Cost-effectiveness Issues of Diabetes Prevention and Treatment

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INTRODUCTION

The costs of diabetes mellitus are enormous. In 2007, direct medical expenditures, that is, the cost of health care services for the treatment of diabetes, its complications, and comorbidities were estimated to be $116 billion (1). Indirect expenditures resulting from lost work days, restricted activity days, permanent disability, and premature mortality attributable to diabetes totaled $58 billion (1). Per capita medical expenditures were $11,744 for people with diabetes and $5,095 for people without diabetes (1). Diabetes costs in the United States rose from approximately $3 billion in 1969 to $174 billion in 2007 (2).

Much of the economic burden of diabetes is related to its complications and comorbidities (1). Only 23% of the direct costs attributable to diabetes were associated with diabetes management. Of direct costs attributable to diabetes, 12% were related to diabetes medications and supplies and 9% to outpatient care (1).

Given the enormous cost of diabetes, the question arises, "Can interventions to delay or prevent the development of diabetes and interventions to treat diabetes and its comorbidities reduce the future economic burden of diabetes?" This article reviews the evidence regarding cost-effectiveness for the prevention and treatment of diabetes.

Health Care Economics and Terminology

Economic analyses, including cost utility, cost-effectiveness, and cost-benefit analyses, evaluate which program or intervention has the greatest effect at the lowest cost. Intervention costs are described in monetary terms. Effects or benefits of the intervention can be expressed as either costs (as in cost-benefit analysis) or health outcomes, such as cases of a disease prevented, years of life gained, quality-adjusted life years (QALYs), or changes in intermediate outcomes (in milligrams per deciliter, for example). The variety of ways in which cost studies present their outcomes makes it a challenge to compare studies. The incremental cost-effectiveness ratio (ICER) is the ratio between the difference in costs and the difference in benefits of two interventions. A threshold value is often set by policy makers, who may decide that only interventions with an ICER below the threshold are cost-effective (and therefore should be funded). While no standard definition exists for the evaluation of interventions, it has been suggested that interventions that cost less than $20,000 per QALY are appropriate ways to use resources, those that cost $20,000 to $100,000 per QALY are probably appropriate, and those that cost more than $100,000 per QALY may not be an appropriate way to use resources (3).

Economic studies derived from clinical trial data are stronger than model-based analyses, but models can help with economic predicting when trial data are not available. Cost analysis perspectives vary based on what costs are included and who pays the costs.

Factors Influencing the Cost-effectiveness of Diabetes

Randomized, controlled, clinical trials from North America, Europe and Asia have demonstrated that lifestyle interventions, metformin, acarbose, and thiazolidinediones can delay or prevent the development of type 2 diabetes mellitus (T2DM) (4–11). The cost of interventions applied to patients with glucose intolerance might be offset by savings arising from a reduced need to treat diabetes and its complications. Thus, what are the costs, quality of life, and health outcomes associated with alternative treatment strategies for glucose intolerance?

Annual direct medical costs increase from $1,400 to $4,600 as an individual progresses from impaired glucose tolerance to uncomplicated diabetes to diabetes requiring pharmacologic treatment to diabetes with complications and comorbidities (12). Similarly, quality of life as assessed by health utility scores, where perfect health is scored as 1.0 and death as 0, decreases as an individual progresses from impaired glucose tolerance to diabetes with complications and comorbidities (13). Simulation modeling has suggested that interventions can delay the onset of diabetes and reduce the cumulative incidence by 22%; this reduction in diabetes incidence will reduce the cumulative incidence of blindness, end-stage renal disease, amputation and cardiovascular disease (14).

A prospective economic analysis conducted by the Diabetes Prevention Program (DPP) Research Group estimated that lifestyle intervention for diabetes prevention is relatively expensive, costing approximately $1,400 per person in its first year and approximately $700 per person per year thereafter (15). The average wholesale price of metformin at the dose used in the DPP was approximately $300 per year, the cost of acarbose as used in the Stop-Non-Insulin-Dependent Diabetes Mellitus (NIDDM) Trial was approximately $1,400 per year, and the cost of rosiglitazone as used in the Diabetes Reduction Assessment with Ramipril and Rosiglitazone Medication (DREAM) trial was approximately $2,000 per year (16). It is important to note, however, that the higher costs of the lifestyle intervention was partially offset by lower costs of other medical care and that costs will decrease when generic acarbose and thiazolidinediones become available. The usual generic cost of a medication is approximately 25% that of the brand medication cost (14).

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The DPP demonstrated that quality of life is better with lifestyle intervention than with metformin treatment or usual care, and no different with metformin treatment relative to usual care (17). Clinical trials of acarbose and rosiglitazone for diabetes prevention have not included prospective utility assessments.

It is clear that lifestyle intervention and thiazolidinediones are most effective with relative risk reductions of between 29% and 58% for lifestyle interventions (4–7) and 55% and 60% (9–11) for thiazolidinediones. Metformin reduced the relative risk for the development of diabetes by 26% to 31% (6,7) and acarbose by 25% (8).

With respect to long-term health outcomes, the DPP and the Stop-NIDDM study suggested that lifestyle intervention and treatment with metformin and acarbose are safe (6,8). The DPP demonstrated that lifestyle intervention and metformin treatment improved intermediate cardiovascular outcomes but had no clear effect on cardiovascular disease or survival (6). The Stop-NIDDM study showed a statistically significant impact of acarbose on the incidence of cardiovascular disease but has not reported a survival benefit (18). The increased risks of fractures and heart failure associated with thiazolidinediones are clear (11,19). The safety of thiazolidinediones remains controversial (20,21).

The Cost-effectiveness of Diabetes Prevention

A number of investigators have assessed the cost-effectiveness of interventions compared with usual care for the primary prevention of T2DM (Table 1) (14,22–26). These analyses have generally modeled the outcomes of clinical trials to project the longer-term cost-effectiveness of interventions from a payer perspective. Different simulations have adopted different national perspectives. Of the five published analyses of lifestyle interventions (14,22–25), four found that lifestyle intervention was cost-saving or resulted in modest expenditure per life-year or QALY gained (Table 1) (14,22–24). Similarly, three of the four published analyses of metformin therapy found it to be cost-saving or extremely cost-effective (Table 1) (14,23,24). The two shorter-term analyses of acarbose for diabetes prevention demonstrated it to be cost-saving or extremely cost-effective (Table 1) (24,26). No published studies have analyzed the cost-effectiveness of thiazolidinediones for diabetes prevention.

The Cost-effectiveness of Diabetes Treatment

The cost-effectiveness of diabetes prevention can be compared with that of diabetes treatment, specifically intensive glycemic management, blood pressure management and lipid management (Table 2) (27–33). Review of four published studies of intensive glycemic management for T2DM suggests that prevention is more cost-effective than the treatment of diabetes (Table 2) (27–30). Three published studies of intensive blood pressure management suggest that blood pressure treatment is cost-saving or extremely cost-effective in most settings

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Table 1. Cost-effectiveness of Interventions for the Primary Prevention of Type 2 Diabetes*

Intervention Type	Author, Year, (Reference)	Country	Time Horizon	Cost per Life Year	Cost per QALY Gained
Lifestyle	Segal, 1998 (22)	Australia	25 y	Cost-saving to A$2,600 (U.S. $1,659)	— †
	Palmer, 2004 (23)	Australia, France, Germany, Switzerland, U.K.	Lifetime	Cost-saving to €6,400 (U.S. $8,056)	—
	Caro, 2004 (24)	Canada	10 y	C$700 (U.S. $551)	—
	DPP, 2005 (14)	U.S.	Lifetime	—	$1,100
	Eddy, 2005 (25)	U.S.	30 y	—	$143,000
Metformin	Palmer, 2004, (23)	Australia, France, Germany, Switzerland, U.K.	Lifetime	Cost-saving to €5,400 (U.S. $6,836)	—
	Caro, 2004 (24)	Canada	10 y	Cost-saving	—
	DPP, 2005 (14)	U.S.	Lifetime	—	$1,800
	Eddy, 2005 (25)	U.S.	30 y	—	$35,400
Acarbose	Caro, 2004 (24)	Canada	10 y	Cost-saving	—
	Josse, 2006 (26)	Spain, Germany, Sweden	3 y	Cost-saving to €800 (U.S. $947)	—

* A$ indicates Australian dollars; C$, Canadian dollars; DPP, Diabetes Prevention Program; €, euros; and QALY, quality-adjusted life years.
† The results of the analysis were not reported.

Table 2. Cost-effectiveness of Interventions for the Treatment of Type 2 Diabetes*

Type of Intervention	Author, Year (Reference)	Country	Time Horizon	Cost per Life Year Gained	Cost per QALY Gained
Glycemic management					
	Eastman, 1997 (27)	U.S.	Lifetime	—	$16,000
	CDC, 2002 (28)	U.S.	Lifetime	—	$41,000
	Coyle, 2002 (29)	Canada	Lifetime	C$7,000 (U.S. $4,383)	—
	Clarke, 2005 (30)	U.K.	Lifetime	—	Cost-saving to €6,000 (U.S. $11,289)
Blood pressure management					
	Elliott, 2000 (31)	U.S.	Lifetime	—	Cost-saving
	CDC, 2002 (28)	U.S.	Lifetime	—	Cost-saving
	Clarke, 2005 (30)	U.K.	Lifetime	—	Cost-saving to €370 (U.S. $696)
Lipid management					
Secondary intervention	Jonsson, 1999 (32)	5 Nordic countries	Lifetime	€1,600 to €3,200 (U.S. $1,888-3,777)	—
Primary prevention	Grover, 2001 (33)	U.S.	12 yrs	$5,100 to 14,200 (men)	—
				$13,100 to 23,800 (women)	
	CDC, 2002 (28)	U.S.	Lifetime	—	$52,000

* C$ indicates Canadian dollars; CDC, Centers for Disease Control and Prevention; €, euros; £, pounds sterling; and QALY, quality-adjusted life years.

(Table 2) (28,30,31). While lipid management as secondary intervention for T2DM appears extremely cost-effective (32), it appears to be less cost-effective as primary prevention than intensive blood pressure management, diabetes prevention (28,33) and intensive glycemic management for established diabetes (Table 2).

SUMMARY

In summary, the cost-effectiveness of diabetes prevention and treatment is well studied. From a payer perspective, lifestyle and pharmacologic interventions for diabetes prevention appear to be cost-effective. In addition, prevention is more cost-effective than intensive treatment of diabetes. Modeling has suggested that interventions can delay the onset and reduce the cumulative incidence of diabetes and this reduction in diabetes incidence will reduce the cumulative incidence of blindness, end-stage renal disease, amputation and cardiovascular disease. Many factors influence the cost-effectiveness of a given intervention, such as the interventions's cost, clinical effectiveness and impact on long-term health outcomes and quality of life. Lifestyle intervention has been shown to be clinically effective and safe. Quality of life is better with lifestyle intervention than with metformin treatment or usual care, and no different with metformin treatment relative to usual care. Hence, lifestyle intervention is a cost-effective option for diabetes prevention. Little is known about the cost-effectiveness of lifestyle intervention for diabetes treatment since lifestyle modification was bundled with other treatment modalities to create intensive treatment. As more generic diabetes medications become available, the cost-effectiveness ratio associated with treatment may become more competitive. Exploration into lower cost but effective and safe lifestyle interventions for diabetes treatment is needed.

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