Trends in Glaucoma Medication Expenditure

Medical Expenditure Panel Survey 2001-2006

Byron L. Lam, MD; D. Diane Zheng, MS; Evelyn P. Davila, PhD, MPH; Kristopher L. Arheart, EdD; Manuel A. Ocasio, BA; Kathryn E. McCollister, PhD; Alberto J. Caban-Martinez, MPH; David J. Lee, PhD

Objective: To study trends of glaucoma medication expenditure from 2001 to 2006 using a nationally representative sample of US adults.

Methods: We analyzed glaucoma medication expenditure trends among participants of the 2001-2006 Medical Expenditure Panel Survey, a subsample of the National Health Interview Survey, which is a continuous multipurpose, multistage area probability survey of the US civilian noninstitutionalized population. After adjusting for survey design and inflation using the 2009 inflation index, data from 1404 participants 18 years and older using glaucoma medication were analyzed.

Results: Mean annual glaucoma medication expenditure per subject increased from $445 in 2001 to $557 in 2006 (slope=20.8; P<.001). Subgroup analysis showed expenditure increased significantly in women (P=.02), those with public-only insurance (P<.001), and those with less than a high school education (P<.008). Over the survey period, a significant decrease in expenditures on β-blockers (P=.048) and significant increases in expenditures on prostaglandin analogs (P=.01) and α-agonists (P=.01) were found.

Conclusions: Factors associated with increasing glaucoma medication expenditure trends include the increasing use of prostaglandin analogs, changes in insurance coverage, and possibly more aggressive glaucoma treatment. The findings are pertinent to the development of cost-effective strategies that optimize treatment and reduce expenditures.

Published online June 13, 2011.

Glaucoma is a leading cause of blindness.1 In 2004, approximately 1.9% of adults were estimated to have primary open-angle glaucoma, which affects an estimated 2.2 million Americans 40 years and older, and the direct annual medical cost related to glaucoma was estimated to be $2.9 billion.2,3 Given the aging population, an estimated 3.4 million Americans are projected to have primary open-angle glaucoma by 2020, with a nearly 50% increase in the number of persons living with glaucoma.2

Treatments of open-angle glaucoma include pharmacologic agents, laser trabeculectomy, and surgery.1 The most common treatment of glaucoma is the use of topical pharmacologic eye drops that decrease aqueous production or increase aqueous outflow. Classes of topical glaucoma medications include prostaglandin analogs, β-blockers, α-agonists, carbonic anhydrase inhibitors, cholinergic agonists, and adrenergic agonists. Adverse effects and multiple daily dosing are major contributors for lack of patient compliance with treatment. Recent research examines not only the efficacy and adverse effects of topical glaucoma medications but also patient compliance and overall patient satisfaction.4,5

Recent research on trends of glaucoma medication expenditure as well as contributory factors of trends is limited. In the past decade, with the increasing use of prostaglandin analogs as well as more aggressive treatment of glaucoma, the overall costs associated with glaucoma medications are likely to have risen. On the other hand, the increased costs of the newer, more expensive medications may have in part been offset by the increasing availability of cheaper generic forms of some drug classes (eg, β-blockers). Moreover, there is a direct correlation between increased expenditure and increased severity of glaucoma, with medication consisting of one-third to one-half of direct costs.6 Greater glaucoma medication expenditure would be ex-
METHODS

Glucoma medication data from participants in the 2001-2006 Medical Expenditure Panel Survey (MEPS) were evaluated. The MEPS is a nationally representative subsample of the National Health Interview Survey, a continuous multipurpose and multistage area probability survey of the US civilian non-institutionalized population living at addressed dwellings. The National Health Interview Survey oversamples black, Hispanic, and, starting in 2006, Asian individuals; in addition, as part of the household selection process, the MEPS oversamples additional important policy-relevant subgroups such as low-income households. Selected MEPS households participate in 5 interviews over a 2.5-year period with a new cohort enrolled annually, being selected from households from the previous year’s National Health Interview Survey. Thus, the longitudinal design of the MEPS consists of an overlapping series of “panels” of annually enrolled households that can be combined to provide both cross-sectional estimates for a given year, as well as provide expenditure estimates over time. The overall MEPS response rate, which also takes into account nonresponse to the National Health Interview Survey from which the MEPS sample was derived, ranged from 66.3% in 2001 to 58.3% in 2006.11 The MEPS participants provided information on prescription medications being used by family members; in addition, participants provided signed releases to obtain data from their pharmacy provider on prescriptions filled during the survey period. Pharmacy response rates ranged from 72.9% to 79.9%.13 Matching algorithms were used to link pharmacy-provided data with those collected in the household.12 Data from MEPS 2007 are available but were not included in this analysis. Starting in 2007, MEPS changed the method for editing pharmacy data. Comparisons of prescription drug

Table 1. Average Glaucoma Medication Expenditure (Adjusted for Inflation to the 2009 Index), MEPS 2001-2006

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>2001 (n=289)</th>
<th>2002 (n=411)</th>
<th>2003 (n=344)</th>
<th>2004 (n=360)</th>
<th>2005 (n=332)</th>
<th>2006 (n=360)</th>
<th>Slope</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>All</td>
<td>445.46 (31.58)</td>
<td>483.29 (32.61)</td>
<td>495.22 (29.15)</td>
<td>512.29 (32.34)</td>
<td>534.19 (36.84)</td>
<td>556.82 (38.46)</td>
<td>20.8</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Sex</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>M</td>
<td>452.86 (49.2)</td>
<td>523.92 (55.2)</td>
<td>485.04 (36.02)</td>
<td>549.01 (53.38)</td>
<td>548.21 (68.18)</td>
<td>452.8 (37.88)</td>
<td>−1.43</td>
<td>.90</td>
</tr>
<tr>
<td>F</td>
<td>440.67 (42.63)</td>
<td>452.64 (33.9)</td>
<td>503.01 (42.62)</td>
<td>482.5 (41.69)</td>
<td>524.37 (42.63)</td>
<td>635.22 (59)</td>
<td>29.4</td>
<td>.02</td>
</tr>
<tr>
<td>Racea</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>White</td>
<td>462.28 (35.49)</td>
<td>498.76 (37.55)</td>
<td>489.29 (33.06)</td>
<td>529.14 (39.55)</td>
<td>520.78 (41.55)</td>
<td>522.93 (41.87)</td>
<td>13.1</td>
<td>.02</td>
</tr>
<tr>
<td>Black</td>
<td>371.71 (55.29)</td>
<td>418.48 (43.32)</td>
<td>529.5 (72.49)</td>
<td>386.22 (44.34)</td>
<td>545.19 (97.44)</td>
<td>651.45 (84.34)</td>
<td>35</td>
<td>.17</td>
</tr>
<tr>
<td>Age group, yb</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>45-64</td>
<td>398.11 (53.11)</td>
<td>422.99 (40.97)</td>
<td>478.69 (42.54)</td>
<td>492.04 (43.11)</td>
<td>582.23 (112.62)</td>
<td>569.36 (72.6)</td>
<td>36.1</td>
<td>.001</td>
</tr>
<tr>
<td>≥65</td>
<td>438.23 (33.96)</td>
<td>512.47 (39.84)</td>
<td>519.03 (38.88)</td>
<td>538.14 (45.17)</td>
<td>521.9 (38.25)</td>
<td>568.01 (45.59)</td>
<td>20</td>
<td>.02</td>
</tr>
<tr>
<td>Insurance type</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Private</td>
<td>477.41 (42.36)</td>
<td>477.31 (39.27)</td>
<td>471.73 (33.31)</td>
<td>503.52 (41.41)</td>
<td>496.11 (45.99)</td>
<td>467.32 (37.28)</td>
<td>0.46</td>
<td>.91</td>
</tr>
<tr>
<td>Public only</td>
<td>381.09 (38.23)</td>
<td>484.72 (50.79)</td>
<td>540 (53.75)</td>
<td>551.49 (52.92)</td>
<td>620.99 (67.01)</td>
<td>765.9 (83.81)</td>
<td>64.6</td>
<td>.001</td>
</tr>
<tr>
<td>Uninsured</td>
<td>301.76 (68.13)</td>
<td>452.97 (39.84)</td>
<td>510.93 (38.88)</td>
<td>538.14 (45.17)</td>
<td>521.9 (38.25)</td>
<td>568.01 (45.59)</td>
<td>20</td>
<td>.02</td>
</tr>
<tr>
<td>Education</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt;High school</td>
<td>443.7 (51.72)</td>
<td>435.5 (44.07)</td>
<td>481.75 (61.67)</td>
<td>515.09 (71.65)</td>
<td>615.96 (69.15)</td>
<td>769.66 (95.41)</td>
<td>55.1</td>
<td>.008</td>
</tr>
<tr>
<td>High school</td>
<td>373.34 (41.68)</td>
<td>589.12 (50.38)</td>
<td>546.01 (44.11)</td>
<td>540.8 (58.79)</td>
<td>474.05 (47.15)</td>
<td>451.81 (42.98)</td>
<td>4.3</td>
<td>.84</td>
</tr>
<tr>
<td>&gt;High school</td>
<td>505.91 (63.3)</td>
<td>436.92 (54.84)</td>
<td>456.27 (44.18)</td>
<td>467.7 (46.61)</td>
<td>543.54 (71.47)</td>
<td>524.71 (30.04)</td>
<td>13.3</td>
<td>.22</td>
</tr>
<tr>
<td>Visual impairment</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>None</td>
<td>403.84 (34.61)</td>
<td>462.14 (35.35)</td>
<td>476.46 (31.74)</td>
<td>505.49 (39.30)</td>
<td>528.37 (39.31)</td>
<td>562.16 (46.49)</td>
<td>29.3</td>
<td>.005</td>
</tr>
<tr>
<td>Any</td>
<td>584.40 (68.68)</td>
<td>564.87 (74.26)</td>
<td>564.52 (60.40)</td>
<td>550.64 (76.26)</td>
<td>571.85 (90.50)</td>
<td>553.62 (64.87)</td>
<td>−4.7</td>
<td>.10</td>
</tr>
</tbody>
</table>

Glaucoma medication data from participants in the 2001-2006 Medical Expenditure Panel Survey (MEPS) were evaluated. The MEPS is a nationally representative subsample of the National Health Interview Survey, a continuous multipurpose and multistage area probability survey of the US civilian non-institutionalized population living at addressed dwellings. The National Health Interview Survey oversamples black, Hispanic, and, starting in 2006, Asian individuals; in addition, as part of the household selection process, the MEPS oversamples additional important policy-relevant subgroups such as low-income households. Selected MEPS households participate in 5 interviews over a 2.5-year period with a new cohort enrolled annually, being selected from households from the previous year’s National Health Interview Survey. Thus, the longitudinal design of the MEPS consists of an overlapping series of “panels” of annually enrolled households that can be combined to provide both cross-sectional estimates for a given year, as well as provide expenditure estimates over time. The overall MEPS response rate, which also takes into account nonresponse to the National Health Interview Survey from which the MEPS sample was derived, ranged from 66.3% in 2001 to 58.3% in 2006. The MEPS participants provided information on prescription medications being used by family members; in addition, participants provided signed releases to obtain data from their pharmacy provider on prescriptions filled during the survey period. Pharmacy response rates ranged from 72.9% to 79.9%. Matching algorithms were used to link pharmacy-provided data with those collected in the household. Data from MEPS 2007 are available but were not included in this analysis. Starting in 2007, MEPS changed the method for editing pharmacy data. Comparisons of prescription drug

Abbreviations: CAI, carbonic anhydrase inhibitor; ellipses, values for cells are suppressed and deemed unstable when the standard error is 30% or more of expenditure; MEPS, Medical Expenditure Panel Survey.

a Data for the “other” race group not shown because of small sample sizes.
b Data for adults 18 to 44 years of age not shown because of small sample sizes.
c Mean annual expenditure per glaucoma medication class for those who are taking the medication within the glaucoma medication class.
Mean inflation-adjusted annual glaucoma medication expenditure for each MEPS participant who was using glaucoma medication are presented in Table 1 for 2001 to 2006. Glaucoma medication expenditure increased from $445 in 2001 to $557 in 2006 (slope = 20.8; P < .001), with the increasing trend driven more by women than men (Table 1 and Figure 1). While increasing glaucoma medication expenditures were observed for both white and black individuals, only the trend for white individuals was significant (P = .02) (Table 1 and Figure 2). Significant trends of increasing glaucoma medication expenditures were found for the middle age group (45-64 years; P = .001) and the older age group (≥ 65 years; P = .02) (Table 1 and Figure 3). A significant trend of increasing expenditure was found for participants with educational attainment of less than high school (slope = 55.1; P = .008) but not for participants with higher education (Table 1).

Glaucoma medication expenditure for participants with public insurance only increased significantly (slope = 64.6; P = .001) but remained stable for participants with private insurance (slope = 0.46; P = .91) (Table 1 and Figure 4). For participants with public insurance only, participants with Medicare only (slope = 64.9; P = .002) and participants with both Medicaid and Medicare (slope = 57.4; P = .01) had significant increases in expenditures (Table 2). Public-only insurance was more common among black individuals (51.6%) and among those 65 years and older (46%). However, private insurance was most common among white individuals (61.2%) and those 18 to 44 years of age (71.6%) (data not shown).

**RESULTS**

Figure 1. Plot of glaucoma medication expenditure overall and by sex, Medical Expenditure Panel Survey 2001-2006.

Figure 2. Plot of glaucoma medication expenditure by race, Medical Expenditure Panel Survey 2001-2006.

Figure 3. Plot of glaucoma medication expenditure for middle and older age groups, Medical Expenditure Panel Survey 2001-2006.
The mean annual expenditures per glaucoma medication class for those who are taking the medication within the glaucoma medication class are included in Table 1. Average expenditure per user increased substantially from $168 in 2001 to $271 in 2006 for prostaglandin analogs but decreased from $167 in 2001 to $69 in 2006 for β-blockers. Most of the participants were taking only 1 class of glaucoma medication each year (range, 61%-68% for 2001-2006). Only 2% to 12% of the participants were taking glaucoma medications from 3 or more medication classes.

Multiple regression analyses were conducted to determine sociodemographic variables associated with the increase in total glaucoma medication expenditure, but no statistically significant results were found except that having public-only insurance was associated with increases in expenditures compared with having private insurance (data not shown).

With respect to self-reported visual impairment status, annual mean glaucoma medication expenditure increased significantly from $404 in 2001 to $562 in 2006 (slope=29.3; \( P = .001 \)) for subjects who were taking glaucoma medication and had no visual impairment. In contrast, glaucoma medication expenditure for subjects with any visual impairment did not change during the study period.

Enrollment in the Medicare Part D prescription drug program started in January 2006. For the 2006 MEPS, the mean glaucoma medication expenditure was significantly higher among participants who enrolled in Medicare Part D (mean [SE], $771.86 [$74.59]) relative to those with private insurance (mean [SE], $439.59 [$23.26]; \( P < .001 \)). The mean glaucoma medication expenditure was also higher among participants with Medicare Part D than those with public insurance but with no Part D coverage (mean [SE], $613.07 [$79.17]), although this difference was not statistically significant (\( P = .12 \)). In addition, the mean glaucoma medication expenditure among those enrolled in Medicare Part D was more than 3 times higher relative to the uninsured (mean [SE], $214.74 [$41.33]; \( P < .001 \)), although this finding should be interpreted with caution given the low sample size for this latter group (\( n = 11 \)).

Given the increase in expenditures among women between 2005 and 2006 (Figure 1), and the observation that more women than men under medication treatment for glaucoma were enrolled in Medicare Part D (41% vs 27%) in 2006 when Medicare Part D started, we undertook post hoc analyses of 2006 expenditure data to determine if women with Medicare Part D coverage had higher expenditures relative to other sex-insurance subgroups. The interaction between insurance type and sex was significant (\( F = 4.58; \ P = .006 \)), with much of this interaction due to differences in expenditures among women vs men enrolled in Medicare Part D ($914 vs $472; \( P < .001 \)).

Given the increase in expenditures among black individuals between 2005 and 2006 (Figure 2), we also undertook post hoc analysis of the 2006 data to determine if there was an interaction between enrollment in Medicare Part D and race with respect to glaucoma medication expenditures. This interaction was not significant (\( F = 0.49; \ P = .78 \)).

In this nationally representative study of trends in glaucoma medication expenditures from 2001 to 2006, we found that expenditures increased significantly, particularly among women, those with public-only insurance, and those with less than a high school education. With the aging of the US population and the corresponding increase in the number of persons living with glaucoma, the impact of glaucoma medication expenditures is expected to grow. The results of our study as well as an understanding of the factors that account for the increase in glaucoma medication expenditure are important to help to develop effective strategies and protocols for the medical management of glaucoma that optimize treatment and control expenditures.

Greater awareness of the benefits of earlier and more aggressive treatment of glaucoma among eye care professionals is a potential explanation of increased glau-
coma medication expenditures. This greater awareness is likely related to the results that became available toward the beginning of the study period from multiple glaucoma clinical trials including the Collaborative Initial Glaucoma Treatment Study, the Ocular Hypertension Treatment Study, and the Early Manifest Glaucoma Trial. We observed a significant increase in annual mean glaucoma medication expenditure for subjects who reported no visual impairment but not in subjects with reported visual impairment. These findings suggest that earlier, better, and perhaps more aggressive treatment of glaucoma increased in subjects without visual impairment during the study period.

In addition, advances in the understanding of glaucoma, including a better understanding of glaucoma in vulnerable groups (ie, black individuals), may have also contributed to the increase in expenditures. Black individuals have 4 times the prevalence of glaucoma and generally have more severe glaucoma with a greater risk of blindness compared with white individuals. Previous studies indicated racial disparities exist with respect to eye care including undertreatment of glaucoma in black individuals.

During the study period of 2001 to 2006, women had a greater increase in glaucoma medication expenditure than men. Overall, health care–related costs impose a greater burden on older women vs older men. This burden is due in part to income differences, which are lower in women, combined with higher overall health care use, relative to men. Medicare Part D started in 2006, and during this first year of Medicare Part D, women under medication treatment for glaucoma were more likely than men to enroll in the new Medicare Part D prescription drug program; women also had higher glaucoma-related expenditures relative to men who enrolled in this new program. However, this may simply be a reflection that persons with recurring medication expenses were more likely to sign up for Medicare Part D, particularly in the first year. Additional research is needed to determine if these sex-specific trends in enrollment and glaucoma medication expenditures continue.

During the study period of 2001 to 2006, participants with public-only insurance had significant increased glaucoma medication expenditure including those with Medicare only and those with Medicare and Medicaid. The trend for participants with Medicaid only was unstable because of the small sample size. In contrast, we found that participants with private insurance demonstrated no increase in expenditure. Potential factors for increased expenditures for public-only insurance may be related to the expansion of coverage and the increase in expenditure for prostaglandin analogs during the study period as well as the initiation of Medicare Part D in 2006. Increase in expenditure among participants with less than a high school education is in part related to the fact that public-only insurance was more common among participants with less than a high school education (63.6%).

In a study of rates of glaucoma medication use among older adults with suspected glaucoma from 1992 to 2002 using the Medicare Current Beneficiary Survey, Stein and associates found use rates decreased substantially for β-blockers and cholinergic agonists and increased for α-agonists, combination β-blocker/carbonic anhydrase inhibitors, and prostaglandin analogs. Our data from 2001 to 2006 are consistent with the trends found in this earlier study. The results of our study indicate a significant decreased trend of expenditure for β-blockers (P = .05) and a significant increased trend for prostaglandin analogs (P = .01) and α-agonists (P = .01) (Figure 5). However, expenditure for cholinergic agonists was already very low beginning in 2001 and remained low throughout our study period, and while we found an increase in expenditure for combination β-blocker/carbonic anhydrase inhibitors, the trend was not significant (P = .10). Although β-blockers had been considered as the most common first-line therapy in the past, prostaglandins are quickly becoming the monotherapy treatment of choice because of their greater efficacy in lowering intraocular pressure, fewer adverse effects, and once-a-day dosing. In addition, the increasing availability of inexpensive generic forms of β-blockers is also a major contributing factor to its decline in expenditure. However, even with prostaglandin treatment, some patients may still need additional medications from the other medication classes, which affects compliance and cost. Looking forward, with the first prostaglandin, latanoprost, going generic in 2011, the expenditure for prostaglandins will likely decrease in future years because of the increasing availability of inexpensive generic forms.

Limitations of our study include the lack of information on patient compliance and disease severity. Patient compliance is one of the largest problems contributing to ineffective treatment and poor patient prognosis related to glaucoma. Poor patient compliance may initially reduce medication expenditure but ultimately will increase medical and surgical expenditures in the long run. Newer glaucoma medications may be better tolerated by some patients, leading to better treatment compliance.

Although glaucoma is a chronic condition, it is also possible some of the study subjects may have been treated for
an acute raise in intraocular pressure (eg, intraocular pressure rise immediately after cataract extraction). However, the number of participants who filled only 1 glaucoma medication prescription was low in our study and ranged from 11% to 18% per year during the study period indicating that, as expected, the vast majority of our participants are long-term users of glaucoma medications.

Another limitation of the study is the number of participants in the current analysis, which ranged from 289 to 411 per year. While MEPS selects participants randomly and the overall study sample size is not small, there could be potential biases in the current analysis compared with a larger study. Because our study period of 2001 to 2006 covered only the first year of Medicare Part D, we had only 130 participants with Medicare Part D. Further future study of the period from 2006 and onward is required to address the effect of Medicare Part D on glaucoma medication expenditure. Available MEPS data do not allow an adequate study of the effects on the trends of glaucoma medication expenditure from the implementation of Medicare Part D beyond 2006, especially given changes in the method of editing pharmacy data starting in 2007 (eg, less editing of prices and quantities reported by pharmacies). Results from 2006 show a nonsignificant difference in increase in expenditures among those who enrolled in Medicare Part D relative to those who were publicly insured but who opted not to enroll in this new program ($772 vs $613; P=.12).

In summary, we found trends of significant increase in glaucoma medication expenditure from 2001 to 2006 particularly in women, those with public-only insurance, and those with less than a high school education. Main factors for these trends include the increasing use of prostaglandin analogs, changes in insurance coverage, and possibly more aggressive glaucoma treatment. Additional research is necessary to understand the underlying reasons for the difference in glaucoma medication expenditure by patient characteristics.

Submitted for Publication: October 12, 2010; final revision received March 29, 2011; accepted April 1, 2011. Published Online: June 13, 2011. doi:10.1001/archophthalmol.2011.142

Correspondence: Byron L. Lam, MD, Bascom Palmer Eye Institute, 900 NW 17th St, Miami, FL 33136 (blam@med.miami.edu).

Financial Disclosure: None reported.

Funding/Support: This work was supported by grant R21 EY019096 from the National Eye Institute.

REFERENCES