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The Economic Burden of Vision Loss and Blindness in the United States

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Purpose: To estimate the economic burden of vision loss (VL) in the United States and by state.

Design: Analysis of secondary data sources (American Community Survey [ACS], American Time Use Survey, Bureau of Labor Statistics, Medical Expenditure Panel Survey [MEPS], National and State Health Expenditure Accounts, and National Health Interview Survey [NHIS]) using attributable fraction, regression, and other methods to estimate the incremental direct and indirect 2017 costs of VL.

Participants: People with a yes response to a question asking if they are blind or have serious difficulty seeing even when wearing glasses in the ACS, MEPS, or NHIS.

Main Outcome Measures: We estimated the direct costs of medical, nursing home (NH), and supportive services and the indirect costs of absenteeism, lost household production, reduced labor force participation, and informal care by age group, sex, and state in aggregate and per person with VL.

Results: We estimated an economic burden of VL of $134.2 billion: $98.7 billion in direct costs and $35.5 billion in indirect costs. The largest burden components were NH ($41.8 billion), other medical care services ($30.9 billion), and reduced labor force participation ($16.2 billion), all of which accounted for 66% of the total. Those with VL incurred $16 838 per year in incremental burden. Informal care was the largest burden component for people 0 to 18 years of age, reduced labor force participation was the largest burden component for people 19 to 64 years of age, and NH costs were the largest burden component for people 65 years of age or older. New York, Connecticut, Massachusetts, Rhode Island, and Vermont experienced the highest costs per person with VL. Sensitivity analyses indicate total burden may range between $76 and $218 billion depending on the assumptions used in the model.

Conclusions: Self-reported VL imposes a substantial economic burden on the United States. Burden accrues in different ways at different ages, leading to state differences in the composition of per-person costs based on the age composition of the population with VL. Information on state variation can help local decision makers target resources better to address the burden of VL. *Ophthalmology 2022;129:369-378 © 2021 by the American Academy of Ophthalmology*

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According to the 2017 American Community Survey (ACS), approximately 2.45% (7.97 million) of Americans self-reported blindness or serious difficulty seeing even when wearing glasses.[1] Other studies estimate that 7.08 million Americans have uncorrectable visual acuity of 20/40 or worse in the better-seeing eye.[2] Vision loss (VL) and blindness result in economic impacts from increased medical costs, a higher risk of nursing home (NH) placement, and productivity losses. The burden of VL and eye problems in the United States was estimated last in a white paper to be $155.5 billion, with the VL-attributable components valued at $89.3 billion in 2017 dollars[3]; however, no peer-reviewed studies have estimated the burden of VL since 2007.[4,5]

Earlier VL burden studies estimated the costs of all eye care, primarily defined impairment as only uncorrectable VL, and estimated state burden by allocating national totals to states based on demographics.[3,4] Estimates could better inform public health policy by focusing on only those costs that result from VL (excluding costs of non-VL eye care), expanding the definition of VL to include anyone with self-reported VL (regardless of whether that VL is correctable), and accounting for state differences in VL prevalence, medical, and labor costs.

This study was designed to provide these improvements. We generate estimates of the economic burden related to self-reported VL regardless of whether this VL is correctable because uncorrected refractive error is a large source of vision morbidity in the United States, and studies that ignore it will underestimate VL burden and the potential benefits of public health intervention.[6] Our study also developed state burden estimates using state-specific data, thereby improving the accuracy of information available to inform state public health practice. Finally, we exclude the costs of eye care that are unrelated to VL to provide a clearer picture of the burden of VL itself. This article is accompanied by an

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online technical report to provide more in-depth methods and an online toolkit to disseminate detailed state results.

Methods

Using the societal perspective and following an analytic framework used previously for diabetes, we estimated the 2017 direct and indirect costs and Social Security payments associated with VL for each state and Washington, DC.[7] Social Security payments are not included in the burden total and are reported as separate costs. We use a top-down approach for the direct costs of medical and NH services and the indirect costs of productivity losses, and we use bottom-up methods for the direct costs of supportive services.[7-9] We estimated all costs in aggregate and per person with VL stratified by state, age group (0−18 years, 19−64 years, and 65 years and older), and sex (male or female) and calculated national costs as the sum of state estimates. Estimating burden components involved calculating each cost component's incremental use per person with VL, the value of each unit, and the number of people who used the component. We used state-level data wherever possible, and all cost estimates include state-level data for at least 1 component (Table 1). Medical costs were inflated to 2017 values based on National Health Expenditure Account data, and nonmedical costs were inflated to 2017 values using the Consumer Price Index for All Urban Consumers.[10] Individual patient-level consent was not required. The NORC Institutional Review Board acknowledges that this study does not require IRB review. All research adhered to the tenets of the Declaration of Helsinki.

Surveys used to create the estimates have different sampling frames, respondents, and response rates that may limit our analysis. For example, the ACS includes all Americans regardless of their housing status, asks the head of household to respond for all household members, and had a 93.7% response rate in 2017.[11] The National Health Interview Survey (NHIS) includes persons in noninstitutionalized settings, asks a family respondent to answer for members of each family, and had a 66.5% response rate in 2017.[12] The Medical Expenditure Panel Survey (MEPS) respondents are drawn using the NHIS sampling frame from the prior year.[13] In this study, we used pooled data from the 2014 through 2016 MEPS with response rates of 48.5%, 47.7%, and 46.0% in each year of collection, respectively.[14] National and State Health Expenditure Accounts (N/SHEA) data are estimates developed from multiple data sources by the Centers for Medicare and Medicaid Services (CMS) Office of the Actuary, National Health Statistics Group.[15] The specific sections below describe the information required to define each target estimate and the data and assumptions used to create them; however, readers should refer to the technical report and cited sources for additional details.

Vision Loss Prevalence

We estimated the prevalence of VL for 306 mutually exclusive groups defined by age, sex, and state as the proportion of each category that endorsed the question, "Are you blind or do you have serious difficulty seeing, even when wearing glasses?" asked in the 2017 ACS.[16]

Direct Costs

Medical Costs. We used an attributable fraction (AF) approach to estimate the proportion of 4 categories of medical services that were caused by VL: (1) hospital care, defined as services conducted in a hospital including inpatient, hospital outpatient, hospital-based NH, emergency care, and ancillary services; (2) ambulatory care, defined as physician, clinical, and other professional services; (3) prescription care, defined as prescription drugs and nondurable medical equipment; and (4) other medical care, defined as durable medical equipment that includes the costs of eyeglasses, contact lenses, and other ophthalmic products; home health care, which includes medical care provided in the home by freestanding home health agencies; other health, residential, and personal care, which includes the cost of Medicaid home-based and community-based waivers, and ambulance services; and dental care (not likely related to VL but included in other services). We then multiplied age group by sex by state estimates of AF by estimates of all-cause expenditures in each state reported in the CMS State Health Expenditure Accounts (SHEA).[15]

Estimating AF requires the estimation of cost ratios, adjustment factors, and prevalence[8]:

$$AF_{i,j,t} = \frac{pVL_{i,j} \times \left(CR_{j,t^{-1}}\right) \times \left(1+\varphi_{j,t}\right)}{pVL_{i,j} \times CR_{j,t} \times \left(1+\varphi_{j,t}\right) + \left(1-pVL_{i,j}\right)}, \quad (1)$$

where AF is the AF estimate, pVL is the prevalence proportion of VL, CR is the cost ratio, $(1+\varphi)$ is the factor used to adjust for differences between people with VL and people without, i indexes the state of interest, j indexes the age group by sex category of interest, and t indexes the service type.

We estimated cost ratios and adjustment factors for each cost category using data from the 2014 through 2016 MEPS using a 2-part health expenditure regression model, a model developed to account for data that have an abundance of 0 values, and a skewed distribution for the remaining values.[17] We estimated the model in Stata software version 15.1 (StataCorp) using the tpm command and used the postestimation margins command to create inputs for cost ratios and adjustment factors. The AF was then multiplied by the total costs by age group and sex in each state for each service category to estimate burden (Appendix, available at www.aaojournal.org).

Nursing Home Costs. Nursing home costs are defined as costs occurring in North American Industry Classification Code 6231 (nursing care facilities) and 623311 (continuing care retirement communities with on-site nursing care facilities).[15] We estimated NH costs using an AF approach and several assumptions. Because of a lack of access to person-level NH data, we conservatively assumed that the NH cost ratio was equal to 1 (meaning that VL does not increase the per-person cost of NH placement), reducing the AF equation to the prevalence of VL in NH minus the prevalence of VL among people in the community. We estimated the prevalence of VL in NH facilities in each state using the 2017 CMS Minimum Data Set (MDS), defining VL as an MDS assessment of impaired vision or worse, and the community prevalence of VL using the 2017 ACS, assuming that the prevalence for those 65 years of age and older was most comparable with MDS data.[18] We created 1 AF for each state and multiplied this by the SHEA estimates of NH costs. We allocated state totals by age group and sex using national distributions observed in the CMS National Health Expenditure Accounts.

Supportive Services Costs. Using bottom-up methods, we estimated the costs of 4 categories of supportive services: (1) federal support programs for the blind that purchase items such as Braille books and rehabilitative equipment and services, (2) vision rehabilitation (including privately funded low-vision services, occupational therapy, low-vision adaptations, and assistive technologies), (3) special education for blind children, and (4) school vision screening programs.

Federal support program costs were estimated as the sum of 2017 budgetary expenditures for the American Printing House for the Blind, the National Library Service for the Blind and Physically Handicapped, the Committee for Purchase program, and the

Table 1. Data Sources Used to Estimate Incremental Differences in Use per Person, Value of Use per Person, Number of People Who Consumed Each Service, and Estimation Elements That Accounted for State Differences

Variable	Difference in Use per Person*	Value of Use per Person†	People Who Consumed Service‡	State Differences Accounted for§
Direct costs				
Medical costs, ambulatory, prescription, and other medical care	MEPS 2014–2016	NHEA 2014, SHEA 2014	ACS 2017	Value, persons
Nursing home care	Assumption	NHEA 2014, SHEA 2014	ACS 2017, MDS 2017	Value, persons
Support services				
Federal support programs	All costs attributable	United States budget, 2017	ACS 2017	Persons
Vision rehabilitation	All costs attributable	VisionServe Alliance	ACS 2017	Persons
Special education	All costs attributable	DOE, 2010	APH, 2019	Persons
School vision screening	All costs attributable	Published estimates	Published estimates	Persons
Indirect costs				
Productivity losses				
Absenteeism	NHIS 2016	BLS 2014	ACS 2017	Use (region), value, persons
Lost household productivity	NHIS 2016	BLS 2014	ACS 2017	Use (region), persons
Reduced labor force participation	NHIS 2016	BLS 2014	ACS 2017	Use (region), value (region), use (region), persons
Informal care	ATUS 2018	BLS 2014	ACS 2017	Persons
Other estimates items				
Reduced earnings	NHIS 2016	BLS 2014	ACS 2017	Use (region), persons
Federal budgetary transfers				
Social Security Insurance and Disability	SSA 2017	SSA 2017	ACS 2017, SSA 2017	Persons

ACS = American Community Survey; APH = American Printing House; ATUS = American Time Use Survey; BLS = Bureau of Labor Statistics; DOE = Department of Education; MDS = Minimum Data Set; MEPS = Medical Expenditure Panel Survey; NHEA = National Health Expenditure Accounts; NHIS = National Health Interview Survey; SHEA = State Health Expenditure Accounts; SSA = Social Security Administration.

*Data used to estimate the difference in services used by a person with vision loss as compared with services they would be expected to use if they did not have vision loss.

†Data used to estimate the cost per unit of service.

‡Data used to determine how many people with vision loss used each cost component.

§Components of burden estimate that accounted for differences by state: use indicates differences in use accounted for state differences, value indicates that value of use per person accounted for state differences, and persons indicates that the number of persons who consumed services incorporated state differences.

Independent Living Services for Older Individuals who are Blind program. We allocated this sum to states by age group and sex based on ACS prevalence. We estimated vision rehabilitation services based on program budget information reported by VisionServe Alliance, a trade association representing vision rehabilitation and other low-vision service industries. VisionServe reported their member organizations' program budgets to the authors in personal communications, and we allocated these costs to states using ACS data.[19] We estimated special education costs as the number of children in each state who, because of blindness, receive special education materials from the American Printing House for the Blind multiplied by the costs per student receiving special education reported by the Department of Education.[20] We estimated school screening costs from published sources on the number of states that conduct screening by grade level, the number of students per grade, and the cost per school and preschool screening.[21,22] We estimated transfer payments as the sum of payments for Supplemental Social Security Income and Social Security Disability Insurance for people who qualify because of blindness.

Indirect Costs

Using top-down methods, we estimated 5 categories of indirect costs that together represent productivity losses: absenteeism, lost household production, reduced labor force participation, reduced earnings, and informal care.

Absenteeism. We defined absenteeism as the number of lost workdays attributable to VL estimated using 2016 through 2017 NHIS data using a 2-part regression model restricted to working people 19 years of age and older. The model estimated a continuous response to the NHIS question, "During the past 12 months, about how many days did you miss work at a job or business because of illness or injury (do not include maternity leave)?" as a function of VL and covariates. Vision loss was defined as a yes response to the NHIS question, "Do you have trouble seeing, even when wearing glasses or contact lenses?" We controlled for age, age squared, sex, Census region, race or ethnicity, education, source of insurance, marital status, work industry, and other comorbidities and used the Stata postestimation margins command to estimate the marginal impact of VL by region, age group, and sex and used the same regional estimates for each state in the region. We used data from the 2014 Bureau of Labor Statistics to estimate the value of a lost work day by state, age group, and sex, assigning Census region estimates of lost work days to all states within that region.[23] We multiplied estimates of the incremental difference in annual lost work days for those with VL by the value of each lost work day by the number of working people with VL in each state to estimate annual absenteeism costs attributable to VL by state.

Lost Household Production. We defined lost household production as the monetary value of nonpaid household productivity, such as home maintenance and childcare, that is lost because of VL. We used the same data sources and analytic methods as absenteeism with the exception of the variable used to estimate days of labor lost and the valuation of this labor. To measure lost household production, we set the dependent variable of our model to the 2016 through 2017 NHIS question, "During the past 12 months, about how many days did illness or injury keep you in bed more than half of the day? (include days while an overnight patient in a hospital)." We estimated the national average value per day of household production as the aggregated 2017 value of household production estimated by the Bureau of Economic Analysis divided by the United States population 19 years of age and older by sex and divided by 365 days.[24] Because household production refers to nonpaid labor maintaining the home, it is not duplicative of absenteeism costs.

Reduced Labor Force Participation. We defined reduced labor force participation as the proportion of people in the NHIS who do not work because of a disability that is attributable to VL. We used logistic regression to estimate the probability of not working because of vision as a function of VL controlling for covariates described above, then estimated the marginal difference in the expected probability of working for people with VL by age group and sex. We multiplied the marginal difference by the prevalent population of nonworking people with VL in each state to estimate the incremental number of people who did not work but who would have if they did not have VL. We multiplied these estimates by estimates of annual mean wages by age group, sex, and state taken from the Bureau of Labor Statistics.[23]

Reduced Earnings among Those Who Work. Using 2016 through 2017 NHIS data, we estimated reduced earnings among working adults ($\geq$19 years of age) with VL as the reduction in earnings conditional on being employed using a generalized linear model with a γ distribution and a log link. We restricted the NHIS sample to only those who worked, then created the dependent variable for the model using the NHIS-reported personal earnings. Because 2016 through 2017 NHIS assigns earnings only by bracket, we assigned the mean value for each bracket to all persons in that bracket for use as the dependent variable and controlled for age group, sex, Census region, race or ethnicity, education, insurance status, and comorbidities and additionally controlled for missed work days to avoid double-counting absenteeism estimates. We used the Stata postestimation margins command to estimate incremental impacts by age group and sex at the national level only because regional estimates exhibited high relative standard error. We multiplied the reduced earnings estimates by the prevalent working population with VL in each state by age and sex to estimate reduced earnings resulting from VL.

Informal Care. We defined informal care costs as the value of additional labor required to care for children and adults with VL. These costs are calculated based on the people with VL receiving care rather than caregivers. For children 0 to 18 years of age, we defined informal care as the incremental increase in the number of hours spent caring for children with VL relative to children without VL. We first estimated the average number of informal care hours per day required to care for a child without VL using the American Time Use Survey: 2.1 hours for children 6 years of age or younger and 50 minutes for children 7 to 18 years of age. We then multiplied these estimates by a coefficient representing the additional time required to care for children with VL using published estimates.[25,26] For people 40 years of age and older, we used published estimates of the yearly number of informal care days required for people with vision impairment (1.2 days) and blindness (5.2 days) and created a weighted average number of days (1.87 days) for all people with VL using the proportion of all visually impaired people who are blind as reported in the composite prevalence estimates from the Centers for Disease Control and Prevention's Vision and Eye Health Surveillance System.[1,5] We valued days of informal care using the mean adult wage by state from the Bureau of Labor Statistics and multiplied these values by the state-specific prevalence of VL by age group and sex.

Social Security Payments

We estimated Social Security transfer payments to provide policy-relevant information but did not include these costs in the total burden estimate. Social Security payments represent those paid to people who qualify based on being legally blind and represent transfers of wealth from taxes to individual citizens with no net impact on burden.

Univariate Sensitivity Analysis

We tested the sensitivity of the burden estimates to assumptions about the medical cost model, the prevalence of VL in NHs and the community, the dependent variable used to measure reduced earnings, and the exclusion of fringe benefits from productivity losses.

Results

Total Burden

We estimated the total economic burden of VL in the United States at $134.2 billion in 2017: $98.7 billion in direct costs and $35.5 billion in indirect costs (Table 2). The largest burden components were NH care ($41.8 billion), other medical care ($30.9 billion), and reduced labor force participation ($16.2 billion), all of which accounted for 66% of the total. Other medical care, which included the costs of eyeglasses, contact lenses, and home health care services, accounted for 23% of the total burden. Vision rehabilitation accounted for most supportive service costs (72%), followed by special education (22%), federal support programs (3%), and school vision screening (3%). Reduced labor force participation accounted for the largest share of indirect costs (46%), followed by informal care (26%), reduced earnings (22%), lost household productivity (5%), and absenteeism (2%).

The economic burden varied by state based on the size and composition of the state population (Fig 1). The highest total burden was in California, New York, Texas, Florida, and Pennsylvania, and the lowest was in Wyoming, Vermont, Alaska, South Dakota, and North Dakota. Vision loss burden was $13.5 billion in California and $191 million in Wyoming (see https://www.cdc.gov/visionhealth/data/ for detailed state results).

Total burden also varied by age group and sex (Fig 2). Women accounted for 58% of the total burden, as compared with 42% for men. People 0 to 18 years of age accounted for 8% of all people with VL and generated 7% of the burden, people 19 to 64 years of age accounted for 51% of people with VL and generated 39% of the burden, and people 65 years of age and older accounted for 41% of people with VL and generated 54% of the burden.

Table 2. Total Burden of Vision Loss and Blindness by Cost Component, Sex, and Age Group in Millions of Dollars

Costs	Male Participants			Female Participants			Total, All Groups
	0–18 Years	*19–64 Years*	*65+ Years*	*0–18 Years*	*19–64 Years*	*65+ Years*	
Direct costs							
Medical and nursing home care							
Hospital care	79	1386	1033	74	1299	1283	5153
Ambulatory care	133	1895	2201	123	2588	2962	9902
Prescription care	66	1779	1446	48	1819	2419	7576
Other medical care	439	5011	6521	439	5381	13 080	30 871
Nursing home care	167	3738	11 002	118	3250	23 512	41 787
Other support services							
Federal support programs	13	6	27	14	6	43	109
Vision rehabilitation	48	270	695	50	284	1100	2446
Special education	301	64	0	316	68	0	749
School vision screening	53	0	0	54	0	0	107
Subtotal direct costs	**1297**	**14 150**	**22 925**	**1236**	**14 695**	**44 399**	**98 702**
Indirect costs							
Productivity losses							
Absenteeism	0	186	104	0	196	99	585
Lost household productivity	0	241	176	0	398	789	1603
Reduced labor force participation	0	7713	1470	0	6210	849	16 242
Informal care	3479	658	456	3428	663	667	9350
Reduced earnings	0	2832	289	0	4250	393	7765
Subtotal indirect costs	**3479**	**11 631**	**2495**	**3428**	**11 717**	**2797**	**35 547**
Total all costs	**4776**	**25 781**	**25 420**	**4664**	**26 413**	**47 196**	**134 249**
Other impacts not included in burden							
Social Security Insurance and Disability	104	626	741	109	659	1177	3416

Boldface differentiates between subtotals/totals and the components of those totals.

Costs per Person with VL

Nationally, VL costs $16 838 per person with VL. Costs per person with VL were highest among people 65 years of age and older, followed by children and adults 19 to 64 years of age. People 0 to 18 years of age had the highest informal care costs and the lowest medical and NH costs. People 65 years of age and older incurred the highest medical and NH costs and the lowest productivity losses, and people 19 to 64 years of age incurred the highest burden from reduced labor force participation.

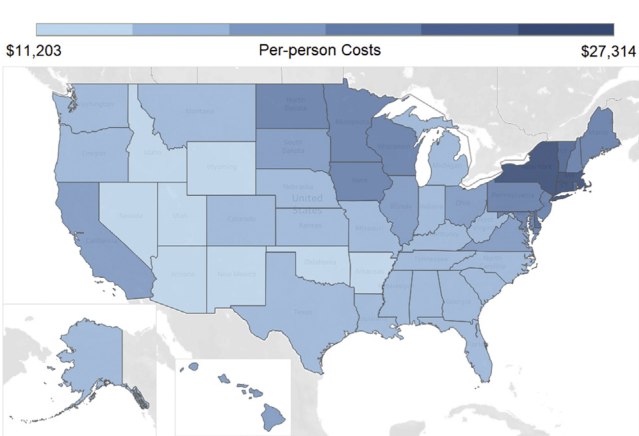

Figure 1. Map showing the state burden of vision loss or blindness per person with vision loss or blindness.

The highest average per-person costs were in New York, Connecticut, Massachusetts, Rhode Island, and Vermont, whereas the lowest were in Nevada, Arizona, New Mexico, Idaho, and Oklahoma (Fig 3). Medical costs contributed more than 50% of the burden in only 1 state and less than 40% in 22 states. Productivity losses contributed more than one-third of the burden in 6 states and less than 20% in 9 states. Nursing home costs contributed more than 40% of the burden in 9 states and less than 20% in 9 states. Supportive services contributed more than 3% of the burden in 8 states and less than 2% in 10 states.

Our total burden estimate was most sensitive to assumptions about VL prevalence in NH, the estimation of medical costs, and the dependent variable used to measure reduced earnings on the high end (Fig 4). Using a more conservative definition of VL in NH would have resulted in an estimate that is $32.1 billion lower, and using prevalence at all ages in the community instead of prevalence among those 65 years of age and older resulted in an increase in burden of $7.5 billion. Including self-reported health status to our model of medical costs reduced the burden by $18.9 billion, whereas controlling for fewer comorbidities increased the burden by $41.5 billion. Excluding reduced earnings from the burden estimate would have decreased the burden by $7.8 billion, whereas using household income instead of household earnings to measure reduced earnings would have increased our burden estimate by $34.7 billion. Setting all parameters to conservative or less conservative estimates resulted in a plausible range of estimated burden of between $76 and $211 billion.

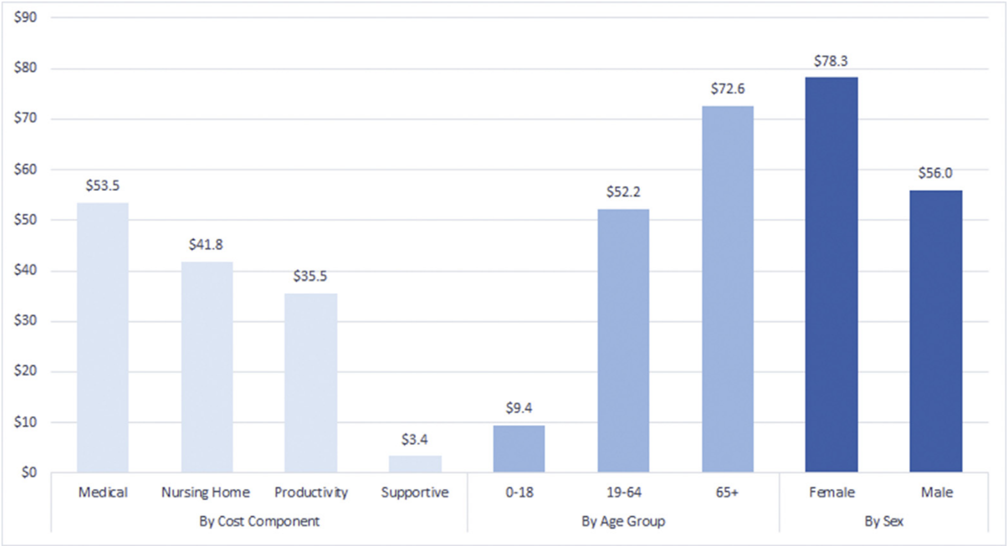

Figure 2. Bar graph showing the total burden of vision loss or blindness by burden component, sex, and age group in billions of dollars.

Discussion

We estimated an economic burden of VL of $134.2 billion ($98.7 billion in direct costs and $35.5 billion in indirect costs) for the United States population in 2017. State variations in total burden were driven primarily by state population size and age composition. Variations in per-person costs were associated with differences in NH costs and, to a lesser extent, medical and productivity costs. Our estimate was most sensitive to the specification of the econometric model to estimate incremental medical costs, using self-reported household income rather than wages to estimate reduced earnings among those with VL, and decisions about how to measure VL in the MDS in NH costs. Our burden estimate is subject to uncertainty and could plausibly range from $76 to $211 billion based on more or less conservative decisions regarding the estimate's inputs.

Our estimate is approximately $14.5 billion, or 10%, lower than that of Wittenborn and Rein,[3] who estimated the total economic burden of eye and vision problems to be $139 billion in 2013 ($149 billion when inflated to 2017). Our estimate of NH costs is $19.7 billion higher than the prior analysis, which is attributable to using SHEA data, rather than the lower, industry-reported annual costs of nursing home care used in the prior report. Our estimated medical costs are $18.2 billion lower than the prior estimate. This difference is likely attributable to the broader scope of medical costs in the prior study, which included costs associated with diagnosed eye disorders regardless of VL, whereas the current analysis considers only costs of VL. We report productivity losses $16.9 billion lower than the previous report, which may be the result of using the NHIS rather than the Survey of Income and Program Participation, as well as the use of personal wages instead of household income as the dependent variable.

Frick et al[5] used MEPS data to estimate the direct medical and informal care costs of vision impairment and blindness at $8.4 billion (after inflating to 2017 dollars), which is 13% of our estimate of $62.9 billion for a comparable combination of services. That study estimated costs only for those 40 years of age and older based on a 2004 estimate of 3.7 million people with VL, whereas our study used data from the 2017 ACS, which indicates that 7.97 million people self-reported VL; Frick et al[5] used MEPS data to estimate medical costs, which results in lower estimates than the N/SHEA. The N/SHEA reports approximately twice the health expenditures as predicted by the MEPS. Differences between aggregated N/SHEA and MEPS data are well documented, and the CMS relies on the N/SHEA to create its official estimate of total health care spending in the United States.[27] The N/SHEA data also capture the costs of nonmedical assistance with activities of daily living, an important source of expenditures for VL that are not captured by the MEPS.[28] Frick et al[5] also used self-reported health status as an independent variable in their prediction of health expenditures. Using this variable in our predictions reduced direct medical costs by approximately 34%. However, VL likely results in lower self-reported health status. Because of this, we chose to control for 15 comorbidities that are correlated with, but not caused by, VL. Frick et al[5] controlled for self-reported health status, hypertension, and diabetes.

Our study used the ACS prevalence of self-reported "blind or serious difficulty seeing even when wearing glasses" as its measure of VL (2.45%), which is higher than a recent meta-analytic estimate of all persons with uncorrectable vision impairment or blindness (2.17%).[2] In contrast, the ACS prevalence we used is lower than estimates of presenting acuity loss among persons 12 years of age and older seen in the National Health and Nutrician Examination Survey (6.4%) and lower than the estimated prevalence of VL for the high-income area of North America (5.0%) estimated by the Global Burden of Disease Project.[6,29] Thus, although our burden estimate

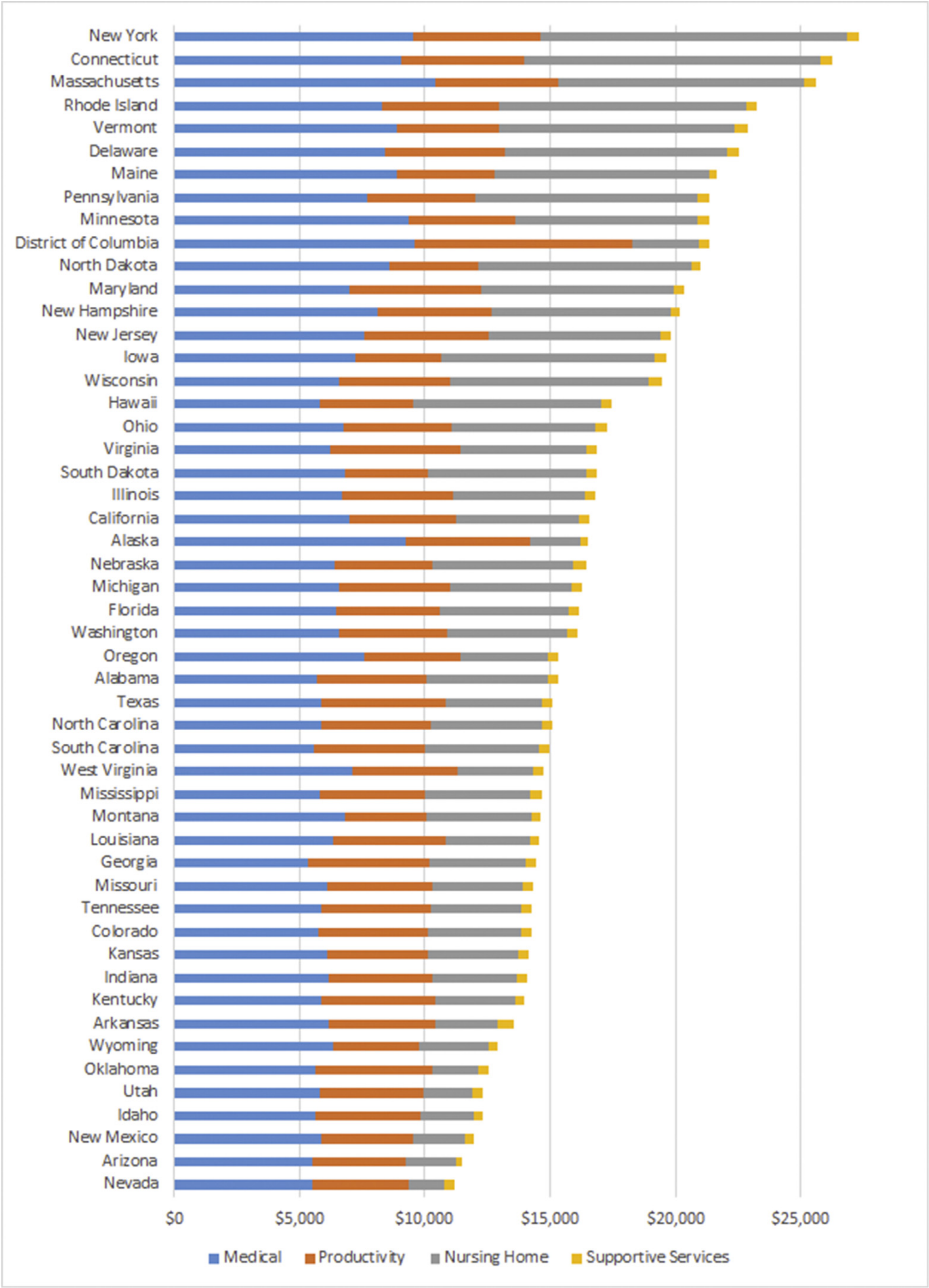

Figure 3. Bar graph showing the state burden of vision loss or blindness per person with vision loss or blindness by cost category and state.

likely includes some people with severe VL that may be correctable with proper refraction, it also likely excludes people who experience vision problems but do not consider themselves to be blind or have serious difficulty seeing even when wearing glasses, as measured by the ACS.

This study is limited by at least the following factors. First, we used publicly available national data from the MEPS instead of restricted-access data with state identifiers to estimate cost ratios. Additionally, publicly accessible NHIS data allow for estimation only at the Census region level, which we applied to all states within the region. Future studies should consider accessing restricted data sources to obtain state identifiers.

Second, the MDS data used to create estimates of VL prevalence within NHs are not measured identically to the ACS. The prevalence of low vision in NHs based on the

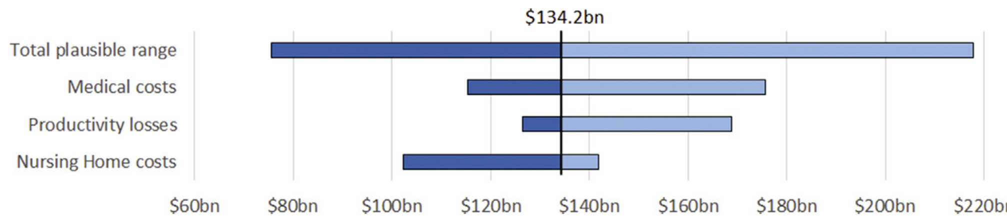

Figure 4. Bar graph showing the sensitivity of burden estimate to major model assumptions and assumptions related to medical, nursing home, and productivity cost inputs.

MDS measure is 29.8%, which is consistent with, although slightly less than, published evaluation-based studies of VL in NHs.[30−32] A more conservative definition of VL in NH would exclude people in the lowest level of MDS-assessed impairment defined as "sees large print but not regular print in newspapers/books" and would result in a prevalence of 12.1% and an NH burden of $9.7 billion, as compared with our estimate of $41.8 billion. Because of a lack of published NH cost data for people with VL, we assumed that that, after being placed in an NH, people with VL cost the same as people without VL, although people with VL likely require more care. Additionally, our analysis assumed that incremental NH placement is attributable to VL; however, some of these incremental costs may be attributable to other co-occurring causes. Finally, because public MDS was not differentiated by age, we compared the VL prevalence of patients in NHs with those in the community 65 years of age and older to calculate AF under the assumption that most patients in NHs were 65 years of age or older. Had we used the ACS prevalence for all ages in our calculation, our NH costs burden would have been $49.3 billion.

Third, our study used NHIS survey responses about missing work and days in bed as a result of one's health as proxy indicators of absenteeism and lost household productivity.[7] Use of these questions are in concordance with previous efforts to estimate these costs; however, their validity has not been evaluated and deserves additional study.

Fourth, although ideally our study would have used only top-down methods, because of data limitations, we used bottom-up methods to estimate certain support service costs.

Fifth, for ease of computation, we used the 2-part model framework for each continuous health outcome. This model is ideal for health expenditures; however, other model functional forms may be superior for inputs such as missed workdays.

Sixth, the number of parameters and data sources used in these analyses precluded us from conducting probabilistic sensitivity analyses. We instead provided univariate and multivariable sensitivity analyses to highlight the estimate's sensitivity to major assumptions, as well as comparisons with earlier estimates as a basis for validation.

Finally, unlike prior studies, our estimates do not include costs of vision or eye-related services among people without VL, which would capture the cost of eye disorders that do not or have not yet caused VL. This narrower perspective is responsible for the lower topline estimate, as compared with earlier work.[3]

In conclusion, the estimated economic burden of self-assessed VL was $134.2 billion in 2017. More than 66% of the burden resulted from the costs of the other medical services category, NH care, and reduced labor force participation. At the state level, total costs varied primarily by the size of the state population. Per-person costs varied based on differences in NH costs primarily, followed by differences in health care costs and wages.

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Author Contributions:

Conception and design: Rein, Wittenborn, Zhang, Ahmed, Saaddine

Analysis and interpretation: Rein, Wittenborn, Zhang, Ahmed, Lundeen, Saaddine

Data collection: Rein, Wittenborn, Ahmed, Lamuda

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Overall responsibility: Rein, Wittenborn, Zhang, Ahmed, Lundeen, Saaddine

Abbreviations and Acronyms:
ACS = American Community Survey; **AF** = attributable fraction; **CMS** = Centers for Medicare and Medicaid Services; **MDS** = Minimum Data Set; **MEPS** = Medical Expenditure Panel Survey; **NH** = nursing home; **NHIS** = National Health Interview Survey; **N/SHEA** = National and State Health Expenditure Accounts; **SHEA** = State Health Expenditure Accounts; **VL** = vision loss.

Keywords:
Absenteeism, Blindness, Burden of disease, Cost of illness, Direct medical costs, Economic burden, Labor force participation, Nursing home costs, Productivity losses, Vision loss.

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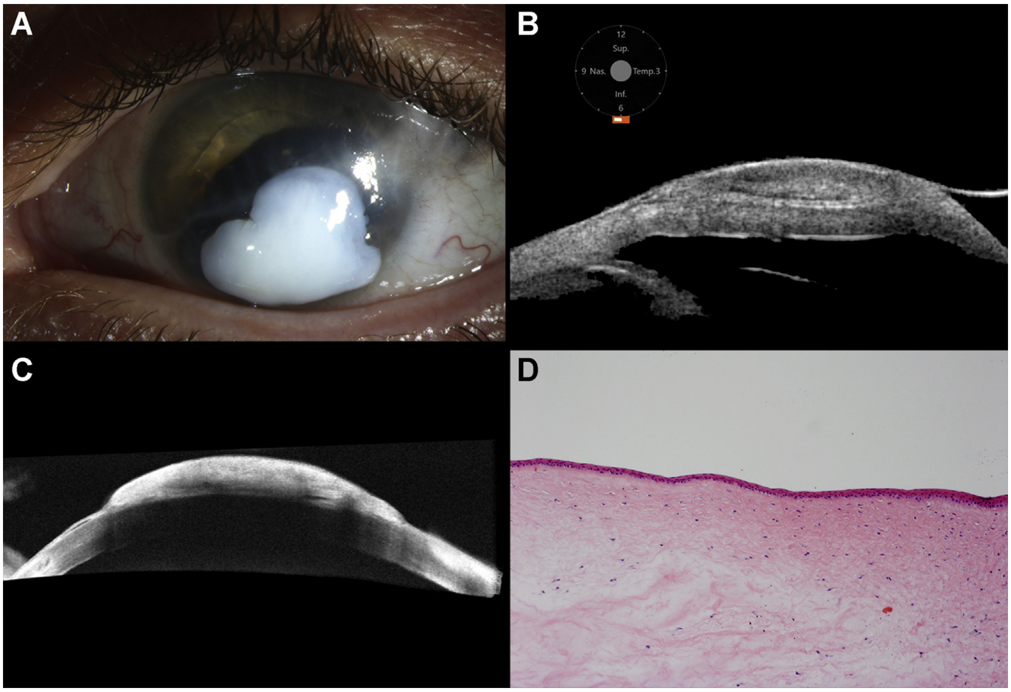
Pictures & Perspectives



Multimodal Imaging and Histopathology Features of a Corneal Keloid

A 38-year-old man with prior penetrating corneal injury from a fishhook presented with left eye opacity, which developed 26 years after trauma. Examination showed a corneal keloid extending inferiorly from the corneal scar (Fig **A**). Ultrasound biomicroscopy (UBM) and anterior-segment (AS) OCT demonstrated a lesion over the cornea that was separated from the corneal epithelium by a distinct plane and occasional clefts. The cornea and the lesion were clearly visualized on UBM, while the cornea was obscured by posterior shadowing in AS OCT (Fig **B**-**C**). Histopathology showed a fibrocellular tissue with bland-looking cells in a matrix of collagen and extracellular material (Fig **D**) (Magnified version of Fig **A**-**D** is available online at www.aaojournal.org).

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