

# Economic Impact of Visual Impairment and Blindness in the United States

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**Objectives:** To assess the economic impact of excess medical and informal care and the health utility loss associated with visual impairment and blindness in adults aged 40 years and older in the United States.

**Methods:** Medical Expenditure Panel Survey data from 1996 to 2002 were pooled to estimate the relationship of visual impairment and blindness with total medical expenditures, components of expenditures, days of informal care received, and health utility. Estimates accounting for the complex sampling design were based on regressions including confounders such as comorbidities and demographics. The aggregate economic impact was estimated by projecting average individual effects to the population of individuals with blindness and visual impairment.

**Results:** Blindness and visual impairment were significantly associated with higher medical care expenditures, a greater number of informal care days, and a decrease in health utility. The home care component of expenditures was most affected by blindness. The aggregate annual economic impact included \$5.5 billion spent for medical care and the value of informal care as well as a loss of more than 209 000 quality-adjusted life years.

**Conclusions:** Visual impairment has a large effect on home care. Any economic analysis of prevention, treatment, and rehabilitation should account for the fraction of the annual monetary cost and loss of quality-adjusted life years that can be averted.

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**U**NDERSTANDING THE COSTS of a condition is useful for making an economic argument about efforts to reduce the burden of the condition.<sup>1</sup> The costs of visual impairment and blindness have been characterized in the United States,<sup>2</sup> Australia,<sup>3</sup> and elsewhere.<sup>4,5</sup> Research on the cost of visual impairment can use administrative, clinical, or survey data. Administrative data often include a large number of records, identify blindness by coded diagnoses, do not capture paid personal care services not covered by third-party payers, and do not capture the cost of informal care. Clinical examinations provide an exact measure of visual impairment but likely would result in a limited sample size because of the resources needed for eye examinations or medical records abstraction. Survey data require individuals to self-identify as visually impaired or blind but can ask about many types of costs. To our knowledge, no study to date has used data from a large national survey to calculate the excess expenditures associated with being visually impaired in the United

States. This type of data can uniquely provide information on home and informal care costs for which visual impairment likely makes a large difference.

The Medical Expenditure Panel Survey is an overlapping cohort survey that has been administered by the Agency for Healthcare Research and Quality since 1996. This panel survey allows researchers to study annual health care expenditures and informal care received.<sup>6</sup> Medical Expenditure Panel Survey data have been used to characterize the costs of conditions including obesity,<sup>7</sup> musculoskeletal conditions,<sup>8</sup> behavioral disorders in children,<sup>9</sup> and diabetes.<sup>10</sup>

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In this article, Medical Expenditure Panel Survey data are used to estimate the economic impact of visual impairment and blindness for individuals aged 40 years and older in the United States. We include cost and quality-of-life measures not previously included in US analyses.

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## DATA

Detailed descriptions of the Medical Expenditure Panel Survey appear elsewhere.<sup>6</sup> In brief, each year a new cohort of study subjects was chosen from the full National Health Interview Survey sampling frame. Each year except the first, data from 2 cohorts were gathered. Each cohort of study subjects was interviewed 5 times over a 30-month period. Thus, each cohort's second year overlapped with the next cohort's first year.<sup>6</sup>

Publicly available data include but are not limited to health care expenditures, health utility, and demographics. Health care expenditure data were collected at computer-aided personal interviews conducted at 6-month intervals. The Agency for Healthcare Research and Quality has aggregated data in annual expenditure figures. Health utility data were collected only once annually using a paper-and-pencil questionnaire sent to respondents aged 18 years and older.

Each year's data set was designed to be nationally representative. Pooled mean and SD estimates are valid when pooled sample design weights provided by the Agency for Healthcare Research and Quality are used.<sup>11</sup>

Analyses included only individuals aged 40 years and older. This age range matched recent US estimates of the prevalence of blindness and visual impairment based on data from multiple epidemiological studies.<sup>12</sup> The previously reported prevalence values were used to project the average individual economic impact to the US population (discussed later). Given the relatively low prevalence of blindness, even among the population aged 40 years and older, multiple years of data (1996-2002) were pooled to obtain a sufficient number of observations to make valid estimates.

## DEPENDENT VARIABLES

The dependent variables were total health care expenditures (regardless of who was responsible for payment), components of health care expenditures, the number of days of informal care provided by individuals not living with the study subject, and health utility. Components of health care expenditures included outpatient facility and provider costs, office-based visit costs, emergency department facility and provider costs, inpatient facility and provider costs, prescription costs, home health agency costs, costs of formal home health care providers that are not included in agencies' costs, the cost of glasses, and the cost of other medical supplies and equipment. All dollar figures were adjusted to 2004 dollars using the medical care consumer price index.<sup>13</sup>

Health utility measures included both the societal and self-rated portions of the EQ-5D.<sup>14</sup> The EQ-5D is a standard questionnaire asking about specific health domains to which an algorithm is applied to obtain a health utility score. Respondents were asked about mobility, self-care, usual activities, pain, and anxiety or depression on the day of the interview. The US-based scoring algorithm was used to assign a societal preference for each health state.<sup>15</sup> This contrasts with past studies<sup>16</sup> in ophthalmology in which individuals were asked about their willingness to make tradeoffs to avoid visual impairment. Individuals also were asked to rate their overall health on a scale from 0—worst health imaginable—to 100—perfect health.

## MAIN INDEPENDENT VARIABLE OF SELF-REPORTED VISION

Each respondent was asked a single question about vision. The individual could indicate that he or she was blind or that he or

she had no difficulty seeing (while wearing glasses if appropriate). Three other categorical responses included the following: "have some difficulty seeing but can read newsprint"; "have some difficulty seeing, cannot read newsprint, can recognize familiar people"; and "have some difficulty seeing, cannot read newsprint, cannot recognize familiar people." The 3 intermediate responses were combined into the category "some problem with seeing (even with glasses or contacts)."

## OTHER INDEPENDENT VARIABLES

Visual impairment was not the only determinant of the outcomes being studied. Other independent variables in regression analyses included age, sex, self-reported health status, race (white in comparison with all other groups, as a sufficient number of minorities with visual impairment is not available to produce stable estimates), education (comparing high school graduates, individuals with some post-high school training, and individuals with at least a 4-year college degree with individuals who did not graduate from high school), income (divided into quartiles), insurance (comparing those who have any public insurance or those with no insurance with those with at least some private insurance), being married, family size (treated as a continuous variable), and having diabetes or high blood pressure. The last two were controlled for, as high blood pressure and diabetes are systemic conditions associated with an increased risk of visual loss that affect utility and costs substantially via nonvisual effects.

## ANALYSES

The primary analyses used weighted linear regressions accounting for sampling strata and population sampling units. Total health care expenditures, total days of informal care provided, and health utility were the dependent variables in 3 separate analyses. Initial analyses evaluated the relationship between blindness or visual impairment and the outcomes in regression models without controlling for other variables. These analyses indicated associations with visual impairment or blindness without evaluating how much of the costs are direct results of impairment. Next, other variables were added to reduce the effects of confounding by exogenous demographic characteristics, comorbidities, and other characteristics that may be related to visual impairment and the outcomes.

Two analyses supplemented the weighted linear regressions. The first was a set of three 2-part models.<sup>17</sup> Each of the 3 models began with a logistic regression in which an indicator of any expenditures, any informal care, or any health utility other than perfect health was the dependent variable with the same independent variables discussed earlier. Then, a linear regression was run for those who had expenditures, informal care, or less-than-perfect health utility. This method was also applied to expenditure components.

The second supplemental analysis was a 2-part model for total expenditures. The natural logarithm of expenditures was used as the dependent variable in the second part of the model.<sup>18</sup> This transformation is common for expenditures that are not normally distributed. One way to infer the effect of blindness using a 2-part model is to predict the expected outcome twice. For example, the expected outcome is the probability of non-zero expenditures multiplied by the expected expenditures conditional on having any. In both predictions, each individual's independent variables are used as reported except for visual impairment. To make an inference about blindness, the first prediction assumes that all individuals have no impairment and the second assumes that all are blind. The inferred effect of blindness is the mean difference in predictions.<sup>8</sup>

**Table 1. Demographic Characteristics of 77 511 Respondents of the 1996-2002 Medical Expenditure Panel Survey Aged 40 Years and Older by Visual Impairment Status**

Characteristic	Individuals With Blindness (n = 512)	Individuals With Visual Impairment (n = 6288)	Individuals Without Visual Impairment (n = 70 711)
Male, %	37.6	39.0	47.6
White, %	81.0	85.7	85.5
Education, %			
<High school	35.4	33.2	19.9
High school or GED	33.9	32.8	34.1
Some college	14.9	17.6	20.6
≥College	15.8	16.5	25.3
Married, %	45.2	47.0	68.0
Excellent or very good self-reported health status, %	29.1	32.8	55.9
Insurance, %			
Any private insurance	54.4	61.1	76.7
Public insurance only	39.0	29.4	15.0
Uninsured	6.6	9.5	8.3
Diabetes, %*	21.5	18.1	8.8
Hypertension, %*	40.9	37.9	26.4
Age, mean (SE), y	66.6 (0.703)	62.1 (0.277)	56.6 (0.128)
Total income, mean (SE), \$†	20 658 (1290)	25 152 (582)	34 139 (379)
Family size, mean (SE), No.	2.0 (0.055)	2.0 (0.022)	2.6 (0.012)

Abbreviation: GED, General Equivalency Diploma.

\*Data from condition file.

†All figures are adjusted to 2004 dollars.

## NATIONAL PROJECTIONS

Data on the average individual effects of visual impairment and blindness were projected to the entire US population in 2004 using previously published estimates of the prevalence of low vision and blindness.<sup>12,19</sup> The total annual economic impact included the combined dollar value of the excess medical care expenditures and the monetary value of excess informal care received. Informal care was valued at the 2004 minimum hourly wage (\$5.15). Quality-adjusted life years (QALYs) lost were also part of the economic impact and were calculated by assuming that the mean health utility impact of blindness or visual impairment applied for the entire year.

## RESULTS

**Table 1** shows the percentages as well as the means and SEs for the independent and dependent variables in the analyses for the 3 vision status groups. A total of 77 511 individuals aged 40 years or older who were surveyed at least 1 year between 1996 and 2002 had all nonmissing data for the variables included in the analysis. Individuals who are blind or visually impaired are less likely to report having a favorable health status. They also are more likely to have public health insurance only and to have hypertension or diabetes. Their mean income is lower, and their mean age is higher.

The first 2 columns of results in **Table 2** show the relationships between only vision status and total health care expenditures, informal care, and health utility. The second 2 columns of results in the table show the relationships when controlling for other potentially confounding variables that are included in Table 1. The differences remain statistically significant when multivariate regression analyses are performed. More than half of the increased total health care expenditure and utility reductions associated with visual impairment and blindness was accounted for by the effect of confounding factors. Nevertheless, even when controlling for other variables, blindness is associated with more than \$2000 of excess medical care expenditures. This is more than double the \$1000 of excess costs for those with some visual impairment. Individuals with blindness required nearly 4 times as many extra days of care provided by someone outside the household as compared with individuals with visual impairment when controlling for confounders, suggesting that blindness, when present, is a primary driver of informal care days. The effects on quality of life are nearly identical when using either the societal algorithm or the visual analog scale. The change associated with blindness is approximately 50% greater than the change associated with visual impairment.

**Table 3** shows the results of the 2-part model. The column showing odds ratios (ORs) describes the odds of having positive medical care expenditures, informal care days, or less-than-perfect health. The linear regression columns show how much outcomes are affected among those with positive expenditures, informal care days, or less-than-perfect health. Compared with individuals with no visual impairment, individuals with blindness have higher odds of receiving informal care, lower odds of having perfect health as rated by society, and similar odds of giving less than a perfect rating to their own health. For individuals who did not rate their health at the top of the visual analog scale, the average difference was 6.7 points on a scale of 0 to 100. The relationships between blindness and visual impairment and the number of informal care days were not statistically significant—likely because of a small number of observations.

The sensitivity analysis using the logarithm of costs implies that the effects of blindness and visual impairment are approximately 40% and 70%, respectively, of the magnitude in the linear regressions. Individuals with blindness had \$843 (95% confidence interval, \$803-\$882) in excess expenditures compared with individuals without visual impairment. Individuals with visual impairment had \$704 (95% confidence interval, \$693-\$714) in excess expenditures in comparison with individuals without visual impairment. These differences remain highly significant.

**Figure 1** shows ORs for having nonzero levels of expenditure components. Most ORs are near 1, implying no difference in the odds of experiencing costs. Individuals with blindness have significantly higher odds of positive home health care expenditures (OR, 2.1; 95% confidence interval, 1.6-2.8), particularly from private providers (OR, 3.8; 95% confidence interval, 2.2-6.5). **Figure 2** shows extra (or diminished) expenditures for each expenditure component among those with positive expenditures. In-

**Table 2. Excess Total Health Care Expenditures, Excess Informal Care Days, and Health Utility Loss for Individuals With Blindness or Some Visual Impairment Compared With Individuals Without Visual Impairment Using 1996-2002 Medical Expenditure Panel Survey Data**

Outcome Measure	Vision-Related Independent Predictor	Vision Measures Only in Regression*		All Variables in Regression†	
		Excess Expenditures, Excess Informal Care Days, or Utility Loss	95% CI	Excess Expenditures, Excess Informal Care Days, or Utility Loss	95% CI
Total expenditure, 2004 \$	Blindness	4988	3623 to 6354	2157	860 to 3454
	Visual impairment	3105	2637 to 3573	1037	559 to 1514
Informal care days	Blindness	6.3	2.3 to 10.3	5.2	1.3 to 9.1
	Visual impairment	2.0	1.4 to 2.5	1.2	0.6 to 1.7
Societal health utility	Blindness	-15.03	-18.85 to -11.21	-7.46	-10.65 to -4.28
	Visual Impairment	-11.35	-12.41 to -10.29	-4.84	-5.69 to -3.98
Self-rated health utility	Blindness	-15.53	-19.20 to -11.85	-6.73	-9.66 to -3.81
	Visual impairment	-11.97	-13.08 to -10.87	-4.43	-5.20 to -3.67

Abbreviation: CI, confidence interval.

\*Linear weighted regression accounting for complex sample design.

†Other variables included in a linear weighted regression accounting for complex sample design were sex, race, education, insurance status, age, diabetes, hypertension, income, and family size.

**Table 3. Two-Part Model Results Comparing Individuals With Blindness and Individuals With Some Vision Impairment With Individuals Without Visual Impairment in the 1996-2002 Medical Expenditure Panel Survey Data**

Outcome Measure	Vision-Related Independent Predictor	Logistic Regression* OR (95% CI)	Linear Regression†		
			Excess Expenditures, Excess Informal Care Days, Or Utility Loss	95% CI	Individuals, No.
Total expenditure, 2004 \$	Blindness	1.15 (0.74 to 1.80)	2221	853 to 3589	484
	Visual impairment	1.50 (1.30 to 1.72)	1043	540 to 1546	5934
Informal care days	Blindness	3.13 (1.98 to 4.95)	26	-32 to 84	30
	Visual impairment	1.95 (1.56 to 2.42)	-3	-20 to 14	208
Societal health utility	Blindness	0.38 (0.23 to 0.64)	-5.33	-8.41 to -2.25	179
	Visual impairment	0.55 (0.49 to 0.63)	-3.45	-4.37 to -2.54	2516
Self-rated health utility	Blindness	0.61 (0.24 to 1.59)	-6.66	-9.50 to -3.82	321
	Visual impairment	0.53 (0.38 to 0.72)	-4.09	-4.83 to -3.34	3607

Abbreviations: CI, confidence interval; OR, odds ratio.

\*Weighted logistic regression accounting for complex sample design describing the odds of having nonzero medical care expenditures, informal care days, or health utility less than 1. Analyses control for sex, race, education, insurance status, age, diabetes, hypertension, income, and family size. The number of observations for all logistic regressions is 77 511.

†Weighted linear regression accounting for complex sample design describing the differences in medical expenditures, informal care days, and health utility for individuals with nonzero medical care expenditures, informal care days, or health utility less than 1. Analyses control for sex, race, education, insurance status, age, diabetes, hypertension, income, and family size. The observations in the linear regressions include 68 917 individuals who had nonzero expenditures, 718 individuals with informal care provided by individuals living outside the household, 22 333 individuals who indicated some problem with at least 1 domain not at its optimal level for the societal health utility analysis, and 31 339 individuals who rated their health as less than 100 on a visual analog scale.

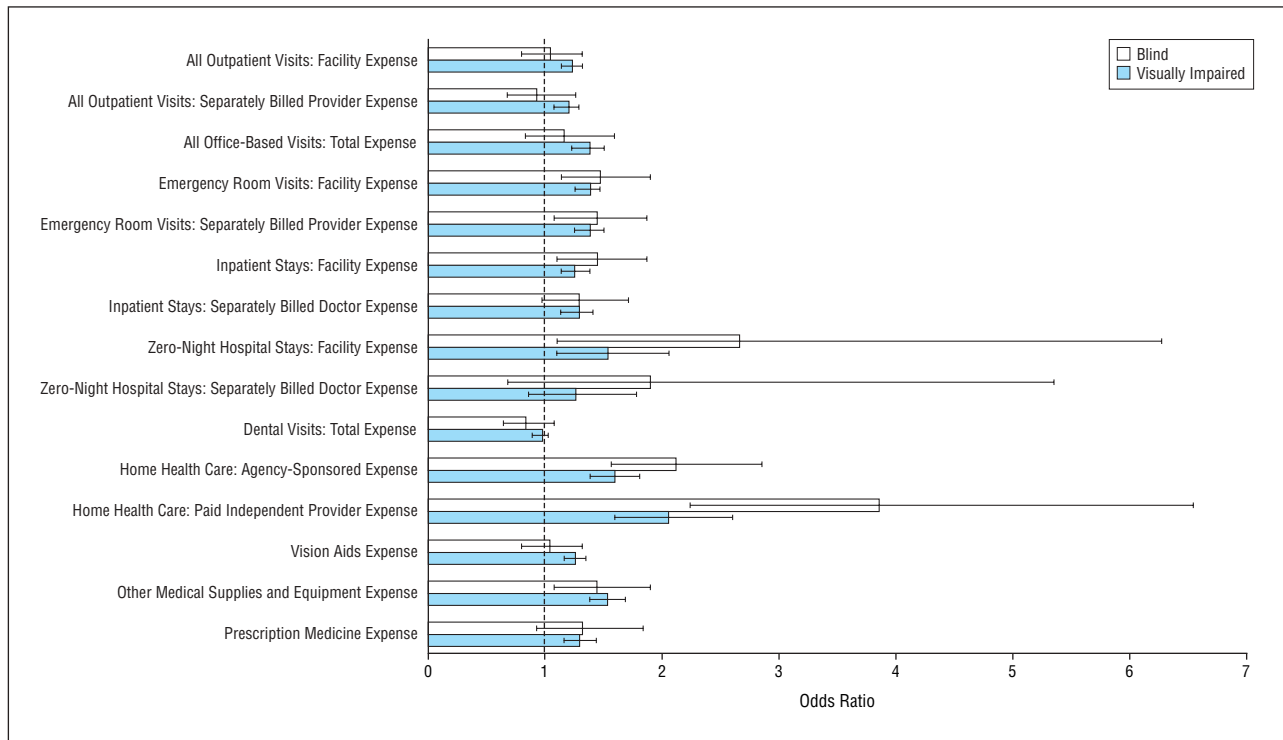
dividuals with blindness who use home health agencies have expenditures that are \$4900 more than those for individuals without visual impairment who have home health agency expenditures ( $P = .005$ ). Individuals with blindness who use private home health providers have expenditures that are \$1200 more than those for individuals without visual impairment who use private home health providers (although not statistically significantly [ $P = .60$ ]).

**Table 4** summarizes the total annual economic impact for the US population. Using previous data on prevalence<sup>19</sup> and the most recent population figures available from the US Census Bureau,<sup>20</sup> the number of cases of blindness and visual impairment were estimated to be 1.1 million and 2.6 million, respectively, in 2004. Total excess medical care expenditures for the visually impaired

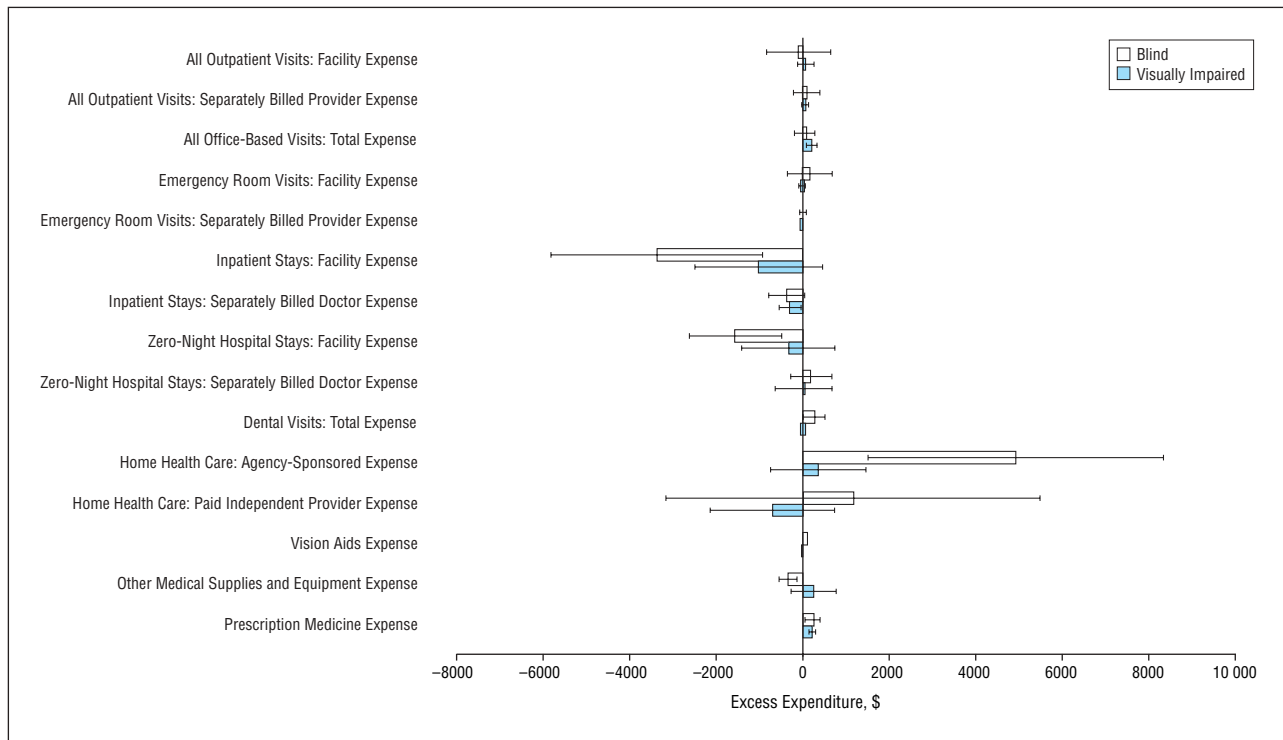
and blind populations are \$5.1 billion, primarily owing to home care. The sensitivity analysis using the logarithmic transformation implied excess expenditures of \$2.8 billion. Assuming that each day of extra informal care requires 8 hours of work valued at minimum wage, the total value of the equivalent of 40 000 full-time caregivers was \$0.4 billion. This total monetary cost was more than \$5.5 billion. Additionally, more than 209 000 QALYs were projected to be lost each year.

#### COMMENT

The annual monetary impact of more than \$5.4 billion represents almost \$1400 per year for each of the 3.7 million



**Figure 1.** Odds of nonzero medical care expenditure components for individuals with blindness and visual impairment compared with those with no visual impairment. Error bars indicate 95% confidence intervals.



**Figure 2.** Excess dollars spent by individuals aged 40 years and older with blindness and visual impairment in comparison with individuals aged 40 years and older with no visual impairment for each medical care expenditure component. Error bars indicate 95% confidence intervals.

individuals who are visually impaired or blind. At this rate, an individual would accumulate \$10 000 of excess expenditure in only 8 years, even when discounting money spent in the future.<sup>21</sup> Although there is controversy about placing a dollar value on QALYs, some researchers have con-

verted QALYs to dollars to conduct cost-benefit analyses.<sup>22</sup> In the United States, a common but arbitrary value for a QALY is \$50 000.<sup>23</sup> Applying this value would imply that QALYs lost are valued at more than \$10 billion and that the total annual economic impact is nearly \$16 bil-

**Table 4. Total Economic Impact of Blindness and Visual Impairment**

	Blindness (95% CI) (n = 1 138 256)*	Visual Impairment (95% CI) (n = 3 705 921)*	Total (95% CI)
Individual excess medical expenditures, mean, \$	2157 (860-3454)	1037 (559-1514)	NA
Excess medical expenditures, \$	2 454 969 053 (978 723 137-3 931 214 969)	2 661 484 407 (1 435 825 009-3 887 143 806)	5 116 453 461 (2 414 548 146-7 818 358 775)
Individual excess informal care days, mean, No.	5.2 (1.3-9.1)	1.2 (0.6-1.7)	NA
Value of excess informal care days, \$	242 047 070 (58 826 058-425 268 081)	123 779 021 (68 175 294-179 382 747)	365 826 090 (127 001 352-604 650 829)
Total annual monetary impact, \$	NA	NA	5 482 279 551 (2 541 549 498-8 423 009 604)
Individual QALYs lost, mean, No.†	0.07 (0.04-0.11)	0.05 (0.04-0.06)	NA
Population QALYs loss, No.	84 954 (48 665-121 243)	124 248 (102 296-146 200)	209 202 (150 961-267 443)

Abbreviations: CI, confidence interval; NA, not applicable; QALY, quality-adjusted life year.

\*From *Vision Problems in the US: Prevalence of Adult Vision Impairment and Age-Related Eye Disease in America*.<sup>19</sup>

†Assuming that the single health utility measurement applies to the entire year.

lion. In any decision about resource allocation for the prevention or treatment of eye disease leading to visual impairment or the rehabilitation of patients with visual impairment, the fraction of the \$16 billion figure that could be offset should be considered.

The \$4000 per person per year economic impact including QALY losses is different from the annual cost to the federal government described by Chiang et al.<sup>2</sup> Chiang and colleagues indicated an annual cost in 1990 of \$11 896 per individual with blindness and of working age and a total cost to the federal government of only \$4 billion. Their analysis included income support and tax credits. In contrast, the only cost in the analysis that could be directly attributed to the federal government would be the cost of treatment paid for by Medicare or Medicaid (for the federal share) and the taxes lost when informal care providers do not work for pay.

Previous studies<sup>2</sup> of the economic effect of blindness and visual impairment in the United States did not provide detailed information on home care provided by agencies that was not covered by insurers, personal care services paid for by the individual with visual impairment or his or her family, or informal care. Excluding these aspects of care for individuals with visual impairment would have limited the estimated total economic impact. Although the estimates here suggest that a large quantity of resources is dedicated to care for individuals with visual impairment at home, even more resources likely would be necessary if these individuals were moved to institutional care.

The importance of care at home may also manifest in hospital expenditures. Individuals with blindness who were admitted for inpatient care had lower expenditures than individuals without visual impairment who were admitted for inpatient care. This suggests a difference in case mix not picked elsewhere in the analysis. Individuals with blindness may be admitted for less serious conditions for which they do not have sufficient care to remain in the home, resulting in a lower average expenditure per admission.

The estimated effect of visual impairment on health utility is smaller than that found in other studies of individuals with blindness or of the general population's perceptions of blindness in which blindness was associated with a loss of 0.4 on a scale in which 0 is equivalent to death and 1 is equivalent to perfect health.<sup>16,24</sup> The finding does not preclude the possibility that the short-run impact of losing vision would be a substantial quality-of-life decrement. Rather, the result suggests that individuals with visual impairment and blindness who remain in the community have a higher quality of life than might be expected. Individuals with blindness likely adapt over time. Further research on the evolution of quality of life for individuals with blindness would clarify this point.

This study has several limitations. First, the estimate of the economic impact is limited because it does not include productivity loss among the individuals with blindness and visual impairment. Second, even when pooling 7 years of data, the number of individuals with blindness was relatively small. This problem is most important for the estimation of quality-of-life-effects; the EQ-5D was administered along with surveys that were used to construct annual figures from 2000 to 2002.

Further, the combined self-reported categories are not exactly aligned with the categories of not visually impaired, low vision, and legally blind. However, these data are the best available in a large national survey that also characterizes expenditures, informal care, and health-related quality of life. If individuals are nondifferentially mischaracterized, the measurement error will bias the estimated differences toward no statistically significant difference. If individuals who are legally blind did not describe themselves as blind, this would also bias toward a smaller difference between individuals with blindness and visual impairment. More research on the relationship between self-report and measured visual acuity would indicate whether large, national, self-reported data sets are useful for refining estimates of the burden of visual impairment.

The finding regarding home care adds to the literature describing community-based supports for individuals living with disability. Policymakers interested in alleviating the burden of blindness should be aware of the burden on caregivers and the burden of finding and paying for home health care.

Any economic evaluation of ophthalmic public health measures should consider the cost of the measure and the degree to which the many components of the burden of visual impairment and blindness described here could be reduced.

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