Cost-Utility Analysis of Screening Intervals for Diabetic Retinopathy in Patients With Type 2 Diabetes Mellitus

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Diabetes mellitus is a leading cause of blindness in the United States. Randomized trials have clearly demonstrated that the risk of developing severe visual loss from proliferative diabetic retinopathy (PDR) and macular edema can be significantly reduced through the use of laser photocoagulation. Thus, screening, detection, and appropriate treatment of PDR and macular edema have the potential to significantly reduce the incidence of visual loss in patients with diabetes.

Screening is vital to preventing visual loss from diabetes because retinopathy is often asymptomatic early in the course of the disease. While no randomized trials have demonstrated that screening directly reduces rates of blindness, simulation models predict a reduction in visual loss with retinal screening. A number of previous cost-effectiveness analyses have demonstrated that annual screening and treatment for PDR and macular edema are cost-effective interventions. As a result of these studies, provision of annual screening is being used as a measure of quality of care. However, the benefit of annual vs less frequent screening intervals has not been well evaluated, especially for low-risk patients.

Objective To examine the marginal cost-effectiveness of various screening intervals for eye disease in patients with type 2 diabetes, stratified by age and level of glycemic control.

Design Markov cost-effectiveness model.

Setting and Participants Hypothetical patients based on the US population of diabetic patients older than 40 years from the Third National Health and Nutrition Examination Survey.

Main Outcome Measures Patient time spent blind, quality-adjusted life-years (QALYs), and costs of annual vs less frequent screening compared by age and level of hemoglobin A1c.

Results Retinal screening in patients with type 2 diabetes is an effective intervention; however, the risk reduction varies dramatically by age and level of glycemic control. On average, a high-risk patient who is aged 45 years and has a hemoglobin A1c level of 11% gains 21 days of sight when screened annually as opposed to every third year, while a low-risk patient who is aged 65 years and has a hemoglobin A1c level of 7% gains an average of 3 days of sight. The marginal cost-effectiveness of screening annually vs every other year also varies; patients in the high-risk group cost an additional $40,530 per QALY gained, while those in the low-risk group cost an additional $211,570 per QALY gained. In the US population, retinal screening annually vs every other year for patients with type 2 diabetes costs $107,510 per QALY gained, while screening every other year vs every third year costs $49,760 per QALY gained.

Conclusions Annual retinal screening for all patients with type 2 diabetes without previously detected retinopathy may not be warranted on the basis of cost-effectiveness, and tailoring recommendations to individual circumstances may be preferable. Organizations evaluating quality of care should consider costs and benefits carefully before setting universal standards.
Previous analyses of screening for diabetic eye disease have not adequately examined the marginal benefits of increased screening frequency or specific methods of targeting patients. For example, it has been suggested that all patients with type 2 diabetes be screened at diagnosis and, if the result is negative, further screening be deferred for 3 to 4 years. Clinical predictors of diabetic retinopathy can also be used to effectively stratify the frequency of diabetic eye screening. For example, risk of retinopathy and eventual blindness can be stratified by level of glycemic control. Thus, we sought to evaluate whether hemoglobin A1c level can be used to effectively stratify the frequency of diabetic retinopathy screening and improve the efficiency and cost-effectiveness of screening.

**METHODS**

We created a nonstationary Markov model to simulate the progression of diabetic retinopathy and macular edema. Simulated patients were classified based on whether they had no retinopathy, nonproliferative retinopathy (defined as visual acuity of less than 20/100 in the better eye). The simulated patients were further classified by whether they had been diagnosed as having retinopathy or macular edema. The key assumptions and estimates for the model are outlined in Table 1.

To provide a population base of patients with type 2 diabetes for the study, we used the characteristics of the diabetic population older than 40 years in the Third National Health and Nutrition Examination Survey (NHANES III), a nationally representative sample of the US population. Patients were grouped into initial levels of eye disease in the model based on the prevalence of various levels of diabetic eye disease reported in NHANES III. We used ordinal logistic regression to smooth the predictions of levels of eye disease based on age and glycemic control. These estimates are outlined in Table 2.

The model structure is outlined in the Figure. The incidence of developing and progressing through the stages of nonproliferative retinopathy was assumed to be related to level of glycemic control, as outlined in Table 1. The relationship was derived from the UK Prospective Diabetes Study (UKPDS), which showed that a decrease of 0.9% in hemoglobin A1c (from 7.9% to 7.0%) was related to a 21% decrease in risk of retinopathy progression over 12 years. Progression beyond nonproliferative retinopathy to PDR, macular edema, and

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**Table 1.** Baseline Case Parameter Estimates and Assumptions

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Baseline Case</th>
<th>Analysis Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Annual Disease Progression Rates</td>
<td>Retinopathy (state 3) to high-risk PDR</td>
<td>0.08</td>
</tr>
<tr>
<td></td>
<td>Retinopathy (state 1 or 2) to macular edema</td>
<td>0.006</td>
</tr>
<tr>
<td></td>
<td>Retinopathy (state 3) to macular edema</td>
<td>0.03</td>
</tr>
<tr>
<td></td>
<td>High-risk PDR to blindness with photocoagulation</td>
<td>0.02</td>
</tr>
<tr>
<td></td>
<td>High-risk PDR to blindness without photocoagulation</td>
<td>0.09</td>
</tr>
<tr>
<td></td>
<td>Macular edema to blindness with photocoagulation</td>
<td>0.03</td>
</tr>
<tr>
<td></td>
<td>Macular edema to blindness without photocoagulation</td>
<td>0.05</td>
</tr>
</tbody>
</table>

**Mortality Multipliers**

- Diabetes mellitus: 1.80, 1.60-2.00
- Retinopathy levels <35%: 1.23, 1.09-1.35
- Retinopathy levels 43-53%: 1.49, 1.37-1.61
- PDR: 1.76, 1.64-1.88
- Macular edema: 1.76, 1.64-1.88
- Blindness: 2.34, 2.22-2.46

**Characteristics of Retinopathy Screening Test**

- No retinopathy called nonproliferative retinopathy: 0.06, 0.04-0.06
- No retinopathy called PDR: 0.003, 0.0002-0.006
- Nonproliferative retinopathy called no retinopathy: 0.22, 0.21-0.23
- Nonproliferative retinopathy called PDR: 0.02, 0.01-0.03
- PDR called no retinopathy: 0.02, 0.01-0.03
- PDR called nonproliferative retinopathy: 0.03, 0.02-0.04
- Sensitivity for macular edema: 0.82, 0.70-0.94
- Specificity for macular edema: 0.79, 0.67-0.91

**Costs, $**

- Visit cost for dilated eye examination: 53, 28-78
- Fluorescein angiogram: 163, 113-213
- Focal photocoagulation: 1490, 1290-1690
- Scatter photocoagulation: 1740, 1540-1940

*PDR indicates proliferative diabetic retinopathy. Annual progression from no retinopathy to retinopathy state 1, state 2 to state 2, and state 2 to state 3 (see Figure) was determined from the UK Prospective Diabetes Study. For patients with hemoglobin A1c of 7%, the annual progression rate was 0.0406; for 9%, 0.0761; for 11%, 0.1425; and for 13%, 0.2669.

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**Table 2.** Estimates of Type 2 Diabetes Distribution by Age and Level of Glycemic Control

<table>
<thead>
<tr>
<th>Age, y</th>
<th>Hemoglobin A1c, %</th>
</tr>
</thead>
<tbody>
<tr>
<td>7</td>
<td>0.085 0.133 0.166 0.203</td>
</tr>
<tr>
<td>9</td>
<td>0.097 0.14 0.18 0.237</td>
</tr>
<tr>
<td>11</td>
<td>0.11 0.152 0.193 0.245</td>
</tr>
<tr>
<td>13</td>
<td>0.122 0.167 0.208 0.251</td>
</tr>
</tbody>
</table>

| Proportion of Population With Early Retinopathy at Entry to Simulation |
|-----------------------------|---------------------|
| 40-49 | 0.063 0.041 0.040 0.018 |
| 50-59 | 0.096 0.097 0.037 0.016 |
| 60-69 | 0.188 0.107 0.036 0.007 |
| 70-79 | 0.141 0.067 0.039 0.005 |

*Estimates are based on smoothed estimates from the Third National Health and Nutrition Examination Survey.

Early retinopathy is defined as level ≤ 35 in the Airlie House classification scheme.
blindness was assumed to be independent of level of glycemic control. Rates of such progression were taken from the Diabetic Retinopathy Study (DRS) and the Early Treatment of Diabetic Retinopathy Study (ETDRS). Mortality rates were based on life tables published by the US government. These were modified to reflect the increased mortality rates observed in patients with diabetes in general and were further adjusted for disease state based on observed mortality risks in observational studies. The mortality multipliers are outlined in Table 1.

The effects of screening were estimated by interposing an eye examination at annual to every fifth year intervals. We assumed that retinal screening was done by ophthalmologists, because primary care physicians typically have low screening accuracy. Screening characteristics were derived from epidemiologic studies (Table 1); these numbers reflect the proportion of patients who are misdiagnosed at examination (for example, in the baseline case, the case in which the simulation is run with the “baseline” estimates in Table 1, 4.6% of patients without retinopathy are diagnosed as having nonproliferative retinopathy, but only 0.32% of patients without retinopathy are diagnosed as having PDR). Patients who were diagnosed, correctly or incorrectly, as having retinopathy were subsequently screened annually. Patients who were diagnosed as having high-risk PDR or confirmed high-risk macular edema were treated with scatter and focal photocoagulation, respectively. Therapy for macular edema was guided by fluorescein angiography. Photocoagulation was assumed to reduce the rate of progression to blindness as shown in reanalysis of the data from the DRS and ETDRS (Table 1). Patients who developed macular edema were assigned the risk of blindness from macular edema, even if they developed PDR. This assumption was made because photocoagulation is less effective in preventing visual loss from macular edema than PDR.

Quality-adjusted life-years (QALYs) were used as the primary model outcome measure. The model predictions for overall life expectancy were adjusted for time spent blind based on a utility for blindness of 0.69 in the baseline case. Because screening for eye disease can appear to improve survival as a result of the increased observed mortality rates seen in patients with more advanced eye disease, we standardized life expectancy to that of annual screening and calculated the total QALYs for each screening interval by using the time spent blind and the utility of blindness. Total effectiveness was then calculated by comparing the total QALYs with each screening interval. All costs and years of life were discounted at 3%.

Costs were standardized by using average Medicare reimbursement for an ophthalmology visit with dilated eye examination, laser photocoagulation (focal and scatter), and fluorescein angiogram. In the baseline case, no direct costs were attributed to blindness, although the impact of attributing medical and societal costs to blindness was explored in sensitivity analyses. In these sensitivity analyses, we used costs of blindness from prior cost-effectiveness analyses to allow comparison between studies. Thus, in the baseline case, we used the perspective of a third-party payer, while governmental and societal perspectives were explored in sensitivity analyses.

We evaluated the costs and effectiveness of screening the US population of patients with known type 2 diabetes using data from NHANES III. The proportions and total numbers of patients with diabetes in the US population were calculated using the survey weights from NHANES III. We assumed that, at baseline, none of the patients had been previously screened, so that at entry, all patients were screened at the intervals defined in the model. On diagnosis of retinopathy, patients were screened annually. The predictions of the model (costs and QALYs) were then applied to the US patient population, stratified by age and level of glycemic control. By summing total QALYs and costs across age and hemoglobin A1c strata and comparing these between screening intervals, we were able to calculate the marginal cost-effectiveness of increasing screening frequency for the population of patients with type 2 diabetes in the United States.

One-way sensitivity analyses were conducted on individual estimates to assess their impact on the costs and effectiveness of screening. The ranges of estimates encompass the ranges reported in the literature. Because only single studies were available in some cases (eg, ETDRS and DRS), a range of possible effectiveness was estimated for the purposes of sensitivity analyses. These ranges are outlined in Table 1. Multivariate sensitivity analyses were conducted using a simulation approach to estimate the variance and distribution of the cost-effectiveness estimates. This approach uses Monte Carlo simulation and repeatedly samples from the multivariate distribution of ranges of the estimates, calculating costs and effectiveness at each sampling. This allows estimation of the distribution of the cost-effectiveness estimate. The technique is more fully described elsewhere. For the purposes of this simulation, we assumed that the estimates were normally distributed, with the baseline case representing the mean and the ranges in Table 1 encompassing 4 SDs. Each vari-
various health states for 3 selected
Blind at Varying Screening Intervals
892 JAMA, February 16, 2000—Vol 283, No. 7
TABLE 3
RESULTS
simulation runs were conducted for each sensitivity analyses, 10 000 Monte Carlo
in the estimates is random rather than
sensitivity analyses and assumes that error can be seen in typical multivariate sen-
approach avoids the extreme variations that
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approach avoids the extreme variations that
multivariate sensitivity analysis. This ap-
variable avoids the extreme variations that
can be seen in typical multivariate sen-
sensitivity analyses, 10 000 Monte Carlo
simulation runs were conducted for each stratum.
RESULTS
TABLE 3 shows model predictions for various health states for 3 selected
<table>
<thead>
<tr>
<th>Risk Group</th>
<th>Risk of Any Retinopathy, %</th>
<th>Average Time Spent Blind in Those Who Become Blind, y*</th>
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<tr>
<td></td>
<td>No Screening</td>
<td>Annual Screening</td>
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<tr>
<td>High (age, 45 y; hemoglobin A1c, 11%)</td>
<td>86.1</td>
<td>22.4</td>
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<td>Moderate (age, 65 y; hemoglobin A1c, 9%)</td>
<td>49.4</td>
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<td>Low (age, 75 y; hemoglobin A1c, 7%)</td>
<td>35.6</td>
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*Average time was not discounted.

TABLE 4. Average Predicted Time Spent Blind at Varying Screening Intervals

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<tr>
<th>Hemoglobin A1c, %</th>
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<th>Every Third Year</th>
<th>Every Year</th>
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<td>Ages 70-79 y</td>
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*Blindness is defined as visual acuity of 20/100 or worse in the better eye; time was discounted at 3% per year. Values reflect the average time spent blind for each patient (patients with and without blindness) in the stratum. All data are presented as days.

RESULTS
TABLE 3 shows model predictions for various health states for 3 selected
<10.3% in the UKPDS).<ref>UKPDS</ref> and those with an average hemoglobin A1c level of 9%, the 12-year incidence was 38.6% in the UKPDS and 37.5% in our model. Examination of stages beyond initial retinopathy progression in the model was similar at all times to those observed in the UK study (e.g., for patients with a hemoglobin A1c level of 7%, the 12-year incidence was 38.6% in the UKPDS and 37.5% in our model). Examination of stages beyond initial retinopathy suggest that the model is highly predictive of the UKPDS results as well. For example, our model predicts that UKPDS patients with an average hemoglobin A1c level of 7% will have a 10-year risk of photocoagulation of 7.6% (also 7.6% in the UKPDS), and those with an average hemoglobin A1c level of 8% will have a 10-year risk of photocoagulation of 10.0% (vs 10.3% in the UKPDS).

Costs and Effectiveness in the US Population
We used data from NHANES III, a representative population-based sample of the United States, to provide estimates of the levels of glycemic control and age of the population

fied by age and hemoglobin A1c levels, is presented in TABLE 5. Given the diminishing returns accrued by greater screening frequency, it is not surprising to find that annual screening usually costs more per QALY gained than less frequent screening intervals. For example, for a 65-year-old patient with an average hemoglobin A1c level of 9%, an annual screening program compared with an every other year screening program would result in spending an additional $123 580 for every additional QALY gained. In this same group, every other year vs every third year screening, costs an additional $62 610 per QALY gained. For many patients, annual screening costs are substantially more, with little marginal benefit, when compared with screening every other or even every third year. The patients who benefit the most, and for whom screening is most cost-effective, are those who have particularly poor glycemic control.

We examined the accuracy of the model by comparing the predictions of the model for clinical end points with those observed in the UKPDS. The cumulative incidence of retinopathy progression in the model was similar at all times to those observed in the UK study (e.g., for patients with a hemoglobin A1c level of 7%, the 12-year incidence was 38.6% in the UKPDS and 37.5% in our model). Examination of stages beyond initial retinopathy suggest that the model is highly predictive of the UKPDS results as well. For example, our model predicts that UKPDS patients with an average hemoglobin A1c level of 7% will have a 10-year risk of photocoagulation of 7.6% (also 7.6% in the UKPDS), and those with an average hemoglobin A1c level of 8% will have a 10-year risk of photocoagulation of 10.0% (vs 10.3% in the UKPDS).
of patients with known type 2 diabetes in the United States. Based on the survey weights from NHANES III, we estimate that approximately 5.3 million people have been diagnosed as having type 2 diabetes (this sample was limited to subjects for whom both age and hemoglobin A1c values were reported). As shown in Table 6, the model predicts that the current population of patients with type 2 diabetes will accumulate 50,081,384 QALYs without any retinopathy screening. Screening at 5-year intervals increases this to 50,216,915 QALYs at a cost of approximately $2.3 billion, for a cost-effectiveness of about $16,790 per QALY gained. However, the marginal cost-effectiveness of increasing screening frequency from every other year to every year costs more than $107,000 per QALY gained.

Sensitivity Analyses

We conducted extensive sensitivity analyses to examine the factors that had the greatest impact on our estimates of cost-effectiveness. While there are few data suggesting that blindness has a direct consequence on medical care costs, blindness has potential costs such as government provision of disability compensation and Medicare. One prior analysis estimated the cost of blindness ranging from $32 per year for those who become blind at age 65 years or older to $14,296 per year for those who become blind prior to age 65 years, while another estimated $5100 per year of blindness. These numbers have a fairly substantial effect on the overall cost-effectiveness of the intervention; in fact, for high-risk populations (those with young onset or poor glycemic control), annual screening appears to save money compared with no screening. However, inclusion of these costs has minimal impact on the marginal cost-effectiveness of increasing screening frequency, with changes of less than $5000 per additional QALY gained (compared with the baseline case results) being typical. The effect of adding societal costs is small because increasing screening intervals have only a small impact on time spent blind for most patients with type 2 diabetes.

The single most important variable in determining overall costs is the cost of the screening examination. When the cost is decreased to $28, approximately half of current Medicare reimbursement for an eye examination, the marginal cost-effectiveness of annual screening vs every other year screening improves, but still remains more than $50,000 per QALY for many subgroups. When the results are applied to the US population, a 50% reduction of the cost of a dilated eye examination leads to a marginal cost-effectiveness of $86,500 per QALY for annual vs every other year screening. Thus, even if the cost of an examination is cut in half, it does not substantially affect the baseline case conclusion that annual screening is not cost-effective when compared with screening every other year.

The variable that had the largest impact on the effectiveness of screening was the utility placed on a year of blindness. In the baseline case, we used a utility of 0.69. One prior analysis used much lower utility values for blind-
ness: 0.48 for the majority of blind individuals, with a subset who had even lower utility values.\(^8\) When a value of 0.48 is used for the utility of blindness, annual screening in the US population appears more cost-effective, with values of approximately $60 000 per QALY gained compared with every other year screening. Other variables affected the effectiveness of screening, but the influence of these variables was not large across a reasonable range of values.

Multivariate sensitivity analyses were conducted by creating distributions of the estimates based on the ranges outlined in Table 1 and running repeated iterations of the model, randomly sampling from these ranges.\(^6\)\(^-\)\(^7\) This produces a distribution of the cost-effectiveness values. The 95% range of cost-effectiveness for 3 groups is outlined in Table 7. The distribution shows only a 17.3% chance that the marginal cost-effectiveness of annual vs every other year screening is greater than $50 000 per QALY for the high-risk group. In contrast, none of the 10 000 simulations performed for the medium- and low-risk groups demonstrated that annual screening is cost-effective compared with every other year screening.

**COMMENT**

Diabetic eye disease remains a major cause of blindness in the United States. Randomized trials have shown that laser photocoagulation can significantly reduce the risk of blindness in patients with advanced eye complications.\(^2\)\(^-\)\(^3\) However, optimal screening intervals have not been adequately evaluated, particularly with regard to variability in eye disease risk in those at low risk. Despite this, many organizations, including the National Committee for Quality Assurance, through HEDIS measures,\(^11\) recommend that annual eye examinations be used not only as a general guideline, but as a quality standard in all patients with diabetes.

Our study suggests that such recommendations may be overzealous. The baseline case analysis shows that in many groups of patients, annual screening offers very little marginal benefit over every other year screening. For some low-risk groups (eg, those with good glycemic control, older age, and no retinopathy on prior examination), every third year screening may be almost as good as annual screening and is a more cost-effective approach. In addition to health care costs, unnecessary patient burden must be considered. Patients with diabetes average 8 to 12 outpatient visits annually,\(^49\) and visits that have little expected benefit can compete with other recommended care, both in terms of health care resources and patient time and energy.

Using NHANES III to estimate the distribution of age and glycemic control in the United States, we have shown that if a single screening strategy were to be recommended for the entire US population, every other year screening would seem to be the optimal choice, if the commonly suggested guideline of $50 000 per QALY gained is used as the definition of a cost-effective intervention.\(^30\) However, recommendations better tailored to individual patient circumstances would seem preferable. A number of potential screening strategies could be proposed. For example, annual screening could be recommended for all patients with hemoglobin A1c values over 10% (<20% of patients with diabetes in the US population according to NHANES III), while the remainder of the population could undergo screening every 2 to 3 years, with the least frequent screening interval being reserved for those with excellent glycemic control. Monitoring and feedback systems would be needed to ensure that this less frequent screening interval did not lead to patients not being screened at all. The most aggressive approach supportable by our results would be to recommend that annual screening is the safest strategy, but that if patients achieve good glycemic control and have normal results of baseline examination, every second or third year screening is almost as good at preventing visual loss. Under this scenario, professional recommendations do not change, but performance and quality measures, particularly those associated with incentive and disincentive payments, must recognize that patients and physicians might choose less frequent screening intervals.

We conducted extensive sensitivity analyses to test the robustness of our conclusions. In general, the largest uncertainty is not how little benefit the low-risk patients receive, but precisely how large the benefit is to the higher risk, and thus higher benefit, patients. Inclusion of a direct cost of blindness into the model had minimal impact on the marginal cost-effectiveness of annual screening, although it dramatically improves the overall cost-effectiveness of any screening com-

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**Table 7. Multivariate Sensitivity Analyses: Estimated Benefit Across Range of Parameter Estimates**

<table>
<thead>
<tr>
<th>Group Characteristics</th>
<th>Ranges of Outcomes</th>
<th>Range of Marginal Value of Screening</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Every 2 vs Every 3 y</td>
<td>Annual vs Every 2 y</td>
</tr>
<tr>
<td>High-risk patients: aged 45 y; hemoglobin A1c, 11%</td>
<td>Range of reduction in time spent blind</td>
<td>Cost-effectiveness range</td>
</tr>
<tr>
<td></td>
<td>$10,990-$28,850</td>
<td>$23,210-$58,920</td>
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<tr>
<td>Moderate-risk patients: aged 65 y; hemoglobin A1c, 9%</td>
<td>Range of reduction in time spent blind</td>
<td>Cost-effectiveness range</td>
</tr>
<tr>
<td></td>
<td>$41,420-$90,030</td>
<td>$89,740-$205,300</td>
</tr>
<tr>
<td>Low-risk patients: aged 75 y; hemoglobin A1c, 7%</td>
<td>Range of reduction in time spent blind</td>
<td>Cost-effectiveness range</td>
</tr>
<tr>
<td></td>
<td>$82,190-$193,150</td>
<td>$169,630-$366,490</td>
</tr>
</tbody>
</table>

*Ranges encompass 95% of all outcomes.*

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*NHANES III, National Center for Health Statistics, National Health and Nutrition Examination Survey III.

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pared with no screening. Sensitivity analyses also show that the cost of the screening examination is an important component of the overall cost-effectiveness of a screening program. However, even when costs are cut in half, the marginal cost-effectiveness of annual vs every other year screening is more than $50,000 per QALY gained. We should also note that, given recent data, hypertension control may further reduce the efficacy of screening since aggressive treatment of hypertension appears to reduce risk of retinopathy substantially.51,52 Therefore, we may have overestimated the benefits of screening for those with excellent blood pressure control.

One weakness of our study is our inability to firmly define the utility of blindness (visual acuity <20/100) and lesser levels of visual impairment. Sensitivity analyses demonstrate that the utility of blindness is an important predictor of the cost-effectiveness of a screening program, and estimates of average utility vary widely.53-55 In addition, we were unable to adequately assess the impact of states of visual impairment less than blindness because of limited information on the risks and utilities of these states. Because utility is likely to vary dramatically from patient to patient, a shared decision-making approach to retinal screening intervals may be best when formulating a plan of care for patients with diabetes. Whether we recommend annual or every second to third year screening, patients should know that the lowest risk will accrue with annual screening; however, as long as glycemic control is good, and screening occurs every 2 to 3 years, the risk of developing blindness is still low. Another potential weakness is that an annual screening program could allow other conditions, such as glaucoma and cataracts, to come to earlier medical attention. However, the impact of screening for these conditions in a diabetic population has not been studied.

This study is also limited in its ability to address potential variations in retinopathy risk in minority populations. While the risk of retinopathy appears to be higher in certain ethnic groups, there continue to be conflicting data on level of risk,33-35 and some or all of the increased risk may be due to hypertension and level of glycemic control.56-58 In particular, it should be noted that there are conflicting data on the risks of retinopathy in the Hispanic population; recent analyses suggest that elevated risk may persist after adjustment for glycemic control and hypertension.58 It should also be noted that the risk estimates used in this analysis were based on the UKPDS study population, which included minorities, but not Hispanic Americans. Thus, the aggregate estimates may reflect reasonable population, but not patient-specific, risks, and certain groups, most notably Hispanics and Native Americans, may not be adequately represented in the analysis.

It is clear that we can improve the efficiency of screening by targeting patients based on commonly measured clinical indicators. Ironically, those who will benefit most from eye screening are the patients whom providers often find the most frustrating to treat; namely, those with poor glycemic control. However, these are the patients who need to be the most aggressively screened. This may run counter to a common impulse to give up on other interventions when patients are noncompliant or are unsuccessful with treatments to improve glycemic control. However, setting a standard of having 80% of a diabetes population receiving annual eye examinations will not be productive if the high-risk patients are the ones not being regularly screened.

Our study suggests that annual retinal screening for most patients with type 2 diabetes produces little benefit that is not achieved with every second to third year screening. Although our conclusions would be stronger if there were empirical data on the efficacy of varying screening frequencies, the results of this analysis suggest that the often-cited policy of annual eye screening for all patients with type 2 diabetes should be reevaluated. Furthermore, groups involved in dissemination of quality-of-care standards need to reconsider the marginal benefit of frequent eye examinations when setting their quality and performance standards. If not, we run the risk of encouraging, or even demanding, inefficiency and requiring care that would not be wanted by many well-informed persons with type 2 diabetes.

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