January 2015

# A Quantitative Analysis Of The Relationship Between Medicare Payment And Service Volume For Cataract, Glaucoma, And Retina Procedures From 2005 To 2009

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# A Quantitative Analysis of the Relationship between Medicare Payment and Service Volume for Cataract, Glaucoma, and Retina Procedures from 2005 to 2009

A Thesis Submitted to the

Yale University School of Medicine

in Partial Fulfillment of the Requirements for the

Degree of Doctor of Medicine

by

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2015

**ABSTRACT**

A QUANTITATIVE ANALYSIS OF THE RELATIONSHIP BETWEEN MEDICARE PAYMENT AND SERVICE VOLUME FOR CATARACT, GLAUCOMA, AND RETINA PROCEDURES FROM 2005 TO 2009. Dan A. Gong, Jun Lin, and James C. Tsai. Department of Ophthalmology and Visual Science, Yale University School of Medicine, New Haven, CT.

The purpose of this study was to evaluate the extent to which changes in the Medicare Physician Fee Schedule influence the volume and intensity of ophthalmic services for cataract, glaucoma, and retina procedures.

We conducted a retrospective, longitudinal analysis using a fixed-effects regression model of Medicare Part B carriers representing all fifty states and the District of Columbia from 2005 to 2009 to calculate Medicare payment-volume elasticities, defined as the percent change in Medicare service volume per 1% change in Medicare payment, for twelve procedures: non-complex and complex cataract surgery (CPT 66984 and CPT 66982), laser trabeculoplasty (CPT 65855), trabeculectomy without and with previous surgery (CPT 66170 and CPT 66172), aqueous shunt to reservoir (CPT 66180), laser iridotomy (CPT 66761), scleral reinforcement with graft (CPT 67255), intravitreal injection (CPT 67028), laser treatment for retinal edema (CPT 67210), laser treatment for proliferative retinopathy (CPT 67228), and optical coherence tomography (OCT) imaging (CPT 92135).

For cataract surgery, we found a significant negative Medicare payment-service volume elasticity. For every 1% decrease in non-complex cataract surgery payment, non-complex cataract service volume increased 0.27% (95% CI [-0.47, -0.06], $p$=0.01). For

every 1% decrease in complex cataract surgery payment, complex cataract service volume increased 1.34% (95% CI [-1.54, -1.14], $p<0.001$). For glaucoma procedures, the payment-volume elasticity was non-significant for four of six procedures studied: laser trabeculoplasty (elasticity=-0.27, 95% CI [-1.31, 0.77], $p=0.61$), trabeculectomy without previous surgery (elasticity=-0.42, 95% CI [-0.85, 0.01], $p=0.053$), trabeculectomy with previous surgery (elasticity=-0.28, 95% CI [-0.83, 0.28], $p=0.32$), and aqueous shunt to reservoir (elasticity=-0.47, 95% CI [-3.32, 2.37], $p=0.74$). For laser iridotomy, the payment-volume elasticity was -1.06 (95% CI [-1.39, -0.72], $p<0.001$). For scleral reinforcement with graft, the payment-volume elasticity was -2.92 (95% CI [-5.72, -0.12], $p=0.041$). For all three retinal procedures, the regression coefficients representing the payment-volume elasticity were non-significant: intravitreal injection elasticity was -0.75 (95% CI [-1.62, 0.13], $p=0.09$); laser treatment for retinal edema elasticity was 0.14 (95% CI [-0.38, 0.65], $p=0.59$); and laser treatment for proliferative retinopathy elasticity was 0.05 (95% CI [-0.26, 0.35], $p=0.77$). For every 1% decrease in Medicare payment for OCT imaging, OCT imaging service volume increased 0.84% (95% CI [-1.36, -0.32], $p=0.002$).

Our analysis of twelve ophthalmic procedures from 2005 to 2009 suggest that there may not be a significant association between Medicare payment and service volume for many glaucoma and retina procedures. Among those procedures, including cataract surgery, that have a significant relationship, different elasticities are observed, suggesting that the volume response to changes in Medicare payments is not uniform across all Medicare procedures. Further research should explore the contributions of patient demand and physician supply to this response.

**ACKNOWLEDGMENTS**

I would like to thank Dr. James Tsai for his support and enthusiasm for my thesis project. His mentorship during my research year enabled me to pursue research in an area combining my interests in ophthalmology and healthcare policy. His encouragement, guidance, and wisdom were instrumental in shaping my thesis. I would also like to thank Dr. Jun Lin for meeting with me regularly to discuss my research and for providing helpful insights and comments with respect to the analysis and interpretation of the data.

Financial support for this project was provided in part by an Unrestricted Departmental Grant from Research to Prevent Blindness, Inc., New York, NY, and the Robert R. Young Professorship. Research to Prevent Blindness, Inc., and the Robert R. Young Professorship had no role in the design and conduct of the study; the collection, management, analysis, and interpretation of the data; the preparation, review, or approval of the manuscript; or the decision to submit the manuscript for publication.

No conflicting relationship exists for any author.

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## 1. INTRODUCTION

The national debate on improving the economic outlook of the United States has prompted discussions about effective means to reduce healthcare spending. Currently representing 18% of gross domestic product (GDP), healthcare expenditures are projected to rise to 25% of GDP by 2037.[1] Concerns about healthcare spending at these levels include the unsustainable growth in the national debt and diversion of resources away from other domains.[1] Among public healthcare expenditures, Medicare spending continues to outpace overall economic growth, adding to these concerns.[2] Congress first introduced the modern-day physician fee schedule for rendered Medicare services in the Omnibus Budget Reconciliation Act (OBRA) of 1989, and then later introduced the sustainable growth rate (SGR) formula with the passage of the Balanced Budget Act of 1997. Through the SGR formula, policymakers have sought to contain Medicare spending by adjusting payment rates for over ten thousand practitioner services. Although the SGR's implementation was intended to adjust Medicare payments according to overall economic growth, policymakers and physicians alike have viewed the SGR as a failed measure both to control healthcare spending and to promote healthcare quality.[3,4]

Irrespective of Congress' decision to delay or repeal the SGR in future years, the original enactment of the SGR to address the increasing volume and intensity of physician services raised the following question: to what extent can changes in Medicare payment contain healthcare spending? The answer to this question depends on how physicians (the supply) and patients (the demand) respond to price changes for procedures and services. When the Medicare Fee Schedule (now Medicare Physician Fee Schedule or MPFS) was first implemented under OBRA 1989, both the Health Care

Financing Administration (HCFA, now Centers for Medicare and Medicaid Services or CMS) and the Congressional Budget Office assumed that in response to fee reductions, physicians would recuperate one-half of lost revenue by increasing the volume and complexity of services, which the HCFA termed the "50% behavioral offset."[5] This assumption of a behavioral offset was largely based on empirical work conducted by the Physician Payment Review Commission (PPRC, now the Medicare Payment Advisory Commission or MedPAC).[6,7] Subsequent studies by both the HCFA Office of the Actuary and independent researchers have found the "physician volume-and-intensity response" for Medicare payment reductions to be lower at 30-40%.[8,9] Based on these studies, CMS believes that "there is a statistically significant relationship between Medicare price reductions for physicians' services and partially offsetting increases in the volume and intensity of such services."[10] However, the last major study to examine this relationship used data from 1994 to 1996. Thus, new research using updated data would be useful to study the extent Medicare price changes influence the volume and intensity of services rendered in today's healthcare landscape.

To answer this question within the field of ophthalmology, we analyzed the association between Medicare payment and service volume for cataract, glaucoma, and retina procedures from 2005 to 2009.

## 1.1 Cataracts

The choice to study cataract surgery was made for several reasons. First, it is the most commonly performed surgical procedure among Medicare beneficiaries in the U.S., representing a significant proportion of Medicare expenditure.[11] According to the

National Health Interview Survey, 31.0% of Americans between 65 and 74 years old and 53.4% of Americans older than 75 years old have been diagnosed with cataracts.[12] The estimated total prevalence of cataracts in Americans 65 years of age and older is 15.6 million.[12] Previous research has found that 61.8 cataract surgeries were performed per 1000 person-years among the Medicare fee-for-service population.[11] Fifty percent of cataract surgeries were performed at an ambulatory surgery center, and fifty percent were performed at a hospital-based operating room, with nearly 12,000 different surgeons performing at least one cataract operation during this period.[11] Recent figures from the Beaver Dam Eye Study have also found continually increasing rates of lens extraction over the past two decades.[13] Second, Medicare is the single largest payer for cataract surgery, and an estimated 80% of cataract surgeries are performed on Medicare patients.[14] Because the vast majority of cataract surgeries are paid for within the Medicare system, there is less concern for non-Medicare policies influencing the association between Medicare payment and Medicare cataract service volume compared to other procedures performed in patient populations with greater diversity in both age and insurance providers. And third, the MPFS contains two different Current Procedural Terminology (CPT) codes for cataract surgeries: one for non-complex types (CPT 66984) and one for complex types (CPT 66982) wherein the latter – requiring devices or techniques not used in routine cataract surgery – is compensated a higher dollar amount. The existence of two different procedures for a similar indication allows for the evaluation of any shifts in the mix or intensity of services furnished to Medicare beneficiaries.

## 1.2 Glaucoma

Glaucoma is a leading cause of blindness in the United States. Previous figures have estimated that glaucoma affects 2.2 million Americans.[15] However, recent research has estimated that this number is likely higher, finding that approximately 2.4 million Americans have undiagnosed and untreated glaucoma, which represents over three-quarters of all patients with glaucoma.[16] Glaucoma represents the most common cause of blindness in Hispanic persons, the second most common cause in black persons, and the third most common cause in white persons.[17] Moreover, black persons and Hispanic persons are 4.4 times and 2.5 times to have undiagnosed and untreated glaucoma compared to white persons.[16] As a disease of aging, glaucoma represents a significant portion of annual Medicare expenditures: in 2000, $1.2 billion were spent on glaucoma treatment, second only to cataract-related expenditures among major eye diseases.[18]

## 1.3 Retina

The number of Americans with visual impairment secondary to retinal diseases has increased over time.[12] Age-related macular degeneration (AMD) and diabetic retinopathy (DR) combined are the leading causes of blindness among white and Hispanic persons in the United States.[17] Among adults over the age of eighteen, AMD is estimated to affect 1.1% of the US population and exhibits an age-related increase in prevalence. Among the 65-74 year old population, 2.8% have AMD; among the 75 and older population, 8.7% have AMD. Patients with advanced AMD in at least one eye number 1.75 million. Diabetic retinopathy affects an even greater population of Americans at an estimated 4 million, and 20% of those affected have vision-threatening

DR.[12] As a percentage of US adults with diabetes, 28.5% and 4.4% of patients have diabetic retinopathy and vision-threatening DR, respectively, according to recent estimates.[19] Although Medicare spending for retinal therapy ranks behind cataract surgery and glaucoma treatment, per Medicare beneficiary expenditure for AMD and DR is increasing[18], raising the need to further study retinal procedures.

## 2. STATEMENT OF PURPOSE

The purpose of this study was to provide a timely, five-year, quantitative analysis of Medicare payment and ophthalmic services volume using data for the entire United States. We included the following twelve procedures – two for cataract, six for glaucoma, and four for retina – to study the most commonly performed ophthalmic procedures.

Cataract

CPT 66984 – non-complex cataract surgery

CPT 66982 – complex cataract surgery

Glaucoma

CPT 65855 – laser trabeculoplasty

CPT 66170 – trabeculectomy without previous surgery

CPT 66172 – trabeculectomy with previous surgery

CPT 66180 – aqueous shunt to reservoir

CPT 66761 – laser iridotomy

CPT 67255 – scleral reinforcement with graft

Retina

CPT 67028 – intravitreal injection

CPT 67210 – laser treatment for retinal edema

CPT 67228 – laser treatment for proliferative retinopathy

CPT 92135 – optical coherence tomography (OCT) imaging

For each service, we first described national trends in Medicare payment and service volume from 2005 to 2009. We then examined the change in service volume for each procedure following Medicare payment changes by calculating payment-volume elasticities—defined as the percent change in Medicare service volume per 1% change in Medicare payment.

## 3. METHODS

### 3.1 Data Sources

This study utilized a retrospective, longitudinal analysis of Medicare Part B carriers representing all fifty states and the District of Columbia. Part B carriers are organizations contracted by the Centers for Medicare & Medicaid Services (CMS) that exercise jurisdiction over a defined geographical area, usually a state, to administer Medicare Part B policies. For each carrier, 2005-2009 service volume data for each procedure were obtained through CMS's Part B Carrier Summary Data Files[20], which includes billed services for the physician/surgeon, assistant surgeon, and ambulatory surgery center facility service charge by CPT code for each procedure we analyzed (CPT 66984, CPT 66982, CPT 65855, CPT 66170, CPT 66172, CPT 66180, CPT 66761, CPT 67255, CPT 67028, CPT 67210, CPT 67228, CPT 92135). Payment data from 2005 to 2009 were obtained through the Medicare Physician Fee Schedule, which listed the Facility Price for each procedure.[21] Because MPFS data for eighteen states were listed by sub-divisions within carriers, payment for these states were weighted by population data from the US Census Bureau[22] to determine a single fee schedule amount corresponding to each carrier, thus matching the reported service volume data. All fee schedule amounts were adjusted for inflation according to the Consumer Price Index[23] using 2005 as the base year.

### 3.2 Regression Analysis

We calculated payment-volume elasticities—defined as the percent change in Medicare service volume per 1% change in Medicare payment—for each procedure using

a fixed-effects regression model, a standard technique used by the PPRC and other research groups to assess the volume response to payment changes.[7,9,24] In our model, the Medicare Part B carrier where the procedure was performed served as the independent unit of analysis.

For each carrier, the MPFS formula is adjusted by a Geographic Practice Cost Index (GPCI) to account for regional variations in practice costs, resulting in differences in year-to-year Medicare payment changes across carriers.[25] This across-carrier variation creates a natural experiment to isolate the association between Medicare payment and service volume within a single carrier. We included a dummy variable representing each Medicare Part B carrier in the regression model to account for inter-carrier heterogeneity that was stable over time.[26] Thus, the model controlled for time-invariant regional variations in procedure demand, patient demographics, and physician practices. We included an additional time variable to control for national trends in service volume due to factors that affected the entire country. The regression model also controlled for carrier-level changes in Medicare beneficiary population, number of ophthalmologists, and income per capita[27], in addition to heteroskedasticity to account for non-normally distributed standard errors as determined by the modified Wald test. Mathematically, the carrier and time fixed-effects regression model can be represented as follows:

$$V_{ijk} = \beta_0 + \beta_1 P_{ijk} + \beta_2 A_{jk} + \beta_3 B_{jk} + \beta_4 C_{jk} + \alpha_j - \gamma_k + \varepsilon_{ijk}$$

$V_{ijk}$ = service volume for procedure $i$ in carrier $j$ and year $k$

$P_{ijk}$ = Medicare fee for procedure $i$ in carrier $j$ and year $k$

$A_{jk}$ = number of Medicare beneficiaries in carrier $j$ and year $k$

$B_{jk}$ = number of ophthalmologists in carrier $j$ and year $k$

$C_{jk}$ = income per capita in carrier $j$ and year $k$

$\beta_0$ = fixed-effects parameter representing the $Y$-intercept

$\alpha_j$ = fixed-effects parameter that represents the stable characteristics of each carrier

$\gamma_k$ = correction for national trend in service volume

$\varepsilon_{ijk}$ = error term

$\beta_1$, $\beta_2$, $\beta_3$, and $\beta_4$ are the regression coefficients to be estimated and represent the effect of their respective covariates on service volume. Because each variable was log transformed, $\beta_1$ represents the percent change in service volume per 1% change in Medicare payment, or the payment-volume elasticity.

For cataract surgery procedures, we also sought to describe any procedural shifts between non-complex and complex cataract surgeries. A similar fixed-effects model was used as the aforementioned model except the independent variable $P$ represented the summed MPFS amount for CPT 66982 and 66984 and the dependent variable $V$ represented the proportion of total cataract services billed under the complex procedure code.

All regression analyses were conducted using StataMP 13 (StataCorp LP, College Station, Texas) with two-sided significance testing and statistical significance set at .05.

3.3 Projection Analysis

For calculating Medicare payment-service volume elasticities, data up to 2009 were included in the regression analysis. In 2010, the Medicare Physician Fee Schedule's payment formula changed on June 1: the conversion factor for the remaining year was 2.2% higher than it was for the first five months.[28] Rather than analyzing 2010 data in the regression and potentially calculating inaccurate estimates due to mismatch in the timing of payment and service volume data, this study used data starting in 2010 in a set of projection analyses to determine the accuracy of the Medicare payment-service volume elasticities derived from 2005-2009 figures. Termed the Elasticity-Adjusted Projection Model (EAPM), the following formulas were used to predict non-complex and complex cataract surgical volumes for 2010 and 2011:

$$PV_{2010} = AV_{2009} \times (1 + \beta \times \Delta P_{2009\text{-}2010}) \times (1 + \Delta G_{2009\text{-}2010}) \times (1 + \gamma)$$

$$PV_{2011} = PV_{2010} \times (1 + \beta \times \Delta P_{2010\text{-}2011}) \times (1 + \Delta G_{2010\text{-}2011}) \times (1 + \gamma)$$

$PV_t$ = predicted volume in year $t$

$AV_t$ = actual volume in year $t$

$\beta$ = Medicare payment-service volume elasticity

$\Delta P_{t1\text{-}t2}$ = percent change in Medicare payment (calculated as a weighted average across carriers) from years $t_1$ to $t_2$

$\Delta G_{t1\text{-}t2}$ = percent change in national Medicare beneficiary population from years $t_1$ to $t_2$

$\gamma$ = average yearly trend in national cataract service volume calculated between 2005 and 2009

The predictions from this model were then compared to an Unadjusted Projection Model (UPM) that excluded Medicare payment-service volume elasticity and only factored in Medicare beneficiary population and the average yearly trend in cataract service volume. Both models were benchmarked against actual 2010 and 2011 service volumes for CPT 66982 and 66984 procedures.

### 3.4 Hypothetical Scenario

To understand the magnitude of the Medicare payment-service volume elasticities on an individual physician level, a hypothetical scenario was constructed of an ophthalmologist responding to 5%, 10%, and 20% reductions in the Medicare fee schedule for CPT 66982 and 66984. The scenario assumed that the ophthalmologist performed 100 cataract surgeries prior to the payment decline, and the pre-reduction payment amounts and ratio of non-complex to complex cataract surgeries were based on actual 2011 figures. The elasticity response, describing the change in service volume, was calculated by multiplying the Medicare payment-service volume elasticity with the percent change in Medicare payment (5%, 10%, or 20%).

*Note: I solely performed all of the above data collection and analyses.*

# 4. RESULTS

## 4.1 Cataracts

### 4.1.1 National Trends (Table 1, Figures 1 and 2)

From 2005 to 2008, average Medicare payment across carriers representing all fifty states and the District of Columbia decreased every year for both the lower-paid non-complex and higher-paid complex cataract surgeries, but 2009 saw a small increase in Medicare fees for both types of procedures. During this five-year period, average Medicare payment for non-complex cataract surgery decreased from $671.22 to $573.79 (2005 $), a real value decline of 14.5%. For complex cataract surgery, average payment decreased from $898.92 in 2005 to $806.33 in 2009 (2005 $), a real value decline of 10.3%. Although payment trends for both procedures mirrored each other closely, the pattern of changes in Medicare service volume differed greatly. The volume of services billed for non-complex cataract surgery decreased 5.6% from 3,372,757 services/year in 2005 to 3,185,130 services/year in 2009; in contrast, the volume of services billed for complex cataract surgery increased 105.1% from 112,331 services/year in 2005 to 230,429 services/year in 2009. In aggregate, the total volume of non-complex and complex cataract services decreased from 3,485,088 services/year in 2005 to 3,415,559 services/year in 2009, a 2.0% decline. Due to the increase in the volume of complex relative to non-complex cataract services, the proportion of total cataract services billed under the complex procedure more than doubled from 3.2% in 2005 to 6.7% in 2009 with an increase of 0.7-1.0 percentage points each year.

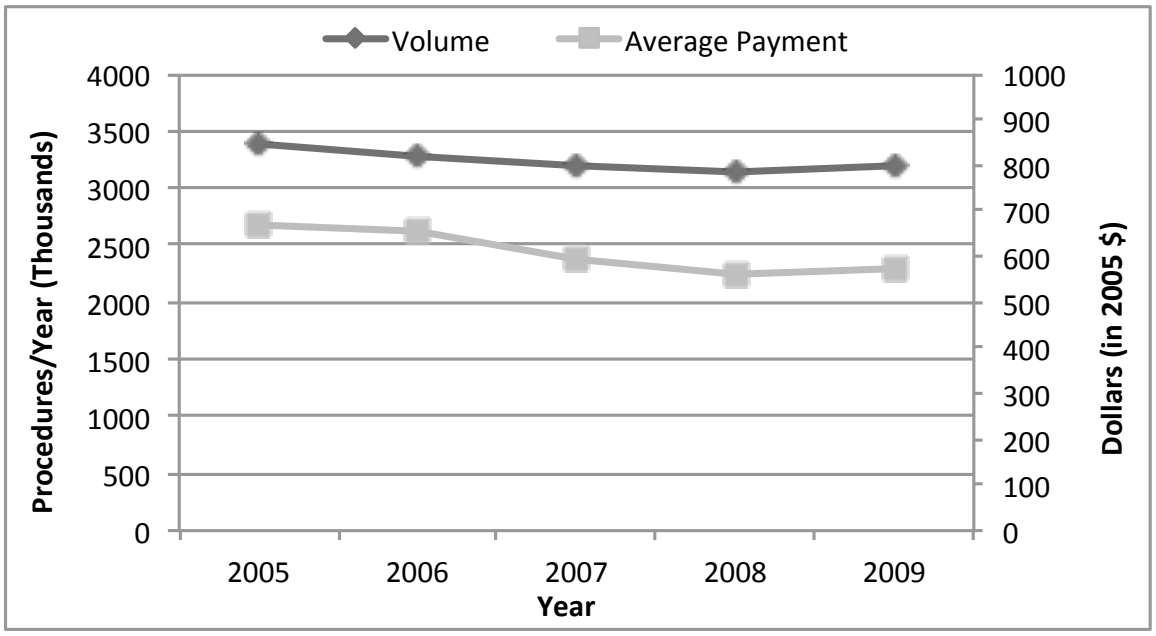
*Table 1. Trends in Medicare Payment and Cataract Service Volume, 2005-2009.*

| **Table 1. Trends in Medicare Payment and Cataract Service Volume, 2005-2009** | | | | | | |
|---|---|---|---|---|---|---|
| Procedure | | 2005 | 2006 | 2007 | 2008 | 2009 |
| Non-Complex Cataract Surgery (CPT 66984) | Service volume (services/year) | 3,372,757 | 3,273,864 | 3,204,754 | 3,132,367 | 3,185,130 |
| | Average payment (in 2005 $) | $671.22 | $656.68 | $597.27 | $561.19 | $573.79 |
| Complex Cataract Surgery (CPT 66982) | Service volume (services/year) | 112,331 | 143,108 | 170,424 | 200,453 | 230,429 |
| | Average payment (in 2005 $) | $898.92 | $882.95 | $843.81 | $794.71 | $806.33 |

*Figure 1. Medicare Payment and Service Volume for Non-Complex (CPT 66984) and Complex (CPT 66982) Cataract Surgeries.*

For each year, service volume equaled the total number of allowed services, including surgeon, assistant surgeon, and ambulatory surgery center facility service charges, for cataract surgeries performed in Medicare carriers representing all fifty states and the District of Columbia. Average payment equaled the weighted average of procedure payments determined by the Medicare Physician Fee Schedule across those carriers and is adjusted for inflation using 2005 as the base year.

A) Non-Complex Cataract Surgery



B) Complex Cataract Surgery

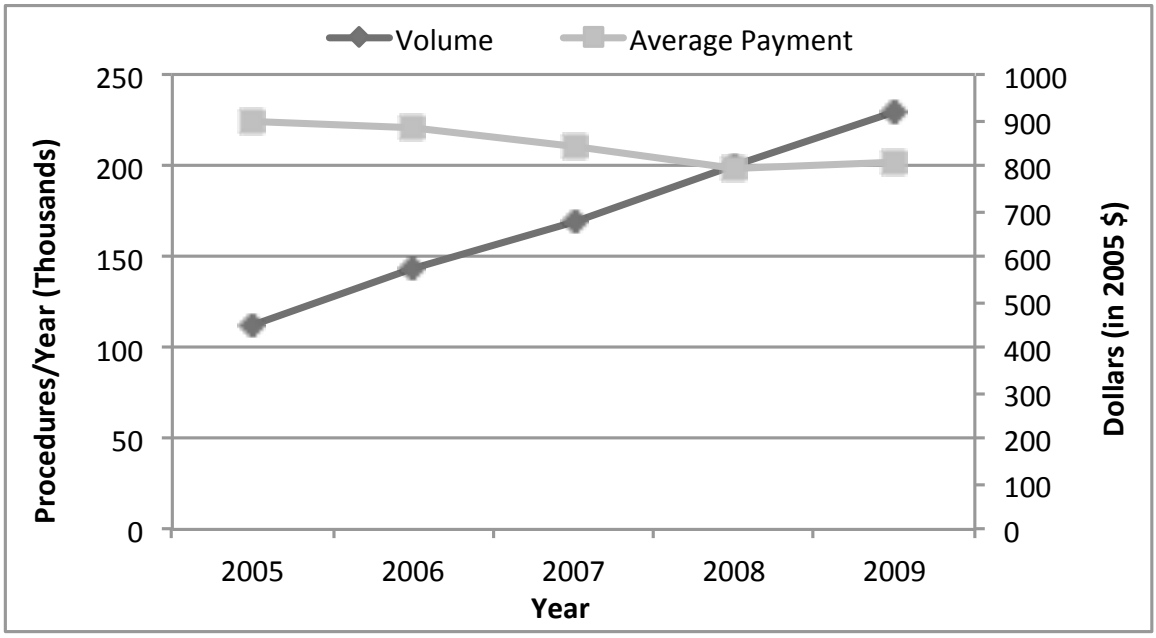
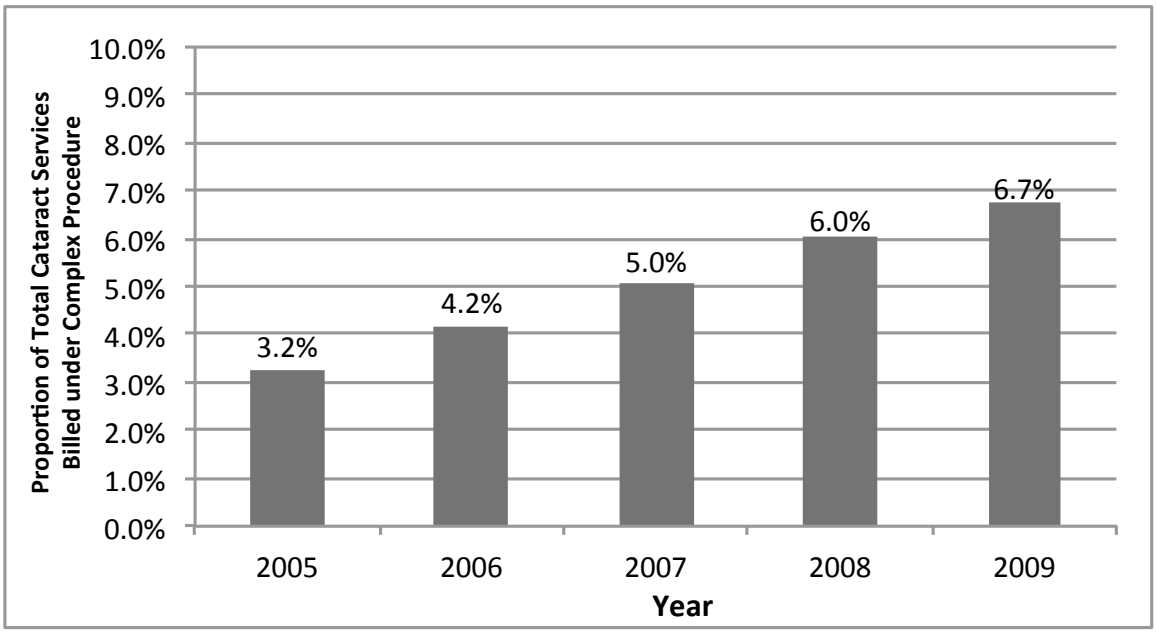


*Figure 2. Proportion of Total Cataract Services Billed under the Complex Procedure Code.*

Proportion of Total Cataract Services Billed under Complex Procedure is defined as (number of CPT 66982 services)/(number of CPT 66982 services + number of CPT 66984 services).



4.1.2 Regression Results (Table 2)

Using a fixed-effects regression model controlling for time-invariant carrier-specific characteristics, carrier-level changes in Medicare beneficiary population, number of ophthalmologists, and income per capita, and national trends in cataract service volume, we calculated payment-volume elasticities for non-complex and complex cataract surgeries to describe the association between Medicare payment and cataract service volume. For non-complex cataract surgery, the payment-volume elasticity was -0.27: for every 1% decrease in Medicare payment for CPT 66984, non-complex cataract service volume increased 0.27% (95% CI [-0.47, -0.06], $p$=0.01). For complex cataract surgery, the payment-volume elasticity was -1.34: for every 1% decrease in Medicare payment for CPT 66982, complex cataract service volume increased 1.34% (95% CI [-1.54, -1.14], $p$<0.001). Thus, the response observed for payment changes to complex cataract surgery was approximately three times the response for payment changes to non-complex cataract surgery. When the sum total of CPT 66982 and 66984 payments decreased by 1%, the proportion of total cataract surgeries billed as complex increased by 1.05% (95% CI [-1.37, -0.73], $p$<0.001).

*Table 2. Association between Medicare Payment and Cataract Service Volume, 2005-2009.*

[A] Fixed effects model controlling for carrier-level changes in Medicare beneficiary population, number of ophthalmologists, and income per capita, and for national trends in cataract service volume.

[B] Fixed effects model controlling for carrier-level changes in Medicare beneficiary population, number of ophthalmologists, and income per capita, and for national trends in the proportion of total cataract services billed under complex procedure.

* Significant at 0.05 level ** Significant at 0.01 level *** Significant at 0.001 level

| Procedure | Variable | | % Change in Volume or Proportion [95% CI] | *p*-value |
|---|---|---|---|---|
| Non-Complex Cataract Service Volume (CPT 66984)[A] | CPT 66984 Payment (% Change) | | -0.27 [-0.47, -0.06] | 0.013* |
| | Medicare Beneficiary Population (% Change) | | 1.31 [-0.25, 2.86] | 0.10 |
| | Number of Ophthalmologists (% Change) | | -0.03 [-0.58, 0.53] | 0.92 |
| | Income Per Capita (% Change) | | 0.57 [0.12, 1.02] | 0.014* |
| | Year | | | |
| | | 2006 | -0.11 [-0.17, -0.06] | <0.001*** |
| | | 2007 | -0.18 [-0.26, -0.10] | <0.001*** |
| | | 2008 | -0.28 [-0.39, -0.17] | <0.001*** |
| | | 2009 | -0.26 [-0.37, -0.14] | <0.001*** |
| Complex Cataract Service Volume (CPT 66982)[A] | CPT 66982 Payment (% Change) | | -1.34 [-1.54, -1.14] | <0.001*** |
| | Medicare Beneficiary Population (% Change) | | 1.88 [-0.07, 3.83] | 0.06 |
| | Number of Ophthalmologists (% Change) | | -0.55 [-1.84, 0.74] | 0.40 |
| | Income Per Capita (% Change) | | 0.42 [-0.47, 1.30] | 0.35 |

| | | | | |
|---|---|---|---|---|
| | Year | | | |
| | | 2006 | 0.11 [-0.01, 0.24] | 0.08 |
| | | 2007 | 0.22 [0.05, 0.38] | 0.012* |
| | | 2008 | 0.26 [0.04, 0.48] | 0.02** |
| | | 2009 | 0.42 [0.21, 0.64] | <0.001*** |
| Proportion of Total Cataract Services Billed under Complex Procedure[B] | CPT 66982 + CPT 66984 Payment (% Change) | | -1.05 [-1.37, -0.73] | <0.001*** |
| | Medicare Beneficiary Population (% Change) | | 0.75 [-0.97, 2.47] | 0.39 |
| | Number of Ophthalmologists (% Change) | | -0.47 [-1.49, 0.54] | 0.36 |
| | Income Per Capita (% Change) | | -0.08 [-0.82, 0.66] | 0.83 |
| | Year | | | |
| | | 2006 | 0.21 [0.12, 0.31] | <0.001*** |
| | | 2007 | 0.33 [0.20, 0.46] | <0.001*** |
| | | 2008 | 0.45 [0.28, 0.63] | <0.001*** |
| | | 2009 | 0.59 [0.42, 0.76] | <0.001*** |

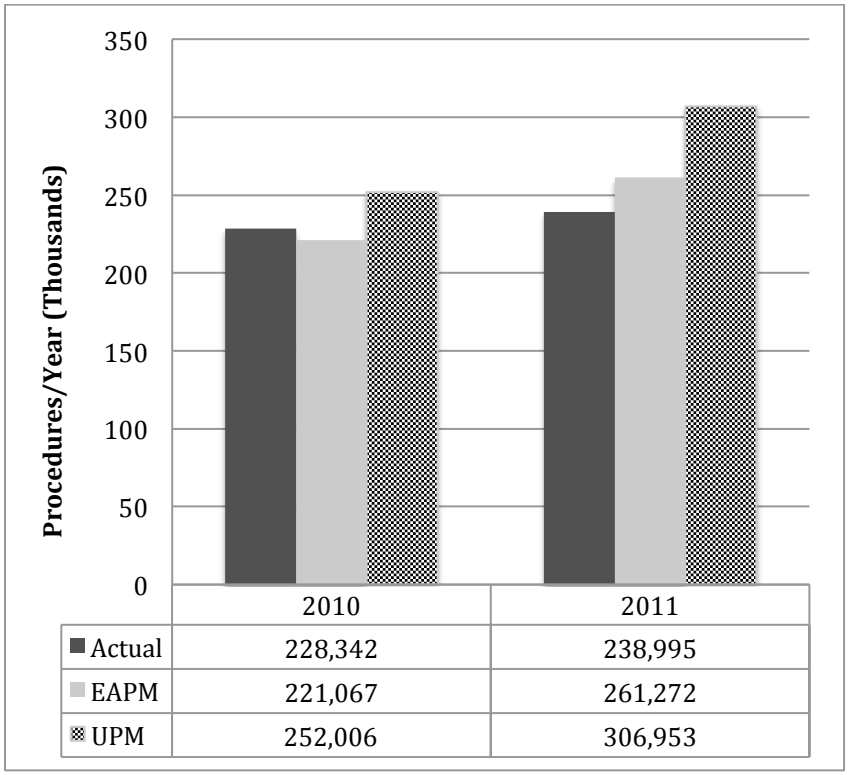
4.1.3 Projection Analysis (Figure 3)

For projecting non-complex and complex cataract surgical volumes, the Elasticity-Adjusted Projection Model factoring in the estimated Medicare payment-service volume elasticity was more accurate than the Unadjusted Projection Model. Compared to the actual non-complex cataract surgical volume in 2010, EAPM's prediction error was 1.3% versus UPM's prediction error of 4.0%; for 2011 non-complex cataract surgical volume, the EAPM's prediction error was 6.1% versus 9.6% for UPM. Similarly, EAPM was more accurate than UPM for predicting 2010 complex cataract surgical volume (prediction error: -3.2% vs. 10.4%, respectively) and 2011 complex cataract surgical volume (prediction error: 9.3% vs. 28.4%, respectively).

*Figure 3. Projection of Cataract Surgical Volume and Proportion of Total Cataract Surgeries Billed as Complex for 2010 and 2011.*

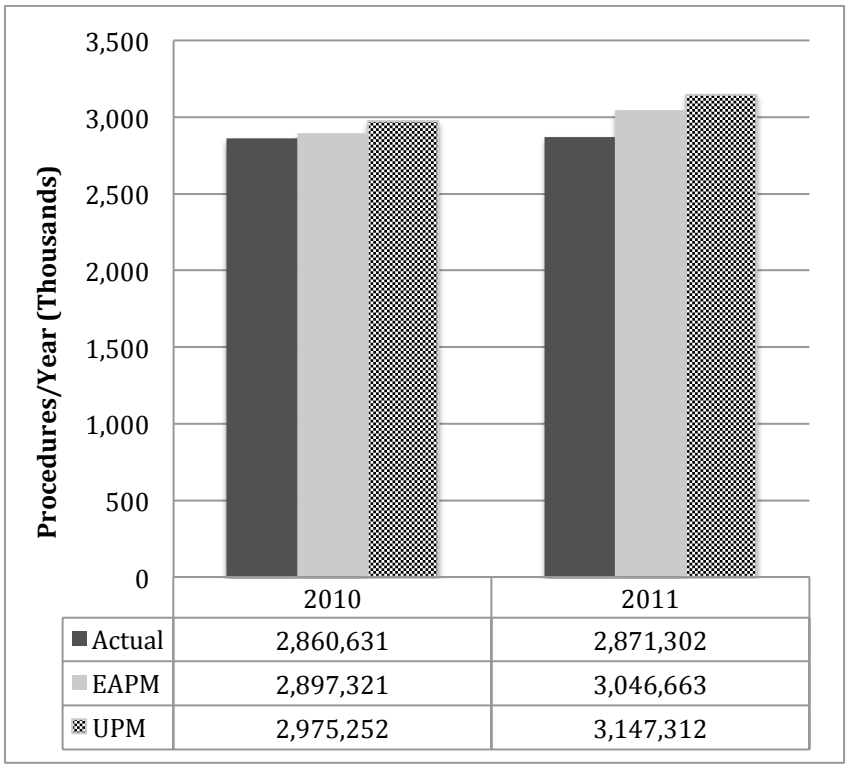
Elasticity-Adjusted Projection Model (EAPM) used the Medicare payment-service volume elasticity and Medicare payment-proportion of complex cataract surgery elasticity, Medicare beneficiary population growth, and average yearly trend in cataract surgical volume and proportion over the 2005 to 2009 time frame to predict surgical volume and proportion in 2010 and 2011. Unadjusted Projection Model (UPM) only used Medicare beneficiary population growth and average yearly trends.

A) Non-Complex Cataract Surgical Volume




| | 2010 | 2011 |
|---|---|---|
| Actual | 228,342 | 238,995 |
| EAPM | 221,067 | 261,272 |
| UPM | 252,006 | 306,953 |

B) Complex Cataract Surgical Volume




| | 2010 | 2011 |
|---|---|---|
| Actual | 2,860,631 | 2,871,302 |
| EAPM | 2,897,321 | 3,046,663 |
| UPM | 2,975,252 | 3,147,312 |

### 4.1.4 Hypothetical Example (Table 3)

In a hypothetical scenario based on 2011 figures, we assumed that an ophthalmologist performed 8.32 CPT 66982 procedures reimbursed at $899.71 and 91.68 CPT 66984 procedures reimbursed at $643.31 prior to a payment decline. The pre-reduction income from performing cataract surgeries was $66,464.10. Without any elasticity response, a 10% decline in payment would reduce that income to $59,817.69, a decline of $6,646.41. However, factoring the elasticity response, the post-reduction income is only reduced to $62,153.63, a decline of $4,310.47. For this ophthalmologist, approximately one-third (35.1%) of the lower income from reduced Medicare payment is recouped by performing more surgeries. Declines of 5% and 20% in Medicare payment yield recoupment of 37.1% and 31.2%, respectively.

*Table 3. Hypothetical Scenario of Elasticity Response to 5%, 10%, and 20% Reduction in Medicare Payment.*

[A] Assume that the pre-reduction surgical volumes for CPT 66982 is 8.32 procedures and for CPT 66984 is 91.68 procedures (total cataract surgeries performed = 100), and the pre-reduction Medicare payments for CPT 66982 is $899.71 and for CPT 66984 is $643.31 (pre-reduction income = $66,464.10). Ratio of complex to non-complex cataract surgeries and payment figures (presented in 2005 $) are based on 2011 data.

| | Pre-Reduction[A] | 5% Reduction | 10% Reduction | 20% Reduction |
|---|---|---|---|---|
| Payment | | | | |
| 66982 | $899.71 | $854.73 | $809.74 | $719.77 |
| 66984 | $643.31 | $611.14 | $578.98 | $514.65 |
| Surgical Volume | | | | |
| 66982 | 8.32 | 8.88 | 9.44 | 10.55 |
| 66984 | 91.68 | 92.92 | 94.16 | 96.63 |
| Income without Elasticity Response | $66,464.10 | $63,140.89 | $59,817.69 | $53,171.28 |
| (% of Pre-Reduction Income) | (100.0%) | (95.0%) | (90.0%) | (80.0%) |
| Income with Elasticity Response | - | $64,373.75 | $62,153.63 | $57,324.06 |
| (% of Pre-Reduction Income) | | (96.9%) | (93.5%) | (86.3%) |
| Change in Income from Elasticity Response | - | +$1,232.86 | +$2,335.94 | +$4,152.78 |
| Change in Income from Performing More 66982 Procedures | - | +$476.46 | +$902.76 | +$1,604.91 |
| Change in Income from Performing More 66984 Procedures | - | +$756.40 | +$1,433.18 | +$2,547.87 |

## 4.2 Glaucoma

### 4.2.1 National Trends (Table 4, Figure 4)

From 2005 to 2009, the three highest paid glaucoma procedures by Medicare were trabeculectomy with previous surgery ($1097.49-$1171.62), trabeculectomy without previous surgery ($873.62-$940.67), and aqueous shunt to reservoir ($858.69-$978.26). For all six glaucoma procedures studied, average Medicare payment across carriers representing all fifty states and the District of Columbia decreased over the five years. Payments for trabeculectomy without and with previous surgery were the most stable with real value declines of only 5.3% and 4.4%, respectively, whereas payments for laser trabeculoplasty and scleral reinforcement with graft declined the most at 18.0% and 12.0%, respectively.

During the time frame studied, the two most highly performed glaucoma procedures were laser trabeculoplasty (889,641 billed services) and laser iridotomy (457,414 billed services), followed by trabeculectomy without previous surgery (165,535 billed services), aqueous shunt to reservoir (73,231 billed services), trabeculectomy with previous surgery (69,682 billed services), and scleral reinforcement with graft (47,916 billed services). The volume of billed services for two of the six procedures, trabeculectomy without and with previous surgery, decreased from 2005 to 2009. The two procedures with the greatest increase in Medicare service volume were aqueous shunt to reservoir and scleral reinforcement with graft, which saw increases of 36.5% and 61.9%, respectively.

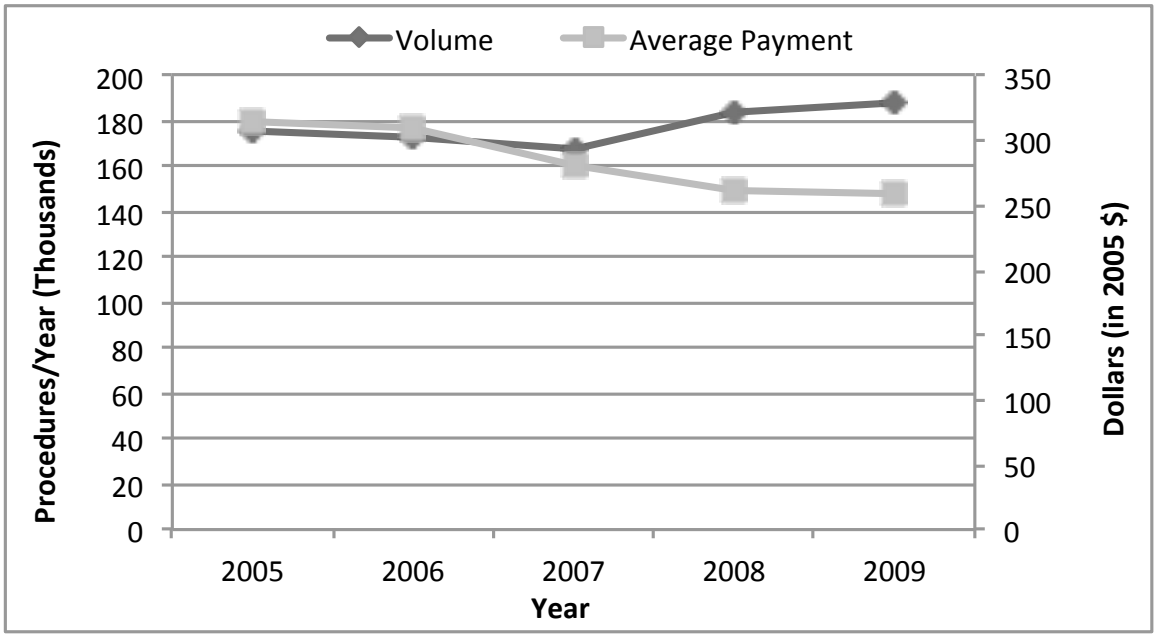
*Table 4. Trends in Medicare Payment and Glaucoma Service Volume, 2005-2009.*

| Table 4. Trends in Medicare Payment and Glaucoma Service Volume, 2005-2009 | | | | | | |
|---|---|---|---|---|---|---|
| Procedure | | 2005 | 2006 | 2007 | 2008 | 2009 |
| Laser trabeculoplasty (CPT 65855) | Service volume (services/year) | 175,910 | 173,459 | 167,866 | 184,216 | 188,190 |
| | Average payment (in 2005 $) | $315.41 | $310.55 | $281.23 | $260.99 | $258.67 |
| Trabeculectomy without previous surgery (CPT 66170) | Service volume (services/year) | 39,051 | 36,402 | 32,147 | 30,231 | 27,704 |
| | Average payment (in 2005 $) | $940.67 | $926.54 | $925.17 | $873.62 | $891.04 |
| Trabeculectomy with previous surgery (CPT 66172) | Service volume (services/year) | 15,808 | 15,565 | 13,316 | 12,921 | 12,072 |
| | Average payment (in 2005 $) | $1,171.62 | $1,148.32 | $1,159.93 | $1,097.47 | $1,119.51 |
| Aqueous shunt to reservoir (CPT 66180) | Service volume (services/year) | 11,674 | 13,160 | 16,014 | 16,451 | 15,932 |
| | Average payment (in 2005 $) | $978.26 | $955.42 | $916.04 | $858.69 | $881.26 |
| Laser iridotomy (CPT 66761) | Service volume (services/year) | 83,429 | 83,671 | 83,739 | 103,113 | 103,462 |
| | Average payment (in 2005 $) | $371.15 | $367.40 | $361.36 | $340.35 | $339.63 |
| Scleral reinforcement with graft (CPT 67255) | Service volume (services/year) | 7,472 | 8,639 | 9,574 | 10,135 | 12,096 |
| | Average payment (in 2005 $) | $717.75 | $704.73 | $673.93 | $626.91 | $631.51 |

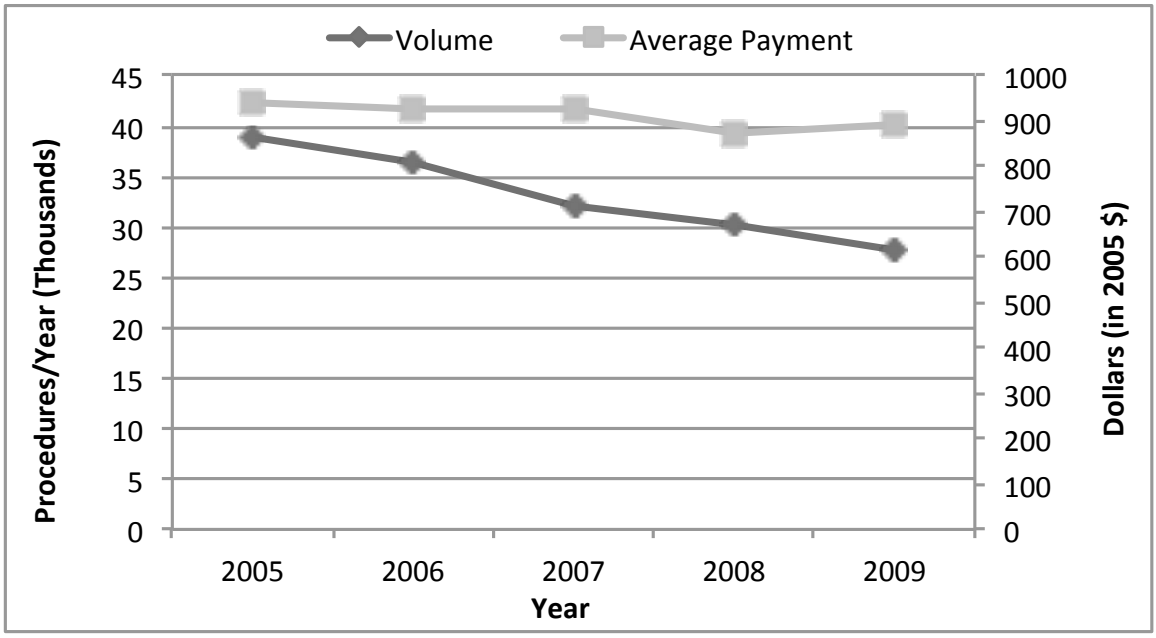
*Figure 4. Medicare Payment and Service Volume for Glaucoma Procedures.*

For each year, service volume equaled the total number of allowed services, including surgeon, assistant surgeon, and ambulatory surgery center facility service charges, for cataract surgeries performed in Medicare carriers representing all fifty states and the District of Columbia. Average payment equaled the weighted average of procedure payments determined by the Medicare Physician Fee Schedule across those carriers and is adjusted for inflation using 2005 as the base year.

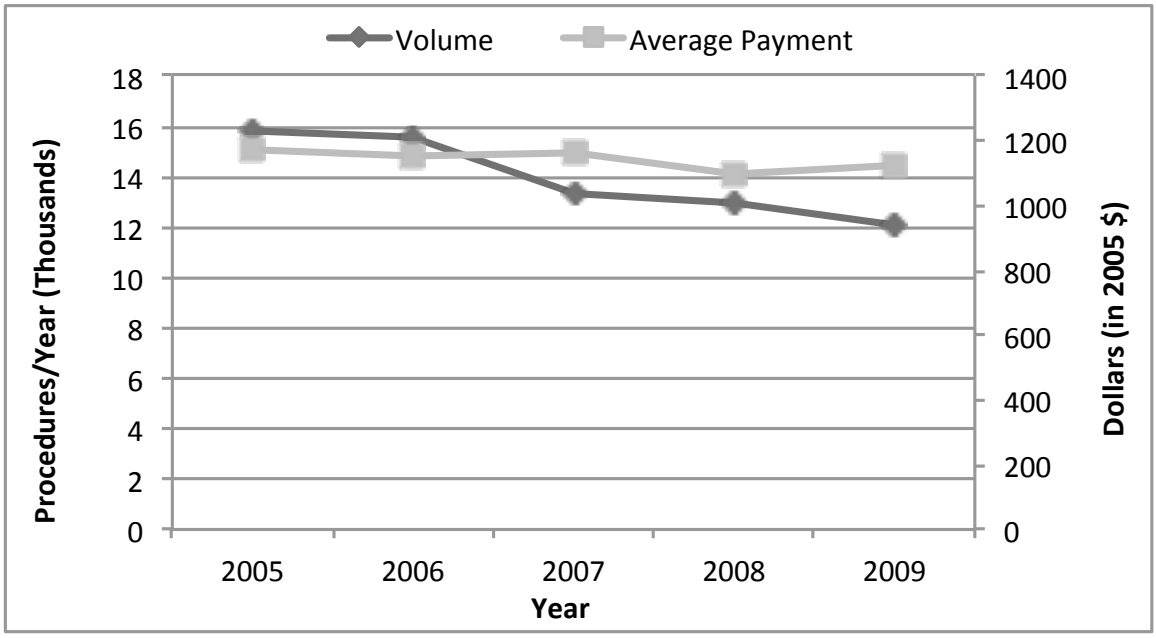
A) Laser trabeculoplasty



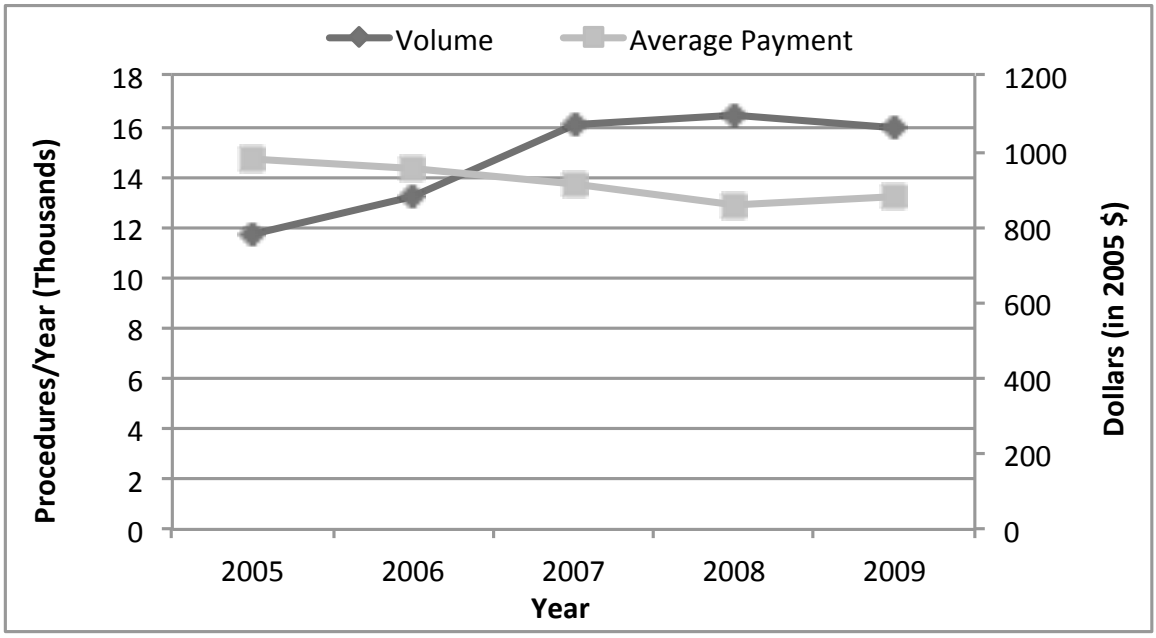
B) Trabeculectomy without previous surgery



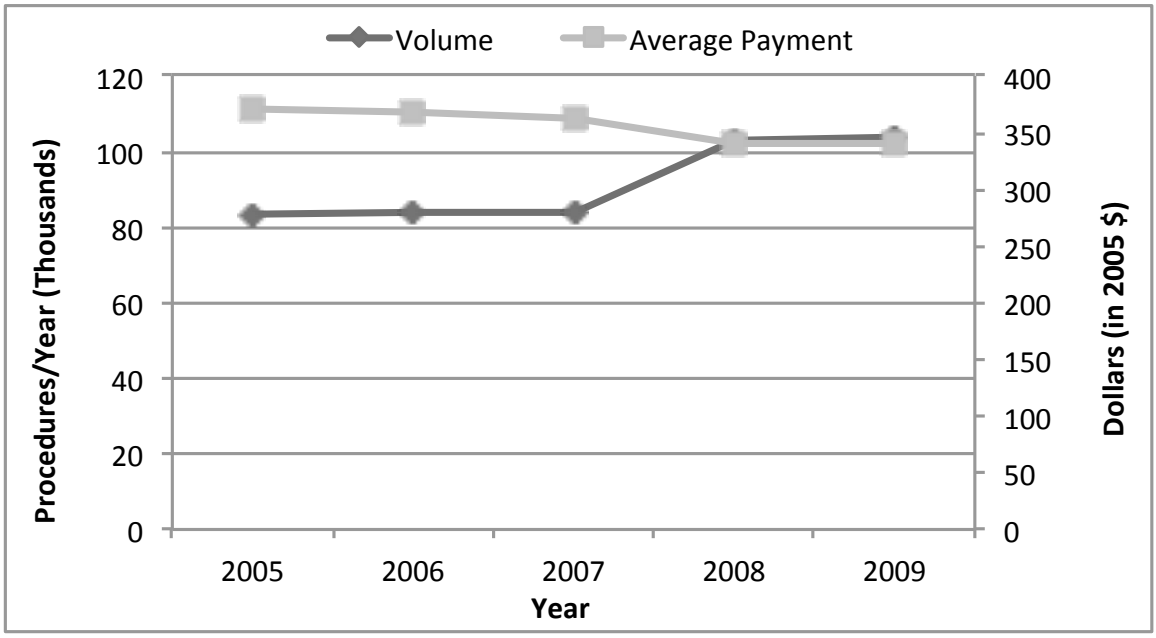

C) Trabeculectomy with previous surgery



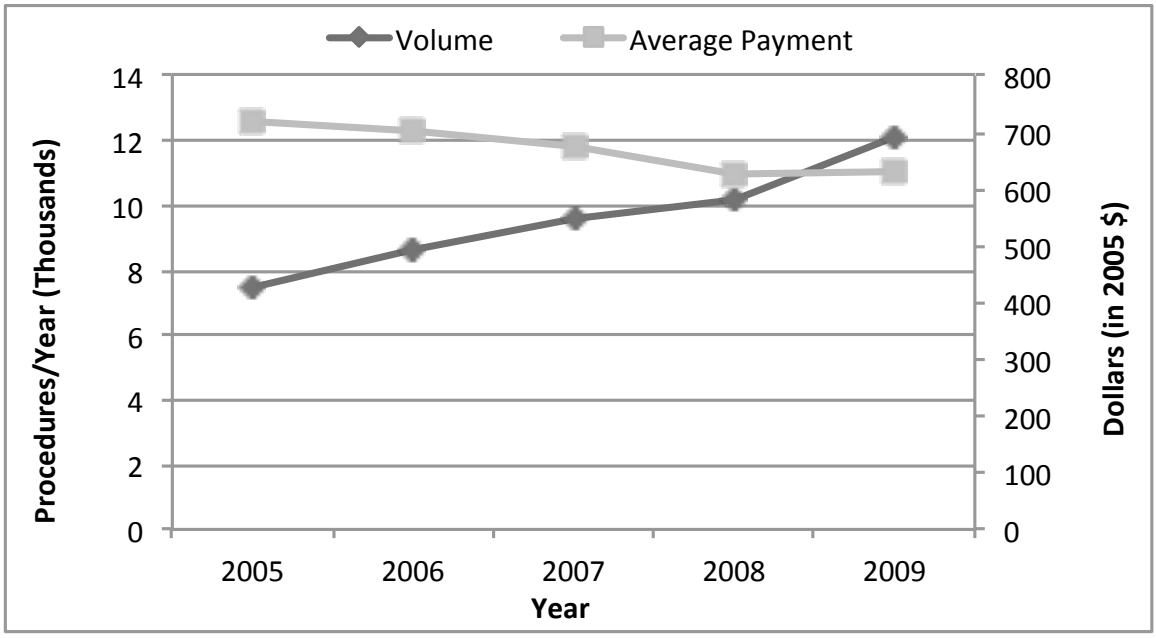
D) Aqueous shunt to reservoir




E) Laser iridotomy



F) Scleral reinforcement with graft



4.2.2 Regression Results (Table 5)

Using a fixed-effects regression model controlling for time-invariant carrier-specific characteristics, carrier-level changes in Medicare beneficiary population, number of ophthalmologists, income per capita, and national trends in glaucoma services volume, we calculated the payment-volume elasticity for each procedure to describe the association between Medicare payment and glaucoma services volume. For four of the six glaucoma procedures studied – laser trabeculoplasty, trabeculectomy without previous surgery, trabeculectomy with previous surgery, and aqueous shunt to reservoir – the regression coefficients were non-significant at the 0.05 level. Thus, there is a lack of evidence to suggest an association between changes in Medicare payment and changes in service volume for these four procedures. The regression coefficients were significant for two procedures: laser iridotomy and scleral reinforcement with graft. For laser iridotomy, the payment-volume elasticity was -1.06 (95% CI [-1.39, -0.72], $p<0.001$): for every 1% decrease in Medicare payment for CPT 66761, laser iridotomy service volume increased 1.06%. For scleral reinforcement with graft, the payment-volume elasticity was -2.92 (95% CI [-5.72, -0.12], $p=0.041$): for every 1% decrease in Medicare payment for CPT 67255, scleral reinforcement with graft service volume increased 2.92%.

*Table 5. Association between Medicare Payment and Glaucoma Service Volume, 2005-2009.*

[A] Fixed effects model controlling for carrier-level changes in Medicare beneficiary population, number of ophthalmologists, and income per capita, and for national trends in glaucoma services volume.

* Significant at 0.05 level ** Significant at 0.01 level *** Significant at 0.001 level

| Procedure | Variable | % Change in Volume [95% CI] | *p*-value |
|---|---|---|---|
| Laser trabeculoplasty (CPT 65855)[A] | CPT 65855 Payment (% Change) | -0.27 [-1.31, 0.77] | 0.61 |
| | Medicare Beneficiary Population (% Change) | 4.07 [-1.36, 9.51] | 0.14 |
| | Number of Ophthalmologists (% Change) | 0.16 [-1.22, 1.54] | 0.82 |
| | Income Per Capita (% Change) | 0.80 [-0.93, 2.52] | 0.36 |
| | Year | | |
| | 2006 | -0.11 [-0.31, 0.08] | 0.25 |
| | 2007 | -0.17 [-0.38, 0.04] | 0.10 |
| | 2008 | -0.25 [-0.56, 0.06] | 0.11 |
| | 2009 | -0.29 [-0.62, 0.04] | 0.087 |
| Trabeculectomy without previous surgery (CPT 66170)[A] | CPT 66170 Payment (% Change) | -0.42 [-0.85, 0.01] | 0.053 |
| | Medicare Beneficiary Population (% Change) | 1.58 [-1.09, 4.26] | 0.24 |
| | Number of Ophthalmologists (% Change) | -0.39 [-1.13, 0.35] | 0.30 |
| | Income Per Capita (% Change) | -0.40 [-1.65, 0.85] | 0.52 |
| | Year | | |
| | 2006 | -0.12 [-0.24, 0.01] | 0.065 |

| | | | | |
|---|---|---|---|---|
| | | 2007 | -0.26 [-0.45, -0.07] | 0.009** |
| | | 2008 | -0.34 [-0.61, -0.07] | 0.013* |
| | | 2009 | -0.50 [-0.81, -0.19] | 0.002** |
| Trabeculectomy with previous surgery (CPT 66172)[A] | CPT 66172 Payment (% Change) | | -0.28 [-0.83, 0.28] | 0.32 |
| | Medicare Beneficiary Population (% Change) | | -0.23 [-3.03, 2.58] | 0.87 |
| | Number of Ophthalmologists (% Change) | | -0.27 [-1.57, 1.03] | 0.68 |
| | Income Per Capita (% Change) | | 0.69 [-0.57, 1.94] | 0.28 |
| | Year | | | |
| | | 2006 | -0.10 [-0.25, 0.05] | 0.18 |
| | | 2007 | -0.25 [-0.47, -0.03] | 0.025* |
| | | 2008 | -0.36 [-0.67, -0.05] | 0.025* |
| | | 2009 | -0.37 [-0.66, -0.08] | 0.012* |
| Aqueous shunt to reservoir (CPT 66180)[A] | CPT 66180 Payment (% Change) | | -0.47 [-3.32, 2.37] | 0.74 |
| | Medicare Beneficiary Population (% Change) | | 0.87 [-1.71, 3.45] | 0.50 |
| | Number of Ophthalmologists (% Change) | | -1.85 [-3.34, -0.36] | 0.016* |
| | Income Per Capita (% Change) | | 1.45 [0.06, 2.83] | 0.041* |
| | Year | | | |
| | | 2006 | -0.11 [-0.33, 0.10] | 0.30 |
| | | 2007 | -0.003 [-0.37, 0.37] | 0.99 |
| | | 2008 | -0.06 [-0.66, 0.55] | 0.85 |
| | | 2009 | -0.03 [-0.56, 0.50] | 0.91 |
| | CPT 66761 Payment (% Change) | | -1.06 [-1.39, -0.72] | <0.001*** |
| | Medicare Beneficiary Population (% Change) | | 2.54 [0.84, 4.25] | 0.004** |
| | Number of Ophthalmologists (% Change) | | 0.23 [-0.73, 1.19] | 0.64 |

| | | | |
|---|---|---|---|
| | Income Per Capita (% Change) | 0.35 [-0.66, 1.36] | 0.49 |
| Laser iridotomy (CPT 66761)[A] | Year | | |
| | 2006 | -0.19 [-0.24, -0.04] | 0.009** |
| | 2007 | -0.16 [-0.32, -0.004] | 0.044* |
| | 2008 | -0.09 [-0.30, 0.11] | 0.38 |
| | 2009 | -0.11 [-0.32, 0.10] | 0.32 |
| | CPT 67255 Payment (% Change) | -2.92 [-5.72, -0.12] | 0.041* |
| | Medicare Beneficiary Population (% Change) | 3.78 [-0.24, 7.80] | 0.065 |
| | Number of Ophthalmologists (% Change) | -1.10 [-2.49, 0.28] | 0.12 |
| | Income Per Capita (% Change) | 1.15 [-0.18, 2.47] | 0.088 |
| Scleral reinforcement with graft (CPT 67255)[A] | Year | | |
| | 2006 | -0.10 [-0.31, 0.11] | 0.37 |
| | 2007 | -0.20 [-0.54, 0.15] | 0.26 |
| | 2008 | -0.48 [-1.07, 0.11] | 0.11 |
| | 2009 | -0.35 [-0.96, 0.26] | 0.26 |

## 4.3 Retina

### 4.3.1 National Trends (Table 6, Figure 5)

When comparing Medicare fees from 2005 to 2009 using the same base year, average payments across Medicare Part B carriers declined for intravitreal injection (-20.7%), laser treatment for retinal edema (-13.0%), laser treatment for proliferative retinopathy (-5.8%), and OCT imaging (-14.2%) during this time period. Among these services, payments for the lower-paid services (intravitreal injection and OCT imaging) declined to a greater extent than the two higher-paid services (laser treatment for retinal edema and laser treatment for proliferative retinopathy). Although payments declined nearly every year for every service, laser treatment for retinal edema did see a real-value increase from 2008 to 2009, and laser treatment for diabetic retinopathy saw an increase from both 2007 to 2008 and 2008 to 2009.

Whereas the payment for all four services trended towards the same direction, the service volume pattern varied from 2005 to 2009. Total service volume declined by 13.5% for laser treatment for retinal edema and by 10.4% for laser treatment for proliferative retinopathy. Intravitreal injection volume more than quadrupled from 251,311 services in 2005 to 1,297,524 services in 2009, and OCT imaging volume more than doubled from 3,694,241 services in 2005 to 7,785,030 services in 2009.

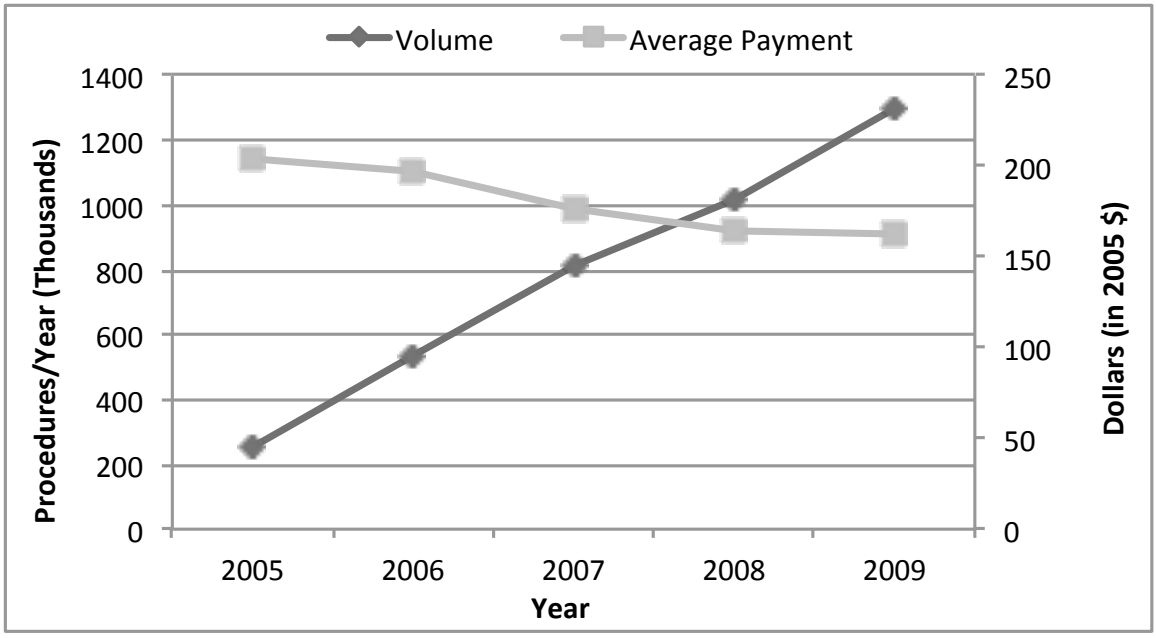
*Table 6. Trends in Medicare Payment and Retina Service Volume, 2005-2009.*

| Table 6. Trends in Medicare Payment and Retina Service Volume, 2005-2009 | | | | | | |
|---|---|---|---|---|---|---|
| Procedure | | 2005 | 2006 | 2007 | 2008 | 2009 |
| Intravitreal injection (CPT 67028) | Service volume (services/year) | 251,311 | 531,652 | 812,505 | 1,019,875 | 1,297,524 |
| | Average payment (in 2005 $) | $204.68 | $197.26 | $176.98 | $165.25 | $162.23 |
| Laser treatment for retinal edema (CPT 67210) | Service volume (services/year) | 163,321 | 147,870 | 139,361 | 139,993 | 141,322 |
| | Average payment (in 2005 $) | $605.92 | $584.84 | $548.01 | $519.79 | $527.10 |
| Laser treatment for proliferative retinopathy (CPT 67228) | Service volume (services/year) | 105,701 | 99,286 | 93,437 | 93,919 | 94,739 |
| | Average payment (in 2005 $) | $962.54 | $920.59 | $863.49 | $881.02 | $907.08 |
| OCT imaging (CPT 92135) | Service volume (services/year) | 3,694,241 | 4,547,713 | 5,665,420 | 6,569,035 | 7,785,030 |
| | Average payment (in 2005 $) | $44.40 | $42.81 | $39.90 | $38.82 | $38.09 |

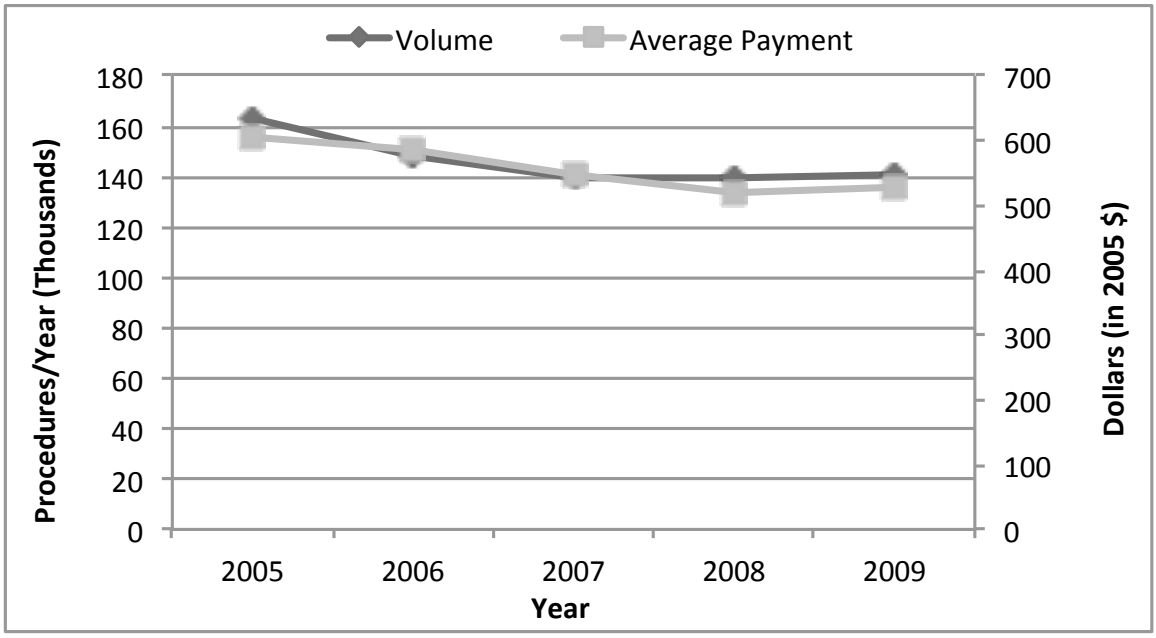
*Figure 5. Medicare Payment and Service Volume for Retina Procedures and OCT Imaging.*

For each year, service volume equaled the total number of allowed services, including surgeon, assistant surgeon, and ambulatory surgery center facility service charges, for cataract surgeries performed in Medicare carriers representing all fifty states and the District of Columbia. Average payment equaled the weighted average of procedure payments determined by the Medicare Physician Fee Schedule across those carriers and is adjusted for inflation using 2005 as the base year.

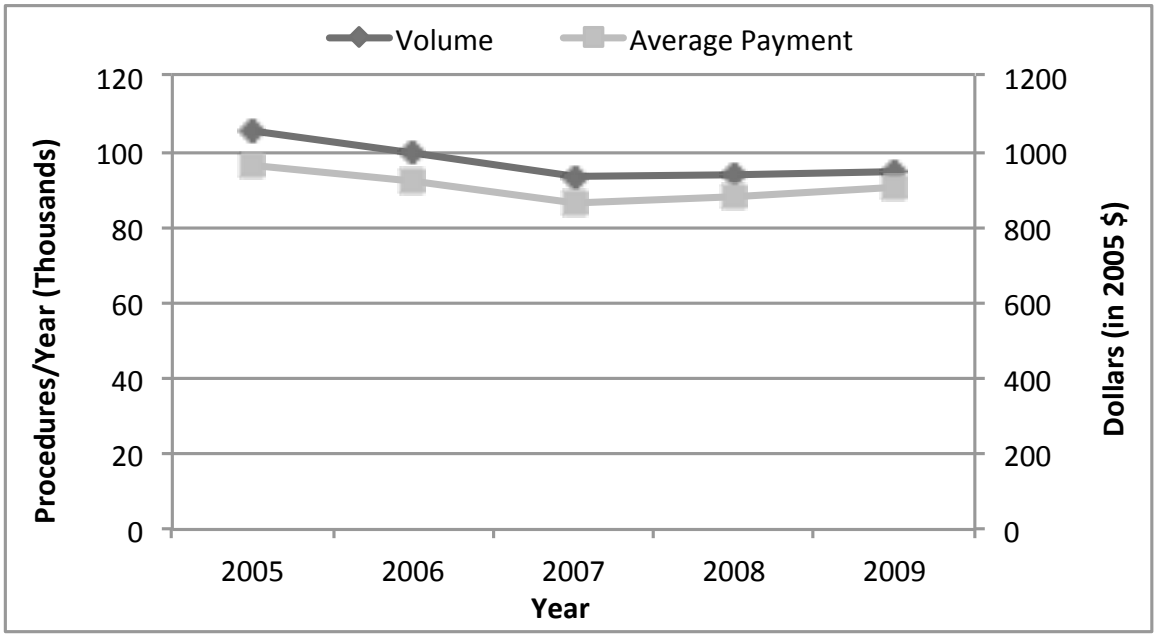
A) Intravitreal injection



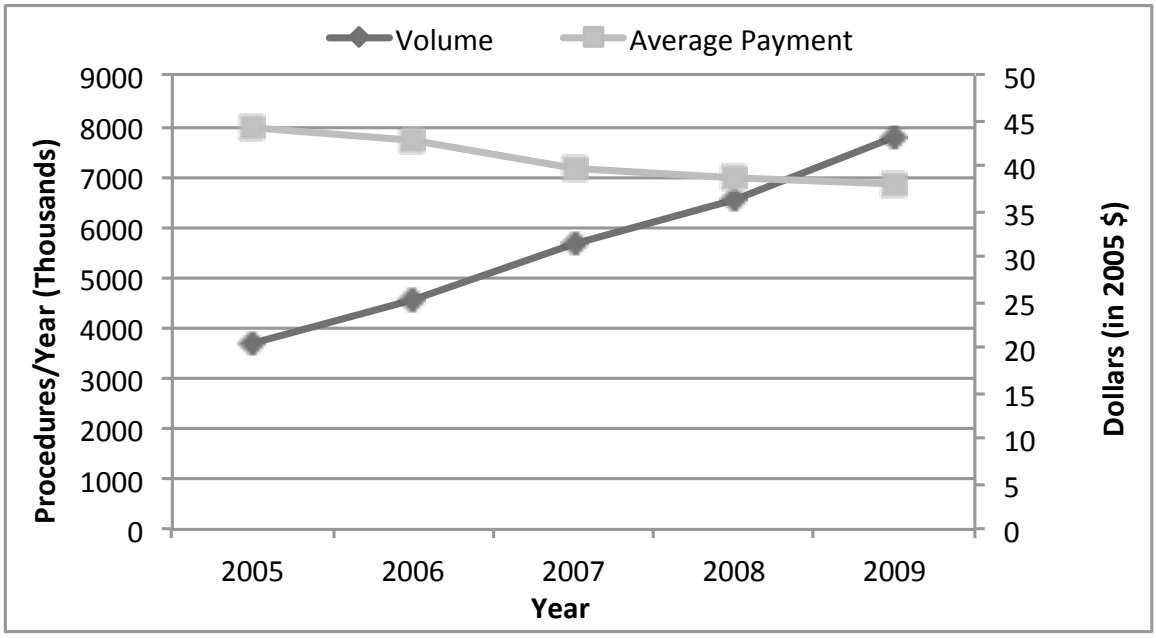
B) Laser treatment for retinal edema




C) Laser treatment for proliferative retinopathy



D) OCT imaging



4.3.2 Regression Results (Table 7)

To calculate accurate payment-volume elasticity for each Medicare service, the fixed-effects regression model controlled for time-invariant carrier-specific characteristics, carrier-level changes in Medicare beneficiary population, number of ophthalmologists, income per capita, and national trends in retinal services volume and OCT imaging volume. For all three retinal procedures, the regression coefficients representing the payment-volume elasticity were non-significant. For intravitreal injection, the elasticity was -0.75 (95% CI [-1.62, 0.13], p=0.09); for laser treatment for retinal edema, the elasticity was 0.14 (95% CI [-0.38, 0.65], p=0.59); and for laser treatment for proliferative retinopathy, the elasticity was 0.05 (95% CI [-0.26, 0.35], p=0.77). For OCT imaging, a significant association between Medicare payment and service volume was found: the calculated elasticity was -0.84 (95% CI [-1.36, -0.32], p=0.002). In other words, for every 1% decrease in Medicare payment for CPT 92135, OCT imaging volume increased 0.84%.

*Table 7. Association between Medicare Payment and Retina Service Volume, 2005-2009.*

[A] Fixed effects model controlling for carrier-level changes in Medicare beneficiary population, number of ophthalmologists, and income per capita, and national trends in service volume.

* Significant at 0.05 level ** Significant at 0.01 level *** Significant at 0.001 level

| Procedure | Variable | | % Change in Volume or Proportion [95% CI] | *p*-value |
|---|---|---|---|---|
| Intravitreal injection (CPT 67028)[A] | CPT 67028 Payment (% Change) | | -0.75 [-1.62, 0.13] | 0.09 |
| | Medicare Beneficiary Population (% Change) | | 1.72 [-0.49, 3.92] | 0.12 |
| | Number of Ophthalmologists (% Change) | | -0.61 [-1.37, 0.14] | 0.11 |
| | Income Per Capita (% Change) | | -0.45 [-1.45, 0.56] | 0.38 |
| | Year | | | |
| | | 2006 | 0.70 [0.59, 0.81] | <0.001*** |
| | | 2007 | 1.06 [0.85, 1.27] | <0.001*** |
| | | 2008 | 1.22 [0.91, 1.54] | <0.001*** |
| | | 2009 | 1.44 [1.10, 1.77] | <0.001*** |
| Laser treatment for retinal edema (CPT 67210)[A] | CPT 67210 Payment (% Change) | | 0.14 [-0.38, 0.65] | 0.59 |
| | Medicare Beneficiary Population (% Change) | | -0.70 [-2.18, 0.78] | 0.35 |
| | Number of Ophthalmologists (% Change) | | 0.45 [-0.23, 1.13] | 0.19 |
| | Income Per Capita (% Change) | | -0.66 [-1.46, 0.13] | 0.10 |
| | Year | | | |
| | | 2006 | -0.06 [-0.14, 0.01] | 0.11 |
| | | 2007 | -0.05 [-0.18, 0.08] | 0.45 |

| | | | |
|---|---|---|---|
| | 2008 | -0.01 [-0.20, 0.18] | 0.90 |
| | 2009 | 0.01 [-0.18, 0.21] | 0.89 |
| Laser treatment for proliferative retinopathy (CPT 67228)[A] | CPT 67228 Payment (% Change) | 0.05 [-0.26, 0.35] | 0.77 |
| | Medicare Beneficiary Population (% Change) | -0.37 [-2.62, 1.88] | 0.74 |
| | Number of Ophthalmologists (% Change) | 0.44 [-0.17, 1.06] | 0.15 |
| | Income Per Capita (% Change) | 0.21 [-0.67, 1.09] | 0.63 |
| | Year | | |
| | 2006 | -0.06 [-0.15, 0.03] | 0.17 |
| | 2007 | -0.12 [-0.26, 0.01] | 0.07 |
| | 2008 | -0.12 [-0.32, 0.08] | 0.25 |
| | 2009 | -0.11 [-0.33, 0.10] | 0.31 |
| OCT imaging (CPT 92135)[A] | CPT 92135 Payment (% Change) | -0.84 [-1.36, -0.32] | 0.002** |
| | Medicare Beneficiary Population (% Change) | 2.89 [0.92, 4.81] | 0.005** |
| | Number of Ophthalmologists (% Change) | -0.46 [1.40, 0.48] | 0.33 |
| | Income Per Capita (% Change) | 0.42 [-0.43, 1.28] | 0.33 |
| | Year | | |
| | 2006 | 0.10 [0.01, 0.19] | 0.03* |
| | 2007 | 0.24 [0.11, 0.37] | 0.001** |
| | 2008 | 0.29 [0.10, 0.48] | 0.003** |
| | 2009 | 0.42 [0.22, 0.62] | <0.001*** |

# 5. DISCUSSION

## 5.1 Cataracts

Our study of two types of cataract procedures found that Medicare service volume for non-complex cataract surgery decreased slightly from 2005 to 2009 whereas the volume for complex cataract services more than doubled during the same time frame. The billing code for non-complex cataract surgery has existed since the implementation of the Medicare Fee Schedule, but the code for complex cataract surgery, CPT 66982, was only introduced in 2001. One of the most common reasons to perform the more complex cataract extraction is when patients are taking alpha-blockers, a class of medications known to increase the complexity of cataract operations.[29] For the newer complex cataract procedure, several factors may explain the observed increase in volume, including 1) improved physician understanding of complex cataract surgery billing codes over time, 2) increased physician awareness of cataract surgery complications in patients taking alpha-blockers, 3) improved history-taking by medical staff to ask about alpha-blocker use in cataract patients, and 4) increased patient awareness to mention alpha-blocker use prior to cataract operations.

The regression analysis we conducted also finds a statistically significant association between Medicare payments and service volume for both types of cataract surgery. Every 1% decrease in Medicare payment for CPT 66984 was associated with a 0.27% increase in non-complex cataract service volume, and every 1% decrease in Medicare payment for CPT 66982 was associated with a 1.34% increase in complex cataract service volume. When payments declined by 1% for both types of cataract surgery, the proportion of total cataract services billed under the complex procedure

increased by 1.05%, suggesting that decreased payment led to an increase in the intensity of services rendered. However, there have been studies conducted on periods of decreasing cataract surgery reimbursement directly before and after the implementation of the Medicare Fee Schedule that found either no association between Medicare payment and surgical volume[30] or a direct correlation between the two.[31] These studies used different regression techniques or examined physician-year data instead of carrier-level data, which may explain the divergent findings. Moreover, our study also differs in that we utilized a 100% sample of Medicare beneficiary data for the entire country without excluding data from any Medicare Part B carrier or physician. In line with previous research by the PPRC, the HCFA, and other researchers using the fixed-effects regression model[7,8,9], we find support for an inverse relationship between Medicare fee changes and the volume and intensity of cataract surgical services rendered.

A set of projection analyses was conducted to test the accuracy of the Medicare payment-service volume elasticities calculated using 2005 to 2009 data. Compared to the Unadjusted Projection Model that excluded the Medicare payment-service volume elasticity, the Elasticity-Adjusted Projection Model was more accurate in predicting the volumes of CPT 66982 and 66984 surgeries in 2010 and 2011. For both years in which Medicare payments actually increased, accounting for the elasticity response helped predict the deceleration in the growth rate of cataract surgical volume compared to previous years in which Medicare payments largely declined. Although a model to accurately predict surgical volume in subsequent years requires knowing more than only the Medicare payment-service volume elasticities, these projection analyses demonstrate that adjusting for elasticity led to more accurate projections.

5.2 Glaucoma

During the 2005 to 2009 time period, Medicare payments for laser trabeculoplasty, trabeculectomy without and with previous surgery, aqueous shunt to reservoir, laser iridotomy, and scleral reinforcement with graft experienced a real-value decline ranging from 4.4% to 18.0%. Over this same period, every procedure except for the two types of trabeculectomies had an increase in Medicare service volume ranging from 7.0% to 61.9%. The decline in the number of trabeculectomies performed has been well documented and is thought to be secondary to the introduction of new drug therapies for lowering intraocular pressure.[32,33] Based on descriptive data alone, it is difficult to determine any relationship between Medicare payment and glaucoma services volume. To date, the most thorough prior study examining this relationship concluded that argon laser therapy and trabeculectomy volume seem unrelated to reimbursement rates using national trend data.[32] However, these figures do not take into account a number of factors that influence nationwide practice patterns for glaucoma management, including greater awareness of new technologies and procedures, better diagnostic tools such as anterior segment imaging, and changes in practice guidelines for the use of laser therapy and surgery versus medical management. In our study, we controlled for these factors by including a time variable to capture the national trend in glaucoma services volume and also accounted for unmeasured carrier-specific characteristics that were stable across time and for carrier-level changes in demographic and provider numbers. With these appropriate controls, we found that only two of the six procedures studied – laser iridotomy and scleral reinforcement with graft – had a significant association between

Medicare payment and service volume. In 2009, these two procedures accounted for less than one third of the total service volume for the six glaucoma procedures included in our analysis.

Previous research has remained mixed about the relationship between the volume of Medicare services rendered and payment depending on which procedure is being studied. And while initial studies conducted by the Physician Payment Review Commission suggested a "50% behavioral offset," subsequent research have found the "physician volume-and-intensity response" for Medicare payment reductions to be lower at 30-40%.[8,9] Although there is a dearth of previous studies examining Medicare payment and volume for glaucoma procedures, one group has studied the relationship between remuneration fees and procedure rates of trabeculoplasties, trabeculectomies, and glaucoma drainage device implantations in Canada from 1992 to 2007.[34] Using a regression model that employed within-province comparisons and controlled for temporal trends in procedure rates, the authors found no influence of physician remuneration fee on procedure rates for these three procedures, consistent with our findings for CPT 65855, CPT 66170, CPT 66172, and CPT 66180.

### 5.3 Retina

Consistent with the general trend for ophthalmic procedures and services, payments for intravitreal injection, laser treatment for retinal edema, laser treatment for proliferative retinopathy, and OCT imaging experienced an overall decrease in real terms from 2005 to 2009. In contrast, the volume of billed services for these retinal procedures and OCT imaging had varying trends over this time period. As previously described,

retinal laser therapy use has seen a modest decline over time whereas the volume of intravitreal injections has increased substantially.[35] For each procedure, total service volume for the entire United States is dependent upon a number of factors that influence nationwide practice patterns. These include the development of new medications and alternative therapies, refinements in pre-existing procedures and surgeries, improvements in diagnostic imaging, and changes in practice guidelines based on clinical research findings. The impact of these factors is most evident when examining the volume of intravitreal injections. The beginning of our study period marked the years in which the U.S. Food and Drug Administration first approved pegaptanib and ranibizumab for treatment of neovascular AMD and the initial studies demonstrating the effectiveness of bevacizumab were published.[36,37,38,39] With the introduction of anti-VEGF agents representing a new frontier in neovascular AMD therapy, it is not surprising to see the 400% growth in intravitreal injections from 2005 to 2009. In addition to improvements in imaging technology, a rise in treatment of AMD patients may partially explain the observed increase in OCT imaging as part of the diagnosis and management of neovascular AMD.

Due to the various factors that influence Medicare service volume over time, it is difficult to conclude any associations between payment and service volume based on national-level correlations alone. An accurate assessment of this relationship requires controlling for both national and local variables that influence service volume independent of the Medicare fee schedule. Our use of a fixed-effects regression model served this exact purpose, similar to its role in analyzing glaucoma procedures. We specifically included a time variable to capture volume trends that affected the entire

country. For example, for intravitreal injections, we expected to see a rise in service volume independent of Medicare payment changes due to the development of new AMD medications. This trend is depicted in the significant positive associations between year and intravitreal injection volume for each year 2006-2009 as noted in Table 7. Using our model, we found that there exists a statistically significant association between Medicare payment and service volume for OCT imaging but not for any of the three retinal procedures studied.

## 5.4 Further Considerations

Because our analysis did not include physician-level data, it was not possible to determine the exact degree of income recoupment seen after payment reductions for ophthalmic procedures. We can only hypothesize in a constructed model, but the calculated payment-volume elasticities cannot be directly compared to the 30-50% "behavioral offset" or "physician response" from prior studies. However, it is clear from our study that different procedures, even within the same subspecialty, can have varying magnitudes of payment-volume elasticities. Therefore, assigning a single number as the volume response to changes in the Medicare fee schedule may oversimplify the relationship between Medicare reimbursement rates and procedural volume. Our findings also suggest that most glaucoma and retina procedures may not have any association between Medicare payment and service volume, raising further flags about grouping all Medicare procedures and services together when discussing how healthcare providers and consumers respond to changes in Medicare payment.

We raise an additional concern about how the relationship between Medicare payment and service volume should be characterized moving forward. Two ways that this relationship has been referred to in the literature are "behavioral offset" and "physician response," suggesting that physicians are engaging in behavior to recoup lost income from declines in Medicare reimbursement by recommending more medical care services to patients. However, without examining patient and physician decision-making more closely, it may be misleading to conclude that only physicians drive shifts in procedural volume. Although a strong income effect can explain why physicians would increase the volume of Medicare services rendered when faced with declining Medicare payment, a downward-sloping demand curve representing patients' preferences can also explain why decreasing Medicare fees would increase patient demand for services. Lower prices for medical care services can induce Medicare beneficiaries to seek more care due to lower out-of-pocket expenses from reduced coinsurance payment. In our research, we elected to use the term "payment-volume elasticity" as a descriptive term to refer to the association between Medicare payment and Medicare service volume.

## 5.5 Limitations and Future Directions

Future streams of research should examine data at physician and patient levels to determine how the supply and demand for procedures influence payment-volume elasticities. For example, for laser iridotomy, increased physician and patient awareness of angle closure glaucoma suspects may be important to study as a factor that impacts both supply and demand. Similar trends in increased patient awareness of cataracts as a surgically reversible cause of decreased vision may increase patient demand for cataract

surgery. An additional variable to consider is the role of increased billing charge capture. This factor may be particularly important for billing of complex cataract surgery, laser iridotomy, and scleral reinforcement with graft. Whether driven by decreasing reimbursement levels or unrelated to Medicare payments, increased capture could explain the increased service volume for these procedures. In addition, because our findings suggest that different procedures for cataract, glaucoma, and retina treatments can have varying payment-volume elasticities, further research on procedures both within ophthalmology and in other fields of medicine is needed to better characterize the variation in the volume response to changes in the Medicare fee schedule across different procedures. As part of this characterization, a central question that remains unexplored is determining which attributes of a procedure result in that procedure having a significant association between payment and service volume. From the provider perspective, one such factor to explore is the relationship between the extent to which a procedure accounts for a practice's total revenue and that procedure's payment-volume elasticity. Procedures accounting for a greater percentage of a provider's income may have more significant associations between payment and service volume. Another factor to consider is how a procedure's elective or non-elective nature may affect the impact of Medicare reimbursements on service volume: for example, consistent with our findings for trabeculectomy, we expect non-elective procedures to have less significant or non-significant associations between Medicare payment and service volume. Identifying the specific factors that make one procedure more elastic than another can help policymakers predict future Medicare spending following changes in the Medicare Physician Fee Schedule.

Our analysis of twelve ophthalmic procedures from 2005 to 2009 suggest that there may not be a significant association between Medicare payment and service volume for many glaucoma and retina procedures. Among those procedures, including cataract surgery, that have a significant relationship, different elasticities are observed, suggesting that the volume response to changes in Medicare payments is not uniform across all Medicare procedures. Approaching the relationship between Medicare payment and service volume with a more nuanced perspective will help policymakers attain a more accurate understanding regarding the impact of changes in the Medicare physician payment system. With forthcoming discussions ranging from a repeal of the SGR formula to the creation of a value-based per-patient payment system,[40,41,42] a better understanding of both patient and physician behavior will lead to more accurate projections about future Medicare spending.

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