The Cost-effectiveness of Screening for Type 2 Diabetes

CDC Diabetes Cost-Effectiveness Study Group

Context.—Type 2 diabetes mellitus is a common and serious disease in the United States, but one third of those affected are unaware they have it.

Objective.—To estimate the cost-effectiveness of early detection and treatment of type 2 diabetes.

Design.—A Monte Carlo computer simulation model was developed to estimate the lifetime costs and benefits of 1-time opportunistic screening (ie, performed during routine contact with the medical care system) for type 2 diabetes and to compare them with current clinical practice. Cost-effectiveness was estimated for all persons aged 25 years or older, for age-specific subgroups, and for African Americans. Data were obtained from clinical trials, epidemiologic studies, and population surveys, and a single-payer perspective was assumed. Costs and benefits are discounted at 3% and costs are expressed in 1995 US dollars.

Setting.—Single-payer health care system.

Participants.—Hypothetical cohort of 10 000 persons with newly diagnosed diabetes from the general US population.

Main Outcome Measures.—Cost per additional life-year gained and cost per quality-adjusted life-year (QALY) gained.

Results.—The incremental cost of opportunistic screening among all persons aged 25 years or older is estimated at $236 449 per life-year gained and $56 649 per QALY gained. Screening is more cost-effective among younger people and among African Americans. The benefits of early detection and treatment accrue more from postponement of complications and the resulting improvement in quality of life than from additional life-years.

Conclusions.—Early diagnosis and treatment through opportunistic screening of type 2 diabetes may reduce the lifetime incidence of major microvascular complications and result in gains in both life-years and QALYs. Incremental increases in costs attributable to screening and earlier treatment are incurred but may well be in the range of acceptable cost-effectiveness for US health care systems, especially for younger adults and for some subpopulations (eg, minorities) who are at relatively high risk of developing the major complications of type 2 diabetes. Although current recommendations are that screening begin at age 45 years, these results suggest that screening is more cost-effective at younger ages. The selection of appropriate target populations for screening should consider factors in addition to the prevalence of diabetes.

RESEARCH DESIGN AND METHODS

We developed a semi-Markov Monte Carlo simulation model (@Risk, Version 3.5 e for Windows NT, Palisades Inc, Newfield, NJ, and Excel, Version 7, Microsoft, Redmond, Wash) using assumptions similar to those used in previous diabetes cost-effectiveness studies.12-14 First, a hypothetical population without clinically diagnosed diabetes is selected and assigned to either opportunistic screening or current clinical practice. Second, for a cohort of 10 000 individuals with diabetes, the model simulates the development and progression of the major complications and several risk factors for macrovascular complications are frequently found.4,5 Early detection of type 2 diabetes through screening may therefore be an appropriate public health strategy.7 However, the health benefits of early detection and treatment of type 2 diabetes have never been firmly demonstrated.8 Additionally, screening may lead to misdiagnosis, inappropriate investigation and treatment, avoidable adverse effects, and unnecessary psychosocial and economic costs.9,10 With the current increase in costs of health care, consideration must be given to the cost and benefit of screening for any disease.

If early treatment of type 2 diabetes reduces the incidence or slows the progression of major complications, it might sufficiently reduce the costs of treatment during later years to offset the costs associated with screening and early treatment. Even if lifetime costs are higher with screening and early treatment, the costs might still be offset by the benefits derived from additional years of life gained or improved quality of life. We estimate the lifetime costs and benefits of opportunistic screening (ie, during routine contact with the medical care system) for type 2 diabetes. We assume that opportunistic screening will reduce the prediagnosis interval by 5 years from 10.5 years (under current clinical practice) to 5.5 years. The lifetime costs and benefits of opportunistic screening were compared with current clinical practice using recommended cost-effectiveness methods.11

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complications of the disease under each assigned alternative. This cohort is followed from onset of diabetes until death or age 95 years. The model parameters (eg, health states, transition probabilities, and costs) relied on major population surveys, epidemiologic studies, clinical trials, and other clinical studies. Interpretation and selection of the most appropriate parameters were accomplished by an expert panel convened for the study. The model adopts the perspective of a single payer for all direct medical costs. We did not consider direct nonmedical or indirect costs. We also did not address the issue or the costs of providing access to medical care for persons who lack access. Costs and benefits are discounted at 3% and costs are expressed in 1995 US dollars. The model structure, parameter assumptions, and relevant references are described below.

Model Structure

The model consists of a screening module and a disease progression module (Figure 1). The screening module assumes that each person is screened only once. The module determines the prevalence of undiagnosed diabetes, costs associated with screening, the likelihood that screening results in a diagnosis of diabetes, and the timing of diagnosis and treatment. A fasting plasma glucose test (FPGT) is used as the screening test (cutoff value, 6.1 mmol/L [110 mg/dL]; sensitivity, 80%; specificity, 96%). For persons testing positive to the first test, an oral glucose tolerance test (OGTT) is used to confirm diabetes. All persons with diabetes (true-positives and false-negatives) enter the disease progression module. Persons with a true-positive test result begin treatment when they are diagnosed through screening, and those with a false-negative test result begin treatment at clinical diagnosis. Conversely, all individuals who do not have diabetes (including false-positives) are excluded from the disease progression module.

The disease progression module models the natural history of diabetes and calculates the average costs of treatment. Unlike previous studies, this module begins at onset of diabetes rather than at clinical diagnosis. The module allows people to develop disease complications before their condition is diagnosed, as a function of the prevalence of complications at clinical diagnosis. At initial onset of diabetes, all persons are assumed to have no complications. The disease states modeled for each of the major complications of diabetes are shown in Table 1. The probability of developing these complications varies with duration of diabetes, race, ethnicity, and level of glycemic control. Monte Carlo techniques are used to progress individuals through the model. At each step, a random number is drawn. Irreversible transition to the next health state occurs if the random number is less than or equal to the transition probability for progression from the current health state to the subsequent state. The transition probabilities (Table 2) are based on studies by Eastman et al and recalibrated to correspond to number of years from onset (rather than from diagnosis) and were thus shifted by 10 years to reflect the average length of the interval from disease onset to diagnosis. For example, if the transition probability for a complication at years 1 through 10 after clinical diagnosis was $x$, we used a transition probability of $x$ for years 11 through 20 after onset. The relative risk adjustments for race are specific to each complication. Persons who have proliferative retinopathy or macular edema and who receive eye examinations are assumed to be treated with appropriate photoocoagulation treatment. Only 1 lower-extremity amputation (LEA) is permitted per individual in a lifetime.

Mortality is modeled as a competing risk for each of the major complications of diabetes. Increased mortality rates among persons with diabetes are attributed to increased mortality due to cardiovascular disease, end-stage renal disease (ESRD), LEA, and other causes. The mortality rate is determined sequentially. For persons who undergo an LEA, the mortality rate varies by anatomic level of amputation. If a patient does not have an LEA during the year or successfully survives the operation, the model assigns that person the mortality rate for ESRD, provided this condition is present. If ESRD is not present, the mortality rate is determined from a combination of the cardiovascular and non-
cardiovascular mortality rates. After adjustment for age, sex, and race, the annual nonvascular mortality among persons with diabetes is 2.75 times that of persons without diabetes.\(^8\) Cardiovascular mortality rate, estimated from the Framingham Heart Study,\(^1\) is a function of age, sex, systolic blood pressure, total cholesterol level, high-density lipid levels, smoking behavior, and left ventricular hypertrophy.

**Key Model Assumptions**

An estimated 9 to 12 years (mean, 10.5 years) elapse between onset and clinical diagnosis of type 2 diabetes.\(^2\) Because variation is considerable across individuals, we assume that this distribution is approximately normal and that the range represents a 70% confidence interval. With screening, both the mean interval from onset to diagnosis and the distribution around the mean will be altered. We assume that screening lessens the mean duration of undiagnosed diabetes by 0.2 percentage points, resulting in an estimated 8.9% at clinical diagnosis,\(^2\) a value comparable with that found in the United Kingdom Prospective Diabetes Study (UKPDS) (9.0%).\(^3\)

Under screening, the HbA\(_1c\) level is on average 7.8% at diagnosis (roughly the midpoint from onset to clinical diagnosis). We estimated the SD at clinical diagnosis as 20% to 26% of the mean HbA\(_1c\) value,\(^2\) and assumed that at screening diagnosis this SD would be roughly half (13%) because true duration is constant across individuals. We also assumed that the coefficient of variation remains constant as the mean glycemic level varies. On the basis of UKPDS results (HbA\(_1c\), 9.0% at randomization and 6.9% at 1 year), we estimated that the reduction in HbA\(_1c\) level after 1 year is 2.1 percentage points with treatment by diet only. Thus, the HbA\(_1c\) reduction was not sustained over time in the UKPDS study.\(^2\)

Thus, our model assumes a rate of increase in HbA\(_1c\) levels after treatment is initiated that is comparable with the UKPDS diet-only group rate at 0.166 percentage points per year (7.5%–6.8%/4.5 years). The average HbA\(_1c\) values for the cohort are not permitted to decrease below 6.0% or exceed 11%.

**Costs**

We assume that screening will occur during an already scheduled physician visit. Therefore, cost will arise for all subjects from the screening test and additional physician time (estimated by the expert panel as a quarter of a physician visit). Persons with positive test results will undergo additional resources by way of a confirmatory test (OGTT) and a full physician visit. Routine costs not specific to diabetes are estimated to average $1939 per year.\(^4\) In addition, costs associated with diabetes occur in 3 categories: outpatient and case management services, self-monitoring, and drugs.\(^5\)

Four treatment modalities were developed: diet and exercise only, oral hypoglycemic agents only, insulin only, and both oral hypoglycemic agents and insulin. The proportion using each modality varied by duration of diagnosed diabetes (estimated from the 1989 National Health Interview Survey Diabetes Supplement [NHSID]).\(^6\) Also, based on data from NHIS, we estimated that compared with persons without diabetes, people with diabetes not receiving insulin use 4 additional physician visits per year, and those receiving insulin use 5 additional visits per year. The cost of diet and exercise treatment at each visit was based on the level of care provided in the conventional treatment arm of the DCCT. For costing oral hypoglycemic treatment in the base case, glyburide at half the maximum dose was used, as was done by Eastman et al.\(^7\)

The cost of insulin treatment was based on the experiences of the control group in the Veterans Affairs trial.\(^8\) The costs of routine treatment specific to diabetes and the costs of treating diabetes complications (Table 3) are expressed in US 1995 dollars and adjusted for inflation. The model assumes that treatment costs vary by duration from onset regardless of when diagnosis occurred. This assumption may underestimate the benefits of screening to the extent that earlier implementation of diet may delay the need for drugs.

**Outcomes**

Primary outcome measures were addition life-years and quality-adjusted life-years (QALYs), as measured from onset of diabetes. A utility value of 1.0 is used for each year of life lived without major complications and less than 1 for each year with a major complication (0.69

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Table 2.—Transition Probabilities for the Health States Modeled

<table>
<thead>
<tr>
<th>Disease State</th>
<th>Hazard Rate</th>
<th>Reference No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Retinopathy</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nonproliferative retinopathy</td>
<td>0.021-0.129(^*)‡†</td>
<td></td>
</tr>
<tr>
<td>Proliferative retinopathy</td>
<td>0.002-0.028(^*)†</td>
<td></td>
</tr>
<tr>
<td>Macular edema</td>
<td>0.047-0.095(^*)†</td>
<td></td>
</tr>
<tr>
<td>Blindness from proliferative retinopathy</td>
<td></td>
<td>23</td>
</tr>
<tr>
<td>Untreated</td>
<td>0.088</td>
<td></td>
</tr>
<tr>
<td>Treated</td>
<td>0.015</td>
<td></td>
</tr>
<tr>
<td>Blindness from macular edema</td>
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<td></td>
</tr>
<tr>
<td>Untreated</td>
<td>0.050</td>
<td></td>
</tr>
<tr>
<td>Treated</td>
<td>0.033</td>
<td></td>
</tr>
<tr>
<td>Nephropathy</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Microalbuminuria</td>
<td>0.010-0.027(^*)†‡</td>
<td>18, 26</td>
</tr>
<tr>
<td>Proteinuria</td>
<td>0.157</td>
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</tr>
<tr>
<td>End-stage renal disease</td>
<td>0.004-0.074(^*)</td>
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</tr>
<tr>
<td>Neuropathy</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Symptomatic neuropathy</td>
<td>0.003-0.014(^*)†</td>
<td>27, 28</td>
</tr>
<tr>
<td>Lower-extremity amputation</td>
<td>0.028-0.467(^*)</td>
<td></td>
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</table>

*Varies with duration of diabetes. †Varies with race or ethnicity. ‡For further details on how hazard rates vary with duration of diabetes and by race or ethnicity, refer to Eastman et al.\(^9\)
for blindness, if 0.61 for ESRD, and 0.8 for LEA). When multiple complications are present, the adjustment uses the lowest of the values.

Analysis

We first modeled the effect of screening using a set of baseline assumptions for all adults 25 years or older. We then separately modeled age- and race-specific groups to examine the effects of screening subpopulations at relatively high risk of developing diabetes and its complications. Because of their relatively favorable cost-effectiveness ratio, the cohort aged 25 to 34 years is selected as the reference case. Sensitivity analysis was based on examining a change in only 1 parameter at a time and was performed for the following parameters: the screening method used, sensitivity and specificity of the FPGT, length of the prediagnosis interval, prevalence of undiagnosed diabetes, alternative assumptions about treatment (intensive glycemic level control and low-cost treatment through diet and exercise only during the early treatment period for persons diagnosed at screening), cost of physician’s time for the screening test, and discount rate. Sensitivity to mortality rates was not assessed because of previously reported insensitivity to this parameter.

RESULTS

Base Case

Screening of all adults aged 25 years or older decreases the average age at diagnosis by nearly 6 years (Table 4). The lifetime cumulative incidence of ESRD, blindness, and LEA are reduced by 26%, 35%, and 22%, respectively, and years of life without major complications are increased (0.08 years, 0.27 years, and 0.15 years). The lifetime incidence of cardiovascular disease is not substantially affected (relative increase, 0.2%) because of increased survival. Screening increases the lifetime costs of treatment by $3388 but results in a gain in life-years of only 0.02 years (1 week). The incremental cost of screening over current clinical practice per additional life-year is estimated at $236,449, and the cost per QALY is estimated at $56,649.

Subpopulations

It is more cost-effective to screen younger cohorts who can potentially gain more life-years free from major complications (Table 4). The greatest gain from screening is observed for blindness, for which the cumulative incidence is reduced by 7.5 percentage points for adults aged 25 to 34 years and by 0.5 percentage points for persons aged 65 years or older. Among adults aged 25 to 34 years, the lifetime incidence of cardiovascular disease actually increases by 0.8 percentage points, attributed to their small gain in longevity. In this age cohort, lifetime cost of treatment decreases by $1275 with screening, for an average gain in life-years of 0.13 (approximately 7 weeks). The cost per life-year for adults aged 25 to 34 years is $35,768 ($13,376/QALY), which is about one-sixth the ratio obtained for all adults. Decreasing gains in both life-years and QALYs are found with increasing age. Compared with persons aged 25 to 34 years, the cost per life-year is nearly twice as high for adults aged 35 to 44 years ($64,878 ($18,707/QALY)), and 19 times higher for those aged 55 to 64 years ($681,989 ($116,908/QALY)). For adults aged 65 years or older, there is no gain in life-years.

Compared with all adults, screening results in greater reductions in the cumulative incidence of major complications among African Americans, resulting in larger increases in life-years and QALYs (Table 5). The model estimates savings of $5539 in the lifetime costs of treatment with screening among African Americans aged 25 to 34 years compared with $1275 among all races of the same age. The cost-effectiveness ratios for African Americans aged 25 to 34 years are $2219 per life-year and $822 per QALY, after screening costs are incorporated.

Sensitivity Analyses

If HbA1c levels of 7.0% or more are used as the screening test, the cost-effectiveness ratio is $46,948 per life-year ($18,790/QALY) (Figure 2). Thus, using HbA1c as the screening test appears slightly more cost-effective because treatment is directed at patients at higher risk (HbA1c ≥ 7.0% at screening) of developing complications. The model is moderately sensitive to the performance characteristics of the screening test (FPGT). If sensitivity and specificity each were 10% lower, the cost per case detected increases, and the incremental cost per life-year rises to $56,274 ($21,044/QALY).

To test the sensitivity to shorter prediagnosis intervals, we halved this interval from 10.5 years to 5.5 years and found the health benefits of screening to be increased and the cost per life-year to be increased nearly 3-fold to $137,148 ($83,985/QALY). We found screening more cost-effective at higher prevalence of undiagnosed diabetes, all else being constant, because of the lower cost per case detected. For example, a prevalence of 1.00% results in a cost per life-year of $21,907 ($23,003/QALY); a prevalence of 3.50% results in a cost per life-year of $79,434 ($29,704/QALY).

If patients receive intensive glycemic treatment rather than standard treatment, the health benefits of screening are reduced. Depending on duration of disease, the annual cost of routine care under intensive treatment ranges from $3311 to $3555, more than double the cost under standard treatment. With screening, these higher treatment costs accru for an additional 5.9 years, and increase the cost per life-year to $132,549 ($46,760/QALY), which is more than 9-fold higher than under baseline assumptions. In contrast, if treatment consists only of diet and exercise during the lead time, the cost per life-year is reduced to $18,449 ($6979/...
Table 4.—Effects of Screening: Baseline Assumptions and Age-Specific Groups

<table>
<thead>
<tr>
<th>Age at Diagnosis, y</th>
<th>Average Age at Death, y</th>
<th>CI ESRD, %</th>
<th>CI Blindness, %</th>
<th>CI LEA, %</th>
<th>CI CVD, %</th>
<th>Life-years QALYs</th>
<th>Screening Costs, $</th>
<th>Treatment Costs, $</th>
<th>Cost/Life-year Gained, $</th>
<th>Cost/QALY Gained, $</th>
</tr>
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<td>Age ≥25 y</td>
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</tr>
<tr>
<td>Without screening</td>
<td>62.71</td>
<td>72.44</td>
<td>3.5</td>
<td>9.1</td>
<td>4.6</td>
<td>42.2</td>
<td>12.33</td>
<td>12.14</td>
<td>...</td>
<td>46.219</td>
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<tr>
<td>With screening</td>
<td>56.79</td>
<td>72.49</td>
<td>2.6</td>
<td>5.9</td>
<td>3.6</td>
<td>42.3</td>
<td>12.35</td>
<td>12.22</td>
<td>1166</td>
<td>49.608</td>
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<td>Screening effect</td>
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<td>0.05</td>
<td>−0.9</td>
<td>−3.2</td>
<td>−1.0</td>
<td>0.1</td>
<td>0.02</td>
<td>0.08</td>
<td>1166</td>
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<tr>
<td>Without screening</td>
<td>35.35</td>
<td>62.96</td>
<td>19.2</td>
<td>32.4</td>
<td>19.0</td>
<td>45.3</td>
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<tr>
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<td>29.51</td>
<td>63.33</td>
<td>15.9</td>
<td>25.9</td>
<td>16.0</td>
<td>46.1</td>
<td>21.11</td>
<td>20.51</td>
<td>5933</td>
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<td>Screening effect</td>
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<td>−2.9</td>
<td>0.8</td>
<td>0.13</td>
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<td>5933</td>
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</tr>
<tr>
<td>Age 35-44 y</td>
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</tr>
<tr>
<td>Without screening</td>
<td>45.41</td>
<td>65.72</td>
<td>10.3</td>
<td>22.4</td>
<td>12.4</td>
<td>46.9</td>
<td>18.06</td>
<td>17.55</td>
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<td>76.098</td>
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<tr>
<td>With screening</td>
<td>39.52</td>
<td>65.87</td>
<td>8.0</td>
<td>15.7</td>
<td>10.0</td>
<td>47.1</td>
<td>18.12</td>
<td>17.77</td>
<td>2629</td>
<td>77.456</td>
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<tr>
<td>Screening effect</td>
<td>−5.88</td>
<td>0.16</td>
<td>−2.3</td>
<td>−6.6</td>
<td>−2.5</td>
<td>0.3</td>
<td>0.06</td>
<td>0.21</td>
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<td>Age 45-54 y</td>
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<tr>
<td>Without screening</td>
<td>55.40</td>
<td>68.75</td>
<td>4.2</td>
<td>11.8</td>
<td>6.1</td>
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<td>68.80</td>
<td>3.0</td>
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<td>−3.8</td>
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<td>0.1</td>
<td>0.02</td>
<td>0.06</td>
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<tr>
<td>Without screening</td>
<td>65.49</td>
<td>73.02</td>
<td>1.4</td>
<td>5.6</td>
<td>2.8</td>
<td>42.7</td>
<td>11.36</td>
<td>11.26</td>
<td>...</td>
<td>40.254</td>
</tr>
<tr>
<td>With screening</td>
<td>59.53</td>
<td>73.03</td>
<td>0.9</td>
<td>3.5</td>
<td>2.0</td>
<td>42.7</td>
<td>11.37</td>
<td>11.30</td>
<td>715</td>
<td>44.334</td>
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<tr>
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<td>−5.96</td>
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<td>−0.5</td>
<td>−1.9</td>
<td>0.0</td>
<td>0.01</td>
<td>0.04</td>
<td>0.07</td>
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<tr>
<td>Without screening</td>
<td>75.37</td>
<td>78.60</td>
<td>0.3</td>
<td>1.7</td>
<td>1.0</td>
<td>39.8</td>
<td>8.49</td>
<td>8.46</td>
<td>...</td>
<td>27.903</td>
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<tr>
<td>With screening</td>
<td>69.47</td>
<td>78.60</td>
<td>0.2</td>
<td>1.1</td>
<td>0.7</td>
<td>39.8</td>
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<td>0.00</td>
<td>0.01</td>
<td>0.52</td>
<td>524</td>
<td>4587</td>
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</table>

*Based on current clinical practice, an average of 10.5 years from onset to diagnosis and a 3% discount rate. CI indicates cumulative incidence; ESRD, end-stage renal disease; LEA, lower-extremity amputation; CVD, cardiovascular disease; QALY, quality-adjusted life-year; and NA, not applicable because denominator is zero. Ellipses indicate data not available.

QALY). This is because the treatment cost for diet and exercise would be only $476 instead of $769 in the base case, reflecting fewer physician visits (2 instead of 4) and lower case management costs.

The cost of the screening test is small compared with the cost of the physician’s time. Therefore, we left the former unchanged and eliminated the latter and found that screening would be more cost-effective at $1058 per life-year ($396/QALY). Raising the discount rate from 3% to 5% increases treatment costs to $767 while leaving screening costs unaffected. At the same time, life-years decrease from 0.13 years to 0.07 years. Thus, cost per life-year more than doubles to $98,305 ($32,844/QALY).

**COMMENT**

Opportunistic screening of all adults aged 25 years or older for type 2 diabetes would cost $236,449 per life-year gained and $56,649 per QALY gained. In comparison, screening mammography for women aged 50 years or older costs from $3400 to $83,830 per life-year gained, an-
We did not assess the effect of repeated screening or the influence of noncompliance with screening and treatment. Both these situations may reduce the cost-effectiveness of screening. Repeat screening scenarios might decrease the cost-effectiveness because the prevalence of undiagnosed diabetes would likely be lowered in subsequent screening efforts and result in a higher cost per case detected. The sensitivity analyses found the model moderately sensitive to the prevalence of undiagnosed diabetes. Noncompliance results in some expenditures without gain in benefit. On the other hand, several of our assumptions may be conservative. A screening program will also identify persons with impaired glucose tolerance who may benefit from early intervention. Our model also does not take into account the potential benefit of early initiation of glycemic level control on the incidence of cardiovascular disease. There is emerging evidence that glycemic level and cardiovascular disease may be associated. Early detection may offer the opportunity to influence macrovascular risk factors other than hyperglycemia. However, we did not incorporate this benefit in our model because of a paucity of empirical data. Finally, our model assumes that microvascular complications are affected only by current glycemic levels. Had we used a less conservative approach of modeling cumulative glycemic exposure (e.g., HbA1c multiplied by duration), the benefits of screening would be enhanced.

Our model was not sensitive to the choice of screening test but was moderately sensitive to the assumptions concerning the performance characteristics of the FPGT. As recently recommended by the American Diabetes Association (ADA), if a second FPGT was used for confirmation in place of an OGTT, we estimate that the total costs would decline by only 2%. The results are thus not particularly sensitive to the choice of the confirmatory test because most of the medical cost associated with the confirmation test is due to the additional physician visit rather than the test itself. For the same reason, using an HbA1c value of 7.0% or more to confirm diabetes, rather than an OGTT, will not dramatically change the cost-effectiveness of screening. The model was sensitive to the assumptions concerning the length of the prediagnosis interval, the prevalence of undiagnosed diabetes, and the intensity of glycemic control therapy. If intensive glycemic control became the standard of care for type 2 diabetes, screening may be less cost-effective. Average glycemic levels with intensive treatment may be sufficiently low that the lifetime incidence of complications is also low, thus allowing little room for further improvement through early diagnosis and treatment. Our estimates of cost-effectiveness are also sensitive to the discount rate and are higher (less cost-effective) at higher discount rates. We considered the possibility that diagnosis of diabetes may have a transient or more long-lasting effect on quality of life. However, because of lack of empirical data we did not assess this issue.

Our study suggests that it is more cost-effective to opportunistically screen young adults for type 2 diabetes, contrary to the current recommendations of the ADA to screen only persons aged 45 years or older. Age-specific cost-effectiveness ratios from this study offer one means of assessing the relative opportunity costs of screening various subpopulations and for framing decisions concerning age thresholds for screening within the constraints of finite financial resources. Our results suggest that the selection of appropriate age groups should not ignore younger persons with impaired glucose tolerance who may benefit from early intervention.
have the financial incentive (eg, reimbursement) to readily adopt such a policy. Implementation of the findings of our study should encourage the acceptance and advocacy of influential groups like state Medicaid agencies, the Health Care Financing Administration, the American Association of Health Plans, and the National Center for Quality Assurance, as well as the ADA.

Members of the CDC Diabetes Cost-Effectiveness Study Group include Michael M, Engelaguia, MD, K. M. Venkat Narayan, MD, Theodore K. Thompson, MS, James P. Boyle, PhD, and David F. Williamson, PhD, Division of Diabetes Translation, National Center for Chronic Disease Prevention and Health Promotion, Centers for Disease Control and Prevention, Atlanta, Ga; W. Dana Flanders, MD, MS, Division of Epidemiology, School of Public Health, Emory University, Atlanta; Diane L. Manninen, PhD, Fred B. Dong, AM, MBA, and Carly W. Petrua, MA, Fraunhofer Center for Public Health Research, Seattle, Wash; Erik J. Dabash, PhD, Merck and Company, Inc, Blue Bell, Pa; Steven M. Teutsch, Merck and Company, Inc, West Point, Pa; Richard Eastman, MD, Division of Diabetes, Endocrinology, and Metabolic Diseases, National Institute for Diabetes and Digestive and Kidney Diseases, National Institutes of Health, Bethesda, Md; William H. Herman, MD, Division of Endocrinology and Metabolism, Department of Medicine, University of Michigan, Ann Arbor, Mich; and Thomas J. Songer, PhD, Department of Epidemiology, School of Public Health, University of Pittsburgh, Pittsburgh, Pa.

References


**Screening for Type 2 Diabetes—CDC Diabetes Cost-Effectiveness Study Group**

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I call for all medical schools to incorporate international humanitarian law and discussion of human rights in their standard curricula.

James C. Cobey, MD, MPH
Health Volunteers Overseas
Washington, DC


In Reply: Dr Cobey’s emphasis on inclusion of material on international humanitarian law and the Geneva Conventions in medical education is extremely important. This material is relevant not only to those who will in the future perform the tasks mentioned by Cobey, such as treating patients affected by war, working abroad with humanitarian organizations or armed forces, and exposing human rights violations, but to all students as well. While in medical school, students can learn to act within their institutions, in their communities, and when appropriate with patients to raise consciousness about these issues and to strengthen the protection for human rights that these principles provide.

To facilitate understanding of these and other human rights principles, students also should be made aware of journals devoted largely to discussion of these issues, including Health and Human Rights and Medicine and Global Survival. Medical schools also should include in their curricula information about organizations within which medical students can work on these issues, both before and after graduation.

These include the organizations in the Consortium for Health and Human Rights—Francois-Xavier Bagnoud Center for Health and Human Rights, Global Lawyers and Physicians, International Physicians for the Prevention of Nuclear War (IPPNW), and Physicians for Human Rights—and other groups as well. Examples include Physicians for Social Responsibility, the US affiliate of IPPNW; the American Public Health Association; the US affiliate of the World Federation of Public Health Associations; and national affiliates of IPPNW and WFPHA around the world. In working with these groups, medical students have opportunities to learn that work with others in organizations devoted to promotion and protection of human rights can magnify the effect any single individual can have.

As the preamble to the constitution of an early mine workers’ union in about 1870 put it:
And by union what we will
Can be accomplished still.
Drops of water turn a mill.
Singly none, singly none.

Victor W. Sidel, MD
Montefiore Medical Center
Bronx, NY

Cancer Mortality After Nonmelanoma Skin Cancer

To the Editor: The observation by Dr Kahn and colleagues1 is important and merits further research. In 1970, we extended earlier work2 establishing that the probability of metastases from colon cancers to lymph nodes was independent of the size of the colon cancer. When we compared metastasizing and nonmetastasizing variants, the most statistically significant characteristic of patients with metastasizing variants was past or present nonmelanoma skin cancer. The host’s exposure to factors (ie, UV rays) severe enough to cause skin cancers appears to have a systemic effect not fully studied.

John S. Spratt, Jr, MD
University of Louisville School of Medicine
Louisville, Ky


In Reply: We thank Dr Spratt for his interest in the association we observed, although in our study the age-adjusted death rate due to cancers of the colon and rectum was not higher among either men or women who reported a history of nonmelanoma skin cancer. However, a previous study based on a cancer registry found that the incidence of colon cancer was positively associated with a skin cancer history among men (standardized incidence ratio [SIR], 1.2; 95% confidence interval [CI], 1.06-1.42), but not women (SIR, 0.85; 95% CI, 0.71-1.01).1

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CORRECTION

Incorrect Value and Incorrect Wording: In the Original Contribution entitled “The Cost-effectiveness of Screening for Type 2 Diabetes” published in the November 25, 1998, issue of THE JOURNAL (1998;280:1757-1763), there was an incorrect value and a sentence was worded incorrectly. On page 1760, in the first sentence of the “Sensitivity Analyses” section, the value read “HbA1c, levels of 0.07.” It should have read “HbA1c, levels of 0.07%.” On page 1762, the sentence in the middle column that read “A screening program will also identify persons with impaired glucose tolerance who may benefit from early intervention, sponsored by the National Institutes of Health” should have read “A screening program will also identify persons with impaired glucose tolerance who potentially may benefit from early interventions, such as those currently being tested in the Diabetes Prevention Program (a multicenter clinical trial sponsored by the National Institutes of Health to test interventions aimed at preventing or delaying progression to diabetes among persons with impaired glucose tolerance).”