The Economic Burden of Major Adult Visual Disorders in the United States

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Objective: To estimate the societal economic burden and the governmental budgetary impact of the following visual disorders among US adults aged 40 years and older: visual impairment, blindness, refractive error, age-related macular degeneration, cataracts, diabetic retinopathy, and primary open-angle glaucoma.

Design: We estimated 3 components of economic burden: direct medical costs, other direct costs, and productivity losses. We used private insurance and Medicare claims data to estimate direct medical costs; epidemiologic evidence from multiple published sources to estimate other direct costs, such as nursing home costs; and data from the Survey of Income and Program Participation to estimate productivity losses. We used budgetary documents and our direct medical and other direct cost estimates to approximate the governmental budgetary impact.

Results: We estimated that the annual total financial burden of major adult visual disorders is $35.4 billion ($16.2 billion in direct medical costs, $11.1 billion in other direct costs, and $8 billion in productivity losses) and that the annual governmental budgetary impact is $13.7 billion.

Conclusions: Major visual disorders among Americans older than 40 years result in substantial economic costs for the US economy. Well-designed public health programs may have the ability to reduce this burden in the future.

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aged 65 years or older, we used 2000 Medicare claims data from a nationally representative sample of 167,993 fee-for-service beneficiaries selected to take part in the Consumer Assessment of Health Plans Survey.

PATIENT ESTIMATES
To estimate the number of patients using services for each disorder, we first identified all patients with at least 1 claim with a primary International Classification of Diseases, Ninth Revision, Clinical Modification diagnosis code for AMD, cataracts, diabetic retinopathy, and glaucoma using codes from previous research. We determined the number of patients aged 40 to 64 years who received services for each disorder by multiplying the number of patients seen in the MarketScan claims by 32.9 (the quotient of the full population of patients aged 40 to 64 years divided by the number of patients in MarketScan). We determined the number of patients aged 65 years or older who received services for each disorder using the data sampling weights with adjustments to account for unrepresented patients.

We only estimated prescription costs for glaucoma because prescriptions are not commonly used to treat other visual disorders. We estimated the number of patients aged 40 to 64 years using glaucoma medications in the same way we estimated other service categories except that we used National Drug Code numbers for identification in place of primary diagnosis codes. Because Medicare did not cover drugs in the observation period, we estimated the number of glaucoma prescriptions issued to patients aged 65 years and older using data from the 2002 National Ambulatory Medical Care Survey and from the National Hospital Ambulatory Medical Care Survey (outpatient department file) using a drug class variable to identify glaucoma prescriptions.

Patients diagnosed with intermediate AMD may take nonprescription, antioxidant-plus-zinc vitamin supplements as a prophylactic therapy, which would not appear in claims data. No good estimate of the number of patients who take antioxidants plus zinc to treat AMD exists, although as many as 35% of American adults take multivitamins daily for any health reason. To conservatively estimate the cost of AMD multivitamins, we assumed that 5% of intermediate AMD patients aged 40 to 54 years, 10% of those aged 55 to 64 years, and 20% of those aged 65 years or older used vitamins according to clinical guidelines.

To estimate the total number of patients with refractive error, we multiplied the number of US residents aged 40 years or older in 2004 by the average proportion of those with hyperopia (spherical equivalence > +0.5 diopters [D]) or myopia (spherical equivalence < −0.5 D) found in 2 major population-based eye studies. We then subtracted the proportion of patients with uncorrected refractive error that were identified in the Baltimore Eye Study and assumed that patients change eyeglasses on average once every 3.4 years and change contact lenses annually.

AVERAGE MEDICAL COST ESTIMATES
We estimated costs for outpatients aged 40 to 64 years by summing outpatient MarketScan claims with a primary diagnosis code for each condition per person; we then estimated the average annual cost per person per condition. We estimated outpatient and inpatient physician services and outpatient facility costs for patients aged 65 years or older similarly, using data from the Medicare physician and outpatient hospital files. The costs of inpatient services (a very small portion of total direct medical expenditures) were estimated in a similar manner.

We estimated the average annual cost per patient and average cost per claim of glaucoma medications by using MarketScan data. Average annual costs were used for people aged 40 to 64 years, and the average cost per claim was used for those aged 65 years or older. Because Medicare claims contained no information on prescriptions during this time period, we assumed that the average claim cost for patients aged 65 years or older was equal to the cost for patients aged 40 to 64 years. We estimated the cost of multivitamins for AMD as the lowest Internet price for the recommended vitamins when taken for 1 year.

We based refractive error costs on research indicating that, of people who use corrective devices, 93.5% use eyeglasses, 1.6% use contact lenses, and 4.9% use both. Eyeglass costs and ophthalmologic visits (1 visit per eyeglass or contact change) were assigned based on the Centers for Medicaid & Medicare Services fee schedule. The cost of fashionable frames or LASIK surgery was not estimated.

OTHER DIRECT COSTS
We included the costs of nursing home care attributable to visual impairment, government purchase programs, and guide dogs for the blind in our estimate of other direct costs. To estimate nursing home placements attributable to visual impairment, we first estimated the total number of nursing home residents aged 65 years or older with vision impairment or blindness by multiplying the proportion of nursing home patients with visual impairment and blindness by the total number of nursing home patients. Second, we estimated the proportion of those aged 65 years or older with visual disorders who resided in nursing homes by dividing the number of nursing home patients estimated in step 1 by the total number of people with visual impairment or blindness. Third, we compared the proportions found in step 2 with the population proportion of people with normal vision residing in nursing homes to estimate the fraction of nursing home placements attributable to visual impairment and blindness. This additional incremental number of patients was multiplied by a previously published estimate of the annual costs of nursing home residence to estimate the costs of nursing home care attributable to visual impairment. We excluded the costs of residential care attributable to visual disorders because of insufficient information.

We considered the federally budgeted cost of 3 programs—the Department of Education’s Independent Living Services for Older, Blind Individuals; the American Printing House for the Blind; and the Library of Congress’ National Library Service for Blind and Physically Handicapped—as other direct costs. We estimated the annual number of guide dog and person teams trained and the cost per team through a direct query of 10 of 12 certified training organizations reported by Guide Dog Users Inc.

PRODUCTIVITY LOSSES
We defined productivity losses as the incremental costs of lower labor force participation and lower wages for visually impaired and blind individuals aged 40 to 64 years who worked compared with those in the same age group with normal vision. We used published analyses of data from the 1997 Survey of Income and Program Participation to estimate earnings and labor force participation, using an affirmative response to “Do you have some difficulty in seeing words or letters?” to indicate visual impairment and an affirmative response to “Do you have severe difficulty in seeing words or letters?” to indicate blindness. These analyses showed a labor force participation rate of 44% among the visually impaired and 30% among the blind, and average annual earnings of $23,345 among the visually impaired and $21,074 among the blind, compared with a labor force participation rate of nearly 85% and average annual earnings of $33,195 for those with normal vision. Because of insuf-
We calculated tax losses based on the standard income tax deduction for the blind and tax losses resulting from lower earnings and labor force participation assuming that annual productivity losses would have been taxed at the US average tax rate of 10.4%. We assumed that 80% of medical costs (excluding prescription drugs) for those aged 65 years or older were paid by Medicare and that Medicaid paid 4.8% of care for individuals aged 40 to 64 years. Finally, we estimated the amount of visual disorder-attributable nursing home care paid for by the federal government by applying the proportion of all nursing home expenditures covered by Medicaid (nearly 51%) and Medicare (10%). We assumed that the federal government paid half of all Medicaid costs and that states paid the rest.

**SENSITIVITY ANALYSIS**

Our total burden estimate is sensitive to measurement error in the number of cases and unit costs of direct medical and other direct costs and to specific assumptions or choices made during the analysis. We evaluated the sensitivity of our estimate for (1) changes of ±25% in our estimates of direct medical and other direct costs; (2) changes of ±25% in the fraction of nursing home placements attributable to visual impairment and blindness; (3) the doubling of the cost of glasses replacement and varying the rate at which they are replaced; (4) the inclusion of 4 other conditions—conjunctivitis, strabismus, trauma, and uveitis (including these conditions could potentially increase our overall direct medical cost estimates by 13%); (5) the use of the older National Health Interview Study rather than the Survey of Income and Program Participation to estimate productivity losses; (6) our assumption that no medical services were used by uninsured patients; and (7) our assuming 0% and 100% use of multivitamins among eligible patients with AMD.

For 2004, we estimated the total financial cost of major visual disorders among US residents aged 40 years or older at $35.4 billion: $16.2 billion in direct medical costs, $11.1 billion in other direct costs, and $8 billion in productivity losses. The direct medical costs for each condition were roughly $6.8 billion for cataracts, $5.5 billion for refractive error, $2.9 billion for glaucoma, $575 million for AMD, and $493 million for diabetic retinopathy (Table 1, Table 2, and Table 3). Outpatient and pharmaceutical services comprised the majority of direct medical costs, with inpatient costs accounting for virtually no costs. Refractive error accounted for the largest share of direct medical costs among those aged 40 to 64 years (46.2%), while cataracts accounted for the largest share among patients aged 65 years and older (56.2%). Across all ages, 75.6% of direct medical costs were attributable to cataracts and refractive error, with another 17.8% attributable to glaucoma.

The costs of AMD and cataracts were substantially higher among the population aged 65 years and older than in the population aged 40 to 64 years. In contrast, the costs of diabetic retinopathy, glaucoma, and refractive error were lower in the older age group than in the younger group. Increased overall costs for AMD and cataracts among patients aged 65 years and older were attributable to increased numbers of patients who use outpatient services for these conditions.

The lower overall diabetic retinopathy costs among patients older than 65 years compared with those aged 40 years was not fully compensated by increased productivity losses associated with visual disorders among people older than 65 years.

**GOVERNMENTAL BUDGETARY IMPACT**

To estimate the overall impact of visual disorders on federal and state budgets, we added the annual cost of income assistance programs, tax losses, and the medical and other direct costs borne by taxpayers. To determine the cost of income assistance programs, we estimated the cost of Supplemental Security Income by multiplying the annual number of recipients eligible because of blindness by the average annual benefit amount, and we assumed that all those receiving Supplemental Security Income benefits also received federal food stamp benefits. To estimate the annual number of people receiving Social Security Disability Insurance because of visual disorders, we assumed that only those aged 40 to 64 years who were considered legally blind (visual acuity ≤20/200) were eligible for benefits. From this number of legally blind individuals, we subtracted those receiving Supplemental Security Income and those in the labor force. Of those remaining, we conservatively assumed that half received Social Security Disability Insurance benefits and multiplied that number by the annual benefit amount. We considered the cost of Social Security Disability Insurance and Supplemental Security Income to be transfer payments and therefore included them in our governmental burden estimate but not in our economic burden. We also included the small cost of the Committee for Purchase from People Who Are Blind or Severely Disabled as a federal transfer.

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**Table 1. Estimated Number of Visual Disorder Patients Aged 40 to 64 Years and Cost per Patient**

<table>
<thead>
<tr>
<th>Disorder</th>
<th>Outpatient</th>
<th>Inpatient</th>
<th>Prescription Drugs, Vitamins, and Other Medications</th>
</tr>
</thead>
<tbody>
<tr>
<td>AMD</td>
<td>186,002</td>
<td>207,455</td>
<td>0</td>
</tr>
<tr>
<td>No. of patients</td>
<td>235,12</td>
<td>110</td>
<td></td>
</tr>
<tr>
<td>Cost per patient (SE), $</td>
<td>305 (12)</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Cataracts</td>
<td>1,683,588</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>No. of patients</td>
<td>1,268 (11)</td>
<td>568,935</td>
<td>0</td>
</tr>
<tr>
<td>Cost per patient (SE), $</td>
<td>629 (10)</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Diabetic retinopathy</td>
<td>473,601</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>No. of patients</td>
<td>2,033,082</td>
<td>263</td>
<td>1,482,941</td>
</tr>
<tr>
<td>Cost per patient (SE), $</td>
<td>276 (2)</td>
<td>471</td>
<td>806 (11)</td>
</tr>
<tr>
<td>Refractive error</td>
<td>18,344,918</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>No. of patients</td>
<td>199,939</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Cost per patient (SE), $</td>
<td>44</td>
<td>0</td>
<td></td>
</tr>
</tbody>
</table>

Abbreviation: AMD, age-related macular degeneration.

*All cost findings were converted to 2004 US dollars using the annual Consumer Price Index for all urban consumers.
†Data from the 2001 MarketScan Commercial Claims and Encounters Research Database.
‡For AMD, we assumed that 5% of intermediate AMD patients aged 40 to 54 years and 10% of those aged 55 to 64 years used vitamins, according to clinical guidelines. For glaucoma patients, estimates represent the number of patients who received at least 1 prescription for glaucoma medications during the year. Cost estimates represent the average annual per patient cost for those patients with at least 1 prescription.
§Cost of glasses is equal to the weighted average of Medicare reimbursements for glasses, contacts, or glasses and contacts (for those who use both), plus the cost of an eye exam. We allowed $124.69 for the purchase of glasses and frames, $163.12 for contacts, and $61.43 for each exam.

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**RESULTS**

For 2004, we estimated the total financial cost of major visual disorders among US residents aged 40 years or older at $35.4 billion: $16.2 billion in direct medical costs, $11.1 billion in other direct costs, and $8 billion in productivity losses. The direct medical costs for each condition were roughly $6.8 billion for cataracts, $5.5 billion for refractive error, $2.9 billion for glaucoma, $575 million for AMD, and $493 million for diabetic retinopathy (Table 1, Table 2, and Table 3). Outpatient and pharmaceutical services comprised the majority of direct medical costs, with inpatient costs accounting for virtually no costs. Refractive error accounted for the largest share of direct medical costs among those aged 40 to 64 years (46.2%), while cataracts accounted for the largest share among patients aged 65 years and older (56.2%). Across all ages, 75.6% of direct medical costs were attributable to cataracts and refractive error, with another 17.8% attributable to glaucoma.

The costs of AMD and cataracts were substantially higher among the population aged 65 years and older than in the population aged 40 to 64 years. In contrast, the costs of diabetic retinopathy, glaucoma, and refractive error were lower in the older age group than in the younger group. Increased overall costs for AMD and cataracts among patients aged 65 years and older were attributable to increased numbers of patients who use outpatient services for these conditions.

The lower overall diabetic retinopathy costs among patients older than 65 years compared with those aged 40 years was not fully compensated by increased productivity losses associated with visual disorders among people older than 65 years.
We estimated that, among Americans aged 65 years or older, 16% of those who are visually impaired and 40% of those who are blind resided in nursing homes, compared with only 4.3% of those in the general population. From this, we estimated that 424,801 more visually impaired and 1,671,333 blind people participated in the labor force than would have worked if fully sighted. Assuming the same average wage as for people with normal vision ($33,195), we estimated that reduced labor force participation by people with visual impairment and blindness accounted for $6.3 billion in lost productivity annually.

For productivity losses, we estimated that 115,583 visually impaired and 74,133 blind people who did not work would have worked if fully sighted. Assuming the same average wage as for people with normal vision ($33,195), we estimated that reduced labor force participation by people with visual impairment and blindness accounted for $6.3 billion in lost productivity annually. Additionally, we estimated that 125,882 visually impaired and 40,671 blind people participated in the labor force but earned less than people with normal vision. Multiplying these numbers by the appropriate wage differen-
tial ($9851 for the visually impaired and $12,121 for the blind), we estimated productivity losses of $1.7 billion from decreased earnings.

In 2004, the total governmental budgetary impact of adult visual disorders was $13.7 billion (Table 5). Of this, the federal government paid $10.8 billion, and states paid an additional $2.9 billion in Medicaid matching funds. (Of this $13.7 billion total, $13.1 billion is included in our estimate of economic burden and an additional $0.59 billion results from transfer payments from one taxpayer to another.) Direct medical costs accounted for $5.5 billion of the budgetary impact; other direct costs accounted for $6.6 billion; and tax losses, transfer payments, and other government services accounted for $1.6 billion.

Our point estimates were most sensitive to possible measurement error in direct costs, the cost and rate of glasses replacement, and the fraction of nursing home placements attributable to visual impairment and blindness (Figure). Our estimates were relatively insensitive to the possible inclusion of omitted conditions, the use of alternative data to estimate productivity losses, the assumption of care for uninsured patients, and the percentage of patients with AMD who use vitamins.
We estimated that the total financial burden of major visual disorders among American adults was $35.4 billion in 2004: $16.2 billion in direct medical costs, $11.1 billion in other direct costs, and $8 billion in productivity losses. We estimated that these disorders cost the federal government and state Medicaid agencies at least $13.7 billion. This represents a conservative estimate of the total burden of major adult visual disorders, because we estimated only the costs of the disorders themselves and excluded the costs of associated comorbidities, such as depression and traumatic injury, as well as the cost of ophthalmic well-care for patients without a diagnosed disorder. The inclusion of these costs could have substantially increased our estimates.

Furthermore, many if not all of these costs should be expected to rise in the future as the US population ages and advances in medical science result in greater medical care use. For example, assuming no changes in the current age-specific disease prevalence or costs and treatments, such as the expanded use of drugs like injections of anecortave acetate suspension and pegaptanib sodium, we project the cost of AMD to increase from $575 million to $845 million during the next 15 years because of increases in the number of people older than 65 years. Similar trends may be expected for cataracts, glaucoma, and perhaps diabetic retinopathy. In addition, the recently enacted Medicare Part D reimbursement for prescription pharmaceuticals should lead to increased prescription use by patients with glaucoma aged 65 years and older. This study, which evaluated a time period prior to Medicare Part D, found dramatically lower prescription use by patients aged 65 years and older compared with patients aged 40 to 64 years.

This study was limited by a number of factors, many of which we attempted to account for in our sensitivity analysis. Prior research indicates that including omitted conditions such as conjunctivitis, strabismus, trauma, and uveitis could have increased our nonrefractive error direct medical cost estimates by as much as 15%.5

Our direct medical cost estimates included only the costs of any services whose primary International Classification of Diseases, Ninth Revision, Clinical Modification code was for a major adult visual disorder, regardless of whether the patient was diagnosed with the condition. Because we used only primary diagnoses, we may not have accounted for some services patients received during medical visits for other reasons. Also, the population from which the MarketScan data were collected is not representative of the general population because it does not include people on Medicaid and those who were uninsured. In 2004, 18.1% of Americans aged 35 to 54 years and 15.7% of those aged 55 to 64 years were uninsured,28 and these patients almost certainly consumed less ocular care than those represented in MarketScan.

Because of insufficient data, we assumed the age-specific proportion of patients who use prophylactic vitamin therapy for AMD. However, this assumption also had little impact on our final result because the relative burden of AMD is small. Our sensitivity analysis indicates that while increasing our vitamin use assumption to 100% for all eligible patients would increase our estimate of the cost of AMD by 22%, it would increase our total burden estimate by less than 1%. We assumed that the costs of glaucoma medications for patients younger than 65 years were the same as for Medicare patients aged 65 years or older.

In estimating nursing home costs, we excluded the costs of community-based assistance and informal care by family members. Readers should note that our study does not demonstrate a causal link between visual impairment and nursing home placement. Our attribution of nursing home costs to visual impairment and blindness is only valid to the extent that the higher than expected rate of nursing home residencies observed among visually impaired and blind people older than 65 years is in fact attributable to their condition. We also excluded the costs of over-the-counter rehabilitative equipment.

Our sensitivity analysis indicates that our total burden estimate is sensitive to uncertainty in our estimates of the quantity and costs of direct medical services generally, and the cost of correcting refractive error specifically, the fraction of nursing home placements attributable to visual impairment and blindness, and estimated productivity costs. We estimated direct medical costs with as much precision as possible and were able to validate our estimates against previously published studies,3 but a degree of estimation error is always possible. Our estimate of the cost of correcting refractive error depended heavily on the glasses replacement rate16 and on the cost of optical lenses and frames. Our estimate of productivity costs depended on the accuracy of the Survey of Income and Program Participation data used to estimate it and would have been $1.5 billion less had we used older National Health Interview Study data to calculate labor force participation levels.

After taking these limitations into account, this study still provides the most comprehensive, updated estimate of the burden of major adult visual disorders to date. Direct medical costs, the largest burden component, were...
measured with the greatest accuracy, and these costs are substantial. Furthermore, as the US population ages over the coming decades, the burden of adult visual disorders is likely to increase. Public health efforts to screen for and treat currently undiagnosed disease may be likely to increase direct medical care costs, but if effective, they will also improve visual outcomes, and potentially reduce productivity losses and nursing home placements associated with visual impairment and blindness. Interventions that prevent blindness, such as diagnosing early AMD and treating its progression with antioxidants plus zinc, or interventions to diagnose and treat uncorrected refractive error, have the potential to be highly cost-effective based on the improvements in patient quality of life they generate. Technological advancements that lead to reductions in the unit costs of glasses, cataract surgery, and medications to treat glaucoma have the potential to lead to substantial direct medical cost savings.

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