ONLINE FIRST

The Cost-effectiveness of Welcome to Medicare Visual Acuity Screening and a Possible Alternative Welcome to Medicare Eye Evaluation Among Persons Without Diagnosed Diabetes Mellitus

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Objective: To estimate the cost-effectiveness of visual acuity screening performed in primary care settings and of dilated eye evaluations performed by an eye care professional among new Medicare enrollees with no diagnosed eye disorders. Medicare currently reimburses visual acuity screening for new enrollees during their initial preventive primary care health check, but dilated eye evaluations may be a more cost-effective policy.

Design: Monte Carlo cost-effectiveness simulation model with a total of 50 000 simulated patients with demographic characteristics matched to persons 65 years of age in the US population.

Results: Compared with no screening policy, dilated eye evaluations increased quality-adjusted life-years (QALYs) by 0.008 (95% credible interval [CrI], 0.005-0.011) and increased costs by $94 (95% CrI, –$35 to $222). A visual acuity screening increased QALYs in less than 95% of the simulations (0.001 [95% CrI, –0.002 to 0.004) and increased total costs by $32 (95% CrI, –$97 to $159) per person. The incremental cost-effectiveness ratio of a visual acuity screening and an eye examination compared with no screening were $29 000 and $12 000 per QALY gained, respectively. At a willingness-to-pay value of $15 000 or more per QALY gained, a dilated eye evaluation was the policy option most likely to be cost-effective.

Conclusions: The currently recommended visual acuity screening showed limited efficacy and cost-effectiveness compared with no screening. In contrast, a new policy of reimbursement for Welcome to Medicare dilated eye evaluations was highly cost-effective.

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ACCORDING TO THE 2005-2006 National Health and Nutrition Examination Survey, 9.2% of patients aged 60 to 70 years have some form of visual impairment, 80% of whom could achieve normal vision with appropriate prescription glasses.[1] Other patients harbor asymptomatic eye disorders such as early age-related macular degeneration (AMD) or glaucoma that could result in irreversible visual impairment if not detected and treated. Visual impairment can develop gradually, and many people who have it are unaware of their condition. However, even unrecognized visual impairment can result in depression or acute injuries.[2,3]

Each year, approximately 2 million Americans enroll in the Medicare health insurance program after turning 65 years of age. Of these, 149 000 are estimated to have uncorrected refractive errors (UREs), 35 000 have impairment from medical causes, and 258 000 have asymptomatic eye disease.[1] Since 2005, Medicare has reimbursed an initial preventive physical examination (IPPE), also known as the Welcome to Medicare health evaluation, within 12 months of enrolling in Medicare Part B. During the IPPE, patients are supposed to receive a visual acuity screening along with other preventive health checks.[4]

The effectiveness of visual acuity screening in primary care at improving vision is unknown and may be limited by its sensitivity and specificity, the need to link positively screened patients to additional services, and the inability of visual acuity screening to detect asymptomatic eye disease. In 2009, the US Preventive Services Task Force reversed its 1996 recommendation in favor of visual acuity screening, citing insufficient evidence to support it. It is undetermined whether Medicare will continue to include visual acuity screening in its IPPE guidelines.[5]

For new Medicare enrollees, a potentially more effective, but more costly, alternative to IPPE visual acuity screening is reimbursement for a onetime autorefractive assessment of visual acuity defects and a dilated eye evaluation by an eye care professional within 12 months of Medicare enrollment. Autorefraction is more sensitive and specific than eye charts administered in primary care, dilated eye examinations detect asymptomatic eye disease, and conducting an evaluation in an eye care setting facilitates linkages to treatment.

For patients aging into Medicare, neither the cost-effectiveness of IPPE visual acuity screening nor the cost-effectiveness of systematic dilated eye examinations has been estimated as far as we are aware. In our study, we used a previously established simulation model to evaluate the incremental cost-effectiveness of each of these policies.[6-8]

METHODS

We modeled the cost-effectiveness of screening or examining patients with no previously diagnosed diabetes mellitus or eye diseases at Medicare entry. We excluded patients with diabetes because the cost-effectiveness of visual screening for them has been established.[8-11] We excluded patients with diagnosed eye disease because preferred practice patterns address their frequency of evaluation and because Medicare reimburses eye care for diagnosed disease.

Using AnyLogic 5.4.1 (XJ Technologies Company), we developed a microsimulation model of patients that included 4 common vision-impairing conditions: AMD, glaucoma, nuclear cataracts, and URE. We started the model at age 50 years to model the prevalence of patients with undiagnosed AMD, glaucoma, nuclear cataracts, and URE at age 65 years. We captured costs and quality-adjusted life-years (QALYs), the relative value of a year of life after accounting for morbidity, from age 65 years until patient's death or age 100 years and discounted them to year 2009 values using an average rate of 3%. We estimated the costs of refractive correction, medical treatment, productivity losses associated with dilation, and incremental long-term care costs attributable to visual loss. We summarized results from the patient, Medicare, and societal perspectives.

DISEASE SIMULATION MODULES

We only briefly review our AMD, glaucoma, and URE modules because they have been described elsewhere.[6-8] The AMD module categorized patients into prevision-threatening and vision-threatening states with transition probabilities based on clinical trial data.[12-15] We modeled glaucoma as an annual incidence, a subsequent annual probability of losing any visual field, and an estimated quantity of field lost in years visual field loss occurred.[7] We used National Health and Nutrition Examination Survey data to estimate the annual incidence of URE by comparing the change in prevalence across age groups.[1,8] After accounting for service utilization prior to age 65 years, we predicted a URE prevalence of 0.003 for African Americans, 0.014 for Latinos, and 0.002 for whites, all at age 65 years.

We modeled nuclear cataracts (not previously explained) using a variable progression rate assigned to simulated persons such that the model reproduced published prevalence of cataracts by age, ethnicity, and sex over the simulated population. We used prevalence data from the Beaver Dam Eye Study to set rates for whites, and data from the Salisbury Eye Evaluation to set rates for blacks.[16,17] We did not differentiate prevalence for Latinos. We calculated the rate by dividing the number 4 (the Wisconsin scoring system nuclear sclerosis score for incident cataracts)[18] by the number of years between age 50 years (when we assumed initial cataract development began) and each age. We then assigned this rate to the proportion of patients who developed nuclear cataracts at that age. Within individuals, nuclear cataracts developed linearly over time, allowing for the determination of progression at any simulation step. We did not model cortical or posterior subcapsular cataracts, which is a limitation of our model.

Using data from the Beaver Dam Eye Study, we assigned visual acuity logMAR values of 0.018, 0.066, and 0.198 for nuclear opacity scores of 2, 3, and 4, respectively. Because there were insufficient data to assess logMAR values for opacity scores of 5, we assumed the same incremental change in visual acuity between opacity scores 4 and 5 that we observed between 3 and 4.

BACKGROUND RATES OF OPHTHALMOLOGIC SERVICES AND DIAGNOSIS OF DISEASE

Without intervention, patients accessed ophthalmologic evaluations at the expected population rate: an annual probability of 0.63 for patients aged 50 to 64 years and of 0.74 for patients aged 65 years or older.[19,20] To be conservative about the benefits of additional screening, we assumed that all background evaluations included a dilated ophthalmoscopy examination to detect AMD and glaucomatous optic nerve cupping, and autorefraction to detect URE at sensitivities and specificities observed in published studies.[21-26] We excluded patients from the simulation who were diagnosed with ocular disorders other than URE during background evaluations prior to age 65 years because we assume that they already received medical treatment.

MEDICAL TREATMENT

Patients whose condition was diagnosed received medical treatment outlined in the American Academy of Ophthalmology Preferred Practice Patterns. Patients with early AMD received antioxidant vitamins plus zinc, reducing their risk of vision-threatening disease by 25%.[13] Patients with geographic atrophy were not treated.[13] Patients with choroidal neovascularization received antivascular endothelial growth factor treatment that resulted in a onetime probability of improving vision and a subsequent reduced probability of losing vision for a period of 2 years regardless of whether vision initially improved.[27] After 2 years of treatment, we assumed individuals with choroidal neovascularization experienced rates of visual loss associated with photodynamic therapy.[14]

Patients diagnosed with glaucoma first received ocular medications followed by laser trabeculoplasty and incisional trabeculotomy if less intensive treatments failed.[28] To be conservative, we used glaucoma treatment efficacy rates from the Early Manifest Glaucoma Trial, a relative risk of annual visual field loss of 0.60, and a lower rate of loss during progression years of 0.826.[29] Patients with URE received 1 eye evaluation, glasses, contact lenses, or both with replacement every 3.4 years for spectacles and annually for contact lenses.[30] We assumed that URE treatment was 100% effective. Further explanations of treatments are published elsewhere.[7,8,31]

Preferred Practice Patterns indicate only that cataracts should be extracted when visual function no longer meets the patient's needs.[32] To model surgery indication, we used data from the Beaver Dam Eye Study's waves 2 through 4 to estimate the proportion of patients with each nuclear opacity score who experienced no impairment, impairment that could be cor-

Table 1. Percentage of Beaver Dam Eye Study Patients With Each Type of Visual Impairment Classified by Nuclear Sclerosis Score

Type of Visual Impairment	Simulated Patients, %				
	No Cataracts (NSS, ≤1)	Mild Cataracts (NSS, >1 to 2)	Moderate Cataracts (NSS, >2 to 3)	Moderate-to-Severe Cataracts (NSS, >3 to 4)	Severe Cataracts (NSS, >4 to 5)
No presenting impairment; no impairment in eye after correction	0.00	0.93	0.87	0.66	0.44
Presenting impairment; no impairment after correction	0.00	0.05	0.05	0.06	0.02
Presenting impairment; still impaired after correction	0.00	0.02	0.08	0.28	0.54

Abbreviation: NSS, Nuclear Sclerosis Score.

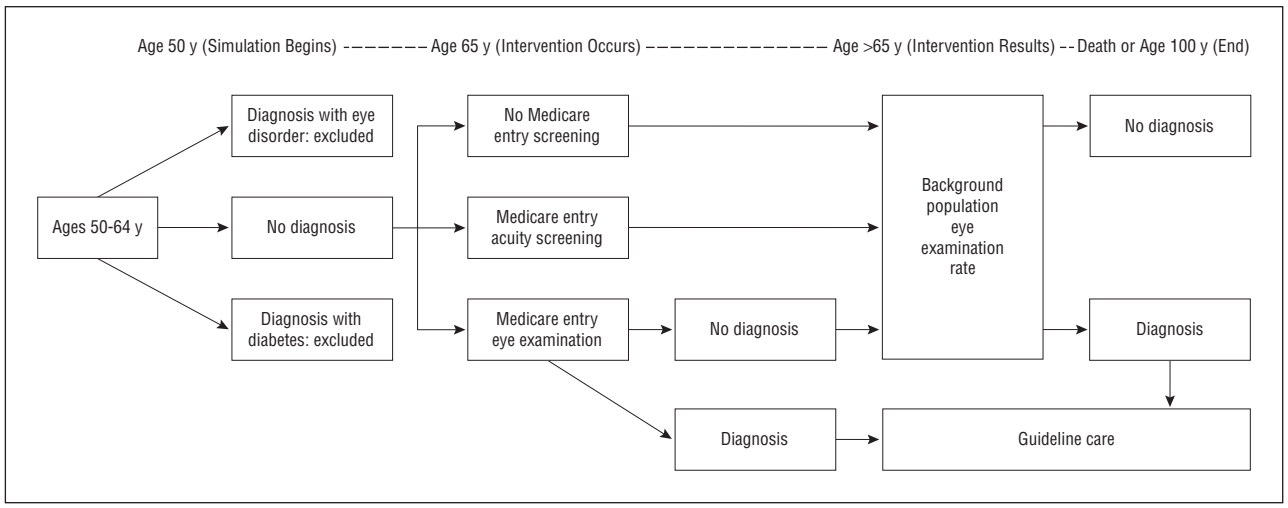

Figure 1. Simulation design. Individuals diagnosed with eye disorders or diabetes mellitus prior to age 65 years are excluded from the analysis because current recommendations direct their use of eye care.

rected with glasses, and impairment that persisted after refraction (**Table 1**). In our model, all patients with a nuclear cataract severity score of 3 or higher received a diagnosis of cataracts and annual eye evaluations thereafter. Persons with eyes with a severity score of 1, 2, or 3 with impairment that could be corrected with glasses received them. Eyes with impairment that could not be corrected with glasses received surgery. Eyes with scores of 4 or 5 received surgery regardless of impairment. Persons who received surgery received annual eye evaluations thereafter.

TREATMENT AND PRODUCTIVITY COSTS

We estimated treatment costs by translating treatment algorithms into *Current Procedural Terminology* codes and frequencies, estimating Medicare reimbursement values for each procedure, and summing costs by disease stage. We used a previous estimate of the annual cost of long-term care.[33] We assigned 4.25 hours of productivity losses to dilated eye evaluations and 8 hours for ocular surgery, and we varied the wages lost per hour based on patient age. Productivity losses from visual impairment are embedded in QALY estimates.[34,35]

SCENARIOS TESTED

We simulated the effect of 3 scenarios: (1) no screening, (2) visual acuity screening during a patient's IPPE visit, or (3) dilated eye examination for 65-year-old patients during their first-year enrollment (**Figure 1**). In scenario 1, eye evaluations occurred at the background rate only.

In scenario 2, persons received a visual acuity screening at age 65 years; this screening detected uncorrectable visual acuity losses with a sensitivity and specificity of 0.94 and 0.92, respectively, and correctable sources of visual impairment with a sensitivity and specificity of 0.70 and 0.92, respectively.[36] Persons whose visual acuity screening was positive for visual impairment were referred to an eye care provider with a compliance rate of 95%.[10] Those persons who truly had visual impairment received treatment. Those persons who had a false-positive screening result incurred confirmatory examination costs. A visual acuity screening costs $2.36, the estimated wages for 5 minutes of nurse practitioner time.

In scenario 3, persons received a dilated eye examination with autorefraction at age 65 years with a sensitivity and specificity of 0.89 and 0.94, respectively, of detecting a URE, 0.81 and 0.85, respectively, of detecting early AMD, 0.75 and 0.79, respectively, of detecting moderate glaucoma, and 0.97 and 0.79, respectively, of detecting severe glaucoma.[22-26] We assumed that dilated eye examinations would detect all cases of advanced AMD and nuclear cataracts with a Lens Opacity Classification System grading score of greater than 3.0. Persons who were truly positive for eye disease received treatment, and those with a false-positive result incurred confirmatory costs. Because everyone was screened at age 65 years, they did not use background routine eye examinations in that year, but, as in other scenarios, those without a diagnosis used routine services in subsequent years.

Table 2. Key Model Parameters Used in the Monte Carlo Simulation

Characteristic	Mean (95% CrI)[a]	Source(s)
Visual acuity screening[b]		
Sensitivity to detect uncorrected refractive error	0.70 (0.64-0.76)	Squirrell et al 2005[36]
Specificity to detect uncorrected refractive error	0.92 (0.85-1.00)	
Sensitivity to detect acuity losses from other causes	0.96 (0.86-1.00)	
Specificity to detect acuity losses from other causes	0.92 (0.85-1.00)	
Sensitivity to detect asymptomatic eye disease	0.0 (not varied)	Assumption
Specificity to detect asymptomatic eye disease	0.0 (not varied)	
Ophthalmoscopy		
Sensitivity to detect uncorrected refractive error[b]	0.94 (0.90-0.98)	Williams et al 2000,[24] Lou et al 266,[25] Tong et al[26]
Specificity to detect uncorrected refractive error[b]	0.89 (0.85-0.93)	
Sensitivity to detect early AMD without visual loss[b]	0.81 (0.78-0.85)	Tikellis et al 2000[22]
Specificity to detect early AMD without visual loss[b]	0.85 (0.82-0.89)	
Sensitivity to detect vision-threatening AMD	1.00 (not varied)	
Specificity to detect vision-threatening AMD	1.00 (not varied)	
Sensitivity to detect glaucoma, optic nerve cupping[b]	0.75 (0.72-0.78)	Harper and Reeves 2000[23]
Specificity to detect glaucoma, optic nerve cupping[b]	0.79 (0.76-0.82)	
Sensitivity to detect nuclear cataracts[c]	1.00 (not varied)	Assumption
Specificity to detect nuclear cataracts[c]	1.00 (not varied)	
Costs, $		
Welcome to Medicare visual acuity screening[d]	2.35 (1.35-3.37)	Estimated (see text)
Dilated eye examination,[d] assuming normal test result	72.27 (40.54-104.43)	Gray and Parkinson 2003,[37] AMA 2002[38]
Annual long-term care[e]	34 211 (19 617-48 923)	Cooney et al 2004[33]
Productivity loss from eye examination,[d] $		
Ages 65-69 y	4.00 (2.55-6.35)	Bureau of Labor Statistics[39,40]
Ages 70-74 y	3.00 (1.56-3.89)	
Ages ≥75 y	1.00 (0.59-1.47)	
QALY[f]		
Baseline, no impairment	0.87 (not varied)	Brown et al 2003 [41]
Monocular impairment	0.84 (0.83-0.85)	
Uncorrected refractive error	0.74 (0.72-0.76)	
20/40 visual acuity	0.69 (0.66-0.72)	
20/60 visual acuity	0.64 (0.60-0.68)	
20/100 visual acuity	0.61 (0.56-0.65)	
20/200 visual acuity	0.57 (0.52-0.62)	
20/400 visual acuity	0.51 (0.45-0.57)	
Incidence rate relative to published values[d]		
AMD	1.00 (0.83-1.17)	Assumption
Glaucoma	1.00 (0.83-1.17)	
Nuclear cataract	1.00 (0.83-1.17)	
Uncorrected refractive error	1.00 (0.57-1.42)	
Other parameters[b]		
Population background screening rate, ages 50-64 y	0.63 (0.55-0.71)	Sloan et al 2004,[20] CDC[42]
Population background screening rate, ages ≥65 y	0.74 (0.66-0.81)	
Discount rate	0.03 (0.01-0.05)	

Abbreviations: AMA, American Medical Association; AMD, age-related macular degeneration; CDC, Centers for Disease Control and Prevention; CrI, credible interval; QALY, quality-adjusted life-year.

[a] The interval used in probabilistic sensitivity analysis.

[b] Beta distributed.

[c] Lens Opacity Classification System grading score of greater than 3.0.

[d] Normally distributed.

[e] Lognormally distributed.

[f] QALYs were varied as a group using a single multiplier that varied from 0.83 to 1.17.

SIMULATION

We performed a Monte Carlo simulation that varied key model parameters based on published guidelines and expert opinion (**Table 2**).[43,44] A Monte Carlo simulation involves sampling parameters from their distribution of possible values and using these values to perform repeated iterations of the model. The results were used to calculate mean outcomes of interests and their credible intervals (CrIs) after accounting for uncertainty in the model's parameters. We simulated 50 000 patients per replication and 2000 replications per scenario using an identical set of 2000 randomly drawn parameters for each scenario. Our baseline results are the mean outcome values across the 2000 simulations. For costs and QALYs, we used the simulation results to estimate a nonparametric 95% CrI, for which we used a bootstrapped-with-replacement method and 1000 replications; this type of resampling method is used to estimate the distribution of a statistical outcome.

OUTCOMES

We estimated per person discounted QALYs and lifetime costs from the patient, Medicare, and societal perspectives. Patient costs in-

Table 3. Costs and QALYs Associated With Different Screening Scenarios and Perspectives

Scenario	QALYs (95% CrI)	Cost to Patient (95% CrI), $	Cost to Medicare (95% CrI), $	Productivity Losses[a] (95% CrI), $	Cost to Society (95% CrI), $
No screening	10.8765 (10.8750-10.8779)	3871 (3835-3909)	3276 (3247-3306)	141 (138-143)	7288 (7227-7354)
Visual acuity screening	10.8776 (10.8761-10.8790)	3894 (3858-3932)	3284 (3255-3314)	142 (140-145)	7320 (7257-7386)
Dilated eye examination	10.8841 (10.8827-10.8855)	3916 (3879-3954)	3319 (3289-3349)	147 (145-150)	7382 (7319-7449)

Abbreviations: CrI, credible interval; QALYs, quality-adjusted life years.
[a] Productivity losses refer only to those that occur as a result of eye evaluations, dilation, or treatment; they do not include losses from visual impairment because these are incorporated into QALY losses.

Table 4. Incremental Cost-effectiveness Ratios Associated With Different Screening Scenarios and Perspectives

Scenario	Perspective (95% CrI), $		
	Patient	Medicare	Societal
Visual acuity screening vs no screening	20 300 (12 800-34 300)	7400 (5100-11 900)	29 100 (18 700-48 400)
Eye examination vs visual acuity screening	3400 (2800-4100)	5300 (4900-5700)	9500 (8500-10 600)
Eye examination vs no screening	5800 (5200-6500)	5600 (5200-6000)	12 300 (11 300-13 400)

Abbreviation: CrI, credible interval.

cluded 20% of outpatient costs (estimated Medicare Part B copayment rate) and long-term care costs. We attributed long-term care to the patient because Medicare reimburses only short-term skilled nursing facility care, a small component of long-term care costs, and because individuals must exhaust their personal finances before receiving Medicaid assistance. We attributed 80% of outpatient costs plus all screening costs to Medicare, and we attributed patient, Medicare, and productivity costs to society.

We calculated the incremental cost-effectiveness ratio (ICER) of visual acuity screening compared with that of no screening and the ICER of eye examination compared with that of both visual acuity screening and no screening, and we estimated their CrIs using published methods.[45] We also calculated the net benefit of each scenario. The net benefit, which results in the same rank order of policy preferences as the ICER but has superior statistical attributes,[46] is defined as $\lambda \times Q - C$, where λ is equal to a willingness-to-pay (WTP) value, Q is the mean QALYs per person in a given scenario, and C is the mean costs from that scenario. Because the net benefit is a linear function, the scenario with the greatest net benefit at each WTP value is considered the most cost-effective without the need to rely on incremental results.

For each scenario, we calculated the net benefit for each simulated iteration at WTP values ranging from $0 to $100 000 per QALY gained and used these results to plot cost-effectiveness acceptability curves. The cost-effectiveness acceptability curves graphed the proportion of simulations (y-axis) in which each scenario (no screening, visual acuity screening, and eye evaluation) was the most cost-effective option (ie, resulted in the greatest net benefit) at each WTP value per QALY gained (x-axis). We present cost-effectiveness acceptability curves from the patient, Medicare, and societal perspectives. We also estimated the cost and value of each policy to Medicare by multiplying the incremental change in QALYs and Medicare costs by 2 million, the estimated number of new Medicare enrollees each year.

SENSITIVITY ANALYSIS

We used logistic regression models to determine which variables significantly predicted that a scenario would be more cost-effective than an alternative given a WTP value of $15 000 (the value when uncertainty about the most cost-effective scenario was highest). We compared visual acuity screenings with no screening, visual acuity screenings with eye evaluations, and eye evaluations with no visual screening, setting the dependent variable to 1 when that scenario was more cost-effective than its alternative and to 0 otherwise. We included variables with intervals listed in Table 2 as independent variables. We considered the results to be sensitive to variables with $P < .05$.

RESULTS

With no Medicare entry screening, we estimated that each patient would experience a mean of 10.877 (95% CrI, 10.875-10.878) discounted QALYs and incur $7288 (95% CrI, $7227-$7354) in total costs over the remainder of his or her life (**Table 3**). Total costs include $3253 in Medicare costs, $3085 in other medical costs, $810 in long-term care costs, and $140 in productivity losses. The Welcome to Medicare visual acuity screening increased QALYs by 0.0011 (95% CrI, –0.0018 to 0.0040) and costs by $32 (95% CrI, –$97 to $109). These changes in costs and QALYs were positive less than 95% of the time. The dilated eye evaluation increased QALYs by 0.0076 (95% CrI, 0.0048-0.0105) and costs by $94 (95% CrI, –$35 to $222). Of the additional costs of the visual acuity screening, 71.9% were borne by the patient, 25.0% were borne by Medicare, and 3.1% were productivity losses. For eye examinations, 47.9% of the additional costs were borne by the patient, 45.7% were borne by Medicare, and 6.3% were productivity losses.

The ICER of visual acuity screenings compared with no screening was $20 300, $7400, and $29 100 per QALY gained from the patient, Medicare, and societal perspective, respectively. The ICER of eye examinations compared with visual acuity screenings was $3400, $5300, and $9500 per QALY gained from the patient, Medicare, and societal perspective, respectively. Eye evaluations extendedly dominated visual acuity screenings. The ICER of eye evaluations compared with no screening was

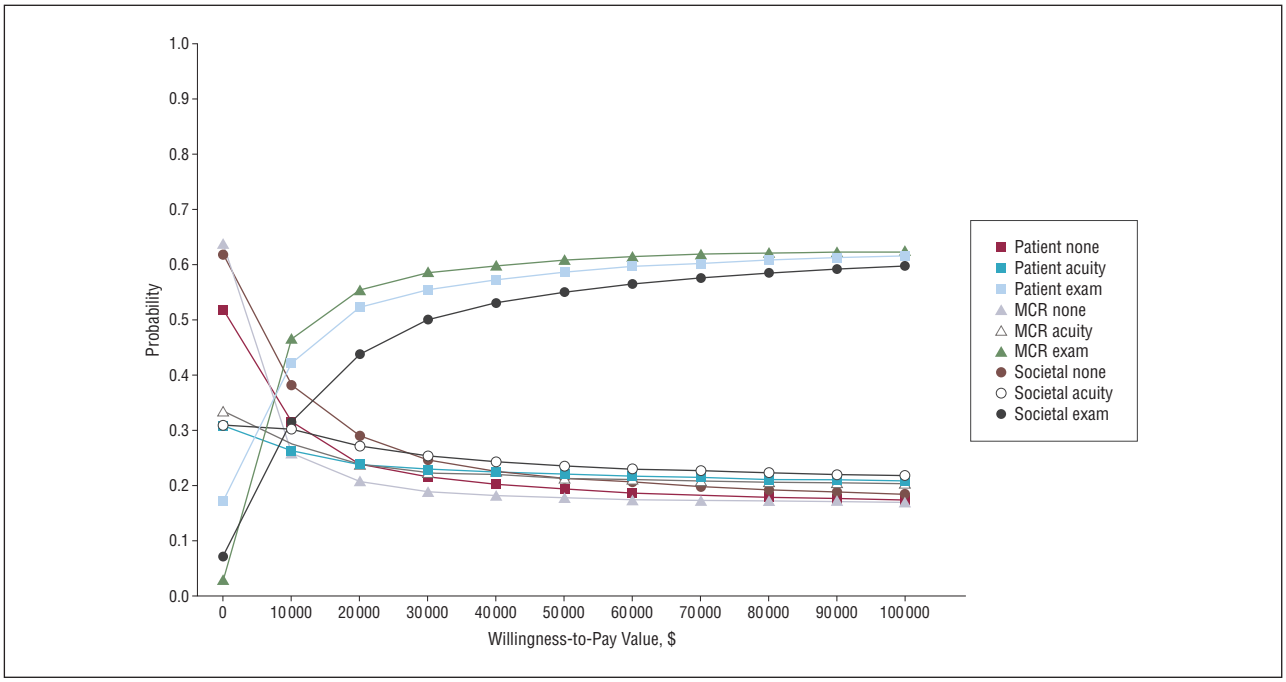

Figure 2. Probability that each screening option is the most cost-effective at each willingness-to-pay value by payer (indicated by shape) and scenario (indicated by color). *MCR acuity* indicates visual acuity screening in primary care at age 65 years from a Medicare perspective; *MCR exam*, dilated eye examination by an eye care professional at age 65 years from a Medicare perspective; *MCR none*, no intervention from a Medicare perspective; *Patient acuity*, visual acuity screening in primary care at age 65 years from a patient perspective; *Patient exam*, dilated eye examination by an eye care professional at age 65 years from a patient perspective; *Patient none*, no intervention from a patient perspective; *Societal acuity*, visual acuity screening in primary care at age 65 years from a societal perspective; *Societal exam*, dilated eye examination by an eye care professional at age 65 years from a societal perspective; *Societal none*, no intervention from a societal perspective.

$5800, $5600, and $12 300 per QALY gained from the patient, Medicare, and societal perspective, respectively (**Table 4**).

From the societal perspective, the no screening scenario was the most likely to be cost-effective up to a WTP value of $15 000 per QALY gained, after which eye evaluations were preferred (**Figure 2**). There were no WTP values at which a visual acuity screening was the most likely to be cost-effective. Eye evaluations were more likely to be the most cost-effective option at lower WTP values from the Medicare perspective than from the patient perspective and from the patient perspective than from the societal perspective.

Assuming 2 million persons newly enrolling in Medicare annually, compared with no screening, current visual acuity screenings increased QALYs by 2200 (95% CrI, –3600 to 8000) and increased lifetime societal costs by $66 million (95% CrI, –$194 million to $318 million). Of these costs, $46 million were paid by the patient, $16 million were paid by Medicare, and $2 million were productivity losses. Compared with no screening, eye examinations increased QALYs by 15 200 (95% CrI, 9600-21 000) and increased total societal cost by $188 million (95% CrI, –$70 million to $444 million). Of these costs, $90 million would be paid by the patient, $86 million would be paid by Medicare, and $12 million would be productivity losses.

At a WTP value of $15 000 per QALY gained, eye evaluations were preferred to no screening 54.0% of the time and were preferred to visual acuity screenings 56.2% of the time. Visual acuity screenings were preferred to no screening 46.7% of the time. Eye evaluations were significantly more likely to be preferred over both no screening and visual acuity losses when medical costs were lower, when QALY losses from visual loss were higher, and when nuclear cataract progression rates were higher. Visual acuity screenings were more likely to be more cost-effective than no screening when productivity losses from dilation were lower and when QALY losses from visual losses were higher.

COMMENT

For patients with no previously diagnosed eye conditions or diabetes, we found that dilated eye examinations at Medicare entry are likely to be cost-effective at a WTP value of $15 000 per QALY gained or higher. We found little evidence that the current policy of visual acuity screening during the Medicare IPPE visit is cost-effective. Dilated eye examinations during a patient's first year of Medicare eligibility would generate approximately 0.008 QALYs per person or an equivalent of 2.77 healthy days of life, at a relatively low cost of $94 per person in societal costs or $43 per patient in Medicare costs. The aggregate benefit of such a policy compared with no screening would be 15 200 QALYs per year at a cost of $188 million, with $86 million of this cost paid by Medicare.

The cost-effectiveness of dilated eye examinations compared with no screening was highly favorable compared with many other health interventions: $12 300 per QALY

gained from the societal perspective and $5600 per QALY gained from the Medicare perspective. This cost-effectiveness ratio was more favorable than the one associated with biennial dilated eye evaluations for persons with diabetes at low risk of progression ($38 000 per QALY gained).[8]

Our results support the conclusions of the US Preventive Services Task Force that currently recommended visual acuity screening in primary care settings cannot be demonstrated to result in meaningfully different outcomes than no screening.[5] In our model, this result is explained by the high rate of routine service utilization that occurs in this population, the lower sensitivity of visual acuity screening in detecting URE, and the inability of visual acuity screening to detect both early, nonvisually impairing cataracts and asymptomatic disease.

The relatively low costs of adding dilated eye evaluations are explained by the high rate of routine service utilization that already occurs in this population. Adding eye evaluations at age 65 years had the primary effect of detecting disease and initiating treatment earlier rather than creating new treatments that would not have otherwise occurred.

Our results were most sensitive to the QALY losses associated with visual loss, the incidence rate of nuclear cataracts, and the medical costs of treatment. Our model uses QALY values for visual impairment that were collected using older and nonstandard methods, leading to potentially larger effects of visual impairment than might be estimated using more standard methods. Additionally, very little research has been conducted to establish QALY losses from URE, so these values were imputed from comparable visual acuity deficits caused by uncorrectable conditions. For this reason, we specified a greater uncertainty interval for QALY losses in this analysis than we specified for other values. This and all visual health cost-effectiveness research would greatly benefit from alternative estimates of the effects of visual impairment.

To manage the complexity of our model, we included only nuclear cataracts. Our sensitivity analysis also indicates that this limitation is likely to be inconsequential because a higher incidence of cataracts led eye evaluations to be more cost-effective. Likewise, although our model was sensitive to medical costs, our study used the Medicare fee schedule to estimate unit costs, limiting the uncertainty associated with this variable.

Our model uses a number of assumptions that affect our cost-effectiveness results as compared with those that would potentially be observed in real-world applications. Most importantly, our model assumes that the policy of dilated eye examinations is only applicable to people without diabetes. In real-world settings, some people with undiagnosed diabetes would receive the same examination. Because people with undiagnosed diabetes are at higher risk of visual loss than people without diabetes, the effect of this assumption is to bias our results toward a less cost-effective outcome. Welcome to Medicare dilated eye evaluations would be more cost-effective than shown here to the extent that the eye examinations would identify people with previously undiagnosed diabetes. Our model also assumes 100% utilization rates when discussing the budgetary implications to Medicare. In real-world applications, likely far less than 100% of enrollees would undergo a dilated eye evaluation, lowering its overall costs.

Despite these limitations, our study represents the first estimate of the cost-effectiveness of visual acuity screening that directly accounts for the simultaneous effect of multiple visual conditions. Our research suggests that the current policy of visual acuity screening is a suboptimal use of resources and that replacing this policy with coverage of a dilated eye evaluation for all healthy patients entering Medicare would be highly cost-effective.

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Author Contributions: Dr Rein and Mr Wittenborn had full access to all simulation data and take responsibility for the integrity of the data and the accuracy of the data analysis. Ms Lee had access to the primary data related to visual status at different cataract levels and takes responsibility for the integrity of the data.
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Disclaimer: The content is solely the responsibility of the authors and does not necessarily represent the official position of the Centers for Disease Control and Prevention or the official views of the National Eye Institute or the National Institutes of Health.
Additional Information: Ms Lee estimated the information included in Table 1 from primary data.

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