing problems	35%	Comprehensive Housing Affordability Strategy data
	Food desert	30%	US Department of Agriculture Economic Research Service

EDFacts, US Department of Education Facts; ESRI, Environmental Systems Research Institute; STD, sexually transmitted disease; TB, tuberculosis.

TABLE 3. Conceptual Framework Matrix for Those 65 Years and Older

Health outcomes (35%)			
Focus area	**Measure**	**Weight**	**Source**
Health outcomes	Life expectancy	15%	National Center for Health Statistics mortality files
	Perceived poor or fair health	30%	Behavioral Risk Factor Surveillance System
	Perceived poor physical health days	25%	Behavioral Risk Factor Surveillance System
	Perceived poor mental health days	30%	Behavioral Risk Factor Surveillance System
Health behaviors (30%)			
Focus area	**Measure**	**Weight**	**Source**
Tobacco use	Adult smoking	5%	Behavioral Risk Factor Surveillance System
Diet and exercise	Adult obesity	15%	CDC Diabetes Interactive Atlas
	Food environment index	35%	US Department of Agriculture Food Environment Atlas, Map the Meal Gap
	Physical inactivity	15%	CDC Diabetes Interactive Atlas
	Insufficient sleep	5%	Behavioral Risk Factor Surveillance System
Alcohol and drug use	Excessive drinking	20%	Behavioral Risk Factor Surveillance System
	Alcohol-impaired driving deaths	5%	Fatality Analysis Reporting System
Access (10%)			
Focus area	**Measure**	**Weight**	**Source**
Access to care	Primary care physicians	25%	Area Health Resources Files/ American Medical Association
	Mental health providers	75%	CMS, National Provider Identification file
Social and economic environment (15%)			
Focus area	**Measure**	**Weight**	**Source**
Income	Median household income and percentage of population ≥ 65 years	10%	American Community Survey
	Food insecurity	25%	Feeding America Data Map
Family and social support	Social associations	25%	County Business Patterns
Community safety	Violent crime	20%	Uniform Crime Reporting (Federal Bureau of Investigation)
	Injury deaths	20%	CDC WONDER mortality data
Physical environment (10%)			
Focus area	**Measure**	**Weight**	**Source**
Air and water quality	Air pollution: particulate matter	30%	Environmental Public Health Tracking Network
	Drinking water violations	15%	Safe Drinking Water Information System
Housing	Severe housing problems	25%	Comprehensive Housing Affordability Strategy data
	Food desert	30%	US Department of Agriculture Economic Research Service

calculated for each individual CRG (1 through 9) and then averaged for each age group before being included in the average calculation from the 4 other outcome results (**eAppendix Table**).

RESULTS

Overall, the individual subcategories of social determinants were mostly shown to be independent based on Pearson correlation coefficients, with a few exceptions. The coefficients and their positive or negative effect are presented in the eAppendix. Food environment and residing in a food desert showed an anticipated correlation for all population groups. Access metrics (access to primary care physicians, access to dentists, and access to mental health professionals) were highly correlated in all populations as well. Dental access was removed from the model because it was highly correlated with other access variables and dental care was not a designated health outcome.

The associations of the various categories in each population matrix to the total medical cost per member per year are shown in Table 4. The largest contributor to cost for the general population and for the group older than 65 years was health outcomes, at 43.5% and 37.7% contribution, respectively. Yet for the population younger than 19 years, the largest contributor to cost was social economic factors, at 40.2%, where high rates of unemployment, single-parent households, and injury rates were associated with higher annual health care costs.

The contributions of the categories varied by population, thus confirming that different social determinants affect populations to varying degrees and may reflect the variation in subcategories for each model. The impact of different and even the same determinants on age-delineated population groups stresses the need to further evaluate how age groups react or are affected by the environment in which they live.

Models also illustrate that health outcome factors were the highest contributor to the acute inpatient admission rate per year for the general population, at 48.2%. However, for the population 65 years and older, health behavior factors were the highest contributor, at 43.5%, with health outcomes accounting for another 31.9%; together they influenced the rate by

TABLE 4. Model-Derived Contribution Percentages of SDOH Components to Various Health Care Outcomes

	SDOH component	Total medical cost	Acute inpatient admission	ED visit	3M CRG	3M CRG severity	Overall mean
General population	AC	14.7%	14.3%	2.6%	1.9%	10.8%	8.9%
	HB	11.9%	7.1%	56.8%	28.5%	24.8%	25.8%
	HO	43.5%	48.2%	7.1%	45.4%	18.7%	32.6%
	PE	0.4%	14.3%	15.0%	12.9%	8.3%	10.2%
	SE	29.5%	16.1%	18.4%	11.3%	37.4%	22.5%
Younger than 19 years	AC	6.0%	22.2%	2.2%	33.5%	11.1%	15.0%
	HB	31.4%	0.0%	19.8%	1.5%	10.9%	12.7%
	HO	11.3%	18.5%	34.6%	8.2%	29.3%	20.4%
	PE	11.1%	29.6%	15.9%	45.1%	16.7%	23.7%
	SE	40.2%	29.6%	27.5%	11.6%	32.0%	28.2%
65 years and older	AC	12.0%	11.6%	11.4%	4.4%	3.7%	8.6%
	HB	37.5%	43.5%	47.2%	2.5%	28.0%	31.7%
	HO	37.7%	31.9%	21.7%	67.3%	24.0%	36.5%
	PE	7.1%	8.7%	9.1%	11.1%	15.7%	10.3%
	SE	5.7%	4.3%	10.6%	14.8%	28.6%	12.8%

AC, access; CRG, Clinical Risk Group; ED, emergency department; HB, health behaviors; HO, health outcomes; PE, physical environment; SDOH, social determinants of health; SE, social and economic.

TABLE 5. Regression Parameter Estimates of SDOH Components to Various Health Care Outcomes[a]

	SDOH component	Total medical cost ($)	Acute inpatient admission	ED visit	3M CRG	3M CRG severity[b]
General population	AC	14.5549***	0.0008***	−0.0007***	−0.0055***	–
	HB	−11.8291**	−0.0004	0.0151***	−0.0842***	–
	HO	−43.0543***	−0.0027***	−0.0019***	−0.1341***	–
	PE	0.3866	0.0008***	−0.0040***	−0.0381***	–
	SE	29.2216***	0.0009***	−0.0049***	0.0335***	–
Younger than 19 years	AC	−3.0552	0.0006***	−0.0008***	−0.1264***	–
	HB	−15.9076*	0.0000	0.0072***	0.0057	–
	HO	−5.7038	0.0005*	0.0126***	0.0309***	–
	PE	5.6405*	0.0008***	−0.0058***	−0.1701***	–
	SE	20.3651***	−0.0008***	−0.0100***	0.0439***	–
65 years and older	AC	18.7819***	0.0008***	0.0029***	0.0078**	–
	HB	56.6317***	0.0030***	0.0120***	−0.0044	–
	HO	−58.8682***	−0.0022***	−0.0050***	−0.1198***	–
	PE	−11.1614***	−0.0006***	−0.0023***	0.0197***	–
	SE	−8.8860***	−0.0003**	−0.0027***	−0.0264***	–

AC, access; CRG, Clinical Risk Group; ED, emergency department; HB, health behaviors; HO, health outcomes; PE, physical environment; SDOH, social determinants of health; SE, social and economic.

*$P < .05$; **$P < .01$; ***$P < .001$.

[a]Parameter estimates are derived from model coefficient results from each model. Linear regression was used for cost, inpatient admissions, and ED visits. Proportional odds models were used for ordinal CRG and CRG severity scores. Larger estimates infer larger effects of SDOH on the outcome of interest. For linear regression results: Positive estimates show a direct relationship (ie, as the SDOH score increases, the outcome of interest increases). Negative estimates show an inverse relationship (ie, as the SDOH score decreases, the outcome of interest increases). For proportional odds model results: Positive estimates show a direct relationship (ie, as SDOH score increases, the odds of going up a CRG level increase). Negative estimates show an inverse relationship (ie, as SDOH score decreases, the odds of going up a CRG level increase).

[b]Comprehensive list of severity parameters in the **eAppendix Table**.

75.4%. The population younger than 19 years experienced greater influence on the inpatient rate per county from the combined factors of physical environment and social/economic environment at 60%. Access was a contributor across all populations.

A markedly different pattern was revealed for the contribution of the various categories to the rates of ED visits per year. For the general population, there was a strong relationship with health behaviors contributing 56.8% to the variations by county. The population 65 years and older also had the strongest relationship with health behaviors (47.2%) but also had a strong relationship with health outcomes contributing 21.7% to the variations across counties. The group younger than 19 years had a strong relationship with health outcomes contributing 34.6% to the variations across counties in the rate of ED utilization. Interestingly, access was a significant but low contributor for the general population and the group younger than 19 years.

A higher CRG risk score is an indicator of poorer health status and greater severity of illness. Table 4 identifies the association of the SDOH categories with the variations in the mean CRG score per county by population group. Health outcomes remained the top contributor for the general population and the group 65 years and older, with a contribution rate of 45.4% and 67.3%, respectively. For the group younger than 19 years, access played a large role at 33.5%, as did physical environment at 45.1%.

Using the resulting percentages created by the model parameters, conceptual framework matrices were developed for each age group as seen in Tables 1 through 3. Percentages taken from the model output were rounded to the nearest 5% for ease of use.

DISCUSSION

This study expanded upon a widely used US SDOH index (Wisconsin's CHRs) through the addition of variables and the use of regression models to determine the impact of SDOH and their aggregated categories for 3 commonly reported health care quality outcomes. In their 2015 analysis of the CHRs at the national level, Hood et al found that health behaviors were the biggest predictor of outcomes in Texas (for mortality and morbidity).[20] In this analysis of Texas counties, health behaviors were found to be the largest predictor for some outcomes and some population segments; however, the overall impact varied. Variation was found in both the suite of factors and weights for each population segment and for the impact of these factors on health care quality outcomes. In particular, in younger populations, physical environment and socioeconomic factors showed the strongest effect on the rate of acute inpatient admissions in the study. The inpatient admission rates of the population 65 years and older were most affected by health behaviors and health outcomes. In the conceptual framework, health behaviors are rates of behavioral variables at the county level, such as the proportion of smokers or the rate of obesity (see eAppendix). For the general population, health outcomes and socioeconomic factors had the largest impact on rate of acute inpatient admissions. The association between access to care and acute inpatient admission rates was consistent across all 3 age groups.

ED utilization rates were most influenced by health behaviors for the general population and the population 65 years and older. Interestingly, although access factors were significant for their relationship to ED use, their contribution was low for the group younger than 19 years and the general population at 2.2% and highest for the group 65 years and older at 11%. For the general population, socioeconomic factors contributed 18%. For the population 65 years and older, socioeconomic factors contributed 11%. For those younger than 19 years, health outcomes and socioeconomic categories were the highest impactors at 35% and 28%, respectively. ED utilization and preventable ED utilization have been consistently linked to populations of lower SES and underserved populations across the United States and are costly in terms of both health care costs and quality of care.[21,22] These results are consistent and find an association between SES and ED utilization. Importantly, socioeconomic factors are upstream and influence health behaviors, leading to a compound effect on outcomes.

It has been widely noted that place contributes to the variation in key health and quality outcomes such as cost, resource use, and risk scores indicating health severity and disease status. However, a recent literature review of risk prediction and segmentation models found that only 20% incorporated geography.[23] They further found that use of demographic data was typically limited to age and gender, and inclusion of community social determinants factors was uncommon.[23] In their recent study, Henning et al[2] found that failing to account for geographic location and associated community-level factors in quality adjustment models may also lead to biased quality scores for Medicare populations.

This study and the developed population-based matrices can provide valuable information for reporting efforts on quality in health care, specifically for health plans reporting on provider results. As the executive order on "Improving Price and Quality Transparency in American Healthcare to Put Patients First" (issued June 24, 2019)[24] is implemented to develop a Health Quality Roadmap that aims to establish, adopt, and improve reporting on quality measures across publicly funded health systems, the need to incorporate SDOH should be addressed. The matrices offered in this study serve as an excellent beginning to enhance the transparency and quality reporting efforts within the Roadmap to be developed.[24] Although the findings were based on Texas metrics, the results may be generalizable to other states because the metrics methods are consistent. Furthermore, with the evidence from this study, interventions from health plans that address such social determinants can be developed and targeted to the relevant populations. A recent study by the Center for Population Health Information Technology at Johns Hopkins Bloomberg School of Public Health supports the prospect that interventions that target social and behavioral risk factors can improve health outcomes.[25] The study proposed a conceptual framework useful for the integration of

social and behavioral data into population health strategies at the patient, health system, and community levels.

Limitations

Limitations to this study are primarily associated with the assignment of population statistics to a geographic area of county, which can vary greatly in size and population diversity. For example, much of the metropolitan area of Houston, Texas, is in Harris County, which includes pockets of very low SES and areas of very high SES. It would have been preferable to use a more refined geographic level, but not all data came in zip codes, so counties were the only consistently available geographic indicator. Additionally, counties that had no reported index value were assigned the mean for the state, which may not accurately reflect conditions. Further limitations included the inability to consider race and income of the study populations.

CONCLUSIONS

This study and the developed population-based matrices can provide a valuable framework for reporting the impact of SDOH on health care quality. The variation suggests the need for further research on how age groups react to the social environment. ■

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