



Association of the Robert Wood Johnson Foundations' Social Determinants of Health and Medicare Ocular Hospitalizations: A Cross Sectional Data Analysis

Dustin D. French · Andrew Wang · Alisa J. Prager ·
Curtis E. Margo

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ABSTRACT

Introduction: Social determinants of health (SDH) may influence inpatient utilization rates and outcomes but have yet to be associated with ocular diagnoses. The purpose of this paper was to determine whether the SDH are associated with ocular hospitalizations.

Methods: Patients from the national Medicare 100% Inpatient Limited Dataset were examined and linked to SDH measures from the Robert Wood Johnson Foundation (RWJF) County Health Rankings. Patients were included in the

study group with either an admitting or primary diagnosis of an ophthalmic condition. All other hospitalized Medicare patients served in the comparison group. Nested logistic regression of these Medicare patients was conducted in their respective communities at the county level. SDH measures were benchmarked above or below the national median.

Results: Positively associated SDH factors included communities with air pollution exceeding 11.62 micro grams per cubic meter (OR 1.05; 95% CI 1.01–1.08), communities where severe housing problems exceeding 14.38% (OR 1.13; 95% CI 1.09–1.18), children in single parent households exceeding 32.13% (OR 1.06; 95% CI 1.02–1.11), violent crime rate exceeding 250.54 per 100,000 (OR 1.07; 95% CI 1.03–1.12), diabetes exceeding 10.95% (OR 1.09; 95% CI 1.04–1.14), and drug poisoning deaths including opioids exceeding 14.17 per 100,000 (OR 1.04; 95% CI 1.01–1.08).

Conclusion: When compared to an all-condition, hospitalized population, ocular hospitalizations tended to have small, yet statistically significant associations with health behaviors, socioeconomic, and physical environment factors. Further research will be needed on how the physical environment, social, and community variables affect ocular health relative to all-cause hospitalizations.

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D. D. French (✉) · A. J. Prager
Department of Ophthalmology, Feinberg School of
Medicine, Northwestern University, Chicago, IL,
USA
e-mail: Dustin.French@northwestern.edu

D. D. French · A. Wang
Center for Healthcare Studies, Feinberg School of
Medicine, Northwestern University, Chicago, IL,
USA

D. D. French
Veterans Affairs Health Services Research and
Development Service, Chicago, IL, USA

C. E. Margo
Department of Ophthalmology, Morsani College of
Medicine, University of South Florida, Tampa, FL,
USA

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Key Summary Points

Why Carry Out this Study?

In this cross-sectional study, several measures of the social determinants of health were associated with ocular hospitalizations compared to all-cause hospitalizations.

What was Learned from the Study?

The social determinants of health should be considered for inclusion in future study designs as they have a small but significant associated effect on ophthalmic conditions.

INTRODUCTION

Clinical, biologic, and genetic factors, along with age, gender, and race, have central roles in influencing health outcomes. Evidence continuously emerges that the social determinants of health (SDH) impact health outcomes [1, 2]. Briefly, the SDH are measures that fit into six key domains: economic stability (e.g., unemployment rate), neighborhood and physical environment (e.g., air pollution), education (e.g., high school graduation rate), community and social context (e.g., children in single parent households, violent crime), food (e.g., access, healthy choices), and health and disease (e.g., diabetes, drug overdose deaths, etc.) [3]. Subsequently, the literature has shown that SDH factors have a strong influence on US health, contributing to over 500,000 deaths in 2000 [4]. Moreover, SDH factors may also influence the number of hospitalizations, inpatient readmissions, and use of ED services [5–8].

In ophthalmology, there have been prior studies associating visual impairment and blindness with low socioeconomic status (low income and education) [9–12], reductions in access to eye care [13], and geographical variations [14]. Socioeconomics have a significant

impact on the use of eye care services among the economically disadvantaged [15]. Furthermore, the prevalence of eye trauma and annual eye exams among the visually impaired varied among states, as well as by race/ethnicity, education, income, and health insurance status [16, 17]. In addition, emerging evidence of environmental factors, such as black carbon, cadmium, and lead may have contributed to ocular dysfunction, such as elevated intraocular pressure and impairment of contrast sensitivity [18, 19]. Only one study, conducted in Sweden, has examined a large group of socioeconomic factors through a neighborhood deprivation index, and showed a positive association with age-related eye diseases [20]. We are not aware of any large scale studies that have involved US populations in exploring the association of the SDH domains on eye care utilization or ocular health.

Our aim was to illustrate the geographic variability of Medicare ocular hospitalization rates and subsequently examine the association of select SDH variables on these hospitalizations relative to all-cause non-ocular hospitalizations.

METHODS

We conducted a cross-sectional study using data from fiscal year 2015 national Medicare 100% Inpatient Limited Dataset (LDS) (October 1, 2014–September 30, 2015) and identified patients with ocular hospitalization from all causes, including chronic conditions and traumatic injuries, who were then merged with the 2015 Robert Wood Johnson Foundation (RWJF) County Health Rankings [21–23]. Fiscal year was chosen over calendar year due to transitions in billing from ICD-9 to ICD-10 during the last few months of 2015. This study abides by the Dataset Use Agreement (DUA) and the Northwestern University Institutional Review Board, which granted a study exemption. All methods adhered to the tenets of the Declaration of Helsinki. All authors declare no conflicts of interest. Under Data Use Agreement (CMS-R-0235L) section 8a no cell less than 11 may be displayed. We employed the national Medicare Inpatient LDS for 2 years (2014, 2015) to create

FY 2015, to identify patients who had either an admitting diagnosis or a principal diagnosis of an ophthalmic condition as previously described [21].

The RWJF County Health Rankings, publicly available datasets (annually from 2011 to 2018), reported an aggregate of 35 health measures and incorporated health rankings for almost every county in the US [24]. Each county's health measures were determined using data from the National Center for Health Statistics, Center Disease Control's Behavioral Risk Factor Surveillance System, the American Community Survey, and the United States Department of and Agriculture Food Environment Atlas. The RWJF data provide general public access and can be obtained annually and across 3191 US counties.

Merging the data at the county level between Medicare LDS and the RWJF data required linkage of Medicare's LDS two-digit state and three-digit county codes to create the Social Security Administration's (SSA) five-digit code. These codes were based on where the patient resides and not the hospital location in order to capture their residential SDH characteristics. The RWJF data sets contain the Federal Information Processing Standards (FIPS) county codes, another format of combined state and county codes, thereby requiring a crosswalk to merge the two datasets. Using the National Bureau of Economic Research data, we cross-referenced the Medicare SSA codes to FIPS county codes and then merged hospitalizations within a county to RWJF county health rankings data [25]. Among all 6,673,799 Medicare inpatients, there was a data loss of 30,853 patients due to minor limitations with the RWJF data of including all patients living in or receiving care in US territories. Henceforth, among all Medicare patients ($N = 6,642,946$), 17,871 Medicare patients had ophthalmic hospitalizations compared to those without ophthalmic hospitalizations ($N = 6,625,075$). The key covariates from the Medicare data included patient-specific adjustments by age cohorts, gender and black race.

The RWJF data were used to create covariates that captured the six key domains of the SDH (economic stability, neighborhood and physical environment, education status, food access,

social and community context, healthcare). Variable selection within domains were based on a literature search among the 35 measures used in the RWJF community health rankings [26]. Due to issues of multicollinearity among these measures, 13 of the 35 measures that encompassed all 6 SDH domains were examined in this study [27]. For interpretation, we converted RWJF measures to binary variables, where '1' represents a county above the median (upper 50%) for a selected measure and '0' represents counties below the median (lower 50%).

Across all six domains, we used standardized measures established by Healthy People 2020, along with other literature, to ensure representation among each domain for analysis [28]. For economic stability, we included measures of unemployment and income inequality because of their known relations to economics and their associations with poor health outcomes [29, 30]. For neighborhood and physical environment, we included measures of air pollution and severe housing problems because of their associations with residential isolation and poor environments [31–33]. We measured education status by level of high school education since it is a well-established measure associated with health [34]. We measured food access by food insecurity, as this measure has been associated with chronic disease and poor health [35, 36]. We measured social and community context by the number of children in single-parent households and the amount of violent crime, as these have been linked to less social cohesion and poor health [37, 38]. Lastly, we measured health care by rates of diabetes, smoking status, injury death, drug poisoning deaths, and sexually transmitted diseases as they are related to poor health [39–44].

For the analysis, we performed nested logistic regression using Proc Gen Mod in SAS[®], nesting Medicare patients in their respective counties. To capture SDH impacts on patients, we nested Medicare patients in their respective counties (where they reside) accounting for the potential effects of community level characteristics, while also capturing specific patient characteristics such as age, gender and race. Nested logistic regression was chosen as the primary method of analysis as it integrates

unobserved attributes of these counties. Using a non-nested logistic regression would be insufficient and unable to address potential endogeneity within each county. For our outcomes, in order to understand the effects of SDH on ocular hospitalizations, we compared patients with ocular hospitalizations (a binary measure of “1”) to those hospitalized without ocular hospitalizations (a binary measure of “0”).

As a secondary analysis we examined regional variation of ocular hospitalizations among Medicare beneficiaries expressed as a rate per 10,000 using a national map at the county level, adjusted with U.S. Census data. The data management and statistical analysis were conducted in SAS[®], version 9.4 Cary, NC, and the map was developed using ArcGIS ArcMap, version 10.5 ESRI.

RESULTS

Across the 3191 counties, almost two-thirds have at least one ocular hospitalization in 2015. The top admitting diagnoses for non-traumatic and traumatic eye conditions were diplopia (11.69%) and closed fracture of the orbital floor (3.76%), respectively [21]. In Fig. 1, the highest rates of these hospitalizations occurred among counties in the regions known as the “Rust Belt”, as well as the Northeast, the Southeast, and select parts of the Southwest. Fewer ocular hospitalizations per 10,000 Medicare beneficiaries occurred in the Western portion of the US. Significant clustering of higher rates of ocular hospitalizations occurred around major urban areas and cities across the country.

Table 1 presents the top 10 counties with the highest rate of ocular hospitalizations and select categories of the 2018 RWJF health rankings [45]. Overall there were 2189 counties with at least one ocular hospitalization. Generally, those with the highest rates of Medicare ocular hospitalizations generally had poor rankings for health outcomes, health behaviors, socioeconomic, and physical environment. For instance, Richmond City, VA had the highest rate of Medicare ocular hospitalization at 13.16 per 10,000, with a health behavior and physical environment ranking near the bottom of all

counties in the state. Similarly, Japer, MO had a high rate of Medicare ocular hospitalizations, “the Tri-State District of southwest Missouri was a world-class producer of zinc and lead [46]. In summary, counties listed in Table 1 ranked at the bottom of the states on most SDH measures.

Table 2 presents the main results of the nested logistic regression model, along with a description of the original data sources of key covariates, median estimates, odds ratios (OR), and corresponding 95% confidence interval (CI) estimates. For Medicare patients, the variables of younger age and black race (OR 1.20; 95% CI 1.15–1.26) were associated with an increased association of ocular hospitalizations while being female had a small protective effect. The youngest Medicare age group was 16% more likely to be hospitalized relative to those in the age group 84 and older (OR 1.11; 95% CI 1.11–1.22). Younger Medicare patients typically qualify for coverage at a younger age because of end-stage renal disease or a medical disability suggesting systemic diseases in ocular hospitalizations.

In assessing communities where Medicare inpatients reside, among those with ocular hospitalizations compared to all-cause non-ocular hospitalizations, we found that physical environment, social and community, and health and disease measures were associated with ocular hospitalizations, while the selected economic and education measures were not associated ocular hospitalizations. First, communities with air pollution that exceeded the national median of 11.62 micro grams per cubic meter had a marginally increased association of ocular hospitalizations (OR 1.05; 95% CI 1.01–1.08). Communities where severe housing problems exceeded the median of 14.38% were 13.0% more likely to have ocular hospitalizations (OR 1.13; 95% CI 1.09–1.18). The variable food insecurity reduced the association by 7.0%.

In communities where the percent of children in single parent households exceeded the national median of 32.13%, we observed a marginal increase in the association of ocular hospitalizations (OR 1.06; 95% CI 1.02–1.11). This association was the similar for those residing in communities where the violent

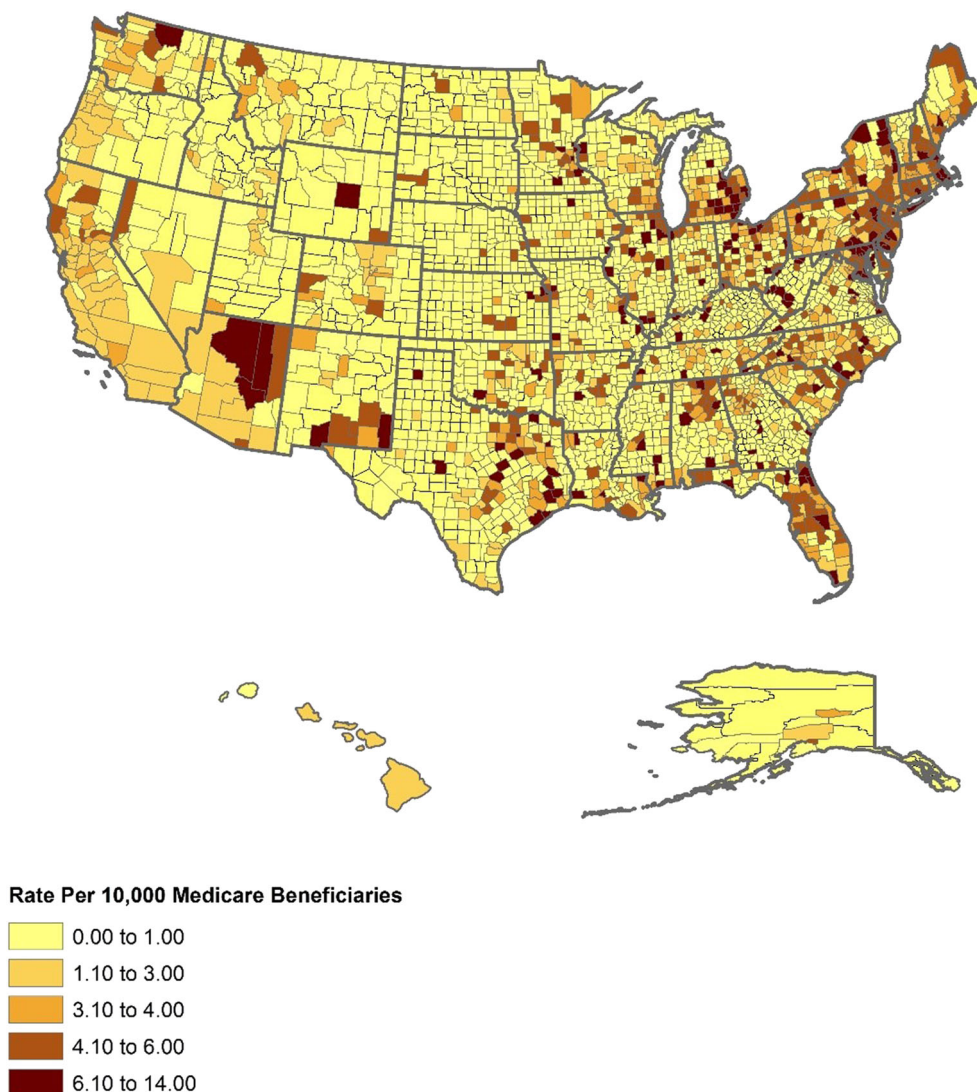


Fig. 1 Regional Variation in Ocular Hospitalizations per 10,000 Medicare Beneficiaries 2015

crime rate exceeded the national median of 250.54 per 100,000.

In the last SDH category of health and disease, those that have resided in communities with a diabetes rate above the national median of 10.95% were 9.0% more likely to have an ocular hospitalization (OR 1.09; 95% CI 1.04–1.14). Communities with drug poisoning deaths including opioids that exceeded the national median of 14.17 per 100,000, were marginally associated with increased ocular hospitalizations (OR 1.04; 95% CI 1.01–1.08). However, communities with higher than the national median of injury deaths exhibited

lower odds of ocular hospitalizations (OR 0.89; 95% CI 0.85–0.93). Finally, the percent of smoking and rates of sexually transmitted disease rates against the national median were statistically insignificant.

DISCUSSION

This is the first study to examine the relationship between social determinants of health derived from RWJF community measures and a surrogate measure of ocular health (hospitalization for ophthalmic conditions). We

Table 1 Highest ocular hospitalization rates by counties compared to select categories of Robert Wood Johnson Foundation health rankings in 2018

County Name	State	Ocular hospitalization rate per 10,000 Medicare beneficiaries	Health outcomes ranking	Health behaviors ranking	Socio-economic ranking	Physical environment ranking
1. Richmond City	VA	13.17	114 out of 133	123 out of 133	125 out of 133	108 out of 133
2. Jasper	MO	12.52	65 out of 115	78 out of 115	51 out of 115	95 out of 115
3. St. Mary's	MD	11.96	8 out of 24	16 out of 24	7 out of 24	9 out of 24
4. Polk	WI	11.59	39 out of 72	24 out of 72	32 out of 72	50 out of 72
5. Monongalia	WV	11.18	2 out of 55	2 out of 55	4 out of 55	21 out of 55
6. Putnam	WV	11.07	3 out of 55	1 out of 55	2 out of 55	31 out of 55
7. Marion	WV	10.96	9 out of 55	49 out of 55	49 out of 55	19 out of 55
8. Washington	LA	10.95	60 out of 64	50 out of 64	51 out of 64	11 out of 64
9. Natrona	WY	10.91	20 out of 23	18 out of 23	22 out of 23	10 out of 23
10. Cerro Gordo	IA	10.82	72 out of 99	30 out of 99	53 out of 99	49 out of 99

Robert Wood Johnson Foundation program, County Health Rankings and Roadmaps: Building a Culture of Health County by County. <http://www.countyhealthrankings.org/>. Accessed 12 April 2019

There were 2189 counties with at least 1 ocular hospitalization

demonstrated regional variation in ocular hospitalizations, with higher rates of hospitalization among areas with lower health rankings. We also found substantial clustering of higher rates of ocular hospitalizations around major urban areas and cities across the country. This phenomenon may be due to the availability of tertiary care facilities in urban areas. Further research is necessary to determine how population density, availability of primary eye care providers, and location of tertiary healthcare facilities influence eye-related hospitalizations.

The study of the social determinants continues to develop and has been accepted as a major factor of health outcomes. Studies showing the effects of SDH on eye health have been limited. Our study found significant associations between ocular hospitalizations (compared to all-cause non-ocular hospitalizations) and several of the SDH domains, namely physical environment, social and community context, and health. The variable food insecurity was shown to be protective. This seemingly

paradoxical outcome might be attributed to the role that federal assistance and food stamps plays within these communities. The social and environmental factors that may impact eye health described in a recent report, Making Eye Health a Population Health Imperative: Vision for Tomorrow by the National Academies of Sciences, Engineering, and Medicine (NAEM) is generally supported by the results of our study [47–49].

Hospitalizations for eye conditions is a broad surrogate marker of ocular health, and could be a marker of advanced or neglected eye disease, or lack of timely access to eye care or preventative care. Non-traumatic disorders of the eye and adnexa comprised the majority of ocular admissions (84.9%). The most common admitting diagnoses for non-traumatic eye conditions were diplopia (11.7%), various types of visual disturbances (11.1%, 7.6, and 6.5%), unspecified visual loss (3.3%), and orbital cellulitis (2.8%). The most common diagnoses for traumatic eye conditions were closed fracture of the

Table 2 County level nested fixed effects model of Medicare ocular hospitalization on the social determinants of health

Medicare measures	Data source	Percent ^a	Odds ratio	95% confidence intervals
<i>Variables</i>				
Age < 65	Medicare	19.07	1.16**	1.11 1.22
65–69	Medicare	17.09	1.12**	1.07 1.18
70–74	Medicare	15.69	1.12**	1.06 1.17
75–79	Medicare	14.47	1.13**	1.08 1.19
80–84	Medicare	13.30	1.08**	1.03 1.14
Age > 84 (reference)	Medicare	20.38	Reference	Reference
Female (= 1)	Medicare	54.96	0.95**	0.92 0.98
Black (= 1)	Medicare	11.37	1.20**	1.15 1.26
Social determinant measures (= 1 when county exceeds the national median)				
Economic				
Unemployment %	U.S. Bureau of Labor Statistics		7.25%	0.97 0.94 1.01
Income inequality (ratio of household income at the 80th percentile to that at the 20th percentile)	U.S. Census Bureau		4.49	1.01 0.97 1.05
Neighborhood and physical environment				
Air pollution—fine particulate matter in micrograms per cubic meter (µg/m ³)	Centers for Disease Control		11.62	1.05** 1.01 1.08
Severe housing problems (overcrowded (> 1.5 person per room); are expensive (housing costs over 50% of household monthly income); have incomplete plumbing facilities; or have incomplete kitchen facilities) %	U.S. Department of Housing and Urban Development		14.38%	1.13** 1.09 1.18

Table 2 continued

Social determinant measures (= 1 when county exceeds the national median)	Robert Wood Johnson Foundation community health rankings documented data sources	National median	Odds ratio	95% confidence intervals
Education				
High school graduation rate %	National Center for Education Statistics	83.00%	1.00	0.96 1.03
Food				
Food insecurity, inability of the population to access food %	Map the Meal Gap	14.75%	0.93**	0.89 0.97
Social and Community Context				
Children in single parent households, raised by a single adult %	U.S. Census Bureau	32.13%	1.06**	1.02 1.11
Violent crime (rate per 100,000)	Federal Bureau of Investigation, Uniform Crime Reporting	250.54	1.07**	1.03 1.12
Health and Disease				
Smoking %	Centers for Disease Control	21.23%	0.95	0.91 1.01
Diabetes %	Centers for Disease Control	10.95%	1.09**	1.04 1.14
Injury deaths (rate per 100,000)	Centers for Disease Control	77.06	0.89**	0.85 0.93
Drug poisoning deaths (rate per 100,000)	Centers for Disease Control	14.17	1.04*	1.01 1.08
Sexually transmitted diseases (chlamydia rate per 100,000 population)	National Center for HIV/AIDS, Viral Hepatitis, STD, and TB prevention	368.40	1.03	0.99 1.07

* P value < 0.05** P value < 0.01^a Medicare percent for ocular and non-ocular hospitalizations

orbital floor (3.8%), ocular laceration (0.94%), contusion of the eye and adnexa (0.6%), and open wound of the eyeball (0.58%). The interplay of the SDH and various disorder of the eye and their underlying diseases is difficult to disentangle with cross-sectional data but is the next step in this research. However, we did adjust for age, capturing younger patients (age less than 65) that qualified for Medicare because of disability and chronic kidney disease, and older patients, who carry higher levels of morbidity. Policymakers may find this information useful when implementing value-based care for underserved regions with constrained resources.

The strengths of this study were the inclusion of all Medicare inpatient beneficiaries across the US and use of at least one measure for each of the six SDH domains. The limitations of this study's design include the potential variation at the county level for SDH factors, attributing individual outcomes at the county level, and inability to assess all SDH variables because of multicollinearity. In addition, this study was limited to one year of data and was not longitudinal. This study also focused on individuals with Medicare and cannot be extrapolated to other populations. Lastly, the design found associations between SDH factors and ophthalmic conditions and did not reflect causality.

CONCLUSION

When compared to an all-condition, hospitalized population, ocular hospitalizations tended to have small, yet statistically significant associations with health behaviors, socioeconomic, and physical environment factors. Further research is needed on how the physical environment, social, and community variables affect ocular health relative to all-cause hospitalization is needed.

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Authorship. All named authors meet the International Committee of Medical Journal Editors (ICMJE) criteria for authorship for this article, take responsibility for the integrity of the work as a whole, and have given their approval for this version to be published.

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Compliance with Ethics Guidelines. This study abides by the Dataset Use Agreement (DUA) and the Northwestern University Institutional Review Board, which granted a study exemption. All methods adhered to the tenets of the Declaration of Helsinki. Under Data Use Agreement (CMS-R-0235L) section 8a no cell less than 11 may be displayed.

Data Availability. Medicare Limited Data Set (LDS) files contain beneficiary level protected health information and are under Federal regulation through the Health Insurance Portability and Accountability Act; By law, LDS requests require a Data Use Agreement (DUA) available at <https://www.resdac.org/cms-data/request/limited-data-sets> and require an Institutional Board Waiver. Our study abides by the CMS' current cell size suppression policy in

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