TECHNICAL REPORT

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

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1.0 Objective

Objective: We estimated incremental state-level expenditures related to vision loss and blindness (VL) by using an attributable fraction (AF) approach. AF approaches have been used to estimate the costs of diabetes, obesity, substance use disorders, and other health conditions.[1-3] We first calculated our estimate by estimating the AF of each medical cost component at the state level, and then multiplied these state-level AF estimates by state-level estimates of health expenditures. Estimating the AF of costs that are related to vision loss is completed by developing data estimates to populate the following equation:

$$\text{Eq. 1.1} \quad AF_{i,j} = \frac{pVL_{i,j} \times (CR_{i,j} - 1)}{1 + pVL_{i,j} \times (CR_{i,j} - 1)}$$

Where "AF" is equal to the attributable fraction of medical costs associated with vision loss, "pVL" is equal to the prevalence of vision loss, "CR" represents the cost ratio of a person with vision loss as compared to what a person with vision loss would cost without vision loss, "i" indexes the state of interest, and "j" indexes the sex by age group category of interest. The Attributable Fraction in state i for age and sex group j is equal to the prevalence of vision loss i,j multiplied by the cost ratio i,j minus 1 divided by 1 plus the prevalence of vision loss i,j multiplied by the cost ratio i,j minus 1. A number of steps are required to estimate each input of this equation, with each estimation step involving multiple details. These AF estimates are then multiplied by state medical expenditures to estimate costs for each state, and these costs are divided by the estimated number of people in each state with vision loss to estimate costs per person with vision loss. Steps in the process include:

1. Estimating total health expenditures by service health service category by state;
2. Adjusting total health expenditure data to account for cost differences by age group and sex;
3. Estimating the prevalence of vision loss by state, sex, and age group;
4. Estimating cost ratios related to vision loss and blindness;
5. Estimating attributable fraction of health expenditures related to vision loss;
6. Combining information to estimate incremental health expenditures

We describe each step and how it was implemented for this study in the sections below.

1.1 Estimating total health expenditures by service health service category by state

National and State Health Expenditure Account Data are created by the Center for Medicare & Medicaid Services (CMS) Office of the Actuary (OACT) and provide aggregated health expenditures for the following categories of health service spending shown in Table 1.[4]

Table 1. Categories of Health Expenditures Contained in State Health Expenditure Account Data

Code	Description
1	Personal Health Care
2	Hospital Care
3	Physician & Clinical Services
4	Other Professional Services
5	Dental Services
6	Home Health Care
7	Prescription Drugs and Other Non-durable Medical Products
8	Durable Medical Products
9	Nursing Home Care
10	Other Health, Residential, and Personal Care
11	Population or Enrollment

In this analysis, we used State Health Expenditure Account (SHEA) data from 2014 (Available from https://www.cms.gov/Research-Statistics-Data-and-Systems/Statistics-Trends-and-Reports/NationalHealthExpendData/Downloads/resident-state-estimates.zip). We used 2014 data because this was the latest available year in which both SHEA and age group by sex stratified National Health Expenditure Account (NHEA) data were both available. We adjusted aggregated SHEA dollar values from 2014 values to 2017 values based on the ratio of total NHEA expenditures in 2017 compared to 2014. Based on guidance from the CDC's Diabetes State Toolkit, we collapsed detailed categories of costs into fewer categories that would be directly comparable to collapsed categories of costs collected in the Medical Expenditure Panel Survey (MEPS), which we used in a subsequent step to estimate cost ratios. Based on that guidance, we combined categories of costs in these data into the following 6 categories displayed in Table 2.[5]

Table 2. Categorization of SHEA Health Expenditures into Variables Used in the Analysis

New Variable	Description	SHEA Category
Hospital	Hospital Care	2
Ambulatory	Physician and Clinical Services, Other Professional Services	3, 4
Prescription	Prescription Drugs and Other Nondurable Medical Products	7
Other	Other including dental, DME, Home Health, Other Health, Residential, and Personal Care	5, 6, 8, 10
Nursing Home	Nursing Home	9
Total	All Costs	1 or sum(2:10)

We retained aggregated cost data from all persons in each state to allow for direct comparison of per capita costs using consistent population denominators in subsequent steps. Briefly described, Hospital Care or Inpatient costs are defined as services provided by hospitals to patients. Ambulatory Care costs include all costs associated with physician and clinical services provided in establishments operated by a medical doctor (M.D.) or doctor of osteopathic medicine (O.D.), outpatient care centers, and laboratory services billed independently of a hospital. These costs also include services provided by an M.D. or O.D. in a hospital setting if these costs were billed independently of a hospital. Also included in this category are costs billed by health providers other than physicians and dentists, such as optometrists, private-duty nurses, or occupational therapists. Prescription costs include the retail costs of drugs, biologics, and diagnostics that are available by prescription only. Other Care costs combine costs from three different categories of services that are highly impacted by vision loss and one category that is likely unaffected by vision loss: (1) Durable medical equipment, which includes the costs of eyeglasses, contact lenses, and other ophthalmic products; (2) Home health care, which includes medical care provided in the home by freestanding home health agencies; (3) Other health, residential, and personal care, which includes the cost of Medicaid home- and community-based service waivers, and ambulance services; and (4) Dental care. Nursing Home costs include costs from nursing home facilities and rehabilitative services provided in freestanding nursing homes. Estimation of nursing home costs are described in a subsequent section of this report but use this category of costs from the SHEA data. A full description of each category can be found in the CMS documentation.[4]

1.2 Adjusting total health expenditure data to account for cost differences by age group and sex

SHEA data provides aggregated expenditure information for all persons in a state but does not provide stratification of these expenditures by age group, sex, or other variables. Stratification at least by age group and sex is important as expenditures can vary substantially by these stratifications. The objective of this step was to stratify information from the SHEA data by age group and sex using information in the NHEA data and assumptions. NHEA data do contain information on aggregated health expenditure data by age group and sex, which are collected using the same methods as SHEA data, but do not include information on state.

In this step, we stratified SHEA state level estimates to account for differences by age group and sex under the assumption that states experience the same relative differences in expenditures by age group and sex as compared to overall expenditures as the differences that can be measured in national data.

To this we performed the following steps:

- Identified NHEA data for comparable year and cost categories (available for download: https://www.cms.gov/Research-Statistics-Data-and-Systems/Statistics-Trends-and-Reports/NationalHealthExpendData/Downloads/AgeandGenderTables.zip)
- Combined cost categories in NHEA data to match those estimated for SHEA data (Table 2)
- Created age groups that could be supported by MEPS data in subsequent steps of the analysis. We analyzed MEPS data from 2014, 2015, and 2016 to estimate sample sizes of persons who responded yes to ‘Serious problem seeing even when wearing glasses” and found at least 40 respondents in each unique age by sex group when we set age group by sex categories to:
  - Male 0 to 18
  - Male 19 to 64
  - Male 65+
  - Female 0 to 18
  - Female 19 to 64
  - Female 65+

We used these age by sex groups in our analyses and combined aggregated NHEA age group costs to fit these groups.

- Compared SHEA to NHEA: To check the concordance of the SHE and NHE data, we aggregated costs across all states and all categories in the SHEA data sum to the aggregated value for the NHEA data, as do costs for each category in the SHEA as compared to same category in the NHEA. Note that very small differences in the sums exist (presumably due to rounding), but these are never greater than .00001% of the total estimate.

- Created national cost ratios: We created cost ratios of the per capita cost for each sex by age group category as compared to the national overall per capita cost for each health expenditure group and for total expenditures.
- Stratified state costs: We used CPS population data to calculate state-level overall costs per capita for each expenditure category. We then divided each state per capita cost by its corresponding national per capita cost to estimate the relative per capita cost in each state as compared to the national cost. We then multiplied each of these relative expenditure category state per capita ratios by the corresponding set of national sex by age group cost ratios in order to estimate relative state costs by age group and sex for each health expenditure category. This resulted in 36 cost ratios for each state (6 age group by sex categories x 6 cost categories).
- Tested the overall fit of state sex by age group estimates: Using CPS data, we created weights in each state for each age group by sex category, which were equal to the proportion of the total state population represented by each age group by sex category. We then estimated the weighted sum of state weights in each cost category and compared them to the overall multiplier in that state. Stratification resulted in small differences between the unadjusted and the adjusted total expenditure value.
- We performed calibration to equalize the sum total of the adjusted state values so that they matched the totals from the unadjusted state values.

1.3 Estimating the prevalence of vision loss by state, age group, and sex

We used 2017 American Community Survey (ACS) data to estimate the prevalence of people with vision loss in each state by age group and sex as defined above. We defined vision loss as a response of "Yes" to the question "Are you blind, or do you have serious difficulty seeing even with glasses?" Prevalence was calculated as the raw number of respondents who answered "Yes" divided by the number of persons in the sex by age group category in each state after applying survey statistical weights. Several national surveys contain similar self-reported questions related to vision loss, including the National Health Interview Survey (NHIS) and the Behavioral Risk Factor Surveillance System (BRFSS). We chose to use the ACS measure due to its large sample size, high response rate, low year-to-year variability, and because its responses tend to track with the central tendency of measures taken across different national surveys.[6] Subsequent sections of this analysis use different surveys in statistical models to estimate the impact of vision loss on different burden inputs. However, across all analyses, the 2017 ACS was used to estimate the prevalence of vision loss in each state by age group and sex.

1.4 Estimating Cost Ratios Related to Vision Loss

Cost ratios are the estimate of the expected annual health expenditures of persons with vision loss divided by their expected annual health expenditures if they did not have vision loss. Cost ratios are needed to calculate AF estimates, which are then used to estimate incremental health expenditures related to vision loss. We explain our methods for estimating cost ratios in three sections: Data Sources for Cost Ratios (1.4.1), Estimating Health Expenditures with and without Vision Loss (1.4.2), and Estimating Cost Ratios (1.4.3).

1.4.1 Data Sources for Cost Ratios

We used pooled MEPS data from the years 2014, 2015, and 2016 to estimate the national relative expected costs of persons with vision loss as compared to all persons in each expenditure category, stratifying by age group and sex. Vision loss was defined as a response of "Yes" to the MEPS survey question "Are you blind, or do you have serious difficulty seeing even with glasses?" (Question: DFSEE42). Other questions exist in MEPS to differentiate the level of vision loss severity. Because the intent of this analysis was to match MEPS respondents to ACS data in order to calculate an AF for application to SHEA data, we used the DFSEE42 question which matches the ACS question "Are you blind or do you have serious difficulty seeing, even when wearing glasses?.

To support analysis we extracted data from the MEPS Household Component and Medical Provider Component on the costs of hospital inpatient, emergency room, outpatient, office-based provider, prescription medication, nondurable medical equipment, dental, vision, home health, and durable medical equipment. Table 3 shows the expenditures that we consolidated to match the expenditure categories from the NHEA and SHEA data.

Table 3. MEPS Expenditure Variables Categorized into Each Expenditure Analysis Variable

Analysis Variable	Description	Included MEPS Variables
HC	Hospital Care	Hospital Inpatient
Ambulatory	Ambulatory Care	Emergency Room, Outpatient, Office-based Provider
Rx	Pharmacy and nondurable medical	Prescription Medication, Nondurable Medical Equipment from other Medical Expenses
Other	Other including dental, DME, Home Health, Other Health, Residential, and Personal Care	Dental, Vision, Home Health, Durable Medical Equipment
NH	Nursing Home	Not in MEPS (see NH section)

From the Household component of the survey, we collected respondent information on:

- Vision loss (defined above)
- Age
- Sex across all categories
- Race/ethnicity
- 4-level Census Region
- Poverty level
- Insurance coverage (public, private, uninsured)
- The presence of the following comorbidities
  - Diabetes
  - Hypertension
  - Smoking
  - Angina
  - Myocardial Infarction
  - Other heart condition
  - Stroke
  - Emphysema
  - Cancer (any)
  - Arthritis
  - Asthma
  - Cognitive difficulties
  - Deafness
  - Obesity (Body Mass Index (B.M.I.) >=30)
  - Pregnancy

To pool data, we combined information from calendar years 2014, 2015, and 2016, adjusting respondent level weights for pooled data as specified in MEPS guidelines. We inflated all expenditures to 2017 values using the Medical Care Component of the Consumer Price Index for all Urban Consumers.

1.4.2 Estimating Health Expenditures With and Without Vision Loss:

We estimated a different model for each category of expenditures, using the same independent variables and distributional assumptions in each. Following recommended health economic guidelines, we used a two-part model to estimate health expenditures as a function of the probability of having any health expenditures in a category and the expected value of those expenditures among persons who had non-zero expenditures. We used probit regression for the first part of the model, and a generalized linear model for the second part of the model. We programmed the model in STATA 15.1 using the TPM command. We tested a number of distributional assumptions for the generalized linear model (GLM) to achieve the best fit of our observed data and achieved the best fit using a negative binomial distribution and a log-link. We also tested a number of alternative specifications of the independent variables above to achieve the best model specification.

Our final model estimated annual expenditures at the person level as a function of a "Yes" response to the vision impairment variable and controlling for the respondent variables listed above. In addition to the variables above, we included an age-squared term to adjust for non-linearity in the effect of age on expenditures.

We controlled for comorbidities identifiable using MEPS diagnostic summary variables that are not caused by vision loss and omitted variables such as depression that may be caused by vision impairment.

1.4.3 Estimating Cost Ratios and Adjustment Factors:

Following previously described methods,[5] we estimated the cost ratio for vision loss cost as

$$\text{Eq. 1.2} \quad CR_{a,s,t} = \frac{E_{a,s,t}(VL=1|VL=1)}{E_{a,s,t}(VL=0|VL=1)}$$

Where "CR" indicates the cost ratio, "a," "s," and "t" index the age group, sex, and service type, "E" represents the expected value of expenditures predicted by the regression models specified above, and "VL" represents a person with vision loss. The cost ratio for age group a, sex s, and service type t is equal to the expected value a,s,t of health expenditures for a person with vision loss when their vision loss is accounted for divided by expected value a,s,t of health expenditures for a person with vision loss when they are assumed to not have vision loss. The equation above estimates the ratio of the expected mean costs of a group of persons with vision loss when their vision loss is accounted for divided by the expected costs for that same group if they did not have vision loss.

Using the model, we also estimated an adjustment factor $(1 + \varphi)$ which is necessary to correct for violations of assumptions in the basic form of AF estimations (Section 1.4). The adjustment factor is estimated as in Eq. 1.2, but is estimated as

$$\text{Eq. 1.3} \quad (1 + \varphi)_{a,s,t} = \frac{E_{a,s,t}(VL=0|VL=1)}{E_{a,s,t}(VL=0|VL=0)}$$

i.e. the expected value of health expenditures for a person with vision loss in the event they did not have vision loss divided by the expected value of health expenditures for a person who did not have vision loss. The adjustment factor 1 + phi for age group a, sex s, and service type t is equal to the expected value a,s,t of health expenditures for a person with vision loss when they are assumed to not have vision loss divided by expected value a,s,t of health expenditures for a person without vision loss. The term is used to adjust for remaining differences in underlying costs between those with vision loss and those without after accounting for the increase in costs related to vision loss.

We used the STATA margins post-estimation command to estimate the expected annual value of costs for persons with vision loss when accounting for their vision loss and when assuming that they had no vision loss, estimating these costs by mutually exclusive age group x sex categories and for each service type. In the same step we also estimated the expected costs of persons without vision loss (when VL=0) which is needed to estimate $(1+\varphi)$. Table 4 shows the resulting estimated cost ratios and adjustment factors for direct medical costs.

Table 4. Estimated Cost Ratios (CR) and Adjustment Factors For Direct Medical Costs

		Hospital Care		Ambulatory Care		Prescription Care		Other Care	
Sex	**Age Group**	**CR**	$(1+\varphi)^b$	**CR**	$(1+\varphi)^b$	**CR**	$(1+\varphi)^b$	**CR**	$(1+\varphi)^b$
M	0-18	1.12	1.09	1.32	1.02	1.39	1.26	2.41	1.03
M	19-64	1.09	2.50	1.29	1.72	1.28	2.94	2.41	1.57
M	65+	1.06	1.57	1.26	1.22	1.24	1.49	2.40	1.45
F	0-18	1.11	1.18	1.31	1.09	1.35	1.41	2.41	1.06
F	19-64	1.09	2.04	1.27	1.67	1.25	2.75	2.41	1.60
F	65+	1.05	1.70	1.25	1.24	1.23	1.67	2.40	1.61

a. CR = Cost Ratio = Expected cost of a person with VL when their VL is accounted for divided by the expected cost of a person with VL in an estimation where one assumes their VIB is excluded.
b. $(1+\varphi)$ = Adjustment Factor = the expected cost of a person with VL in an estimation where one assumes their VL is excluded divided by the expected cost of a person without VL. This adjustment accounts for the fact that persons with VL may be different with respect to costs than persons without VL even after their VL is accounted for.

1.5 Estimating Attributable Fraction of Health Expenditures Related to Vision Loss

Eq. 1.1 describes the standard formula for calculating attributable fraction (AF) as a function of prevalence of vision loss and cost ratios. However, this equation assumes that the expected value of a person with vision loss when the cost attributable to vision loss is removed is equal to expected value of the costs of a person without vision loss. This is not the case as persons with vision loss may be more frail or prone to health conditions that are not entirely controlled for using covariates in the model. Expenditures among persons with vision loss in each age group and sex category differ from those without vision loss even after statistical adjustment to remove the effect of vision loss and other covariates. Correcting for this violation of assumptions required us to adjust the AF calculation based on previously published methods.[5]

As stated in Eq. 1.3, the adjustment factor $(1 + \varphi)$ is estimated as the ratio of the estimated cost of a person with vision impairment if they did not have vision impairment, divided by the cost of a person without vision impairment. After incorporating this adjustment, the equation we used to calculate AF was:

$$\text{Eq. 1.4} \quad AF_{i,j,t} = \frac{pVL_{i,j} \times (CR_{j,t} - 1) \times (1 + \varphi_{j,t})}{pVL_{i,j} \times CR_{j,t} \times (1 + \varphi_{j,t}) + (1 - pVL_{i,j})}$$

Where "AF" is the attributable fraction estimate, "pVL" is the prevalence proportion of vision loss, "CR" is the cost ratio estimated in 1.4.3 , $(1 + \varphi)$ is the adjustment factor described in 1.4.3, "i" indexes the state of interest, "j" indexes the age group by sex category of interest, and "t" indexes the service type. The Attributable Fraction in state i for age and sex group j for service type t is equal to the prevalence of vision loss i,j multiplied by the cost ratio j,t minus 1 multiplied by the adjustment factor 1 + phi j,t with this product divided by the prevalence of vision loss i,j multiplied by the cost ratio j,t multiplied by the adjustment factor 1 + phi j,t plus 1 minus the prevalence of vision loss i,j. Note that while prevalence was estimated separately by state, because the MEPS supported only national-level estimates just one cost ratio and one adjustment factor were estimated per age group by sex category.

1.6 Combining information to estimate incremental health expenditures

We estimated state-level expenditures by multiplying the AF estimate calculated above by the total population all cause health expenditures in each state by service category, age group, and sex.

$$\text{Eq. 1.5} \quad CVL_{i,j,t} = AF_{i,j,t} \times TC_{i,j,t}$$

Where "CVL" is the cost of vision loss, "i" indexes the state of interest, "j" indexes the age group by sex category of interest, "t" indexes the service type, "AF" is the attributable fraction as estimated above, and "TC" is the estimated total cost for all persons in each service category. The cost of vision loss in state i, for sex and age group j, for service category t is equal to the attributable fraction i,j,t multiplied by the total cost i,j,t. These calculations produced an estimate of the total costs attributable to vision loss in each state, for each age group by sex category, for each service type.

To estimate costs per person with vision loss, we divided estimates of CVL by the estimated number of persons in each state by sex by age group category. Finally, because all costs estimated represent those for the year 2014, we multiplied all cost estimates by 1.09, the adjustment factor needed to inflate June 2014 costs to June 2017 costs using the Medical Care Component of the U.S. Consumer Price Index for all Urban Consumers.[7]

2.0 Nursing Home Costs

Objective

We estimated Nursing Home (NH) Costs using an attributable fraction approach and assumptions regarding relative costs of nursing home and long-term care stays associated with persons with vision loss as compared to all other persons. Cost estimates are solely attributable to incremental increases in the probability of any NH treatment and, because of limited data, do not include differences in the unit costs of NH. We assumed that the NH unit costs of persons with vision loss were equal to the costs of other persons in NH because limited data did not allow us to directly estimate cost differences. This assumption is likely to lead to a conservative estimate of the incremental cost of NH because persons with vision loss likely require more intensive care than similar persons without vision loss.

2.1 Estimating Attributable Fraction of Nursing Home and Long Term Care Costs in Each State

In the case of NH costs, we assume that $CR_{i,j}$ (the cost ratio in state i for demographic group j) is equal to 1 which eliminates the CR from attributable fraction calculation. We then estimate the AF of NH placements as:

$$2.1\quad AF_i = \left(\frac{{N_i}^{VL}}{{N_i}^{T}}\right) - {C_i}^{VL}$$

Where "N" is the estimated number of persons in NH, "C" is the community prevalence, "VL" indicates persons with vision loss, "T" indicates total number of persons, and "i" indexes the state. The attributable fraction in state i is equal to the number of persons in nursing homes with vision loss in state i divided by the total number of persons in nursing homes in state i minus the prevalence of vision loss in state i.

We estimate equation 2.1 using data from CMS Minimum Data Set (MDS), and state level estimates of vision loss prevalence from the American Community Survey (ACS).

We used MDS data for 2016 to estimate N^{LV} and N^{T}. In the MDS, each nursing home resident is evaluated based on their ability to see with their normal refractive device in adequate light and scored on a 5 point scale as follows:[8]

0 –Adequate: sees fine detail, including regular print in newspapers/books
1 –Impaired: sees large print, but not regular print in newspapers/books

2 –Moderately Impaired: limited vision; not able to see newspaper headlines but can identify objects

3 –Highly Impaired: object identification in question, but eyes appear to follow objects

4 –Severely Impaired: no vision or sees only light, colors or shapes; eyes do not appear to follow object

MDS reports the proportion of patients with each response as well as the total number of nursing home residents by state but not by age and sex in their MDS frequency report.[9] We assumed that patients in categories 1 through 4 were impaired at approximately the same degree as persons who would have answered "Yes" to the ACS question "Are you blind, or do you have serious difficulty seeing even with glasses?", and used the summed proportions of nursing home residents with these evaluations multiplied by the total number of nursing home residents in a state as our estimate of N^{VL}. We used the MDS reported number of total nursing home residents in a state as our estimate of N^{T}. Finally, we used the proportion of the population age 65 or older in each state in the ACS who replied "Yes" to the question "Do you have serious difficulty seeing even with glasses?" as our estimate of C^{VL}. Although there are persons in nursing homes who are younger than 65, we used the age 65+ community prevalence as the best approximate estimate for the community prevalence among the persons most comparable to those residing in nursing homes.

Table 5 shows the following data: 1) nursing home and long-term vision loss population 2) the nursing home total population 3) the proportion of nursing home patients with vision loss 4) the prevalence of vision loss in the general population and 5) and attributable fraction.

Table 5. Nursing Home and Long-Term Care Vision Loss Population (NVL), Nursing Home Total Population (NT), Proportion of Nursing Home Patients with VL (VLOT), Prevalence of VL in the General Population (CVL) and Attributable Fraction (AF)

STATE	NVL	NT	VLOT	CVL	AF
US	379,042	1271954	0.298	0.066	0.232
AK	198	578	0.343	0.070	0.272
AL	8,785	21606	0.407	0.080	0.327
AR	4,474	17176	0.261	0.088	0.172
AZ	2,164	10375	0.209	0.066	0.143
CA	29,835	95228	0.313	0.066	0.248
CO	3,686	15632	0.236	0.053	0.182
CT	5,663	21689	0.261	0.051	0.210
DC	651	2306	0.282	0.092	0.190
DE	1,107	3965	0.279	0.048	0.231

STATE	NVL	NT	VLOT	CVL	AF
FL	18,228	68708	0.265	0.065	0.201
GA	12,645	31997	0.395	0.073	0.323
HI	1,323	3463	0.382	0.055	0.327
IA	5,244	23089	0.227	0.049	0.178
ID	790	3648	0.217	0.069	0.148
IL	16,238	64770	0.251	0.062	0.189
IN	7,367	36833	0.200	0.069	0.131
KS	3,636	16866	0.216	0.074	0.142
KY	6,692	21898	0.306	0.090	0.215
LA	8,650	25403	0.341	0.087	0.254
MA	10,548	37509	0.281	0.057	0.224
MD	6,203	23241	0.267	0.056	0.211
ME	1,436	5630	0.255	0.049	0.207
MI	8,937	36284	0.246	0.056	0.191
MN	5,777	23082	0.250	0.054	0.196
MO	7,985	36264	0.220	0.070	0.150
MS	6,259	15233	0.411	0.098	0.313
MT	1,023	4118	0.248	0.065	0.184
NC	9,994	34415	0.290	0.073	0.217
ND	1,612	5331	0.302	0.081	0.221
NE	2,681	10944	0.245	0.066	0.179
NH	1,639	6341	0.259	0.055	0.203
NJ	10,900	41196	0.265	0.057	0.208
NM	1,559	5420	0.288	0.083	0.205
NV	1,041	4580	0.227	0.074	0.154
NY	41,460	99376	0.417	0.060	0.357
OH	17,759	70388	0.252	0.061	0.192
OK	4,124	17580	0.235	0.088	0.147
OR	1,352	6719	0.201	0.059	0.142
PA	20,558	72797	0.282	0.061	0.221
RI	2,195	7473	0.294	0.054	0.239
SC	5,637	16009	0.352	0.069	0.283
SD	1,698	5906	0.288	0.075	0.212
TN	8,089	25510	0.317	0.080	0.237
TX	38,165	90848	0.420	0.081	0.339
UT	1,099	4992	0.220	0.059	0.162

STATE	NVL	NT	VLOT	CVL	AF
VA	8,185	26680	0.307	0.066	0.241
VT	739	2480	0.298	0.045	0.253
WA	4,103	15391	0.267	0.063	0.204
WI	5,906	23539	0.251	0.043	0.208
WV	2,504	9065	0.276	0.094	0.182
WY	549	2310	0.238	0.077	0.161

2.2 Estimating Nursing Home and Long Term Care Costs in Each State

We estimated total NH costs in each step, by multiplying the AF estimated in 2.1 by the estimated costs associated with NH as provided by the 2014 SHEA data. For NH costs, we used costs associated with the NHEA/SHEA category "Nursing Care Facilities and Continuing Care Retirement Communities" (Category 9) which is defined as: "Nursing and rehabilitative services provided in freestanding nursing home facilities." These services are generally provided for an extended period of time by registered or licensed practical nurses and other staff. Care received in state & local government facilities and nursing facilities operated by the U.S. Department of Veterans Affairs are also included. These establishments are classified in North American Industry Classification System (NAICS) category 6231-Nursing Care Facilities and NAICS 623311-Continuing Care Retirement Communities with on-site nursing care facilities."[4]

2.3 Adjusting State Estimates to Reflect Age Group by Sex Differences

A limitation of the MDS frequency reports is that they do not allow us to break out vision loss evaluations by age group and sex. Rather, using MDS data produces a single estimate of prevalence for all nursing home residents in a state. To adjust for this and create estimates of nursing home costs by age group and sex, we used data from the 2014 NHEA to estimate the proportion of total nursing home costs attributable to each of our framework's six age by sex groups.[4] Table 6. below shows the proportion of total national nursing home and long-term care costs by age group and sex.

Table 6. Proportion of Total National Nursing Home and Long-Term Care Costs Consumed by Each Mutually Exclusive Group as Defined by Age Group and Sex

Sex	Age Group	Total Costs (%)
Male	0-18	0.4%
Male	19-64	8.9%
Male	65+	26.3%
Female	0-18	0.3%
Female	19-64	7.8%
Female	65+	56.3%

We inflated all age group by sex estimates from 2014 values (contained in SHEA) to 2017 values using the June estimates of Medical Care component of the Consumer Price Index (CPI) for all Urban Consumers.[7]

3.0 Productivity Costs of Vision loss

Objective

Productivity costs include forgone, reduced or diverted earnings attributable to vision loss. We estimate five components of productivity losses:

- **Absenteeism**: The value of lost work days, derived from the number of work days missed due to illness that can be attributed to vision loss.
- **Household Productivity Loss**: The value of household production activities such as cleaning, cooking, childcare and maintenance that are lost due to vision loss.
- **Reduced Labor Force Participation**: The costs of lower rates of employment among persons with vision loss.
- **Informal Care**: The monetary value of additional time spent towards the unpaid care of individuals with vision loss.
- **Reduced Wages**: The reduction in wages attributable to vision loss among working individuals with vision loss.

3.1 Absenteeism:

"Absenteeism" refers to days of work missed because of an illness. We estimated state-level costs of absenteeism in the following steps: 1. Estimated the number of work days missed attributable to vision loss by census region, age group, and sex; 2. Assigned values to workdays to account for state differences from national averages; and 3. Estimated the number of people with blindness and vision loss who are employed and used this to estimate total absenteeism costs. Below, we describe using this approach as applied to vision loss.

3.1.1 Estimating work days lost attributable to vision loss

We estimated the number of workdays missed attributable to vision loss using NHIS data. The NHIS contains question measuring self-assessed vision loss (AVISION: "Do you have trouble seeing, even when wearing glasses or contact lenses?") and a second question measuring workdays lost (WKDAYR: "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)?").

We fit a two-part probit/GLM model to 2016-2017 NHIS data using the Stata 'TPM' command. The model first fits a probit to a dummy variable that represents whether or not a respondent had at least one missed day of work in the last year. The second part is a GLM model with log link to estimate the number of days missed, conditional on missing any days.

Missed days of work = f(vision loss, age, age^2, sex, region, race, comorbidities, education, insured, marital status, occupation)

The comorbidities include diabetes, arthritis, back problems, heart conditions, lung/breathing problems, cancer or pregnancy. Table 7 shows the estimated work days lost attributable to vision loss by age group, sex, and region.

Table 7. Estimated work days lost attributable to vision loss

	Male 19-64	Male 65+	Female 19-64	Female 65+
Northeast	1.09	0.03	0.36	0.12
South	0.55	-0.01	0.39	0.23
Midwest	0.54	0.74	0.56	0.00
West	0.64	0.13	0.56	0.03

3.1.2 Estimating average wages per state

The next step in the analysis of absenteeism costs is to multiply the number of missed workdays attributable to vision loss by the average daily wage by state, age group and sex. We calculated this using mean annual wages by state, age group and sex from 2014 Bureau of Labor Statistics (BLS) data.[i] Because these mean wages are reported separately by state, age group and sex, we used the 2017 estimated population for each state by age and sex to calculate the mean wages for each state by combination of age group and sex.[13]

3.1.3 Calculating Productivity Costs of Absenteeism by State

Multiplying the estimated work days lost due to vision loss by proportion of persons with vision loss who work in NHIS and by the average daily wage by state, age group and sex yields the predicted productivity losses from absenteeism.

3.2 Household Productivity Loss

"Household productivity refers" to the value of non-paid work performed in the home, including tasks such as housekeeping, meal preparation and child care. Even when controlling for health, age and other personal characteristics, persons self-reporting vision loss also reported higher numbers of days in bed in NHIS data. We estimated the number of days persons were unable to perform household domestic labor by using days in bed.

3.2.1 Estimating household work days lost attributable to vision loss

We estimated the number of workdays missed attributable to vision loss using NHIS data. The NHIS contains a measure measuring whether an individual "has trouble seeing even when wearing glasses," and a second question measuring days in bed due to health issues (BEDDAYR: "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 fitted a two-part probit/GLM model to 2016-2017 NHIS data. The model first fits a probit model to a dummy variable that represents whether or not a respondent had at least one bed day in the last year. The second part is a GLM model with log link to estimate the number of bed days.

Bed days = f (vision loss, age, age^2, sex, region, race, comorbidities, education, insured, marital status)

The comorbidities include diabetes, arthritis, back problems, heart conditions, lung/breathing problems, cancer or pregnancy. Table 8 shows the estimated household work days lost attributable to vision loss results separately for age group, sex and region. We assume no household production losses among children, but we separately estimate cost of informal care for children with vision loss.

Table 8. Estimated household work days lost attributable to vision loss

	Male 19-64	Male 65+	Female 19-64	Female 65+
Northeast	3.68	3.27	2.72	5.69
South	3.24	3.55	3.95	6.71
Midwest	2.96	2.56	3.02	6.13
West	2.66	3.52	2.81	7.77

3.2.2 Monetary value of a day of household production

The Bureau of Economic Analysis (BEA) calculated the value of household production to be $4.516bn nationally in 2017.[14] Dividing by the US adult population of approximately 252 million in 2017, we calculated per person household production as $17,910, or $49.07 per day. In an earlier report, the BEA reported weekly household production hours by sex in 2010; 26 hours for women and 17 hours for men. We adjusted the daily household by these hours allocations such that estimated daily household production is $59.37 for women and $38.82 for men.

3.2.3 Calculating Productivity Costs of Lost Household Productivity

Multiplying the estimated days in bed due to vision loss by the per-person value of household productivity by the estimated prevalent population with vision loss yields the predicted productivity losses from lost household production.

3.3 Reduced Labor force Participation

Persons with vision loss report lower rates of employment, even when controlling for health, age and other personal characteristics. To calculate the value of reduced labor force participation attributable to vision loss, we first estimated the excess probability of not working attributable to vision loss. Then we multiplied these estimates by the estimated number of persons in each state with vision loss by region, age-group, and sex in the estimates. We then multiplied these values by annual wages by age group, sex and state.

3.3.1 Estimating reduced labor force participation attributable to vision loss

We used logistic regression to estimate the probability of working as a function of vision loss controlling for comorbidities, region, age and sex in 2016-2017 NHIS. We used predicted marginal effects to estimate the difference in labor force participation attributable to vision loss, among persons with vision loss by region, age group and sex.

Probability of not working = f (vision loss, age, age^2, sex, region, race, comorbidities, education, insured, marital status)

The comorbidities include diabetes, arthritis, back problems, heart conditions, lung/breathing problems, cancer or pregnancy. Table 9 displays the estimated proportion of persons with vision loss currently not working due to vision loss by age group, sex, and region.

Table 9. Estimated proportion of persons with vision loss not working due to vision loss

	Male 19-64	Male 65+	Female 19-64	Female 65+
Northeast	0.085	0.099	0.056	0.040
South	0.080	0.071	0.103	0.034
Midwest	0.066	0.064	0.083	0.056
West	0.045	0.082	0.060	0.047

3.3.2 Calculating Productivity Costs of Reduced Labor force Participation

We multiplied the estimated proportion of persons with vision loss not working due to vision loss by the proportion of persons who worked by age and sex in NHIS. We then multiplied this by annual wages and the estimated prevalent population with vision loss in each state by age and sex to calculate the predicted productivity losses from reduced labor force participation.

3.4 Informal Care

Persons with vision loss, particularly children with vision loss, may require higher than average levels of informal care. Informal care is unpaid care typically provided by a parent or relative. The cost of informal care is actually the opportunity cost of care giving time spent by the caregiver, not the person receiving care. However, we attribute these costs to the vision loss population because the caregiver population is unknown, while the vision loss population is known. This is why we attribute most informal care costs to children with vision loss, while presumably most of these costs are actually borne by their parents. Consensus guidance for visual health economics identifies the cost of informal care for persons with vision loss as a vital component of vision cost estimates.10 We calculated the cost of informal care for adults aged 40 and older using previously published estimates and methods. We assume persons aged 18-39 would not require additional informal care due to vision loss.

3.4.1 Estimating informal care for adults

The number of hours and estimated cost for informal care due to vision loss among persons aged 40 and older was previously estimated by Frick et al (2007).[11] Using information from the 1997-98 Caregiver supplement in the MEPS, Frick et al estimated that adults aged 40 and older with visual impairment and blindness required 1.2 and 5.2 additional days of informal care per year, respectively. We were unable to find more recent values for these parameters. Because the current analysis uses self-reported vision loss from ACS that does not differentiate between impairment and blindness, we calculated the weighted average care days per year using the proportion of best-corrected vision loss that is blindness in NHANES data as calculated using VEHSS (16.67%). Following the Frick et al. approach, assuming 8 hours of care per "care day", we estimate 14.93 hours of informal care per day for someone with vision loss. We then multiplied the hours of informal care by the ACS-derived prevalent population with vision loss to estimate the total number of care hours, and then multiplied these hours by average wages by state, age group and sex.

3.4.2 Estimating informal care for children

We used the 2018 American Time Use Survey (ATUS) conducted by the Bureau of Labor Statistics to obtain estimates of the number of hours spent on childcare by adults in households with children younger than age 18. This survey found that caregivers spend an average of 2.1 hours per day providing primary care for children younger than age 6 and 50 minutes per day caring for children aged 6 to 17.[12] As part of the HID survey conducted by the Institut National de la Statistique et des Etudes Economiques in France, respondents were asked to indicate the limitations placed on them as a result of their work as the caregiver of a disabled individual. Using these data, Lafuma et al. estimated that, compared with control individuals, relatives reported spending 3.3-fold more time caring for blind children and 2.0 times as much time caring for those with vision loss when controlling for age.[13] Multiplying the number of care hours per child from ATUS by the excess care coefficients for care of blind and visually impaired children yields an estimate of 498 incremental hours per year required for care of a child with vision loss. We multiplied this estimated time by the prevalent population with vision loss by state, age group and sex, and by the average wage by state and sex to estimate state level costs of informal care.

3.5 Reduced Earnings among Persons with VL who Work

Working persons with vision loss report lower annual earnings, even when controlling for personal characteristics such as age, race, sex, education and region. We estimated reduced income among persons with vision loss who worked in the past year, based on self-reported earnings among adults and the population of persons with VL who work.

3.5.1 Estimating the proportion of persons with vision loss who worked

Because we attempt to estimate the reduced income attributable to vision loss among persons with vision loss who worked, we first estimate the working population with vision loss. Table 10 shows the estimated proportion of persons with vision loss who reported working the past year by age group and sex.

Table 10. Estimated proportion of persons with vision loss who worked at all in the past year

	Male 19-64	Male 65+	Female 19-64	Female 65+
Proportion working	75.0%	17.0%	63.9%	16.7%

3.5.2 Estimating wage reduction attributable to vision loss among working persons with vision loss

We estimated the reduction in household income attributable to vision loss among persons with vision loss who work using 2016-17 NHIS data. NHIS contains a measure whether an individual "has trouble seeing even when wearing glasses". NHIS also reports annual earnings by bracket (ERNYR: "What is your best estimate of [respondents] earnings before taxes and deductions from ALL jobs and businesses in [last calendar year]?").

We used a GLM model to estimate the reduction in wages attributable to vision loss.

Reduced wages = f (vision loss, workdays, age group, sex, region, race, comorbidities, education, insured)

The comorbidities include diabetes, arthritis, back problems, heart conditions, lung/breathing problems, cancer or pregnancy. We include workdays to control for absenteeism and work force participation. We estimated results separately for age group and sex. We used age group (0 to 18, 19 to 64, and 65+) in place of age and age-squared do to better fit the nonlinearity of earnings data. We assume no wage reduction among children. Table 11 shows the estimated lost wages attributable to vision loss among working people with vision loss by age group and sex.

Table 11. Estimated lost wages attributable to vision loss, among working persons with vision loss

	Male 19-64	Male 65+	Female 19-64	Female 65+
Reduced wages	$1,295	$704	$2,310	$757

4.0 Other Supportive Services Costs

Objective

We estimated expenditures associated with supportive services for individuals who are blind by first identifying the total budgetary cost of each federal program, summing these costs, and then apportioning these costs to each state according to the population of individuals in each age group by sex category residing there. The federal programs we included in our analysis fell into four overarching categories: (1) federal support programs, (2) vision rehabilitation (including privately funded vision loss services, occupational therapy, vision loss adaptations and assistive technologies), (3) special education for blind children, and (4) school vision screening programs. We estimated the state-specific economic burden of these programs and services by allocating their costs to each state on the basis of their population for each age group by sex category. For the purposes of our analysis, we divided the population into three main age groups: (1) children aged 0-17 years, (2) adults aged 18-64 years, and (3) adults aged 65 years or older. Furthermore, we bisected each age group into two sex categories, to generate six unique age/sex groups. In certain instances, if the program/service we were examining was only made available to a certain age group (e.g. school-aged children), we apportioned the program costs to that age group alone.

In addition, we calculated the state-specific economic burden of government transfers to individuals who are blind by first summing the federal budgets of the two main income support programs (i.e. Social Security Disability Insurance and Social Security Income) and then distributing those costs to each state in proportion to the population of each age by sex category residing there. These costs were not included in the total burden estimates.

4.1. Federal Support Programs

The federal support programs for individuals who are blind included in this analysis are as follows: (1) the American Printing House for the Blind (APH), (2) National Library Service for the Blind and Physically Handicapped (NLS), (3) the Committee for Purchase (CFP) program, and (4) the Independent Living Services for Older Individuals who are Blind (OIB) program. Table 12 displays the budgetary cost of these federal support programs by age group.

Table 12. Budgetary Cost of Federal Support Programs, by Program and Age Group

Age group	APH Costs	CFP Costs	NLS Costs	OIB Costs	Total Program Costs
0-17	$25,431,000	$0	$2,143,258	$0	$34,527,382
18-64	$0	$8,000,000	$20,706,270	$0	$28,706,270
65+	$0	$0	$28,741,472	$32,384,124	$61,125,596
Total	$25,431,000	$8,000,000	$51,591,000	$32,384,124	**$117,406,124**

4.1.1 American Printing House for the Blind

Established in 1879 and administered by the Department of Education, the American Printing House for the Blind (APH) supplies accessible educational materials for legally blind students who are enrolled in primary and secondary education programs. APH provides textbooks in large type and Braille, special education tools such as Braille printers and computer software and interfaces, teaching aids, and other special supplies.[14] APH is funded by an annual federal appropriation, and credits for APH materials and services are allocated to state education programs in proportion to the number of legally blind individuals in each state. In fiscal year 2017, $24.505 million was appropriated by Congress for use by APH.[15] Because this program is utilized primarily by school-aged children, we allocate all of its cost to children aged 0 to 17 displayed in Table 13.

Table 13. Budgetary Cost of American Printing House for the Blind

Age group	Cost
0-17	$24,505,000
18-64	$0
65+	$0
Total	**$24,505,000**

4.1.2 Independent Living Services for Older Individuals Who Are Blind

The Independent Living Services for Older Individuals who are Blind (OIB) program, housed within the Rehabilitation Services Administration (RSA) under the Department of Education, awards grants to states to support the independent living goals of older (aged 55+) individuals who are blind.[16] Table 14 below shows the budgetary cost of the OIB program. In fiscal year 2017, the program was funded for $32 million, which we apportion to each state according to the population of individuals aged 65 years or older residing there

Table 14. Budgetary Cost of the OIB Program

Age Group	Cost
0-17	$0
18-64	$0
65+	$32,000,000

4.1.3 Committee for Purchase from Individuals Who Are Blind or Severely Disabled

Under the Javits-Wagner-O'Day Act signed into law in 1971, the federal government is required to purchase certain products and services from nonprofit organizations that primarily employ individuals who are blind or severely disabled. In accordance with this law, the Committee for Purchase from People who are Blind or Severely Disabled ensures that 75% of the labor used to produce materials purchased under the Javits-Wagner-O'Day Act is completed by individuals who are blind or severely disabled. Materials that fall under the Javits-Wagner-O'Day Act include furniture, office supplies, janitorial supplies, and numerous other products and services. Table 15 displays the budgetary cost of the Committee for Purchase. In the 2017 fiscal year, approximately $8 million was appropriated by Congress for use by the Committee for Purchase from People who are Blind or Severely Disabled.[17] Because this program is primarily utilized by working-age individuals, we allocate all of its costs to people aged 18-64. We consider these as direct costs as the purchase program would not be necessary if people did not have VL. We also assume that all of these costs are related to assistance to programs for the blind although some portion may have been spent on services for those who are disabled but without VL.

Table 15. Budgetary Cost of the Committee for Purchase from People Who Are Blind

Age group	Cost
0-17	$0
18-64	$8,0000
65+	$0
Total	**$8,000,000**

4.1.4 National Library Service for the Blind and Physically Handicapped

The National Library Service for the Blind and Physically Handicapped (NLS) is a federal service administered by the Library of Congress that supplies adapted reading materials to individuals who are blind or physically handicapped. Materials delivered by mail to clients free of charge include books and magazines available in both Braille and audio formats, with more than 26 million titles circulated each year. In fiscal year 2017, Congress appropriated more than $51 million in support of NLS services.[18] Although a small portion of these funds was used to support services for physically handicapped individuals who are not legally blind, the majority of NLS services are provided for the blind and visually impaired. Table 16 below shows the budgetary cost of the National Library Service for the Blind. Assuming that non-blindness-related expenditures by NLS are negligible and that services are used equally across age groups, we allocate the federal budgetary cost of the program based on the proportion of blind persons in each age group.

Table 16. Budgetary Cost of the National Library Service for the Blind

Age group	National Library
0-17	$2,143,258
18-64	$20,706,270
65+	$28,741,472
Total	**$51,591,000**

4.2 Vision Rehabilitation Services

Table 17 (below) shows the estimated costs of vision rehabilitation and vision loss services. These costs are based on 2017 program and organizational budgets as reported by the VisionServe Alliance, a national trade association for groups, non-profits and corporations providing a broad range of services for the vision loss community, typically persons who are blind.[19] These services include vision rehabilitation including occupational therapy and training programs, and also provision of vision loss adaptations and devices, guide dogs and adaptive technology.

Table 17. Vision Rehabilitation Services Program Expenses

Age Group	Cost
0-17	$101,630,820
18-64	$981,867,550
65+	$1,362,887,594
Total	$2,446,385,964

4.3 Education Costs

The Individuals with Disabilities Education Act requires states to provide education and intervention services for children who meet certain eligibility criteria from birth through age 21. When this bill was passed, Congress authorized the federal government to pay up to 40% of the excess cost of educating students with disabilities, although it routinely funds considerably less than this amount.[20] For congressional purposes, the excess cost of educating a student with a disability is equal to the national average per pupil expenditure (APPE), suggesting that it is approximately twice as expensive to educate a student with a disability than it is to educate a student without a disability.[20] This assumption is supported by a report for the Department of Education by the Special Education Expenditure Project, which found that per pupil expenditures on disabled students were approximately double the per pupil expenditures on students who are not disabled.[21] Thus, we assume that the excess cost associated with educating a disabled student is equal to the APPE. In 2008, the National Center for Education Statistics reported the APPE to be $10,297.[22] We adjusted this value for inflation using the Consumer Price Index, resulting in an estimated APPE of $12,623 in 2020.

We assumed that only blind students would require special education accommodations. The APH maintains a registry of children registered by state departments of education to receive special education materials due to blindness. Table 18 below shows the cost of special education for the blind in 2013 by grade level. We excluded individuals registered as adult, postgraduate, or vocational students, resulting in an estimate of 51,388 blind students requiring special education. Table 19 shows the estimated education costs in 2020 by multiplying the 2013 number of students by the APPE.

Table 18. Cost of Special Education for the Blind, 2013

Program	State Departments of Education	Schools for the Blind	Rehabilitation Programs	Multiple Disabilities Programs	Totals
Infant	3,860	1,513	286	27	5,686
Preschool	5,163	418	16	13	5,610

Program	State Departments of Education	Schools for the Blind	Rehabilitation Programs	Multiple Disabilities Programs	Totals
Kindergarten	2,331	125	1	0	2,457
Grade 1	2,262	52	2	1	2,317
Grade 2	2,233	86	3	2	2,324
Grade 3	2,085	102	5	1	2,193
Grade 4	2,077	118	1	3	2,199
Grade 5	2,015	130	6	4	2,124
Grade 6	2,027	130	0	1	2,158
Grade 7	1,963	135	3	1	2,103
Grade 8	1,896	179	1	3	2,079
Grade 9	1,897	195	1	1	2,094
Grade 10	1,886	203	2	2	2,093
Grade 11	1,776	232	6	2	2,016
Grade 12	2,101	321	26	2	2,450
Nongraded	1,366	348	2	8	1,724
Other registrants	8,803	747	25	136	9,711
Total					**51,338**

Note: APH = American Printing House for the Blind

Table 19. Cost of Special Education for the Blind, 2013

Age group	Cost
0-17	$617,112,835
18-39	$131,948,136
46-64	$0
65+	$0
Total	**$749,060,971**

4.4 School Screenings

School and preschool vision screening programs conduct vision screening tests among children to identify unmet need for eye glasses or treatment of eye disorders that cause vision loss, including amblyopia. We estimate the cost of state-mandated vision screening programs. Non-state mandated screening conducted by individual schools or school districts are not included.

4.4.1 Identification of School Screening Programs

Naser and Hartman conducted a survey identifying the ages at which preschool and school-based vision screening is conducted in each state.[23] The authors identified school screening programs in 46 states and the District of Columbia, with screening occurring in nearly five grade levels on average per state with school screening. Naser and Hartman identified 15 states with preschool screening, and we have identified an additional 3 states for a total of 18 states with preschool screening. We assume that preschool screening programs target only 3-year-olds.

4.4.2 Screening Costs and Uptake

We based per student preschool screening costs on the program and volunteer labor costs incurred by Prevent Blindness Georgia (PBGA).[24] PBGA conducts symbol acuity and stereopsis tests on all 3-year-olds enrolled in state-funded preschools. Contract costs for PBGA were $6.49 per child screened. About 10% of screens were conducted by volunteers, typically preschool teachers or administrators. We assigned costs for volunteer labor based on the average per capita hourly wage and the time per child screened as estimated by PBGA staff. Including these costs, we estimate the total economic cost of screening to be $6.72 per child screened in 2008. Because Georgia's state-funded preschool program is unique, we based preschool screening penetration on the rates achieved by North Carolina's Prevent Blindness Screening Program, which reaches approximately 44% of state residents in the targeted age group per year. We do not base costs on the North Carolina program because it uses a unique and relatively costly universal photoscreening program that costs $17 per child.

We estimate the cost of school-based vision screening to be $4.15 per child screened, which is the average estimated program and volunteer labor cost per child screened observed in North Carolina and Virginia. Both programs report near universal screening compliance for targeted age groups, and therefore we assume that 100% of residents at each targeted age level in school screening programs will receive a screen.

Tables 20 and 21 show the total per state costs for preschool and school vision screening, respectively. Table 22 shows the total budgetary cost of school screenings. Costs were updated to 2020 levels based on the Consumer Price Index.

Table 20. Preschool Screening Costs, by State

State	Age 3 Population	Estimated # Screened	Screening Costs
Arizona	90,501	39,268	$321,829
Arkansas	39,526	17,150	$140,556
California	516,391	224,061	$1,836,339
Colorado	68,089	29,544	$242,134
Connecticut	45,390	19,695	$161,415
District of Columbia	5,601	2,430	$19,916
Georgia	138,420	60,060	$492,234
Idaho	23,837	10,343	$84,768

State	Age 3 Population	Estimated # Screened	Screening Costs
Iowa	40,444	17,549	$143,827
Kansas	40,386	17,523	$143,613
Michigan	130,226	56,505	$463,099
Minnesota	71,337	30,953	$253,682
Nevada	36,945	16,030	$131,377
New Mexico	28,815	12,503	$102,471
North Carolina	126,758	55,000	$450,764
Oregon	48,136	20,886	$171,176
West Virginia	21,523	9,339	$76,540
Total	**1,472,325**	**638,839**	**$5,235,739**

Table 21. School Screening Costs, by State

State	Average Grade Level Population	# of Grades Screened	Estimated # Screened	Screening Costs
Alaska	10,410	1	10,410	$52,689
Alabama	62,914	3	188,742	$955,287
Arkansas	39,526	6	237,156	$1,200,327
Arizona	90,501	6	543,006	$2,748,337
California	516,391	4	2,065,564	$10,454,519
Colorado	68,089	7	476,623	$2,412,350
Connecticut	45,390	8	363,120	$1,837,873
District of Columbia	5,601	5	28,005	$141,743
Delaware	11,431	5	57,155	$289,281
Florida	222,338	1	222,338	$1,125,328
Georgia	138,420	3	415,260	$2,101,771
Hawaii	16,879	14	236,306	$1,196,025
Iowa	40,444	7	283,108	$1,432,905
Idaho	23,837	5	119,185	$603,236
Illinois	173,843	2	347,686	$1,759,757
Indiana	89,350	2	178,700	$904,461
Kansas	40,386	5	201,930	$1,022,036
Kentucky	56,854	0	0	$0
Louisiana	62,112	1	62,112	$314,370
Massachusetts	78,829	1	78,829	$398,980
Maryland	75,165	5	375,825	$1,902,178
Maine	15,252	13	198,276	$1,003,542
Michigan	130,226	6	781,356	$3,954,707
Minnesota	71,337	6	428,022	$2,166,364

State	Average Grade Level Population	# of Grades Screened	Estimated # Screened	Screening Costs
Missouri	79,191	2	158,382	$801,625
Mississippi	41,975	14	587,650	$2,974,296
Montana	12,420	1	12,420	$62,862
North Carolina	126,758	1	126,758	$641,565
North Dakota	8,326	0	0	$0
Nebraska	25,512	1	25,512	$129,125
New Hampshire	15,957	1	15,957	$80,764
New Jersey	114,734	2	229,468	$1,161,415
New Mexico	28,815	3	86,445	$437,527
Nevada	36,945	3	110,835	$560,973
New York	240,274	13	3,123,562	$15,809,405
Ohio	151,708	5	758,540	$3,839,228
Oklahoma	51,648	3	154,944	$784,224
Oregon	48,136	4	192,544	$974,530
Pennsylvania	155,120	13	2,016,560	$10,206,493
Rhode Island	12,442	8	99,536	$503,785
South Carolina	60,026	0	0	$0
South Dakota	11,267	0	0	$0
Tennessee	83,111	9	747,999	$3,785,876
Texas	381,435	6	2,288,610	$11,583,430
Utah	48,390	5	241,950	$1,224,591
Virginia	102,982	6	617,892	$3,127,361
Vermont	7,180	4	28,720	$145,362
Washington	87,853	6	527,118	$2,667,923
Wisconsin	74,416	1	74,416	$376,645
West Virginia	21,523	1	21,523	$108,935
Wyoming	7,522	0	0	$0
Total	**4,121,191**		**20,146,055**	**101,966,007**

Table 22. Total Budgetary Cost of School Screenings

Age group	Cost
0-17	$107,201,746
Total	**$107,201,746**

5.0 Estimated Costs that are Not Included In the Burden Total

We estimated transfer payments that are not included in the burden total, but which we thought would be useful for decision makers, and for comparisons to other published estimates. Federal transfer payments are tax transfers from the general tax pool to specific individuals to improve their welfare. Therefore, there are not considered economic costs as the tax loss from public is transferred to individuals who receive the benefit. Because of a lack of empirical evidence, we did not estimate deadweight losses, which would be economic costs, due economic inefficiency that may result from transfer payments.

5.1 Federal Transfer Payments

5.2.1 Supplemental Security Income

Supplemental Security Income (SSI) is a public benefit program paid for by the U.S. Treasury that supports individuals of all ages who are unable to work as the result of a disability. Managed by the Social Security Administration, eligibility for this program is based on the income and resources available to the disabled individual or, in the case of disabled children, the income and resources available to their parents. SSI recipients may also be eligible for other government assistance programs, including Social Security benefits and the Supplemental Nutrition Assistance Program. The Social Security Administration reports that 4.2 million blind and disabled individuals and 810,000 children under the aged of 18 received SSI benefits in 2017.[25] Using population-level data about the incidence of blindness within the general population, we were able to calculate what proportion of SSI expenditures are attributable to individuals who are blind (versus those with another form of disability). Table 23 below shows budgetary costs of the SSI program stratified by age group.

Table 23. Budgetary Cost of Supplementary Security Income

Age group	Cost
0-17	$206,773,332
18-64	$754,803,050
65+	$250,995,044
Total	$1,212,571,425

5.2.2 Social Security Disability Insurance

Social Security Disability Insurance (SSDI) is a public benefit program that is administered by the Social Security Administration. This program allows adults who become disabled prior to retirement to collect Social Security benefits early on the basis of their payroll contributions to the Social Security system. Adults who become disabled before age 22 may also be eligible for SSDI payments based on the work record and contributions of their parents. Individuals younger than age 18 are not eligible for SSDI benefits. The Social Security Administration reports that 131,948 blind individuals were receiving SSDI benefits in December 2017.[26] Table 24 below shows the budgetary cost of social security disability insurance. As of May 2020, the average benefit amount for SSDI recipients was $1,419.93 per month.[27] Multiplying the average benefit amount by the total number of SSDI recipients, we estimate that SSDI payments constituted a total government transfer of $2.25 billion in 2020.

Table 24. Budgetary Cost of Social Security Disability Insurance

Age group	Cost
0-17	$0
18-64	$530,535,529
65+	$1,717,747,555
Total	$2,248,283,084

6.0 Sensitivity Analysis

We conducted univariate sensitivity analyses to estimate the potential impact of major assumptions and uncertainty in the analysis. We show the impact on total results of selected alternative analyses, assumptions or parameter values that have the largest impact on overall results. We did not conduct a full probabilistic sensitivity analysis due to the complexity of the overall analysis and limited resources to conduct the analyses.

The estimated burden would have been over $41bn higher, totaling $175.7bn if we had used fewer independent variables to estimate medical costs in MEPS data. This would mirror the approach used by the CDC's diabetes state toolkit. However, in this analysis we elected to use a more conservative approach for the baseline estimates by including additional covariates. Productivity loss estimates could have been $34.7bn higher (to total $168.9bn) if we had used household income rather than job related wages to calculate reduced earnings. Again, we elected to use the more conservative approach for the overall estimate. Using household income may have biased results because we could not control for certain factors such as number of working persons per household. The next largest potential increase in burden would be if we had used a less conservative approach to calculating the differential prevalence of vision loss in nursing homes using the full ACS sample rather than age-matched. Although not tested, the nursing home cost estimate would also be substantially higher if we had used published values of the prevalence of objectively measured visual acuity loss in nursing homes rather than using the self-assessed visual difficulty in the ACS group quarters population, or if we had assumed that nursing home residents that are blind require higher costs than residents who are not blind.

The largest potential reduction in burden would be from using only the two rather than three highest visual loss severity scores in the MDS vision assessment scale, which would reduce total burden by $29.3bn to $104.9bn. However, this would mean excluding persons who are assessed as "sees large print, but not regular print in newspapers/books" from the definition of vision loss. In addition, because we used conservative options for estimating the prevalence and unit costs of persons with vision loss in nursing homes we elected to use the less conservative approach for interpreting the MDS scales. The second largest potential reduction in the overall estimate (18.9bn reduction to a total of $115.3bn) would be if we added self-reported health status to the medical cost regressions. We elected not to do this because self-reported low health may not be independent from vision loss, vision loss may cause a person to report that they have health problems. Also, we already used a more conservative approach in selecting control variables than were previously used in the CDC Diabetes State Toolkit. Two changes in productivity cost assumptions would have reduced the burden by about $7.3-7.5 bn; excluding reduced earnings from the overall estimate and excluding fringe benefits of 45% from the wage estimates.

Table 25. Sensitivity Analysis: Effect of Assumption Changes that Result in the Largest Net Change in the Overall Burden Estimate, $bns

	Change	Resulting Burden Estimate
Use only diabetes, hypertension and smoking as independent variables for medical costs	+$41.5	$175.7
Use household income instead of wages from employment to calculate the productivity costs of reduced earnings	+$34.7	$168.9
Use ACS all ages prevalence for calculating incremental NH prevalence	+$7.5	$141.8
Baseline	$0.0	$134.2
Exclude fringe benefits (45%) from labor costs in productivity estimates	-$7.4	$126.9
Exclude reduced earnings from the overall burden estimate	-$7.8	$126.5
Add self-reported health status as independent variable for medical costs	-$18.9	$115.3
Use only top two instead of three most severe MDS vision loss categories	-$32.1	$102.2

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