Trends in cost of major eye diseases to medicare, 1991 to 2000

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Trends in Cost of Major Eye Diseases to Medicare, 1991 to 2000

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• PURPOSE: **To estimate impacts of physician-diagnosed eye diseases (age-related macular degeneration (AMD), cataract, diabetic retinopathy, and glaucoma) on Medicare payments in the periods 1991 to 1995 and 1996 to 2000.**
• DESIGN: **A retrospective cohort study to estimate program payments per capita and in total for each of the major eye diseases and the four eye diseases in total.**
• METHODS: **Data from the 1994 and 1999 National Long-Term Care Survey (NLTCS) and medical claims to Medicare from 1991 to 2000 were merged with the NLTCS. Medicare payments for eye-related procedures on persons with and without major eye diseases as reported on Medicare claims and self-reported data from NLTCS.**
• RESULTS: **Overall, the burden of major eye diseases was to increase Medicare spending by $4.8 billion (1999 USD) in 1991 to 1995 and by $4.5 billion in 1996 to 2000. The most expensive eye disease was cataract, costing Medicare $3.8 billion in 1991 to 1995 and $3 billion in 1996 to 2000.**
• CONCLUSIONS: **Prevalence of major eye diseases increased over time, but the effect of major eye diseases on Medicare payments decreased, mainly as a result of lower payments for cataract surgery in the later years. (Am J Ophthalmol 2006;142:976–982. © 2006 by Elsevier Inc. All rights reserved.)**

EYE DISEASE DISPROPORTIONATELY AFFECTS THE elderly, who account for more than half of the persons visiting ophthalmologists.[1] The population is aging rapidly, with the number of persons aged 65+ expected to more than double from 2000 levels by 2035.[2] As the population ages, overall spending on health care services is expected to rise as a consequence.[3–6] Increased spending will almost inevitably lead to further pressures to reduce private and public personal health care expenditures. Vision care will be no exception. Accurate information on the costs of eye diseases principally responsible for visual impairment, age-related macular degeneration (AMD), cataract, diabetic retinopathy (DR), and glaucoma, and how such costs are changing over time will be important to the decision-making process.

Previous studies of the cost of eye disease to Medicare have focused on a single disease,[7,8] and some have used Medicare data from secondary sources.[8,9] One study[10] used Medicare data more than 20 years old to evaluate the cost of all ophthalmic surgery. There is more as well as more recent information on the cost of eye care in other countries;[11–23] however, these studies rely on small samples from few clinical settings or estimates of disease prevalence, sometimes combined with a projected or modeled course of illness, to calculate costs, and they typically examine only one disease. Clinical samples from only a handful of hospitals present problems for generalization. Studies of single diseases have excluded costs associated with comorbid eye diseases. Most importantly, none of the above studies documents trends in costs.

This study estimates the costs to Medicare of AMD, cataract, DR, and glaucoma on the basis of a national longitudinal sample of Medicare beneficiaries followed for up to 10 years. It includes costs of common joint diagnoses. Rather than summing procedure costs, we estimated costs by calculating counterfactuals—costs incurred by Medicare beneficiaries who were identical on a number of observable characteristics but were not diagnosed with a major eye disease. In this way, we avoided attribution of costs for procedures that would also have been used in absence of the study diagnoses. The total annual cost of the four eye diseases to Medicare in 1996 to 2000 was $6.7 billion (1999 USD), less than such annual costs for 1991 to 1995, which were $7.4 billion (1999 USD).

METHODS

THE SAMPLE CONSISTED OF MEDICARE BENEFICIARIES PARticipating in the 1994 and/or 1999 National Long-Term Care Survey (NLTCS), a national household survey of the US elderly, and Medicare claims and enrollment data, merged with the NLTCS. This study was conducted with

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intuitional review board approval. The sample frame for the NLTCS is a national random sample of Medicare beneficiaries aged 65+ years. In 1994, the NLTCS sample consisted of 19,171 persons. For respondents in this sample, we used information on all years from 1991 to 1995 for which Medicare payment data were available. The total number of person-year observations for the 1991 to 1995 periods was 80,488. The 1999 NLTCS sample consisted of 19,079 persons which included both respondents interviewed in 1994 who survived to the 1999 survey and were added to the randomly selected sample from which the 1999 NLTCS sample was drawn, as well as about 5,000 sample persons who turned 65 between 1994 and 1999. For the 1996 to 2000 sample, we used information on all years between 1996 and 2000 for which Medicare payment data were available. The total number of person-year observations for the 1996 to 2000 period was 74,477. Payment data are not reported in Medicare claims for beneficiaries enrolled in Medicare risk plans. Persons enrolled in a Medicare risk plan for more than six months in a year were excluded from our analysis. Medicare enrollment files provided data on demographic information, dates of first diagnosis of AMD, cataract, DR, and glaucoma, and Medicare payments made on behalf of sample persons. The NLTCS provided information on nursing home residence status, race, and years of education.

Diagnosis of AMD, cataract, DR, and glaucoma were provider coded and identified from ICD-9-CM diagnosis codes (codes listed in Supplementary Appendix A available at AJO.com). By using Medicare claims files from Part B and outpatient physician visits, we estimated annual Medicare payments related to AMD, cataract, DR, and glaucoma for each person in each year, on the basis of CPT[24–29] or ICD-9[30–32] procedure codes in vision care (see Supplementary Appendices B and C available at AJO.com). All payments were converted to constant 1999 US dollars by multiplying nominal payments with the Consumer Price Index in 1999, and dividing by the Consumer Price Index for the current year.

We imputed values for missing data on years of education and race by using a sequence of regression models.[33] Imputations were obtained by means of imputation and variance estimation software.[34]

We used linear regression to estimate the effects of the four major eye diseases on Medicare payments. We estimated separate regression models (Stata 8.0, StataCorp, College Station, Texas, USA) for the 1991 to 1995 periods and 1996 to 2000 periods. The dependent variable was Medicare payment for a beneficiary per year for vision care related to the four diseases.

For the cost analysis for each disease, we included a set of independent variables; separate variables indicated whether the observation was in the year of first diagnosis, the year after first diagnosis, years 3 and 4 of diagnosis, or year 5+ after diagnosis. The count of number of years after first diagnosis started in the year of first diagnosis (year 1). Once a sample person was diagnosed with an eye disease, the person was assumed to have the disease for the rest of the observational period or for life. We also controlled for the effects of joint diagnoses of the most common types: cataract and glaucoma, and cataract and AMD. Persons with a joint diagnosis had a diagnosis of both conditions at some time in the past, not necessarily at the same date. The date of a joint diagnosis was defined as the time of the first diagnosis for either disease. Medicare claims data did not report information on diagnosis before 1991; thus, patients with a first diagnosis before 1991 could only be identified as having first been diagnosed in 1991. We included an independent identifying variable for persons first diagnosed in 1991 for each disease.

We also controlled for age, gender (male), race (white vs nonwhite), years of education, and the Diagnostic Cost Group (DxCG, Inc, Boston, Massachusetts, USA) score computed from the diagnoses and procedures the beneficiary had in the previous year, except for the eye diseases.[34] The DxCG score is a comprehensive measure of overall health, which is predictive of future health care spending on behalf of an individual. The DxCG score was calculated for each person for every year from 1991 to 2000 and was based on diagnosis and procedure codes recorded on sample persons' Medicare claims in the previous year (DxCG risk adjustment software, analytic guide release 6.0). In addition, we controlled for nursing home residency and the number of months in the current year a person was enrolled in a Medicare risk plan. In our estimation procedure, observations were weighted to reflect the elderly Medicare population in 1994 and 1999, respectively. We estimated robust standard errors that allow for a possible correlation in Medicare payments for the same person in different years.

We used a counterfactual approach to calculate Medicare payments attributable to AMD. A counterfactual approach aims to compare payments on behalf of sample persons, who except for not having a diagnosis of AMD, for example, are identical to AMD patients. These persons could be called "AMD patients without an AMD diagnosis." Once we calculated the costs for an "AMD patient without AMD," we calculate the costs attributable to AMD as the difference in cost for the actual AMD patient and the "AMD patient without AMD". This counterfactual design differs from previous approaches that simply calculate cost for procedures used on behalf of AMD patients without employing a control group of otherwise identical patients. Calculating total costs incurred by AMD patients includes costs patients might have incurred in the absence of the diagnosis, for example for the care of comorbidities not related to AMD or for routine eye exams. Without controlling for the costs AMD patients would have incurred had they not suffered from the disease, previous estimates inadvertently attribute costs to AMD that are more properly attributed to other reasons.

We used the same approach to calculate mean annual payments per Medicare beneficiary attributable to the three

TABLE 1. Characteristics of Medicare Beneficiaries Participating in 1994 and/or 1999 National Long-Term Care Survey

Characteristic	1991 to 1995 Period		1996 to 2000 Period	
	Mean*	SD	Mean*	SD
Medicare payment for vision care† (in 1999 USD)	236.37	1327.6	201.66	963.70
Fraction of claims in year with recorded diagnosis of				
AMD	0.034	0.209	0.045	0.238
Cataract	0.238	0.453	0.262	0.460
Diabetic retinopathy	0.008	0.096	0.013	0.115
Glaucoma	0.069	0.280	0.085	0.304
Cataract and AMD	0.011	0.123	0.013	0.136
Cataract and glaucoma	0.023	0.171	0.026	0.175
Age	73.835	7.674	74.410	8.141
Male gender	0.425	0.484	0.426	0.485
White	0.855	0.318	0.889	0.290
Years of education	11.157	3.656	11.163	3.674
DxCG score	0.719	0.885	0.841	1.063
Nursing home resident	0.045	0.266	0.040	0.240
Months enrolled in risk plan	0.048	0.003	0.102	0.004
Observations	80,488		74,477	

AMD = age-related macular degeneration; DxCG = diagnostic cost group; SD = standard deviation; USD = United States dollars.
*Sample means account for population weights.
†Payment on behalf of procedure and device codes listed in Appendices B and C (available at AJO.com).

other eye diseases, and all four eye diseases combined. We computed the burden of eye diseases separately for 1991 to 1995 and 1996 to 2000. In our calculations, observations were weighted to reflect the elderly Medicare population in 1994 and 1999, respectively. To calculate total program payments attributable to each of the four eye diseases and to all four diseases combined, we multiplied per beneficiary payments by the number of aged Medicare beneficiaries in the year of the NLTCS survey (1994 and 1999).

We used a sample of 200 bootstrap runs to calculate standard errors of mean payments.

RESULTS

MEAN ANNUAL PAYMENT PER MEDICARE BENEFICIARY FOR vision care (in 1999 USD) was $236 during 1991 to 1995 and $202 during 1996 to 2000 (Table 1). The eye diseases examined in this study were quite common. In the 1991 to 1995 period, 3.4% of sample persons had a Medicare claim containing a diagnosis of AMD in the current year, 23.8% with cataract, 0.8% with DR, and 6.9% with glaucoma. A total of 1.1% of sample persons had a diagnosis of both cataract and AMD, and 2.3% had both cataract and glaucoma. In 1996 to 2000, diagnosis rates were higher for all diseases; the share of persons with a diagnosis of eye disease in the current year was 4.5% for AMD, 26.2% for cataract, 1.3% for DR, 8.5% for glaucoma, 2.6% for a joint diagnosis of cataract and glaucoma, and 1.3% for a joint diagnosis of glaucoma and AMD. In 1991 to 1995, the mean age in the sample was 73.8 years; 42.5% of sample beneficiaries were men; 85.5% were white; and 4.5% were nursing home residents. On average, the beneficiaries had 11.1 years of education. In 1996 to 2000, mean age was 74.4 years; 88.9% were white; and nursing home residency decreased to 4.0%.

Although there are some differences in the parameter estimates, patterns in key variables are similar between 1991 to 1995 and 1996 to 2000 (Table 2). A diagnosis of AMD increased Medicare payments (1999 USD) in the year of first diagnosis by $425 in 1991 to 1995 and $579 in 1996 to 2000. The rise in Medicare payments in subsequent years was lower. A diagnosis of cataract increased Medicare payments in the year of diagnosis by $680 in 1991 to 1995 and by $466 in 1996 to 2000. The effect of a cataract diagnosis on Medicare payments were lower in subsequent years, but in years 5+ of the diagnosis, payments were still $194 in 1991 to 1995 and $204 in 1996 to 2000. Among the four eye diseases, those with a diagnosis of DR had the highest spending per diagnosed person. Medicare payments in the year of diagnosis were increased by $1,630 in 1991 to 1995 and $1,176 in 1996 to 2000. The effect on payments in subsequent years decreased to $333 in 1991 to 1995 ($366 in 1996 to 2000) in years 5+ of the diagnosis. A diagnosis of glaucoma increased of Medicare payments by $306 in 1991 to 1995, and $287 in 1996 to 2000 in the year of first diagnosis and by $196 in 1991 to 1995 and $37 in 1996 to 2000 in year 5+ of the diagnosis.

There were important interaction effects of Medicare payments for both glaucoma and AMD with cataract. Payments were increased by $893 in 1991 to 1995 ($1,290 in 1996 to 2000) in the first year of a joint diagnosis of

TABLE 2. Medicare Payments per Beneficiary per Year for Vision Care: Regression Results[†]

Characteristic	Payment Amount (USD) 1991 to 1995	Payment Amount (USD) 1996 to 2000
AMD		
In year of first diagnosis	424.69** (53.77)	578.74** (70.51)
In year 2	5.61 (50.81)	80.18 (61.78)
In years 3 and 4	77.33 (55.84)	100.70 (62.46)
In years 5+	59.13 (91.92)	103.62* (60.61)
Cataract		
In year of first diagnosis	680.20** (27.36)	465.51** (28.51)
In year 2	328.51** (21.27)	201.92** (20.51)
In years 3 and 4	235.43** (19.17)	201.10** (13.17)
In years 5+	194.41** (38.60)	204.19** (13.21)
Diabetic retinopathy		
In year of first diagnosis	1,629.88** (265.80)	1,175.53** (206.34)
In year 2	507.28** (130.82)	472.42** (98.25)
In years 3 and 4	344.23** (132.65)	573.26** (113.33)
In years 5+	333.31 (273.34)	365.52** (111.91)
Glaucoma		
In year of first diagnosis	306.39** (52.85)	286.66** (47.17)
In year 2	130.08** (46.20)	105.81** (46.29)
In years 3 and 4	88.83 (50.98)	136.28** (35.27)
In years 5+	196.08** (86.02)	36.76 (33.98)
Cataract and AMD[+]		
In year of first diagnosis	892.74** (249.42)	1,289.82** (311.28)
In year 2	227.16* (119.44)	587.12* (335.35)
In years 3 and 4	73.65 (70.11)	105.64 (81.97)
In years 5+	5.25 (69.47)	−22.46 (54.12)
Cataract and glaucoma[‡]		
In year of first diagnosis	1132.50** (200.13)	1,293.94** (402.63)
In year 2	454.82** (113.83)	479.84* (229.29)
In years 3 and 4	260.01** (65.81)	137.85* (65.22)
In years 5+	26.15 (60.89)	102.89** (33.27)
Age	2.48** (0.76)	−0.30 (0.53)
Male gender	−20.46* (9.18)	−13.14 (5.44)
White	−20.23 (13.51)	1.12 (9.68)
Years of education	−0.90 (1.36)	1.05 (0.66)
DxCG score	19.89** (6.97)	15.28* (5.08)
Nursing home resident	−114.35** (18.60)	−149.50** (10.84)
Months enrolled in risk plan	−17.46** (5.58)	−14.67** (3.09)
R^2	0.09	0.10
Observations	80,488	74,477

AMD = age-related macular degeneration; DxCG = diagnostic cost group.

*Significant at 5%.

**Significant at 1%.

[†]Regression accounts for population weights. Standard errors account for clustering at the respondent level. Standard deviations of estimation coefficients are in parentheses. Coefficients for binary variables whether first diagnosis of diabetic retinopathy, glaucoma, cataract, and AMD was in 1991 are not shown.

[‡]Year of diagnosis is based on the earlier diagnosis.

cataract and AMD, and by $1,133 in 1991 to 1995 and $1,294 in 1996 to 2000 in the first year of a joint diagnosis of cataract and glaucoma.

After controlling for diagnoses of diseases, such demographic factors as age and gender only had a small effect on Medicare payments, and there was no statistically significant effect for race. Patients with comorbidities, as measured by the DxCG score, received more vision care, whereas nursing home residents received less of such care. Being a resident of a nursing home decreased payments by $114 per year in 1991 to 1995 for all major eye diseases ($150 per year in 1996 to 2000). Mean payments per

TABLE 3. Medicare Payments for Vision Care: Burden of Illness Estimates

Payments Attributable To:*	Payments per Medicare Beneficiary† (in 1999 USD)		Total Program Payments‡ (in Millions of 1999 USD)	
	1991 to 1995	1996 to 2000	1991 to 1995	1996 to 2000
AMD	15.98 (2.47)	21.61 (2.18)	524.12 (81.07)	733.25 (74.21)
Cataract	187.25 (6.21)	140.04 (5.45)	6,141.61 (203.75)	4,751.70 (184.956)
Diabetic retinopathy	11.51 (1.86)	17.38 (1.62)	377.52 (61.17)	589.72 (55.24)
Glaucoma	38.26 (4.18)	36.31 (2.57)	1,254.89 (137.36)	1,232.04 (87.34)
All four diseases	226.65 (7.97)	196.65 (7.47)	7,432.24 (261.44)	6,672.53 (253.734)

AMD = age-related macular degeneration; USD = United States dollars.

*Standard errors are in parentheses.

†Difference between mean predicted payments with actual prevalence of disease and counterfactual mean predicted payments with zero prevalence of disease.

‡Calculated as payments attributable to disease per Medicare beneficiary times the number of aged Medicare beneficiaries in 1994 and 1999, respectively.

Medicare beneficiary for eye disease–related care decreased from $227 in 1991 to 1995 to $197 in 1996 to 2000 (Table 3). Total annual Medicare payments for all four eye diseases were $7.4 billion in 1991 to 1995 and $6.7 billion in 1996 to 2000, with the largest reduction in payments being for cataract; annual Medicare payments attributable to cataract declined from $6.1 billion in 1991 to 1995 to $4.8 billion per year in 1996 to 2000. Annual payments attributable to glaucoma were $1.3 billion in 1991 to 1995 and $1.2 billion in 1996 to 2000. Such payments for AMD and DR were substantially lower than this.

Future Medicare payments for vision care depend on two components: (1) the future mean per-beneficiary payment for vision care, and (2) the number of Medicare beneficiaries. The aged Medicare population is predicted to grow to 38.2 million in 2010 and 43.8 million in 2015.[2] The future trajectory of per-beneficiary Medicare payments for vision care is unknown. However, if the trend of declining per-beneficiary payments were to continue (linearly) into the future, total annual Medicare payments for vision care would decline to $5.0 billion in 2010 and to $4.4 billion in 2015 (in 1999 USD).

DISCUSSION

TOTAL MEDICARE PAYMENTS FOR VISION-RELATED CARE ON behalf of persons with the four major eye diseases amounted to from $6.5 to $7.5 billion (1999 USD) annually during the 1990s, or about 4% of total Medicare payments overall. In spite of the growth of the age 65+ population during the 1990s, a trend which is expected to continue throughout the 21st century, four total Medicare payments in 1999 US dollars actually were lower in the second half than in the first half of the 1990s. This largely reflects reductions in Medicare reimbursement rates for cataract care.[35,36] Institution of the Resource-Based Relative Value Scale (RBRVS) let to a substantial drop in reimbursement rates. Reimbursement for the most commonly coded cataract surgery declined throughout the decade from $1,092 (1999 USD) in 1991 to $536 (1999 USD) by 2000.

By contrast, payment for care of beneficiaries with AMD increased during the period. Photodynamic and anti–vascular endothelial growth factor therapies, the principal treatments for AMD, were introduced after the period our study examines. The increase in costs we documented may reflect higher utilization of general eye care services by beneficiaries with AMD as well as an increase in rates of thermal laser treatment. After the introduction of new technologies and drugs treating AMD, such payments may be expected to increase further.

Medicare payments attributable to DR rose over the 1990s. There are several possible explanations for this trend. Attention to ophthalmologic evaluation and screening of diabetics increased over the study period.[37–39] In addition, introduction in the later 1990s of coding for indocyanine green angiography as a diagnostic[27] and laser photocoagulation as a treatment[28] likely contributed to increasing payments. Payments for glaucoma were stable over time. But importantly, until 2006, Medicare did not cover the cost of prescription drugs, which are particularly important for treatment of glaucoma.

Our study differs from previous research on this topic in four major respects. First, patients were followed for several years in our study. For all four diseases, there were substantial reductions in Medicare payments as time since initial diagnosis increased. For some diseases, in particular AMD, this pattern plausibly reflects limits in effective therapies, whereas for others, such as cataract, lower payments probably reflect the existence of effective therapy. Second, rather than confine the analysis to a single disease, our analysis incorporated all four major eye diseases affecting the elderly population. For the more prevalent diseases, our analysis allowed for cost effects when two diseases coexist. Joint diagnoses resulted in

far greater additional costs. Third, in disease costing, it is common not to have a control group. By contrast, our results controlled for what cost would have been absent the diagnosis for the eye disease. Our estimates reflected the difference in costs between persons with and without the diagnosis after controlling for all other characteristics. Fourth, the sample sizes were both national and larger than those used in previous studies.

Our estimates of costs to Medicare for care of cataract are somewhat higher than the $4 billion (1999 USD) reported in a previous study,[41] even when one accounts for the differences in study years. The difference may be attributable to differences in the methodologies of the two studies. We measured costs to Medicare from the date of first diagnosis. By contrast, the $4 billion estimate in the other study included ophthalmologic services obtained within a time window starting from 90 days before surgery to four years after surgery. Our estimates included a period of watchful waiting as well as the time around surgery and, for some sample persons, a period of time extending several years after surgery.

One previous study, examining costs of primary open-angle and exfoliation glaucomas, a narrower definition than the one used in our study, at 12 hospitals in the United States and Sweden estimated two-year costs at $2,371 and $2,428 in 1994 (1999 USD) in the United States and Sweden, respectively.[15] Studies in other countries found mean annual costs for glaucoma patients of $280 to $423 (Canada, 2001),[14] $594 (The Netherlands, 1996),[21] $447 (France, 1991 to 1994),[15] and $705 (United Kingdom, 1991 to 1994).[15] Examining all patients with diagnoses of glaucoma, as we did, unsurprisingly yields lower average estimates of charges than do studies of hospital populations,[16,21] or including only patients with extensive follow-up.[14] In the case of the results from France and the United Kingdom, the study sites might have tended to include service providers treating more severe glaucomas given the study's focus on examining the cost of new drug therapies. Further, none of these studies used a counterfactual design, raising the possibility that some of the treatment costs included were for procedures unrelated to glaucoma.

A previous study of the costs associated with severe DR resulting in blindness estimated the per person annual cost to Medicare and Medicaid in 1990 at $49,899 (costs are derived from previously published estimates[43]). In addition to focusing on the most expensive cases of the disease, the authors also included drug costs, which were excluded in our study.

We acknowledge several limitations in our study. First, our analysis only included costs of care incurred by Medicare. Most importantly, we did not include prescription drug expense, which, during the observational period, was excluded from Medicare coverage. Second, we did not include such intangible costs as those associated with low vision or blindness. Although such outcomes are fortunately uncommon, they are costly to patients and their families when they do occur. More frequent are losses in functional status attributable to impaired vision in elderly populations.[44] Third, observed changes in disease prevalence and treatment utilization may reflect changes in coding practices. Particular diagnoses or treatments may have become more or less common over the study period as a result of issues unrelated to disease prevalence or severity, such as improved diagnostic testing, increased coding as a result of audit pressures, or the introduction of new billing or claims software. Fourth, technological change is a dynamic process, as is third-party payment policy. The experience of the 1990s may not be repeated in future years. Phasing in of the RBRVS greatly altered Medicare reimbursement for certain treatments. In particular, the cost trends for cataract may not be repeated for technologies developed to treat the other eye diseases, many of which were introduced well after the RBRVS. Finally, our counterfactual design does not ensure that our control group is a perfect match. Our estimation is valid only under the assumption that we could control for all important determinants of payments.[40–42]

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REFERENCES

1. Javitt JC, Chiang YP. Preparing for managed competition: utilization of ambulatory eye care visits to ophthalmologists. Arch Ophthalmol 1993;111:1034–1035.
2. Boards of Trustees; Federal Hospital Insurance and Federal Supplementary Medical Insurance Trust Funds. 2005 Annual Report of the Boards of Trustees, Federal Hospital Insurance and Federal Supplementary Medical Insurance Trust Funds. URL: http://www.cms.hhs.gov/ReportsTrustFunds/downloads/tr2005.pdf. Access Date: August 15, 2006.
3. Seshamani M, Gray A. Health care expenditures and aging: an international comparison. Appl Health Econ Health Policy 2003;2:9–16.
4. Stearns SC, Norton EC. Time to include time to death? The future of health care expenditure predictions. Health Econ 2004;13:315–327.
5. Steinman L, Tesler H, Zweifel P. The impact of aging on future healthcare expenditure. Working paper 0510, Socio-economic Institute, University of Zurich 2005, Forthcoming.
6. Zweifel P, Felder S, Meiers M. Aging of population and health care expenditure: a red herring? Health Econ 1999;8:485–496.
7. Steinberg EP, Bergner M, Sommer A, et al. Variations in cataract management: patient and economic outcomes. Health Serv Res 1990;25:727–731.
8. Javitt JC, Canner JK, Sommer A. Cost-effectiveness of current approaches to the control of retinopathy in type I diabetics. Ophthalmology 1989;96:255–264.

9. Javitt JC, Aiello PL, Chiang Y, Ferris FL, Canner JK, Greenfield S. Preventive eye care in people with diabetes is cost-saving to the federal government. Implications for health-care reform. Diabetes Care 1994;17:909–917.
10. Frenkel M. Analysis of ophthalmic surgical charges for services to Medicare recipients: 1980–1985. Arch Ophthalmol 1989;107:1132–1134.
11. Bernth-Petersen P. Outcome of cataract surgery, IV: socioeconomic aspects. Acta Ophthalmol (Copenh) 1982;60: 461–468.
12. Bonastre J, Le Pen C, Soubrane G, Quentel G. The burden of age-related macular degeneration: results of a cohort study in two French referral centers. Pharmacoeconomics 2003;21: 181–190.
13. Calissendorff BM. Costs of medical and surgical treatment of glaucoma. Acta Ophthalmol Scand 2001;79:286–288.
14. Iskedjian M, Walker J, Civente C, et al. Cost of glaucoma in Canada: analysis based on visual field and physician's assessment. J Glaucoma 2003;12:456–462.
15. Kobelt G, Jönsson L. Modeling cost of treatment with new topical treatments for glaucoma: results from France and the United Kingdom. Int J Technol Assess Health Care 1999; 15:207–219.
16. Kobelt-Nguyen G, Gerdtham UG, Alm A. Costs of treating primary open-angle glaucoma and ocular hypertension: a retrospective, observational two-year chart review of newly diagnosed patients in Sweden and the United States. J Glaucoma 1998;7:95–104.
17. Matz H, Falk M, Gottinger W, Kieselbach G. Cost-benefit analysis of diabetic eye disease. Opthalmologica 1996;210: 348–353.
18. Chou SL, Misajon R, Gallo J, Keeffe JE. Measurement of indirect costs for people with vision impairment. Clin Exp Ophthalmol 2003;31:336–340.
19. Meads C, Hyde C. What is the cost of blindness? Br J Ophthalmol 2003;87:1201–1204.
20. Muralikrishnan R, Venkatesh R, Prajna NV, Frick KD. Economic cost of cataract surgery procedures in an established eye care centre in Southern India. Ophthalmic Epidemiol 2004;11:369–380.
21. Oostenbrink JB, Rutten-van Molken MP, Sluyter-Openoordt TS. Resource use and costs of patients with glaucoma or ocular hypertension: a one-year study based on retrospective chart review in the Netherlands. J Glaucoma 2001;10:184–191.
22. Smith AF. The economic impact of ophthalmic services for persons with diabetes in the Canadian province of Nova Scotia: 1996–1996. Ophthalmic Epidemiol 2001;8:13–25.
23. Wang J, Chew PT. What is the direct cost of treatment of primary angle closure glaucoma? The Singapore model. Clin Exp Opthalmol 2004;32:578–583.
24. American Medical Association. Current procedural terminology, 1991 (CPT 1991). Chicago, Illinois: American Medical Association Press, 1990.
25. American Medical Association. Current procedural terminology, 1995 (CPT 1995). Chicago, Illinois: American Medical Association Press, 1994.
26. American Medical Association. Current procedural terminology, 1996 (CPT 1996). Chicago, Illinois: American Medical Association Press, 1995.
27. American Medical Association. Current procedural terminology, Professional Edition, 1997 (CPT 1997). Chicago, Illinois: American Medical Association Press, 1996.
28. American Medical Association. Current procedural terminology, Professional Edition,1998 (CPT 1998). Chicago, Illinois: American Medical Association Press, 1997.
29. American Medical Association. Current procedural terminology, Professional Edition,1999 (CPT 1999). Chicago, Illinois: American Medical Association Press, 1998.
30. American Medical Association. International classification of diseases, 9th revision, clinical modification, 1983 (ICD-CM 1983). Chicago, Illinois: American Medical Association Press, 1982.
31. American Medical Association. International classification of diseases, 9th revision, clinical modification, 1999 (ICD-CM 1999). Chicago, Illinois: American Medical Association Press, 1998.
32. American Medical Association. International classification of diseases, 9th revision, clinical modification, 1998 (ICD-CM 1998). Chicago, Illinois: American Medical Association Press, 1997.
33. Raghunathan TE, Lepowski JM, Solenberger PW, et al. A multivariate technique for multiply imputing missing values using a sequence of regression models. Surv Methodol 2001; 27:85–95.
34. Raghunathan TE, Solenberger PW, van Hoewyk J. IVEware: imputation and variance estimation software user guide. Ann Arbor, Michigan: University of Michigan, Survey Research Center, Institute for Social Research, 2002.
35. American Medical Association. Medicare RBRVS: The physicians' guide, 1995. Chicago, Illinois: American Medical Association Press, 1994.
36. American Medical Association. Medicare RBRVS: the physicians' guide, 1999. Chicago, Illinois: American Medical Association Press, 1998.
37. Brechner RJ, Cowie CC, Howie LJ, et al. Ophthalmic examination among adults with diagnosed diabetes mellitus. JAMA 1993;270:1714–1718.
38. Martin TL, Zhang D, Selby J. Physician and patient prevention practices in NIDDM in a large urban managed-care organization. Diabetes Care 1995;18:1124–1132.
39. Wylie-Rosett J, Basch C, Walker EA, et al. Ophthalmic referral rates for patients with diabetes in primary-care clinics located in disadvantaged urban communities. J Diabetes Complications 1995;9:49–54.
40. Steinberg EP, Javitt JC, Sharkey PD, et al. The content and cost of cataract surgery. Arch Ophthalmol 1993;111:1041–1049.
41. Chiang YP, Bassi LJ, Javitt JC. Federal budgetary costs of blindness. Milbank Q 1992;70:319–340.
42. Sloan FA, Ostermann J, Brown DS, Lee PP. Effects of changes in self-reported vision on cognitive, affective, and functional status and living arrangements among the elderly. Am J Ophthalmol 2005;140:618–627.
43. Ellis RP, Pope GC, Iezzoni L, et al. Diagnosis-based risk adjustment for Medicare capitation payments. Health Care Financ Rev 1996;17:101–128.
44. Shapiro I, Shapiro MD, Wilcox D. Measuring the value of cataract surgery. In: Cutler DM, Berndt ER, editors. Medical care: output and productivity. Chicago, Illinois: University of Chicago Press, 2001:411–437.

APPENDIX A.

Diagnosis Codes Used to Identify Major Eye Diseases

Disease	ICD-9 Diagnosis Code
Diabetic retinopathy	
Background	362.01
Proliferative	362.02
Unspecified	362.0
Glaucoma	
Suspected	365.0, 365.00, 365.01, 365.04
Primary open angle	365.1, 365.10, 365.11, 365.12, 365.15
Narrow angle	364.73, 365.02, 365.2x, 365.61
Other	365.03, 365.13, 365.14, 365.24, 365.3x, 365.4x, 365.5x, 365.6, 365.60, 365.62, 365.63, 365.64, 365.65, 365.8x, 365.9
Cataract	365.51, 366.x, 379.31, 743.30, 743.31, 743.32, 743.33, 743.34, 743.39, V43.1
Age-related macular degeneration	
Dry	362.51, 362.57
Wet	362.52, 362.53
Unspecified	362.5, 362.50

APPENDIX B.

Procedure Codes Used to Identify Major Eye Diseases

Disease	CPT or ICD-9 Procedure Codes
For all diseases	90000–90650††, 99201–99499*, (where accompanied by provider specialty code 18 or 41, costs obtained from Part B records only)
	92002, 92012, 92019, 92004, 92014, 92018, 92225, 92226, 92235, 92250, 92392
	95.02, 95.03, 95.04, 95.05, 95.06, 16.21, 95.12, 95.11, 95.13, 95.16, 95.31, 95.32, 95.33, 95.36
Diabetic retinopathy	
With any ocular complication	92260, 76511, 76512, 76513, 67208, 67210, 67220***, 67227, 67228
With any form of diabetic retinopathy	92287, 92235, 92240**, 92287
	14.11, 14.19, 14.21–14.27, 14.29, 14.31–14.35, 14.39
Claims only with 362.02 as primary diagnosis	67036, 67038, 67039, 67040, 67108, 67109, 67112
	14.72, 14.74, 14.79, 15.51-14.55, 15.59, 14.9, 14.41, 14.49
Glaucoma	
Any form	65820, 92135**, 92020, 92081–92083, 92100, 92120, 92130, 92140, 65850, 65855, 66150,
	66155, 66160, 66165, 66170, 66172‡, 66180, 66185, 66700*, 66701††, 66702†, 66710‡,
	66720‡, 66721††, 66740*, 66741††
	95.05, 95.21, 95.26, 12.11, 12.14, 12.22, 12.34, 12.35, 12.39, 12.54, 12.55, 12.61–12.65,
	12.69, 12.71–12.73, 12.93
Narrow angle only	65865, 65870, 65880, 66500, 66505, 66600, 66625, 66830, 66761, 66762
Other	92287, 65900, 65930
Cataract	66830, 66840, 66850, 66852, 66920, 66930, 66940, 66983, 66984, 66985, 66986, 76516,
	76519
	13.1, 13.11, 13.19, 13.2, 13.3, 13.4, 13.41–13.43, 13.5, 13.51, 13.59, 13.6, 13.64–13.66,
	13.69, 13.7, 13.70–13.72, 13.8
Age-related macular degeneration	
Any form	92235, 92240, 92283, 92284, 92287, 67208, 67210, 67218
	95.07, 14.21–14.25, 14.27, 14.29, 14.72, 14.74, 14.79
Wet only (362.52, 362.53)	67220**

*Codes first used in 1992.
**Codes first used in 1997.
***Codes first used in 1999.
†Codes dropped between 1992 and 1994.
††Codes dropped in 1993.
‡Codes first used between 1992 and 1994
Codes dropped before 1991 or added and dropped between 1992 and 1994.
Codes included only where associated with provider specialty codes 18 (ophthalmology) or 41 (optometry). Costs for these codes are included only from Medicare Part B.

APPENDIX C.

Device Codes Used to Identify Major Eye Diseases

Disease	HCPCS Device Codes
All diseases (eyeglass lenses and frames, contact lenses, and low vision aids)	V2020, V2025, V2100–V2499, V2610, V2618, V2730, V2755, V2770, V2780, S0500, S0512, S0513, S0514, V2500–V2599, V2600, V2610, V2615
Glaucoma (aqueous shunt)	L8612
Cataract (intraocular lenses)	V2630, V2631, V2632, Q1001, Q1002, Q1003, Q1004, Q1005

Biosketch

Martin Salm, MA, is a PhD candidate in economics at Duke University, Durham, North Carolina. He is a student of Professor Frank Sloan and a research assistant at the Center for Health Policy at Duke University. Dr Salm has recently accepted a research position in economics at the University of Mannheim, Institute for the Economics of Aging (MEA). Dr Salm's research interests include cost of disease studies, health insurance, and health behaviors.

Biosketch

Frank A. Sloan, PhD, is the J. Alexander McMahon Professor of Health Policy and Management and Professor of Economics at Duke University, Durham, North Carolina, since 1993. He is the former Director of the Center for Health Policy, Law, and Management at Duke (CHPLM) that originated in 1998. Dr Sloan was the Director of CHPLM from 1998 to 2004. Professor Sloan did his undergraduate work at Oberlin College, Oberlin, Ohio, and received his PhD in economics from Harvard University. Before joining the faculty at Duke in July 1993, Professor Sloan was a research economist at the Rand Corporation and served on the faculties of the University of Florida and Vanderbilt University. Dr Sloan was Chair of the Department of Economics at Vanderbilt from 1986 to 1989. Dr Sloan current research interests include alcohol use and smoking prevention, long-term care, medical malpractice, and cost-effectiveness analyses of medical technologies. Professor Sloan also has a long-standing interest in hospitals, health care financing, and health manpower. He has served on several national advisory public and private groups. Dr Sloan is a member of the Institute of Medicine of the National Academy of Sciences and was recently a member of the Physician Payment Review Commission.