Geographic Variation in the Rate and Timing of Cataract Surgery Among US Communities

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IMPORTANCE Previous studies using data from the 1980s found relatively little geographic variation in cataract surgery rates across the United States. We do not know whether similar patterns hold true today, nor do we know the patient- and community-level factors that might explain any recent geographic variations in the rate and timing of cataract surgery.

OBJECTIVE To assess the extent of geographic variation in patient age at initial cataract surgery and the age-standardized cataract surgery rate in a large group of insured US patients with cataracts.

DESIGN, SETTING, AND PARTICIPANTS Retrospective cross-sectional study of 1,050,815 beneficiaries older than 40 years of age with cataracts who were enrolled in a nationwide managed-care network during the period from 2001 to 2011. The data analysis was started in 2014 and refined in 2015.

MAIN OUTCOMES AND MEASURES Median age at initial cataract extraction, age-standardized cataract surgery rate, and time from initial diagnosis to first surgery for patients with cataracts were compared among 306 US communities. Multivariable regression modeling generated hazard ratios (HRs) with 95% CIs identifying factors associated with patients’ likelihood of undergoing cataract surgery.

RESULTS A total of 243,104 patients with cataracts (23.1%) underwent 1 or more surgical procedures (55.1% were female patients). Communities with the youngest and oldest patients at initial surgery differed in age by nearly 20 years (59.9-60.1 years in Lansing, Michigan, and Aurora, Illinois, vs 77.0-79.6 years in Marquette, Michigan; Rochester, New York; and Binghamton, New York). The highest age-standardized cataract surgery rate (37.3% in Lake Charles, Louisiana) was 5-fold higher than the lowest (7.5% in Honolulu, Hawaii). The median time from initial cataract diagnosis to date of first surgery ranged from 17 days (Victoria, Texas) to 367 days (Yakima, Washington). Compared with white patients, black patients had a 15% decreased hazard of surgery (HR, 0.85 [95% CI, 0.83-0.87]), while Latino patients (HR, 1.08 [95% CI, 1.05-1.10]) and Asian patients (HR, 1.09 [95% CI, 1.05-1.12]) had an increased hazard. For every 1° higher latitude, the hazard of surgery decreased by 1% (HR, 0.99 [95% CI, 0.98-0.99]). For every additional optometrist per 100,000 enrollees in a community, the hazard of surgery increased 0.1% (HR, 1.001 [95% CI, 1.001-1.001]).

CONCLUSIONS AND RELEVANCE In recent years, patient age at first cataract surgery and the age-standardized surgery rate have varied considerably among some US communities. Future research should explore the extent to which such variations may affect patient outcomes.
**Cataract** is a leading cause of visual impairment, affecting more than 24 million Americans. With the aging of the US population, this number is projected to increase to 38.7 million by 2030. The rate of cataract surgery also increased over the past several decades. From 1980 to 2003, the cataract surgery rate for Medicare beneficiaries increased from 13.4 to 61.8 persons per 1000 person-years.

Using Medicare claims data from the late 1980s, Javitt and colleagues found that cataract surgery rates in US communities varied relatively little compared with other surgical procedures. In addition to identifying communities with disproportionately high and low surgery rates, they ascertained several variables associated with communities’ cataract surgery rate, including patient age, sex, race, latitude, density of optometrists, and allowed cataract surgery charge. Other variables, including density of practicing ophthalmologists, were not statistically significant.

Approximately 20 years after Javitt and colleagues’ seminal work, we revisit geographic variation in cataract surgery rates among US communities using 2001-2011 data from a large managed-care network. We assess whether communities with relatively low and high surgery rates in the earlier study continue to show similar patterns. Moreover, we assess variation in the time from first cataract diagnosis to surgery and evaluate whether factors affecting cataract surgery rates years ago remain important now.

**Methods**

**Data Source**
The Clininformatics DataMart database (OptumInsight) has de-identified records of all beneficiaries in a nationwide managed-care network. We had access to data for all eye care recipients during the period from 2001 to 2011. Beneficiaries were included in the data set if they had 1 or more International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9-CM) codes for any eye-related diagnosis (ICD-9-CM codes 360-379.9); a Current Procedural Terminology (CPT) code for any eye-related visit or for diagnostic or therapeutic procedures (CPT codes 65091-68899 or CPT codes 92002-92499); or any other ophthalmologist- or optometrist-submitted claim during their time in the plan. The data contain all of beneficiaries’ medical claims for ocular and nonocular conditions and their sociodemographic information (age, sex, race, education, and income); they have been used in other ocular disease-related studies. The University of Michigan institutional review board approved our study as a nonregulated study. Informed consent was not obtained because the data were deidentified.

**Sample Selection**
We identified all persons older than 40 years of age who had 1 or more diagnoses of cataract (ICD-9-CM codes 366, 366.0-04, 366.09, 366.1x, 366.41, and 366.45) during their time in the plan. Prior work comparing billing records with medical records found that billing records accurately capture persons with cataracts.
ophthalmologist who performed the surgery and compared the median timing from first diagnosis to surgery among the HRRs.

**Factors Affecting Receipt of Cataract Surgery**

Hierarchical Cox regression modeling was performed to identify community- and patient-level variables affecting receipt of cataract surgery. The community-level variables considered in the model were supply of ophthalmologists and optometrists, average cost of living, number of days of sunshine annually, latitude, longitude, UV index, proximity to an ophthalmology residency program, median charge, and proportion of persons in the HRR who drive to work. Patient-level variables included race, sex, income, educational level, urban/rural status of residence, common medical and ocular comorbidities, and the Charlson Comorbidity Index, which is a measure of overall health. The best subset selection method identified which covariates to include in the model. The regression models generated hazard ratios (HRs) with 95% CIs. For all analyses, $P < .05$ was considered statistically significant.

**Results**

Of the 1,050,815 eligible enrollees who received a diagnosis of cataracts, 243,104 (23.1%) underwent cataract surgery in 1 or 2 eyes during their time in the plan. The mean (SD) duration in the plan of all eligible enrollees was 1,539 (977) days; 238,242
enrollees (98.0%) were followed up for 6 months or more while in the plan. Among cataract surgery recipients, the mean (SD) time from plan enrollment to first cataract surgery was 933 (814) days. A higher proportion of men with cataracts than women with cataracts underwent surgery (109106 of 460615 men [23.7%] vs 133998 of 590200 women [22.7%]; P < .001). The proportions of white, black, Latino, and Asian patients who underwent surgery were 24.4% (176518 of 723262), 21.2% (11816 of 55624), 22.2% (10321 of 46414), and 19.5% (4284 of 21966), respectively (P < .001).

Among all eligible enrollees (except those with missing data in their records), 202794 of 900233 enrollees (22.5%) had at least a college diploma, and 166802 of 862970 enrollees (19.3%) had an income of $100,000 or more (Table 1). The mean and median number of eligible patients with cataracts in a given HRR was 3434 and 1312, respectively (range, 61-68872 patients). The mean and median number of patients undergoing surgery in an HRR were 795 and 307, respectively (range, 21-16259 patients).

**Median Age of Patients at First Cataract Surgery**

The overall median age of patients at first cataract surgery was 67.7 years. The median age of patients at first cataract surgery was youngest among residents of Lansing, Michigan; Aurora, Illinois; and Lafayette, Indiana (range, 59.9-61.0 years), and was oldest among residents of Marquette, Michigan; Rochester, New York; and Binghamton, New York (range, 77.0-79.6 years) (Figure 1; Table 2; Table 3).

**Variation in Age of Patients at First Cataract Surgery**

Communities with the highest variation in median age of patients at first cataract surgery (ie, there is a wide age range from younger to older beneficiaries undergoing surgery within the community) include Bloomington, Illinois; Santa Cruz, California; Flint, Michigan; Altoona, Pennsylvania; and Marquette, Michigan. In these communities, the variation in median age of patients at first cataract surgery ranged from 12.4 to 12.7 years. By comparison, communities with the lowest variation include Lawton, Oklahoma; Yakima, Washington; Victoria, Texas; Petoskey, Michigan; and Binghamton, New York, where the dispersion in age of surgery recipients was 6.4 to 7.8 years (eFigure 1 in the Supplement; Tables 2 and 3). eFigure 2 in the Supplement shows a distribution of the median age of patients at initial cataract surgery for all the communities, stratified by urban/rural status, along with error bars capturing the variability in the point estimates.

**Age-Standardized Cataract Surgery Rates**

After excluding 82 of the 306 HRRs with limited numbers of enrollees to adequately perform the age-standardization procedure to account for differences in the average age of patients at the first diagnosis of cataract among the various HRRs, we observe a nearly 5-fold difference in the cataract surgery rate between the HRRs with the lowest and the HRRs with the highest age-standardized cataract surgery rates (7.5% in Honolulu, Hawaii, vs 37.3% in Lake Charles, Louisiana). Of the...
Six of the 10 HRRs with the lowest age-standardized rates were in New York or northern New Jersey (Figure 2; Tables 2 and 3).

### Timing From Diagnosis to Surgery

Communities with the longest median time from initial cataract diagnosis to first surgery include Yakima, Washington (367 days); Mason City, Iowa (278 days); and San Francisco, California (232 days). By comparison, those with the shortest time include Victoria, Texas (17 days); Hattiesburg, Mississippi (20 days); and Oxford, Mississippi (21 days) (Tables 2 and 3).

Communities with the highest median number of days between initial diagnosis and surgery by the same ophthalmologist include San Francisco, California (90 days); San Mateo County, California (78 days); and Burlington, Vermont (69 days), while the communities with the lowest median number of days include Muncie, Indiana (14 days); Dothan, Alabama (15 days); Abilene, Texas (17 days); and Jackson, Tennessee (17 days) (eFigure 3 in the Supplement; Tables 2 and 3).

### Factors Associated With Cataract Surgery

After adjusting potential confounders, we found that for every additional year of patient age at initial cataract diagnosis, the hazard for surgery increased by 2.5% (adjusted HR, 1.02 [95% CI, 1.02-1.03]). Compared with white patients, black patients had a 15% decreased hazard for surgery (adjusted HR, 0.85 [95% CI, 0.83-0.87]), whereas Asian patients (adjusted HR, 1.09 [95% CI, 1.05-1.12]) and Latino patients (adjusted HR, 1.08 [95% CI, 1.05-1.10]) had an increased hazard for surgery. Beneficiaries earning less than $30,000 had an elevated hazard for cataract surgery, relative to those with incomes of $60,000 or more (P < .001 for all comparisons), and the higher one’s income level, the lower the hazard for surgery. Compared with

### Table 2. Top 10 Communities With the Highest Values in Timing and Rate of Cataract Surgery (continued)

<table>
<thead>
<tr>
<th>Parameter and HRR</th>
<th>Value</th>
<th>Patients, No.</th>
<th>Total</th>
<th>Surgery</th>
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<tbody>
<tr>
<td>Age of patient at initial cataract surgery, SD, y</td>
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<td></td>
<td></td>
<td></td>
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<tr>
<td>Bloomington, IL</td>
<td>12.74</td>
<td>106</td>
<td>33</td>
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<tr>
<td>Santa Cruz, CA</td>
<td>12.74</td>
<td>272</td>
<td>60</td>
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<tr>
<td>Flint, MI</td>
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<td>Altoona, PA</td>
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</tr>
<tr>
<td>Marquette, MI</td>
<td>12.42</td>
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<td>22</td>
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<tr>
<td>Bangor, ME</td>
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<tr>
<td>Alameda County, CA</td>
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<tr>
<td>Minneapolis, MN</td>
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<td></td>
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<tr>
<td>Duluth, MN</td>
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<td>793</td>
<td></td>
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<tr>
<td>Santa Barbara, CA</td>
<td>11.96</td>
<td>324</td>
<td>58</td>
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<tr>
<td>Time from cataract diagnosis to cataract surgery, median, d</td>
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<td></td>
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<tr>
<td>Yakima, WA</td>
<td>367</td>
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<td>Mason City, IA</td>
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<td>San Mateo County, CA</td>
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</table>

10 HRRs with the highest age-standardized cataract surgery rates, 2 were in Indiana (Indianapolis, 33.8%; Gary, 31.3%), and 2 were in Colorado (Denver, 31.6%; Colorado Springs, 32.2%).
the least-educated patient group, all other patients had a lower likelihood of surgery ($P < .001$ for all comparisons).

For every 1° increase in latitude, the likelihood of cataract surgery decreased by 1% (adjusted HR, 0.99 [95% CI, 0.98-0.99]). For example, the hazard for cataract extraction was 20% lower in Portland, Oregon (45° latitude), than in Miami, Florida (25° latitude). Persons residing in rural communities had a 5% to 7% increased hazard of surgery compared with those living in urban locales ($P < .001$). For every additional optometrist in the community per 100 000 enrollees, the hazard increased by 0.1% (adjusted HR, 1.001 [95% CI, 1.001-1.001]). Persons with ocular trauma had a 30% increased hazard for surgery. Patients with diabetes (uncomplicated or involving end-organ damage) had a lower hazard for surgery than did patients without diabetes ($P < .001$). The hazard for surgery was 60% decreased in communities with higher, vs lower, overall practice expenses for medical care (adjusted HR, 0.40 [95% CI, 0.38-0.43]) (Table 4).

### Discussion

In this large analysis of insured US patients with cataracts, we find substantial variation across communities in the median age of patients at first cataract surgery and in the age-standardized cataract surgery rate. The median age of patients at initial cataract surgery was as young as 60 years in some communities but approached 80 years in others. Furthermore, the age-standardized cataract surgery rate varied considerably among communities—notably, from 7.5% in Honolulu, Hawaii, to 37.3% in Lake Charles, Louisiana.
In addition to Javitt and colleagues’ US-based analysis, the literature contains studies of within-country geographic variation in cataract surgery in England and Canada, where considerable variation was documented. Although these analyses and our analysis had different study designs and insurance types, making direct comparison difficult, all 4 studies identified substantial differences in communities between the lowest and highest surgery rates. Javitt and coworkers found many communities with similar cataract surgery rates but observed an 11-fold difference between the communities with the lowest (Billings, Montana) and the communities with highest (Lake Charles, Louisiana) rate. Likewise, we find a 5-fold difference between the lowest (Honolulu, Hawaii) and highest (Lake Charles, Louisiana) age-standardized cataract surgery rates. Of interest, Lake Charles, Louisiana, had the country’s highest cataract surgery rate in both studies despite the studies’ use of different data sources (commercial insurance plan vs Medicare) and an approximately 20-year difference in observation periods. Although it is unclear why this particular community has such high surgery rates, possible reasons include patient-related factors (eg, increased patient motivation for surgery), health care professional-related factors (eg, differences in health care professionals’ aggressiveness in recommending surgery), or factors specific to that particular community (eg, environmental exposures). Lake Charles is a major center for petrochemical refining, and chronic exposure to naphthalene and other pollutants involved in the refinery process increase the risk for cataracts. In contrast, Billings, Montana, which had the lowest surgery rate in the study by Javitt and colleagues, is among the top 10 communities with the highest age-standardized cataract surgery rates in our analysis.

We are unaware of other studies comparing age at initial cataract surgery among persons residing in different communities throughout the United States. While our analysis identified large variations in the timing of first cataract surgery, more work is required to understand the factors contributing to the large differences in timing observed. Communities differ with respect to the characteristics of the patients residing in them, eye care professional availability, how assertive the ophthalmologists are at recommending surgery, and different environmental and lifestyle factors that can affect the timing of surgery. Visual demands may also vary among persons residing in one community versus another. For example, some communities have better public transportation systems, so there may be less of a need to see well enough to operate a motor vehicle to drive to work.

Factors Associated With Cataract Surgery

Age

Our study and the study by Javitt and colleagues indicate an increased likelihood of cataract surgery among older patients. Studies have shown that lens opacities of all types are more likely to be present in older persons. This is attributable to the natural aging process. Increased cataract density has a greater effect on visual acuity and quality of life, and this effect is likely influencing the decision for surgery. In addition, as patients age, the majority of them have spouses or...
acquaintances who have undergone successful cataract surgery, which may factor into their decision-making process.

Race

Our finding of a reduced likelihood for cataract surgery among black patients, as was noted 2 decades ago, indicates that racial disparities persist. While it is known that racial inequities exist in the proportions of patients carrying health insurance and that this affects utilization, in both our analysis and that of Javitt and coworkers, all the eligible patients had health insurance; thus, at least theoretically, everyone had access to eye care services. Possible explanations for black patients’ decreased hazard for surgery include racial differences in the type of lens opacification present by race, reduced health care resource use, and less awareness of the potential benefits of cataract surgery. In focus groups of older black patients and eye care professionals, the most frequently cited barrier to care was the lack of transportation and accessibility to ophthalmologists’ offices for the surgery and postoperative care. Other barriers to surgery for black patients may include issues with trust and communication with physicians, differences in social support, and out-of-pocket costs (copayments, deductibles, and prescription medications). Given that cataracts are a leading cause of blindness among black people and yet racial disparities in receipt of cataract surgery persist, additional work is needed to better identify and to eliminate black patients’ barriers to surgery.

Socioeconomic Status and Education

In our analyses, persons with incomes of less than $30,000 had an increased hazard for surgery. Some previous studies similarly found that lower socioeconomic status was associated with an increased likelihood of cataract surgery. Less-affluent persons may have greater exposure to environmental influences (eg, sunlight and pollutants) from their jobs, increasing their cataract density and precipitating the need for surgery. Lifestyle factors, including cigarette smoke, diet, UV exposure, and stress, may also contribute. Our finding regarding persons of lower socioeconomic status is particularly noteworthy given that this population has been documented generally to have lower utilization rates and poorer access to health care services.

UV Light Exposure

In our study and in the study by Javitt and colleagues, the hazard of surgery was reduced for persons living in communities further away from the equator (higher latitude). This highlights the importance that UV light exposure can have on the development and progression of cataracts.

Urban vs Rural Residence

An interesting finding from our analysis is the relationship between location of residence and likelihood of undergoing cataract surgery. We find that patients in rural communities are more likely than patients in urban communities to undergo cataract extraction. This may be due to differences in environmental, employment, and lifestyle factors, with greater exposure to sunlight among those living in rural communities. Alternatively, those living in rural communities, where there is less access to public transportation and greater distances to travel for work and leisure activities, may require better vision for driving.

Number of Ophthalmologists or Optometrists

We and Javitt and colleagues found that cataract surgery rates were not associated with the number of ophthalmologists in
the community but were associated with the number of optometrists per 100 000 residents. It may be easier for patients who are struggling with their eyesight to access eye care services in communities with more optometrists. With increased access, more patients are receiving cataract diagnoses and referrals for surgery.

**Study Strengths and Limitations**

Our large sample of patients with cataracts enabled us to compare the timing and rates of surgery among various communities. Second, because all the enrollees had health insurance, we could identify the variables associated with the timing and rate of surgery beyond the known factor of inadequate access to care. Third, the use of health care professional-submitted billing codes to identify the presence of cataracts and the timing of surgery provides greater accuracy than self-reports by patients.41

Our study has several limitations. First, we could not consider information absent in claims data, including best-corrected visual acuity, degree of symptoms, and the visual needs of each enrollee. These variables all clearly affect the decision to undergo surgery and the timing of surgery; yet, the variation among communities is unknown. Second, our findings may not be generalizable to persons with other insurance types or to noninsured individuals who would surely have lower surgery rates. Third, with claims data alone, we cannot assess the appropriateness of the surgical procedures that were performed. Fourth, some community-level variation in median age and rate of surgery could be due to chance alone. However, because most of the communities studied contributed hundreds of patients or more, this is unlikely to have much of an effect on our results. Finally, the patients’ community of residence was known only for the time of plan enrollment, and we could not account for persons who may have moved from one community to another.

**Conclusions**

In conclusion, considerable geographic variation exists in the timing of initial cataract surgery and in the cataract surgery rates among different US communities. Future studies should explore the underlying causes for this geographic variation and its effect on patient outcomes.

**REFERENCES**


**Geographic Variation in Cataract Surgery Rates Searching for Clues to Improve Public Health**

Scott D. Smith, MD, MPH

Cataract is a public health problem that has a substantial global impact. The effects of visual impairment from cataract can extend to every aspect of an affected individual’s life. The risk of falls and bone fractures,1 the incidence of automobile accidents,2 and the rates of depression and anxiety3 are elevated in those visually impaired by cataract. To avoid these and other negative impacts on the quality of life of the individual and the associated economic impact on the community, significant health care resources are allocated to cataract surgery in the United States each year. The cost of providing these services, of course, has its own economic impact by contributing to the rising cost of health care or the diversion of limited resources away from other areas of importance. For each of these reasons, the reduction in the development of cataracts, the optimization of access to cataract surgery once it occurs, and the avoidance of overutilization of health care resources are related and important priorities.

One avenue that has been used to gain insight into these issues has been the analysis of cataract surgery utilization data. Using data from a nationwide managed-care network, Kauh and colleagues4 evaluated geographic variation in cataract surgery rates and compared their results with that of previous work based on Medicare claims data.5 The analysis also included an investigation of demographic and socioeconomic factors, as well as factors affecting access to care. Making sense of the results of this type of analysis is not an easy task. Are regions with a high rate of cataract surgery afflicted with an increased risk of disease, or are they more effective at providing access to cataract surgery services once cataracts develop? Can regional differences in the mean age of patients who undergo cataract surgery be influenced by differences in ophthalmology or optometry practice patterns leading to effective early intervention, or is there perhaps overutilization of services in some areas? Are there significant geographic, racial, or socioeconomic barriers to access to treatment that may be more prevalent in some regions than in others? Do the surgery rates among enrollees in the managed-care network differ from those of the respective regional populations at large? Of course, the answers to these questions are subject to conditions at the local level; there is no single answer that applies across the board.

Adding to the complexity of interpreting the data is the unavoidable issue of random variability. Day-to-day, year-to-year, and decade-to-decade differences in the occurrence of