

**The Cost-Effectiveness of Screening for Prediabetes among Overweight
and Obese U.S. Adults**

Thomas J. Hoerger, PhD,¹ Katherine A. Hicks, MS,¹ Stephen W. Sorensen, PhD,² William H. Herman, MD, MPH,³ Robert E. Ratner, MD,⁴ Ronald T. Ackermann, MD, MPH,⁵ Ping Zhang, PhD,² Michael M. Engelgau, MD²

¹Center of Excellence in Health Promotion Economics, RTI International,
Research Triangle Park, NC

²Centers for Disease Control and Prevention, Atlanta, GA

³Departments of Internal Medicine and Epidemiology and the Michigan Diabetes Research
and Training Center, University of Michigan Health System, Ann Arbor, MI

⁴MedStar Research Institute, Washington, DC

⁵Department of Medicine, Indiana University School of Medicine, Indianapolis, IN

Corresponding author:
Thomas J. Hoerger, PhD
RTI International
3040 Cornwallis Road
P.O. Box 12194
Research Triangle Park, NC 27709
E-mail: tjh@rti.org

Received for publication 7 May 2007 and accepted in revised form 7 August 2007.

Additional information for this article can be found in an online
appendix at <http://care.diabetesjournals.org>.

ABSTRACT

Objective: To estimate the cost-effectiveness of screening overweight and obese persons for prediabetes and then modifying their lifestyle based on the Diabetes Prevention Program (DPP).

Research Design and Methods: A Markov simulation model was used to estimate disease progression, costs, and quality of life. Cost-effectiveness was evaluated from a health care system perspective. We considered 2 screening/treatment strategies for prediabetes. Strategy 1 included screening overweight persons and giving them the lifestyle intervention included in the DPP if they were diagnosed with both impaired glucose tolerance (IGT) and impaired fasting glucose (IFG). Strategy 2 included screening followed by lifestyle intervention for persons diagnosed with either IGT or IFG or both. Each strategy was compared with a program of no screening.

Results: Screening for prediabetes and treating those identified as having both IGT and IFG with the DPP lifestyle intervention had a cost-effectiveness ratio of \$8,181 per quality-adjusted life year (QALY) relative to no screening. If treatment was also provided to persons with only IGT or only IFG (Strategy 2), the cost-effectiveness ratio increased to \$9,511 per QALY. Changes in screening-related parameters had small effects on the cost-effectiveness ratios; the results were more sensitive to changes in intervention-related parameters.

Conclusions: Screening for prediabetes in the overweight and obese U.S. population followed by the DPP lifestyle intervention has a relatively attractive cost-effectiveness ratio.

The Diabetes Prevention Program (DPP) clearly demonstrates that behavioral modifications or drug treatments can delay or prevent the development of type 2 diabetes in persons with impaired glucose tolerance (IGT) (1). The DPP randomly assigned persons with IGT and elevated fasting glucose concentrations to 3 treatment groups: placebo, a lifestyle-modification program with goals of 7% weight loss and 150 minutes of weekly physical activity, or metformin. The average follow-up was 2.8 years. In comparisons with placebo, the lifestyle and metformin interventions reduced the incidence of type 2 diabetes by 58% and 31%, respectively (1).

Previously, we estimated the lifetime cost-effectiveness of the DPP interventions using a Markov simulation model to estimate disease progression, costs, and quality of life for individuals known to have prediabetes (0). Versus placebo, the lifestyle and metformin interventions were estimated to delay development of type 2 diabetes by 11 and 3 years, respectively; the corresponding reductions in absolute lifetime incidence of diabetes were 20% and 8%. Compared with placebo, the cost per quality-adjusted life year (QALY) from a health system perspective was approximately \$1,100 and \$31,300 for the lifestyle and metformin interventions, respectively.

Because our previous study focused on persons with known IGT, it did not answer a distinct, but important public health question: is it cost-effective to screen patients to identify persons with prediabetes who might benefit from the DPP interventions? Screening incurs costs and has imperfect sensitivity and specificity. A previous study examined the costs, sensitivity, and specificity of screening individuals with prediabetes but did not

evaluate the benefits of treating those identified with prediabetes (0).

To evaluate the screening issue, we performed a new cost-effectiveness analysis to compare screening/treatment strategies for prediabetes (defined formally as IGT and/or impaired fasting glucose [IFG]) among overweight and obese U.S. adults aged 45 to 74 years. We added screening to the simulation model to compute the possible benefits and costs of screening to identify prediabetes in the population. We compared 2 screening/treatment strategies with a baseline scenario of no screening and no treatment for prediabetes to estimate each strategy's cost-effectiveness.

RESEARCH DESIGN AND METHODS

Overview of the simulation model

The model consisted of 3 modules: screening, prediabetes, and diagnosed diabetes. In the screening module, overweight persons without diagnosed diabetes underwent a 1-time screening test for prediabetes during a scheduled physician visit. Those who screened positive underwent diagnostic testing. Persons who had prediabetes entered the prediabetes module and received the DPP lifestyle intervention if dictated by the treatment strategy (see below). Some of the persons with prediabetes eventually developed diabetes; they were assumed to be diagnosed shortly after onset and entered into the diagnosed diabetes module.

Those who screened negative entered the prediabetes module with undiagnosed prediabetes. If they developed diabetes, they were followed until they developed symptoms of diabetes and were clinically diagnosed; they then entered into the diagnosed diabetes module. Because our primary interest was in screening for and treating prediabetes, our main analysis focused only on persons with prediabetes.

Target population

We analyzed the effects of screening and treatment for the overweight and obese (body mass index ≥ 25) population aged 45 to 74 in the United States. We created the study cohort using data from the overweight population in the 1999–2000 National Health and Nutrition Examination Survey (NHANES) and U.S. Census population estimates for 2000 ((0,0,0,0)).

Screening tests

We assumed a 1-time opportunistic screening program for overweight and obese adults that occurred during a scheduled physician office visit. Screening was performed through a random capillary blood glucose (CBG) test and added 10 minutes to a usual 15-minute office visit, incurring costs of \$32.68 per screened person. The CBG test and physician costs come from Medicare fee schedules (0,0). The CBG test was selected for screening based on its relatively low costs (0). Based on previous analysis, we set 100 mg/dL as the screening cutoff point for the random CBG test, with corresponding sensitivity and specificity (0).

Estimates of the prevalence of undiagnosed diabetes and prediabetes come from the NHANES III dataset. Among overweight persons aged 45 to 74 not previously diagnosed with diabetes, prevalence was 9.7% for undiagnosed diabetes, 10.4% for both IFG and IGT, 23.2% for IFG only, and 7.0% for IGT only.

Diagnostic tests

All persons with a positive screening test received a diagnostic test (either a fasting plasma glucose [FPG] or oral glucose tolerance test [OGTT]). If the first diagnostic test was positive, a second was performed as confirmation. Because 2 consecutive elevated FPG tests or OGTT define diabetes (0), we assumed that this strategy has 100% sensitivity and 100% specificity for diabetes and for IGT and/or

IFG. The cost per diagnostic test totaled \$42.92, including \$11.61 (because either test may be used for diagnosis, we averaged FPG [\$5.42] and OGTT [\$17.80] costs) for the test, \$3.00 for the blood draw (0), and 10 extra minutes of physician time.

Prediabetes treatment strategies

We considered 2 different screening-plus-treatment strategies for persons with prediabetes. In Strategy 1, only persons diagnosed with both IGT and IFG received the DPP lifestyle intervention. This approach nearly matches the DPP eligibility requirements: most participants had IGT and an FPG value above 95 mg/dl (1). In Strategy 2, persons diagnosed with either IFG or IGT (or both) received the lifestyle intervention. In both strategies, the lifestyle intervention was provided until the person develops diabetes.

Key parameters for the prediabetes module are shown in Table 1. Progression to diabetes depended on whether the person has both IGT and IFG or only 1 of the conditions. The progression rate for persons with both IGT and IFG came directly from the DPP (0), whereas the progression rate for persons with only 1 condition was set to half the DPP value, based on the Hoorn study (0). We assumed that the lifestyle intervention produced the same percentage relative risk reduction if the person had both IGT and IFG or only 1 of these conditions.

The cost of the DPP intervention equaled the incremental cost of the DPP lifestyle intervention relative to placebo. The DPP lifestyle intervention had a median follow-up of 3 years; for our analysis, we had to make assumptions about the intervention's costs and effectiveness in subsequent years. We assumed that the intervention's year 3 costs and the reduction in risk from participating in the DPP continued in subsequent years as long as the intervention was continued.

Health utility scores for persons with IGT were measured annually during the DPP (0). Utility scores were higher in the lifestyle intervention than in placebo.

Diabetes

Persons with prediabetes entered the diabetes module after developing diabetes. The diagnosed diabetes module, which has been described elsewhere (0,0), models the progression of 5 complications of type 2 diabetes: nephropathy, neuropathy, retinopathy, coronary heart disease, and stroke. Based on earlier analyses (0,0), we assumed that persons with diagnosed diabetes receive intensive glycemic control once their HbA1c levels reach 6.8% and that persons with hypertension and diagnosed diabetes receive intensive hypertension control. Transition probabilities for diabetes complications were based primarily on results from the United Kingdom Prospective Diabetes Study (0–0).

We applied a multiplicative equation that estimated annual direct medical costs for diabetes according to demographic characteristics, diabetes treatment, risk factors for cardiovascular disease, and microvascular and macrovascular complications (0,0). Health utility scores for patients with diabetes were estimated using an additive prediction model (0).

Main analysis

We used the simulation model to assess lifetime progression of disease, costs, and QALYs. We calculated incremental cost-effectiveness ratios for the 2 screening/treatment strategies relative to a baseline of no screening and, consequently, no treatment for prediabetes. We adopted a health system perspective that considered only direct medical costs and discounted costs and QALYs at 3% per year. Costs are expressed in U.S. dollars (year 2001).

Sensitivity analyses

We conducted numerous 1-way sensitivity analyses; for example, we increased and decreased the prevalence of prediabetes by 20% and performed separate analyses for different age groups. We also calculated the cost-effectiveness of the screening strategies from the societal perspective. Societal costs of the DPP lifestyle intervention included direct medical and nonmedical costs (participant time costs, exercise classes, exercise equipment, food, and transportation) and were \$637 higher than health care system costs in the intervention's first year and \$404 higher in subsequent years (0).

We examined repeated screening, with screening tests performed 3 times, 3 years apart; for computational purposes, this analysis focused on a single cohort. Additional analyses of screening parameters doubled screening and diagnostic test costs, applied a higher CBG cutoff of 120 mg/dL, and defined IFG based on an FPG value of ≥ 95 mg/dl, matching the DPP criterion.

Several analyses focused on the intervention received by patients diagnosed with prediabetes. We evaluated screening followed by applying the DPP metformin intervention (assuming generic metformin costs) for patients diagnosed with prediabetes. We also evaluated the lifestyle intervention provided in a group setting, assuming it would produce the same risk reduction but have lower costs. In our main analysis, the intervention continued and had the same cost and relative reduction in risk as during the 3-year DPP trial. To assess this critical assumption, we assumed that, for all years, the relative reduction in risk from the DPP was actually 20% lower than that observed in the trial; costs were the same as in the main analysis. We then assumed that people received the DPP intervention for only 3 years, neither

receiving benefits nor paying costs thereafter.

Because some persons diagnosed with prediabetes may forego the intervention, we evaluated cost-effectiveness when only 50% of those diagnosed began the intervention. We also performed an analysis where the lifestyle intervention did not directly affect the quality of life for persons while they had prediabetes. Other analyses included the costs and benefits of treatment for persons diagnosed with diabetes during the screening process and varied the discount rate for costs and QALYs from 0% to 5% (0).

RESULTS

Main analysis

Under Strategy 1, 80% of overweight persons with IFG and IGT were diagnosed and began treatment. Strategy 2 diagnosed and treated these same persons, but also provided DPP treatment to 53% of persons with only IFG or only IGT; as a result, the total number of persons receiving treatment tripled.

Relative to no screening, Strategy 1 lowered the percentage of persons with both IFG and IGT who subsequently developed diabetes from 76.4% to 58.6%. Strategy 2 produced the same reduction for persons with both IFG and IGT; among persons with only IFG or only IGT, this strategy lowered cumulative incidence from 57.4% to 45.2%.

In Table 2, the cost-effectiveness of Strategies 1 and 2 are compared with the alternative of no screening. The first panel presents numbers per person screened, whereas the second panel highlights the costs and benefits per screened person with prediabetes—the primary target for the screening/treatment interventions. This alternative presentation does not change the cost-effectiveness ratios.

Strategy 1 produced higher total costs and more QALYs than the no-screening alternative. Per-person screening costs accounted for a relatively small fraction of the overall cost increase; treatment costs increased because persons with IFG and IGT received the lifestyle intervention. This treatment reduced the cost of diabetes complications but not enough to generate total cost savings. Strategy 1 had a cost-effectiveness ratio of \$8,181 per QALY. Strategy 2 produced higher costs and higher QALYs than Strategy 1, because more persons received the lifestyle intervention. The cost-effectiveness ratio for Strategy 2 was \$9,511 per QALY relative to no screening and \$10,167 per QALY relative to Strategy 1 (an appropriate comparison because Strategy 2 has higher costs and QALYs than Strategy 1).

Sensitivity analyses

Increasing or decreasing the prevalence of prediabetes had small effects on the cost-effectiveness ratios for Strategies 1 and 2 (Table 3). For both strategies, the cost-effectiveness ratios increased with age. From the societal cost perspective, the cost-effectiveness ratios were \$16,345 and \$18,777 per QALY for Strategies 1 and 2, respectively.

Changing screening parameters produced relatively small changes in the cost-effectiveness ratios; repeated screening every 3 years, for example, produced small increases in these ratios. Doubling the costs of screening and diagnostic tests increased the ratios for Strategies 1 and 2 by about \$1,700 and \$600, respectively. Changing the CBG cutoff or using an alternative IFG definition had negligible effects.

Changing assumptions about the intervention provided to persons diagnosed with prediabetes produced relatively large changes in cost-effectiveness ratios. Using a metformin intervention produced much

higher cost-effectiveness ratios than the lifestyle intervention. If the lifestyle intervention could be applied in a group setting with lower costs and the same effectiveness, Strategy 1 would be cost saving (i.e., higher effectiveness and lower costs) and Strategy 2 would have a very low cost-effectiveness ratio. Conversely, if the effects of the lifestyle intervention were 20% less than seen in the DPP, the cost-effectiveness ratios would rise by \$5,000 per QALY. If the DPP lifestyle intervention was implemented for only 3 years and subsequently did not affect progression to diabetes or incur costs, the cost-effectiveness ratios would also rise. If the lifestyle intervention had no direct effect on the quality of life of persons with prediabetes, the cost-effectiveness ratios for Strategies 1 and 2 would be \$12,773 and \$16,149 per QALY, respectively. If 50% of persons diagnosed with prediabetes chose not to participate in the intervention, the strategies would still have nearly the same cost-effectiveness ratios as in the main analysis.

Including the costs and benefits of treating persons diagnosed with diabetes during screening had relatively small effects on cost-effectiveness. Lowering the discount rate reduced cost-effectiveness ratios, and raising this rate increased the ratios.

CONCLUSIONS

The DPP demonstrated that an intensive lifestyle intervention could prevent or delay the onset of type 2 diabetes. However, the intervention was expensive and some worried that it might not prove cost-effective. To address this issue, we previously applied a simulation model to estimate lifetime outcomes and costs for persons known to have IGT and elevated fasting glucose concentrations (0). We found that the DPP lifestyle intervention

had a relatively attractive cost-effectiveness ratio from the perspective of the health care system. Other studies (0–0) have examined the cost-effectiveness of lifestyle interventions or drug therapy to prevent type 2 diabetes among persons with IGT. These studies all found that the interventions delay or prevent diabetes onset and, with one exception (0), reported favorable cost-effectiveness ratios.

Our previous results led to a natural next question: If applying the DPP lifestyle intervention to persons known to have IGT and IFG is cost-effective, would it also be cost-effective to screen for prediabetes and then treat persons identified as having the condition? To answer this question, we considered 2 screening and treatment strategies for prediabetes. For Strategy 1, we estimated a cost-effectiveness ratio of \$8,181 per QALY. This is generally considered to be a relatively attractive cost-effectiveness ratio.

We found that Strategy 2 (which included treatment for persons with either IGT or IFG or both) had a higher cost-effectiveness ratio than Strategy 1 (which limited treatment to persons with both conditions). Although Strategy 2 has a less attractive cost-effectiveness ratio than Strategy 1, its ratio is still attractive when compared with many existing health care interventions. However, Strategy 2's cost-effectiveness depends on whether the lifestyle intervention will produce the same relative reduction in risk for the only IGT/only IFG group (a subset of those receiving Strategy 2) as it produced in the DPP for persons with both IGT and IFG. If the intervention produces a smaller relative risk reduction for this group, the cost-effectiveness ratio for Strategy 2 will be higher (less attractive) as shown by the sensitivity analysis with reduced DPP effects. Future research should evaluate whether a DPP-like intervention can reduce

the risk of progression to diabetes for persons with only IGT or only IFG.

Screening costs accounted for a small share of the incremental costs associated with Strategies 1 and 2, and the sensitivity analyses indicate that the type of screening test—and its cost, sensitivity, and specificity—will have small effects on the cost-effectiveness of the strategies. In contrast, the costs of the DPP lifestyle intervention are comparatively large, and the intervention must be effective for the overall screening and treatment strategies to have attractive cost-effectiveness ratios. Our sensitivity analyses confirm that assumptions about the intervention have large effects on cost-effectiveness. Particularly important are the intervention's costs and effectiveness in the period beyond the 3-year duration of the DPP.

Our analysis has several limitations inherent in efforts to estimate the cost-effectiveness of interventions targeting chronic diseases. Most deal with the use of a simulation model to project the lifetime costs and health outcomes of simulated persons. Simulation is particularly useful when intervention costs are incurred immediately and produce improved health outcomes years later. In such situations, clinical trials are extremely expensive and cannot produce timely recommendations; in their absence, simulations can help policymakers make better informed decisions. All simulation models must make assumptions about the future using the best possible medical, epidemiologic, and economic data. In our main analysis, we assumed that the probability of diabetes progression does not change over time; that adherence to, cost of, and effectiveness of the DPP intervention do not change over time; that the cost of prediabetes is lower than the cost of uncomplicated diabetes; that patient utility levels are higher with

prediabetes than with uncomplicated diabetes; and that transition probabilities for diabetes complications are unaffected by the lifestyle intervention. One might argue with some of these assumptions. We have tried, however, to make these assumptions transparent, and we varied many of them in sensitivity analyses.

Our results may provide useful information for policymakers deciding whether to adopt screening for prediabetes followed by interventions to delay or prevent diabetes. Overall, our analysis supports the case for screening overweight and obese adults aged 45 to 74 for IGT and IFG and treating those who have both conditions with the DPP lifestyle intervention. There is no broadly accepted consensus on the cost-effectiveness ratio that represents the cutoff for deeming an intervention as “cost-effective” or “not cost-effective” (0). Some researchers have proposed a cutoff of \$50,000 per QALY, whereas others recommend comparing an intervention's cost-effectiveness ratio to the highest ratios for treatments currently covered by Medicare or other insurers. Against either of these criteria, screening for prediabetes followed by the DPP lifestyle intervention has a favorable cost-effectiveness ratio.

ACKNOWLEDGMENTS

Dr. Hoerger and Ms. Hicks received support from the Centers for Disease Control and Prevention (CDC) under Contract #200-2002-00776. Drs. Herman, Ratner, and Ackermann were supported, in part, by the Diabetes Prevention Program (DPP). We thank the DPP participants and investigators; DPP Research Group members are listed elsewhere (1).

This article's findings and conclusions are those of the authors and do not necessarily represent the views of CDC.

REFERENCES

1. Knowler WC, Barrett-Connor E, Fowler SE, et al.: Reduction in the incidence of type 2 diabetes with lifestyle intervention or metformin. *N Engl J Med* 346:393-403, 2002
2. Herman WH, Hoerger TJ, Brandle M, et al. The Diabetes Prevention Program Research Group: The cost-effectiveness of lifestyle modification or metformin in preventing type 2 diabetes in adults with impaired glucose tolerance. *Ann Intern Med* 142:323-332, 2005
3. Zhang P, Engelgau MM, Valdez R, Benjamin SM, Cadwell B, Narayan KM. Costs of screening for pre-diabetes among US adults: a comparison of different screening strategies. *Diabetes Care* Sep;26(9):2536-2542, 2003
4. Flegal KM, Carroll MD, Ogden CL, Johnson CL: Prevalence and trends in obesity among US adults, 1999-2000. *JAMA* 288:1723-1727, 2002
5. U.S. Census: Table 1a. Projected population of the United States, by race and Hispanic origin: 2000 to 2050. Available from: <http://www.census.gov/ipc/www/usinterimproj>. Accessed 18 March 2004
6. U.S. Census: Table 2a. Projected population of the United States, by age and sex: 2000 to 2050. Available from: <http://www.census.gov/ipc/www/usinterimproj>. Accessed 18 March 2004
7. Benjamin SM, Valdez R, Geiss LS, Rolka DB, Narayan KM: Estimated number of adults with prediabetes in the US in 2000: opportunities for prevention. *Diabetes Care* 26:645-649, 2003
8. Medicare clinical diagnostic laboratory fee schedule. Available from: <http://www.cms.hhs.gov/providers/pufdownload/clfdwn.asp>. Clinical Laboratory Fee Schedules for CY2001 (April release). Accessed 6 April 2005
9. RBRVS: Relative Value Studies, Inc. *St. Anthony's Complete RBRVS*. Eden Prairie, MN, St. Anthony Publishing, 2001
10. Zhang P, Englegau MM, Valdez R, Cadwell B, Benjamin SM, Narayan KM: Efficient cutoff points for three screening tests for detecting undiagnosed diabetes and pre-diabetes: an economic analysis. *Diabetes Care* 28:1321-1325, 2005
11. American Diabetes Association (ADA): Screening for diabetes. *Diabetes Care* 25:S21-S24, 2002
12. de Vegt F, Dekker JM, Jager A, et al.: Relation of impaired fasting and postload glucose with incident type 2 diabetes in a Dutch population: The Hoorn Study. *JAMA* 285:2109-2113, 2001

13. Diabetes Prevention Program Research Group: Within-trial cost-effectiveness of lifestyle intervention or metformin for the primary prevention of type 2 diabetes. *Diabetes Care* 26:2518-2523, 2003
14. The CDC Diabetes Cost-Effectiveness Group: Cost-effectiveness of intensive glycemic control, intensified hypertension control, and serum cholesterol level reduction for type 2 diabetes. *JAMA* 287:2542-2551, 2002
15. Hoerger TJ, Harris RH, Hicks KA, Donahue K, Sorensen S, Engelgau M: Screening for type 2 diabetes mellitus: a cost-effectiveness analysis. *Ann Intern Med* 140:689-699, 2004
16. UK Prospective Diabetes Study Group (UKPDS 33): Intensive blood-glucose control with Sulphonylureas or insulin compared with conventional treatment and risk of complications in patients with type 2 diabetes. *Lancet* 352:837-853, 1998
17. UK Prospective Diabetes Study Group: Tight blood pressure control and risk of macrovascular and microvascular complications in type 2 diabetes: UKPDS 38. *BMJ* 317:703-713, 1998
18. Stevens RJ, Kothari V, Adler AI, Stratton IM: The UKPDS risk engine: a model for the risk of coronary heart disease in Type II diabetes (UKPDS 56). *Clin Sci (Lond)* 101:671-679, 2001
19. Kothari V, Stevens RJ, Adler AI, et al.: UKPDS 60: risk of stroke in type 2 diabetes estimated by the UK Prospective Diabetes Study risk engine. *Stroke* 33:1776-1781, 2002
20. Adler AI, Stevens RJ, Manley SE, et al.: Development and progression of nephropathy in type 2 diabetes: the United Kingdom Prospective Diabetes Study (UKPDS 64). *Kidney Int* 63:225-232, 2003
21. Brandle M, Zhou H, Smith BR, et al.: The direct medical cost of type 2 diabetes. *Diabetes Care* 26:2300-2304, 2003
22. Coffey JT, Brandle M, Zhou H, et al.: Valuing health-related quality of life in diabetes. *Diabetes Care* 25:2238-2243, 2002
23. Diabetes Prevention Program Research Group: Costs associated with the primary prevention of type 2 diabetes mellitus in the Diabetes Prevention Program. *Diabetes Care* 26:36-47, 2003
24. Gold MR, Siegel JE, Russell LB, Weinstein MC, eds.: *Cost-Effectiveness in Health and Medicine*. New York, Oxford University Press, 1996.

25. Palmer AJ, Roze S, Valentine WJ, Spinass GA, Shaw JE, Zimmet PZ: Intensive lifestyle changes or metformin in patients with impaired glucose tolerance: modeling the long-term health economic implications of the diabetes prevention program in Australia, France, Germany, Switzerland, and the United Kingdom. *Clin Ther* 26:304-321, 2004
26. Caro JJ, Getsios D, Caro I, Klittich WS, O'Brien JA: Economic evaluation of therapeutic interventions to prevent type 2 diabetes in Canada. *Diabet Med* 21:1229-1236, 2004
27. Quilici S, Chancellor J, Maclaine G, McGuire A, Andersson D, Chiasson JL: Cost-effectiveness of acarbose for the management of impaired glucose tolerance in Sweden. *Int J Clin Pract* 59:1143-1152, 2005
28. Eddy DM, Schlessinger L, Kahn R: Clinical outcomes and cost-effectiveness of strategies for managing people at high risk for diabetes. *Ann Intern Med* 143:251-264, 2005

Table 1—Screening and prediabetes parameters

	Parameter	Source
Prevalence among overweight persons aged 45–74 not previously diagnosed with diabetes		
Undiagnosed diabetes	9.7%	NHANES III
IFG and IGT	10.4%	NHANES III
IFT only	23.2%	NHANES III
IGT only	7.0%	NHANES III
Screening test (CBG)		
Sensitivity		
Diabetes	83.0%	Zhang et al. (0)
Both IGT and IFG	80.0%	NHANES III, derived by Zhang and CDC colleagues in August 2005
Either IGT or IFG (not both)	53.0%	NHANES III, derived by Zhang and CDC colleagues in August 2005
Specificity (non-normoglycemia)	63.0%	NHANES III, derived by Zhang and CDC colleagues in August 2005

Cost	\$32.68	Lab and physician fee schedules (0,0)
Diagnostic tests		
FSG costs	\$36.73	Lab and physician fee schedules (8,9)
OGTT costs	\$49.11	Lab and physician fee schedules (8,9)
Annual probability of developing diabetes		
Both IGT and IFG	10.8%	Herman et al. (0)
IGT or IFG, but not both	5.4%	de Vegt et al. (0)
DPP lifestyle intervention reduction in risk for onset of diabetes	55.3%	Herman et al. (0)*
Incremental cost of participating in the DPP lifestyle intervention		
First year	\$1,200	Diabetes Prevention Program Research Group (0)
Second year and beyond	\$600	Diabetes Prevention Program Research Group (0)
Health utility scores		

With no intervention	0.68**	Diabetes Prevention Program Research Group (0)
With DPP lifestyle intervention	0.70**	Diabetes Prevention Program Research Group (0)

Abbreviations: CBG, capillary blood glucose; DPP, Diabetes Prevention Program; FSG, fasting serum glucose; IFG, impaired fasting glucose; IGT, impaired glucose tolerance; OGTT, oral glucose tolerance test.

*The 55.3% value used in this and the Herman et al. paper (0) is slightly lower than the 58% value reported in the original DPP study (1). The 58% risk reduction was based on the data as of April 1, 2001, which were the data from the DSMB report when the DPP was terminated early. The DPP then continued to follow all participants through July 31, 2001, on their masked intervention. Beginning August 1, patients came to the clinic for unmasking and study results. The 55.3% risk reduction we use is based on all data through the end of July.

**For men. Utility scores for women were 0.02 lower.

Table 2—Costs, QALYs, and cost-effectiveness

	Per Screened Person					Per Screened Person with Prediabetes				
	No Screening		Strategy 1		Strategy 2	No Screening		Strategy 1		Strategy 2
	Total	Total	Incremental	Total	Incremental	Total	Total	Incremental	Total	Incremental
Screening costs (\$)	—	68	68	68	68	—	168	168	168	168
Treatment costs (\$)	10,342	10,784	443	11,879	1,538	25,440	26,530	1,089	29,223	3,783
Complication costs (\$)	6,209	6,026	(182)	5,724	(484)	15,273	14,825	(448)	14,082	(1,192)
Total costs (\$)	16,550	16,879	329	17,672	1,122	40,714	41,523	809	43,473	2,759
Life years (undiscounted)	n.c.*	n.c.*	0.043	n.c.*	0.122	18.705	18,811	0.106	19.005	0.300
QALYs	n.c.*	n.c.*	0.040	n.c.*	0.118	8.910	9.009	0.099	9.200	0.290
CE ratio relative to no screening (\$/QALY)			8,181		9,511			8,181		9,511

Abbreviations: CE, cost-effectiveness; QALY, quality-adjusted life year; n.c., not computed.

*Only life years and QALYs for individuals with prediabetes are tracked. Because life years and QALYs for individuals without prediabetes are not affected by the intervention, we can calculate incremental life years and QALYs.

Table 3—Sensitivity analyses: cost-effectiveness ratios

	Strategy 1	Strategy 2
Different Cases for Sensitivity Analysis	\$/QALY	\$/QALY
Base analysis	8,181	9,511
Sensitivity analyses		
Increased prevalence of prediabetes by 20%	7,960	9,445
Reduced prevalence of prediabetes by 20%	8,518	9,633
Ages 45–54 years, U.S. overweight population	4,009	5,419
Ages 55–64 years, U.S. overweight population	7,199	8,939
Ages 65–74 years, U.S. overweight population	11,708	13,519
Societal cost perspective	16,345	18,777
Periodic screening (every 3 years for up to 3 total screens; white nonsmoking female aged 45 years with hypertension and high cholesterol)		
One screen	4,774	6,303
Two screens	5,442	6,731
Three screens	5,988	7,025
Cost of screening and diagnostic tests doubled (screening test cost = \$65.36, diagnostic test cost = \$85.84)	9,885	10,092
Sensitivity/specificity of tests		
CBG cutoff = 120 mg/dL	8,296	9,076
DPP definition of IFG (FSG score \geq 95)	8,283	9,548
Metformin intervention (generic price)	19,902	20,161
Group DPP intervention (reduced costs)	Cost saving	267
20% reduced DPP effects	13,179	14,387

No DPP costs or effects after 3 years	19,422	18,111
Lifestyle intervention has no direct effect on quality of life	12,773	16,149
50% participation in DPP of people diagnosed with prediabetes	9,032	9,801
Include outcomes and costs of identified diabetes cases	9,925	10,101
0% discount rate	4,687	6,022
5% discount rate	10,847	12,078

Abbreviations: ADA, American Diabetes Association; CBG, capillary blood glucose; DPP, Diabetes Prevention Program; FSG, fasting serum glucose; IFG, impaired fasting glucose.