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Costs and Benefits Associated With Diabetes Education

A Review of the Literature

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Purpose

The purpose of this article was to review the published literature and evaluate the economic benefits and costs associated with diabetes education.

Methods

The Medline database (1991-2006) and Google were searched. Articles that addressed the economic and/or financial outcomes of a diabetes-related self-care or educational intervention were included. The study aim, population, design, intervention, financial and economic outcomes, results, and conclusions were extracted from eligible articles.

Results

Twenty-six papers were identified that addressed diabetes self-management training and education. Study designs included meta-analysis (1); randomized controlled trials (8); prospective, quasi-experimental, and pre-post studies (8); and retrospective database analyses (9). The studies conducted cost analyses (6), cost-effectiveness analyses (13), cost-utilization analyses (7), and number needed to treat analyses (2). More than half (18) of the 26 papers identified by the literature review reported findings that associated diabetes education (and disease management) with decreased cost, cost saving, cost-effectiveness, or positive return on investment. Four studies reported neutral results, 1 study found that costs increased, and 3 studies did not fit into these categories.

Conclusions

The findings indicate that the benefits associated with education on self-management and lifestyle modification for people with diabetes are positive and outweigh the costs associated with the intervention. More research is needed to validate that diabetes education provided by diabetes educators is cost-effective.

In 2006, the United States spent 16% of its gross domestic product (GDP) or $2 trillion on health care,[1] and people with chronic conditions accounted for 85% of the expenditure.[2] Diabetes affects 7% of Americans and represents more than $116 billion of these expenditures.[3] The overall economic cost of diabetes in 2007 was $174 billion, with reduced national productivity accounting for $58 to $105 billion.[3,4] Moreover, the prevalence of the disease is rising, and total health care is expected to reach 20% of GDP by 2016.[1] Interestingly, even with these considerable expenditures, in 2005, the Centers for Medicare and Medicaid Services (CMS) reimbursed only $4.8 million on diabetes self-management training codes G108 and G109.

Diabetes education, also known as diabetes self-management training (DSMT) or diabetes self-management education (DSME), is defined as a collaborative process through which people with or at risk for diabetes gain the knowledge and skills needed to modify behavior and successfully self-manage the disease and its related conditions. DSMT/DSME is an interactive, ongoing process involving the person with diabetes (or the caregiver or family) and a diabetes educator(s).[5] Diabetes educators are health care professionals who focus on helping people with and at risk for diabetes and related conditions achieve behavior change goals that, in turn, lead to better clinical outcomes and improved health status.

Diabetes education is effective in helping people with diabetes control their illness and maximize their health[6-9] and is generally accepted as a cost-effective strategy. There is, however, a lack of available published information regarding economic evaluations of the benefits and costs of diabetes education and the value that may be added by a diabetes educator. Even among those providing diabetes self-management education and training, the studies that demonstrate this fact are not well-known.

In late 2007, the authors undertook an analysis of the literature to better understand the economic benefits and costs associated with diabetes education. This article reports on the review of published literature and evaluates the economic benefits and costs associated with diabetes education.

Methods

Data Sources

The authors searched MEDLINE (1991-2006) and Google in the fourth quarter of 2007 using combinations and variations of the following search terms: (1) diabetes complications, diabetes mellitus, type 1 diabetes mellitus, or type 2 diabetes mellitus; (2) disease management, health promotion, patient education as topic, or self care; and (3) cost control, cost of illness, cost savings, cost-benefit analysis, costs and cost analysis, direct service costs, health care costs, health expenditures, health services, outcome assessment (health care), program evaluation, or quality-adjusted life years.

Inclusion and Exclusion Criteria

Diabetes self-management training and education programs were defined broadly. By defining the topic broadly, this study was able to identify a wider variety of economic studies on diabetes education to support this analysis. Inclusion criteria were any article reporting the economic and/or financial outcomes of a diabetes-related self-care or educational intervention. This study excluded articles published prior to 1991, not published in English, or not reporting the results in a quantifiable manner.

Study Selection and Data Extraction

Two of the investigators (KAF, JES) reviewed the titles and abstracts of the identified citations and applied a screening algorithm based on the inclusion and exclusion criteria described above. The "potentially eligible" studies were then reviewed in full. Data abstraction was performed by one investigator independently (KAF) using a structured abstraction process, and the abstractions were independently reviewed by another investigator (PP). Any discrepancies between the 2 investigators were resolved through discussion and consensus. The information extracted from the articles into the tables

included (1) study aim, (2) study population (eg, sample size, age, type 1 or type 2 diabetes, gender, race/ethnicity, and recruitment location), (3) study design, (4) intervention, (5) financial and economic outcomes, (6) results, and (7) conclusions.

Results

Literature searches identified 609 articles. The titles and abstracts were screened, and 26 articles were identified that addressed the costs and benefits of diabetes education, using this study's broad definition, and were included in this review (Table 1).[10-35] Most studies were conducted in the United States, and 2 studies were conducted in the Netherlands.[16,25] Data from 40 588 patients are represented in the studies. Most of the studies included adults, and 1 study focused on adolescents.[13] Studies involved patients with impaired glucose tolerance (IGT),[18,22,23,27] type 1 diabetes,[13] type 2 diabetes,[30,32,34] or both type 1 and type 2 diabetes.[10,12,14,24-26,28,29,31,35] Several studies did not specify the type of diabetes.[11,15-17,19-21,33] Study designs included meta-analysis,[26] randomized controlled trials (RCTs),[13,16,18,22-24,27,34] prospective quasi-experimental pre-post studies,[10-12,14,15,20,25,29] and retrospective database analyses.[17,19,21,28,30,31-33,35] The studies conducted cost analyses,[13,19,22,28,29,32] cost-effectiveness analyses,[10-12,14-16,18,21,23,24,26,34,35] cost-utilization analyses,[10,11,17,20,30,31,33] or number needed to treat (NNT) analyses.[25,27] The types interventions that were studied included comprehensive diabetes education or disease management programs,[10-12,14-17,19,20,25,29,31,33] diabetes prevention programs,[18,22,23,27] education for depression,[24] transmission of glucose values,[13] initiation of insulin therapy,[30] diet education,[34] and retrospective analysis based on A1C level.[21,28,32,35] The outcome measures generally addressed cost savings and included the following: total health care costs,[11,12,14-17,19-21,30,31,33,35] total diabetes-related costs,[10,16,25,30,32] outpatient costs,[13,24] inpatient costs,[28] medication costs,[16] cost per quality-adjusted life year,[18,23,24] cost of primary prevention of diabetes,[22,22,29] number needed to treat to reduce 1 case of diabetes,[27] cost per depression-free day,[24] and cost of restricted activity.[34]

Based on the results and conclusions presented in Table 1, each of the articles was assigned to 1 of 3 cost impact categories: (1) cost reduction/cost-effectiveness associated with the intervention (18 studies),[10,11,13-15,17,19,20,25,26,28-35] (2) neutral impact associated with the intervention (4 studies),[16,18,23,24] or (3) increased cost associated with the intervention (1 study).[22] Three studies did not fit into these categories.[12,21,27] More than half (18) of the 26 articles identified by the literature review reported findings that associated diabetes education (and disease management) with decreased cost, cost saving, cost-effectiveness, or positive return on investment (ROI). One study demonstrated increased productivity at the workplace.[34] Three studies did not report on diabetes education per se but imply that a well-designed diabetes education program could be effective in reducing costs. These are Gilmer et al's work on costs associated with rising A1C,[21] Rubin et al's findings that inpatient utilization declines with better management,[31] and Rosenblum et al's report of a 40% decrease in health care costs following initiation of insulin.[30] One study found the Diabetes Prevention Program (DPP) to be too costly for broad implementation and called for more affordable approaches for achieving weight loss outcomes that are associated with better health for people with or at risk of diabetes.[18] The DPP group suggests that self-management interventions are likely to be affordable in routine clinical practice when education is conducted in a group and generic drugs are prescribed.[27] The oldest of the studies reported on a randomized control study that found no effect from education.[16]

Discussion

Health care policy makers and payers, faced with considerable resource constraints, are increasingly focused on interventions that work well and do so for reasonable cost. Glycemic control among those with diabetes is a cost-effective strategy,[36] and health management programs that empower people with chronic illnesses to self-manage their conditions are of interest in the workplace.[37,38] Behavior change is crucial to effective self-management. Diabetes educators are experts at fostering positive behavior change in people with diabetes, and the interventions they use are effective.[10] The CMS and many other payers reimburse for diabetes self-management education/training, implicitly recognizing the importance and value of the intervention.[39] Diabetes education aims to achieve optimal health status and better quality of life, as well as reduce the need for costly health care. The primary purpose of this analysis is to increase understanding of the economic value of diabetes education for people with diabetes.

Table 1

Diabetes Education

Author (Year)	Study Aim	Study Population	Study Design	Intervention	Financial/ Economic Outcome	Results	Conclusions
Balamurugan et al (2006)[10]	Implement a diabetes self-management education (DSME) program for Medicaid recipients using a continuous quality improvement (CQI) process and evaluate results of the participants' clinical outcomes and health care costs	212 Arkansas Medicaid recipients with diabetes for at least 1 year and enrolled in Medicaid for 11 continuous months. Children (<19 years), end-stage renal disease patients, and pregnant women were excluded.	Participants received 12 hours of group education (over 3 visits-initial visit, 6 months, and 1 year) on nutrition and self-management from a registered nurse and a registered dietician.	Diabetes self-management education program	Expenditures; overall and those related to diabetes	Over 1 year, DSME participants had a 0.45% decline in mean A1C, fewer hospital admissions, emergency room visits, and outpatient visits. Over 3 years, the estimated savings in diabetes-related cost was $415 per program completer. Over 10 years, completers were estimated to experience a decrease in coronary heart disease event and microvascular disease events by 12% and 15%, respectively.	This DSME program reduced health care use among Medicaid recipients with diabetes within 1 year and is likely to reduce costs associated with decreased utilization over a longer period of time.
Berg and Wadhwa (2002)[11]	Assess differences in behavior and medical service use comparing baseline, 6-month, and 1 year results	127 persons with diabetes in a health maintenance organization (HMO) and preferred provide organization (PPO).	Historical control comparison of diabetes disease management participants in community-based setting	Diabetes disease management program	Return on investment (ROI)	The number of participants getting an A1C test increased by 44.9% ($P < .001$), and hyperglycemia symptoms decreased by 53.2% ($P = .002$). Inpatient admissions decreased by 391 per	The implementation of the diabetes program that provides comprehensive information and counseling for self-management of diabetes is associated with positive behavioral change and substantial reduction in

(continued)

Table 1 (continued)

Author (Year)	Study Aim	Study Population	Study Design	Intervention	Financial/ Economic Outcome	Results	Conclusions
						1000 for each group ($P <$ .001), while controlling for age, length of membership, and the number of comorbid claims for congestive heart failure.	medical service utilization. Cost analysis of disease management program costs found a $4.34:1 ROI.
Burton and Connerty (1998)[12]	Assess a worksite diabetes education program	53 employed individuals	Mean A1C values at baseline and 3 months were calculated	3-month worksite diabetes education program	Direct and indirect health care cost, productivity	The mean fasting blood glucose levels fell from 197.8 to 179.6 mg% ($P = .12$), mean glycohemoglobin declined from 11.5% to 10.1% ($P < .001$), and mean A1C declined from 9.0% to 8.3% ($P < .001$).	Although the values in this study were still higher than the ideal, any improvement in glycemic control has been shown to reduce the risk for diabetes-related complications and subsequent direct and indirect health care costs.
Chase et al (2003)[13]	Comparison of a modem transmission intervention to usual clinic visit	70 adolescents with type 1 diabetes for at least 1 year, ages 15-20	Randomized control trial (RCT)	Control group (quarterly clinic visits) vs modem group (transmitted glucose readings every 2 weeks for 6 months instead of clinic visits)	Savings/patient for the modem group as compared with the control group	The average cost for 6 months was $305 for the visit group and $163 for the modem group (savings of $142 per patient per 6 months).	While the A1C values did not differ significantly between the control and modem groups, the average occurrence of mild to moderate hypoglycemic episodes was similar between groups with no severe hypoglycemic episodes for either.

(continued)

Table 1 (continued)

Author (Year)	Study Aim	Study Population	Study Design	Intervention	Financial/ Economic Outcome	Results	Conclusions
Christensen et al (2004)14	Evaluate the cost savings and clinical effectiveness of a diabetes education program for improving nutrition knowledge, food portioning skills, hemoglobin A1C, and anthropometric indices	155 participants; ages 54.54 (11.87) years; females, 71.4%; type 1, 5.8%; type 2, 67.7%; no diabetes, 26.5%; 63.2%, ≥ college graduate	Quasi-experimental, pre- and postcourse anthropometric measurements; a written food portion test; an observational food-portioning skill test; and A1C test were administered and scored for all participants.	3-month diabetes education course focusing on food-portioning skills	Medical cost savings (inpatient)	Improved food portion knowledge (49.67% pre vs 59.56% post, $P = .004$), improved food-portioning skills out of 5 (2.43 pre vs 4.29 post, $P = .023$), A1C decreased 0.73% ($P = .000$), body mass index (BMI) decreased 0.82 kg/m2 ($P = .000$), waist circumference decreased 1.27 in ($P = .000$), hip circumference decreased 0.6 in ($P = .000$), and waist-to-hip ratio decreased 0.01 ($P = .000$).	Improved nutrition knowledge, anthropometric measures, and glucose control are estimated to reduce medical costs (hospitalizations) by $94 010.
Cranor et al (2003)[15]	Assess the continuity of outcomes for 5 years, ensuing after the initiation of community-based pharmaceutical care services	136 patients with diabetes covered by self-insured employers' health plans	Quasi-experimental, longitudinal pre-post cohort study	Education by certified diabetes educators (CDEs), long-term community pharmacist follow-up using scheduled consultations,	Mean total direct medical cost; productivity estimates in dollars and days of sick time	Mean A1C decreased at all follow-ups. The number of patients with optimal A1C values (<7%) also increased at each follow-up. More than 50% of patients demonstrated improvement in A1C values and in lipid levels at every measurement.	Patients maintained improvement in A1C over time, and employers experienced a decline in mean total direct medical costs.

(continued)

Table 1 (continued)

Author (Year)	Study Aim	Study Population	Study Design	Intervention	Financial/ Economic Outcome	Results	Conclusions
	(PCS) for diabetic patients			clinical assessment, goal setting, monitoring, and collaborative drug therapy management with physicians		Patients with higher baseline A1C values were more likely to improve; those with higher baseline costs were likely to have lower costs following education. Total mean direct medical costs decreased by $1200 to $1872 per patient per year compared with baseline. Days of sick time decreased every year (1997-2001) for one employer group, with estimated increases in productivity estimated at $18 000 annually.	
De Weerdt et al (1991)[16]	Evaluate if an outpatient education program for insulin-treated diabetic patients improved the level of self-care	558 patients from 15 hospitals	Randomized control study; 2 experimental groups (guided by a health care professional or a fellow patient) and a control group	Education program designed to assist insulin-treated diabetic patients in self-care	Cost of therapy	The effect of the program on metabolic control, quality of life, and costs of therapy was assessed, but no significant changes were noted.	No significant effect of education on any one of these variables could be identified.

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Table 1 (continued)

Author (Year)	Study Aim	Study Population	Study Design	Intervention	Financial/ Economic Outcome	Results	Conclusions
"Diabetes Cost Savings Legislation Would Save Millions for Ohio Insurance Industry, Business, and Taxpayers in Productivity, Emergency Room Visits, and Hospital Stays" (2005)[17]	Rationalize the implementation of the Diabetes Cost Reduction Act (DCRA) in Ohio by providing evidence of cost savings in states with DCRA and highlighting increased costs for Ohio in absence of the act	Persons with diabetes	Comparing cost in medical claims for patients who took the diabetes education course to patients with similar symptoms and problems who did not attend diabetes chronic disease workshops	Diabetes chronic disease workshops	Medical claims cost	Patients who completed a diabetes education course had $2324 less in medical claims per year than patients with similar symptoms and problems who did not go to a diabetes education workshop.	The implementation of the DCRA in Ohio will enable Ohioans with diabetes to obtain a better control of their blood glucose, thereby minimizing the occurrence of costly diabetes-related complications, promoting cost savings for the insurance industry in terms of decreased medical claims, emergency room visits, hospital stays, and surgeries.
Eddy et al (2005)[18]	Estimate the effects of the lifestyle modification program used in the Diabetes Prevention Program (DPP) on health and economic outcomes	3234 adults at high risk for diabetes (BMI >24 kg/m2, fasting plasma glucose level of 5.2725-6.9375 mmol/L [95-125 mg/dL], 2-hour glucose tolerance test	Cost-effectiveness analysis using the Archimedes model	No prevention, DPP's lifestyle modification program, lifestyle modification initiating after a person develops diabetes, and metformin	Cost-effectiveness of DPP lifestyle program in terms of quality-adjusted life years (QALYs) gained and cost/person	The DPP compared with no prevention would reduce a high-risk person's 30-year chances of getting diabetes by about 11%, the chances of getting a serious complication by 8%, and the chances of dying of a complication of diabetes by 2.3%. Compared with the	Lifestyle modification should be recommended to all high-risk people because it is likely to have important effects on the morbidity and mortality of diabetes. The program used in the DPP study, however, may be too expensive for health plans or a national program to

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Table 1 (continued)

Author (Year)	Study Aim	Study Population	Study Design	Intervention	Financial/ Economic Outcome	Results	Conclusions
		result of 7.77-11.0445 mmol/L [140-199 mg/dL])				no-prevention program, the expected 30-year cost/QALY of the DPP lifestyle intervention from the health plan's perspective would be about $143 000. From a societal perspective, the cost/QALY of the lifestyle intervention compared with doing nothing would be about $62 600. Either using metformin or delaying the lifestyle intervention until after a person develops diabetes would be more cost-effective, costing about $35 400 or $24 500 per QALY gained, respectively, compared with no program. Compared with delaying the lifestyle program until after diabetes is diagnosed, the marginal cost-effectiveness of beginning the DPP lifestyle program immediately would be about $201 800.	implement. Less expensive alternatives are needed.

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Table 1 (continued)

Author (Year)	Study Aim	Study Population	Study Design	Intervention	Financial/ Economic Outcome	Results	Conclusions
Fries and McShane (1998)[19]	Compare effectiveness and cost savings of health education programs in high-risk persons to those persons with all risk levels	2586 participants of the high-risk group were mostly members of employee groups, were white-collar workers, had private health insurance, and had a mean age of 49.7 years. Employee group had a mean age of 41.2 years. Senior group had a mean age of 73.3 years.	Historical control comparison of management of participants	Randomly selected participants received health assessment questionnaire, letter, a report, and health education material based on high-risk program areas (arthritis, diabetes, high blood pressure, smoking, etc).	Direct and total costs; ROI	Previous year costs were $1138 in direct costs for high-risk groups (HR) compared with $352 in employee (E) and $995 in senior group (S). At 6 months, direct costs were reduced by $304 (HR) compared with $57 (E) and $70 (S). Total costs were reduced by $484 (HR) vs $87 (E) and $120 (S). The ROI was 6:1 in the high-risk group vs 4:1 in the comparison groups.	Intensive educational interventions may be justified in high-risk groups when they result in larger changes in high-risk persons than in unscreened persons for use and costs.
Garrett and Bluml (2005)[20]	Assess clinical benefits, satisfaction, and economic measures from a collaborative health management program involving community	256 diabetic patients under self-insured employers' health plans; 80 community pharmacy providers with training who were reimbursed by employers	Quasi-experimental, pre-post cohort study	Community pharmacist patient care services using scheduled consultations, clinical goal setting, monitoring, and collaborative drug therapy	Mean projected total direct medical costs	95.7% reported being very satisfied/satisfied with care from pharmacist. Influenza vaccination rates increased from 52% to 77%, eye exam rates increased from 46% to 82%, foot exam rates increased from 38% to 80%, and patient satisfaction with overall	Patients who participated in the program had increased satisfaction with diabetes care, higher rates of self-management goal setting and achievement, and significant improvement in clinical indicators of diabetes management. Employers experienced a decline in

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Table 1 (continued)

Author (Year)	Study Aim	Study Population	Study Design	Intervention	Financial/ Economic Outcome	Results	Conclusions
	pharmacists and health care providers aimed to assist diabetic patients with treatment, education, and self-management strategies			management with physicians and referrals to diabetes educators		diabetes care improved 57% to 87% in highest range. Mean A1C decreased from 7.9% to 7.1%, mean low-density lipoprotein cholesterol (LDL-C) decreased from 113.4 to 104.5 mg/dL, and mean systolic blood pressure decreased from 136.2 to 131.4 mm Hg. Total mean costs/patient were $918 lower than projection from initial year of enrollment.	mean projected total direct medical costs.
Gilmer et al (1997)[21]	Assess changes in economic and clinical indicators	3017 adults with diabetes who were continuously enrolled in a large HMO over a 4-year period	Regression analysis used to estimate relationship between glycemic control and medical care charges	Diagnosis of diabetes was ascertained from diagnostic and pharmaceutical databases with sensitivity of 0.91 and specificity of 0.99.	Standardized cost differentials for 1% changes in A1C for patients with diabetes and other chronic diseases and for those with diabetes only	Standardized 3-year estimates of charges ranged from $10 439 (patients without comorbidities) to $44 417 (patients with heart disease and hypertension). Medical care charges increased significantly for every	A1C provides useful information to providers and patients regarding both health status and future medical care charges. Economic data suggest that clinicians should assign high importance to low A1C results and aggressively

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Table 1 (continued)

Author (Year)	Study Aim	Study Population	Study Design	Intervention	Financial/ Economic Outcome	Results	Conclusions
						1% increase of A1C above 7%. For example, for a person with an A1C value of 6%, successive 1% increases in A1C resulted in cumulative increases in charges of approximately 4%, 10%, 20%, and 30%. The increase in charges accelerated as the A1C value increased. The rate of increase in charges with A1C was consistent for patients with diabetes only as well as diabetes plus other chronic conditions.	maintain the A1C status of patients who have low A1C values. The medical charge data suggest that investment in clinical systems to improve diabetes care may benefit both payers and patients.
Herman et al (2003)[22]	Report the costs of the DPP interventions	3234 participants with impaired glucose tolerance (IGT) enrolled in the DPP interventions	Cost analysis	Lifestyle intervention or metformin use	Direct medical costs, direct nonmedical costs, and indirect costs of the placebo, metformin, and	Over 3 years, the direct medical costs of the groups assigned to the interventions were $79/participant for the placebo, $2542 for metformin, and $2780	Modest incremental costs are associated with metformin use and lifestyle interventions when comparisons are made to a placebo intervention. Future

(continued)

Table 1 (continued)

Author (Year)	Study Aim	Study Population	Study Design	Intervention	Financial/Economic Outcome	Results	Conclusions
					intensive lifestyle interventions over the 3-year study period of the DPP from the perspective of the health system and society	for lifestyle. Direct medical costs (direct nonmedical costs) of care were $272 ($9) less per participant for the metformin group and $432 less ($1445 greater) for the lifestyle group as compared with the placebo group. Indirect costs by intervention were $230 more/participant for metformin and $174 less for lifestyle as compared with the placebo group.	evaluation of costs relative to health benefits can be used to establish the value of these interventions to health systems.
Herman et al (2003)[23]	Assess the cost-effectiveness of the DPP lifestyle and metformin interventions relative to the placebo intervention	3234 participants with IGT enrolled in the DPP interventions	Cost-effectiveness analysis of the DPP interventions from both health system and societal perspective	Intensive lifestyle and metformin interventions	Direct medical costs, direct nonmedical costs, and indirect costs; QALY from a societal and health system perspective	Over 3 years, the lifestyle and metformin interventions cost approximately $2250 more per participant than did the placebo in the DPP study. If implemented in clinical practice (and from a societal perspective), the lifestyle intervention cost $13 200 and metformin	Over 3 years, the lifestyle and metformin interventions were found to be both effective and cost-effective from a health system and societal perspective. Moreover, these interventions are likely to be affordable in routine clinical practice when education is conducted in a group and

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Table 1 (continued)

Author (Year)	Study Aim	Study Population	Study Design	Intervention	Financial/ Economic Outcome	Results	Conclusions
						cost $14 300 per case of diabetes delayed or prevented. Lifestyle interventions cost $27 100/QALY; metformin cost $35 000/QALY gained. The lifestyle intervention was more cost-effective than the metformin intervention from both the health system and societal perspectives.	generic drugs are prescribed. Health plans are likely to acquire important personal and member benefits at a reasonable cost and in a short term by adoption of the diabetes prevention programs.
Katon et al (2006)[24]	Determine the incremental cost-effectiveness and net benefit of a depression collaborative care program compared with usual care for patients with diabetes and depression	A total of 418 of 1801 patients randomized to the Improving Mood-Promoting Access to Collaborative (IMPACT) intervention (n = 204) vs usual care (n = 214) had coexisting diabetes	Preplanned subgroup analysis of patients with diabetes from the IMPACT RCT	IMPACT, through a depression care manager (DCM), who offered education, behavioral activation, and a choice of problem-solving treatment or support of antidepressant management	Incremental cost-effectiveness and net benefit	Relative to usual care, intervention patients experienced 115 more depression-free days over 24 months. Total outpatient costs were $25 higher during this same period. The incremental cost per depression-free day was 25 cents, and the incremental cost per QALY ranged from $198 to $397. An incremental net benefit of $1129 was found.	The IMPACT intervention is associated with high clinical benefits at no greater cost than usual care.

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Table 1 (continued)

Author (Year)	Study Aim	Study Population	Study Design	Intervention	Financial/ Economic Outcome	Results	Conclusions
Keers et al (2005)[25]	Determine the cost and benefits of an intensive diabetes education program for patients with prolonged self-management problems and to determine the inclusion criteria for optimal outcomes	61 participants of a diabetes education program	Pre- and postintervention data on glycemic control (A1C), diabetes-related distress, and costs were compared with a reference group of 230 nonreferred consecutive outpatients.	Multidisciplinary intensive diabetes education program (MIDEP)	Diabetes-related costs; immediate and future costs of diabetes complications; number needed to treat	The effect of MIDEP on A1C and diabetes-related distress was satisfactory, with 1 in less than 3 patients having a 0.5% reduction in A1C and 1 in slightly more than 2 patients reporting a decrease of >1 SD at the diabetes-related distress. Selection of patients with A1C 8.0% and diabetes-related distress scores ≥ 40 further increased MIDEP's efficiency without excluding many patients.	The intervention is effective and cost-effective in improving glycemic control and diabetes-related distress for patients with prolonged self-management difficulties. Stricter inclusion criteria related to A1C and diabetes-related distress scores may enhance the program's efficiency.
Klonoff and Schwartz (2000)[26]	Stratify interventions for diabetes according to their economic impact	Articles documenting or modeling the achievement of a desired outcome or benefit along with an economic	Meta-analysis/ literature review	Diabetes disease management programs	Cost saving and cost-effectiveness	(1) Clearly cost-saving interventions included eye care and preconception care. (2) Clearly cost-effective interventions included nephropathy prevention in type 1 diabetes and improved glycemic	Widely practiced interventions for patients with diabetes can be cost saving and cost-effective from both a medical and an economic perspective.

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Table 1 (continued)

Author (Year)	Study Aim	Study Population	Study Design	Intervention	Financial/ Economic Outcome	Results	Conclusions
		analysis for 17 widely practiced interventions for diabetes				control. (3) Possibly cost-effective interventions included nephropathy interventions in type 2 diabetes and self-management training. Unclear economic impact interventions include case management, MNT, self-monitoring of blood glucose, foot care, blood pressure (BP) control, blood lipid control, smoking cessation, exercise, weight loss, A1C measurement, and influenza and pneumococcus vaccinations.	
Knowler et al (2002)[27]	Assess a lifestyle intervention for controlling and preventing diabetes	3234 participants with IGT enrolled in the DPP interventions	RCT	Comparison of a placebo group with groups assigned to an intensive lifestyle change or metformin use	Efficacy at decreasing the incidence of diabetes	The lifestyle intervention was more effective than metformin. Fifty percent of the participants in lifestyle intervention experienced >7% loss of body weight. The incidence of diabetes reduced by 58% in the	While not explicitly stated, the reader could assume that by reducing the incidence of diabetes, costs relating to the treatment of the disease and comorbid conditions are reduced.

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Table 1 (continued)

Author (Year)	Study Aim	Study Population	Study Design	Intervention	Financial/ Economic Outcome	Results	Conclusions
						lifestyle intervention group and by 31% in the metformin group as compared with the placebo group.	
Menzin et al (2001)[28]	Examine impact of improved glycemic control on short-term complications of diabetes and associated costs	3294 adults with diabetes in a managed care setting	Retrospective cohort design	No intervention; patients divided into 3 groups on basis of mean A1C level: good control (≤ 8%), fair control (8%-10%), and poor control (>10%)	Savings	About 10% of 2394 patients with diabetes had at least 1 inpatient stay for a short-term complication. Over 3 years, the adjusted rate of inpatient treatment for 3 groups ranged from 13:16:31 per 100 patients for good:fair:poor A1C control ($P = .05$). The corresponding mean adjusted charges were $970, $1380, and $3040, respectively.	Patients with good glycemic control on average saved $410 to $2070 over the span of 3 years when compared with fair and poor control group costs.
Ragucci et al (2005)[29]	Evaluate the effectiveness of pharmacist-administered diabetes mellitus education and management	191 patients with diabetes at 3 university-based primary care clinics	One-year observational study	Pharmacist-administered diabetes education and management services	Savings and cost avoidance for those patients with improved patient care outcomes-reductions in A1C	Average A1C at 1 year was 7.8% (range, 4.5%-13.9%) vs 9.5% (range, 5.4%-19%) at baseline (change -1.7%, $P < .05$). Of the patients, 38% had a 1% or greater	Clinical pharmacist provision of diabetes management services achieved significant improvements in A1C values, blood pressure, and aspirin use. Continued

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Table 1 (continued)

Author (Year)	Study Aim	Study Population	Study Design	Intervention	Financial/ Economic Outcome	Results	Conclusions
	services on selected diabetes performance measures				of at least 1%, blood pressure control, and documented aspirin use	reduction in A1C. Average blood pressure decreased over the study period from 141/79 to 135/75 mm Hg ($P = .007$), but average LDL levels did not change to a statistically significant extent (114-112 mg/dL, $P > .05$). There was an increase from 34% at baseline to 73% at 1 year ($P < .0001$) in aspirin use. The program achieved the A1C and LDL values that would qualify for National Committee for Quality Assurance (NCQA) diabetes recognition. Cost avoidance was calculated as $59 040, based on an estimated savings of $820 for each 1% decrease in A1C.	efforts in diabetes education and management are needed to further improve clinical, economic, and humanistic outcomes.

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Table 1 (continued)

Author (Year)	Study Aim	Study Population	Study Design	Intervention	Financial/ Economic Outcome	Results	Conclusions
Rosenblum and Kane (2003)[30]	Analysis of the cost and utilization of health care services before and after the initiation of insulin therapy in patients with type 2 diabetes	1177 patients with type 2 diabetes between the ages of 18 and 65 years and continuously enrolled in a managed care organization for 9 months before and after their insulin start date	Medical, facility, and pharmaceutical services in the preinsulin and postinsulin time period were examined along with a subanalysis of all types of medical service cost categories	Initiation of insulin therapy for patients with type 2 diabetes to determine decrease in disease-related and total health care costs	Total costs, disease-related costs, and costs associated with various aspects of direct care	Average total and disease-related costs increased after insulin was started, with a mean difference of $2220 ($P < .001$) for average total costs and $430 ($P < .001$) for disease-related costs. Much of the cost increase after the start of insulin occurred in the initial 2-month postinsulin period, after which both total costs and disease-related costs decreased by 57% ($P < .001$) and 49% ($P < .001$), respectively, throughout the remainder of the postinsulin time period. Facility costs decreased at all postinsulin measurement intervals. Pharmacy costs were the only treatment component to remain above the preinsulin period.	Initiation of insulin therapy in the management of type 2 diabetes involves an approximate 10% increase in total health care expenditures. This is offset by a 40% decrease in subsequent total health care expenditures 9 months following insulin initiation.

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Table 1 (continued)

Author (Year)	Study Aim	Study Population	Study Design	Intervention	Financial/ Economic Outcome	Results	Conclusions
Rubin et al (1998)[31]	Identify the potential to reduce diabetes complications and costs through intensive management	7000 people with diabetes being treated through 7 managed care plans	Retrospective analysis of short-term baseline and follow-up clinical, economic, member, and provider satisfaction	Implementation of a comprehensive health care management program for people with diabetes	Gross economic savings	Gross-adjusted savings of $50/member with diabetes/month (12.3%) was achieved, with gross unadjusted savings of $44/diabetic member/month (10.9%). Hospital admissions per 1000 diabetic member years decreased by 18%, and bed days fell by 21%. Patients with diabetes were more likely to get A1C tests, foot exams, eye exams, and cholesterol screenings while enrolled in the program.	Implementation of a comprehensive health care management program for people with diabetes cannot only lead to substantial improvements in costs and clinical outcomes in the short term but also result in continuing improvements in health status and a reduction in the number of future diabetic complications over time.
Shetty et al (2005)[32]	Assess difference in costs associated with different A1C levels	3121 patients (46%) at target A1C level (≤ 7%) and 3659 patients (54%) above target A1C level (≤ 7%)	Retrospective database analysis using eligibility data, medical and pharmacy administrative claims data, and laboratory data from a large US managed care organization	No intervention; type 2 diabetes patients <7% vs >7% A1C levels were followed for 1 year to determine difference in costs	Diabetes-related costs	After adjusting for confounders, the predicted total diabetes-related cost for the above-target group during the 1-year follow-up period was $1540/patient, 32% higher than the total diabetes-related cost ($1171) for the at-target group ($P < .001$).	Managed care members with type 2 diabetes who stayed continuously at the target A1C of 7% or less over a 1-year period incurred lower diabetes-related costs vs those who were continuously over the target of ≤ 7% A1C.

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Table 1 (continued)

Author (Year)	Study Aim	Study Population	Study Design	Intervention	Financial/ Economic Outcome	Results	Conclusions
Sidorov et al (2002)[33]	Assess the impact of diabetes disease management (DDM) program on medical costs for patients with diabetes	6799 patients fulfilling Health Plan Employer Data and Information Set (HEDIS) criteria for diabetes, of whom 3118 patients (45.9%) enrolled in DDM and 3681 patients (54.1%) not enrolled in DDM	Retrospective examination of paid health care claims and other measures of health care use by the cohort over 2 years	DDM program	Average gross savings; ROI	Lower inpatient use among DDM patients (0.12 admissions and 0.56 inpatient days/patient/year vs 0.16 admissions and 0.98 inpatient days/patient/year for non-DDM). Mean number of emergency room visits was 0.49 (DDM) vs 0.56 (non-DDM). DDM patients had more primary care office visits 8.4 vs 7.8/patient/year but lower mean paid claims among commercial insurance ($302.19 DDM vs $527.96 non-DDM) and Medicare ($424.00 DDM vs $500.37 non-DDM).	Patients enrolled in the DDM averaged $394.62/member/month in paid claims vs $502.48 for those not in DDM (21% statistically significant reduction in costs for both commercial and Medicare risk insurance). Average gross savings: $1294.32 per person/year. Patients in DDM not only experienced lower charges but also had significantly higher measures in the key diabetes HEDIS measures.
Testa and Simonson (1998)[34]	Examine short-term outcomes of glycemic control in type 2 diabetes	569 employed individuals with type 2 diabetes	12-week randomized, controlled, double-blind study	Diet and titration with either 5 to 20 mg of glipizide gastrointestinal therapeutic	Change in glucose and A1C levels, symptom distress, quality of life (QOL), and health economic	At 12 weeks, mean A1C and fasting blood glucose levels decreased with active therapy (glipizide GITS) vs placebo (7.5% ± 0.1% vs	Lost earnings associated with absenteeism were $24/male worker/month with improved glycemic control but were $115 for those without uncontrolled

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Table 1 (continued)

Author (Year)	Study Aim	Study Population	Study Design	Intervention	Financial/ Economic Outcome	Results	Conclusions
				system (GITS) or placebo	indicators (productivity) from questionnaires and diaries	9.3% ± 0.1% and 7.0 ± 0.1 mmol/L [126 ± 2 mg/dL] vs 9.3 ± 0.2 mmol/L [168 ± 4 mg/ dL], respectively; $P < .001$). Quality-of-life treatment differences for symptom distress general perceived health and cognitive functioning were significantly better for those in active therapy. Economic outcomes for glipizide GITS included higher retained employment (97% vs 85%; $P < .001$) and productive capacity (99% vs 87%; $P < .001$), less absenteeism (losses = $24 vs $115/worker per month; $P < .001$), fewer bed days (losses = $1539 vs $1843 per 1000 person days; $P = .05$), and fewer restricted-activity days (losses = $2660 vs	blood sugar. Lost earning due to restricted activity were $2660/1000 person days for male employees with good glycemic control vs $4275 for those without. Lost wages for those restricted to bed rest were $1539/1000 person days compared with $1843 for poor glycemic control. Improved glycemic control for patients with type 2 diabetes is associated with substantial short-term symptomatic, QOL, and health economic benefits. Employees who improved their glycemic control were more productive on the job (99% vs 87%) and able to remain employed longer (97% vs 85%) than employees who did not control and lower their blood sugar levels.

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Author (Year)	Study Aim	Study Population	Study Design	Intervention	Financial/ Economic Outcome	Results	Conclusions
						$4275 per 1000 person days; $P = .01$).	Absenteeism rate dropped by 1% compared with an 8% increase in employees with poor glycemic control.
Wagner et al (2001)[35]	Determine impact on cost of patients with improved A1C	4744 diabetes patients ≥ 18 years, continuously enrolled, and had A1C measured at least once a year	Historical cohort study between 1992 and 1997 in a staff-model HMO; 732 patients whose A1C decreased ≥ 1% between 1992 and 1993 and was maintained through 1994 formed the improved group. 4012 patients whose levels decreased 0.9% comprised the unimproved group.	Compare patients with diabetes whose A1C improved to those whose did not	Mean total costs; cost savings	Patients with diabetes whose A1C improved had similar demographics to those whose did not but had higher baseline measurements (10.0% vs 7.7%). Cost savings in improved cohort were statistically significant only among those with the highest baseline levels (>10%) and were unaffected by complications at baseline. Utilization was consistently lower in the improved cohort for primary care and specialty visits.	A sustained reduction in A1C level among adult patients with diabetes is associated with significant cost savings (mean total health care costs were $685 to $950 less each year in the cohort with improved A1C measurements) within 1 to 2 years of improvement.

MNT: medical nutrition therapy.

Most professional diabetes educators are members of the American Association of Diabetes Educators. Some diabetes educators are certified diabetes educators (CDEs) or Board Certified Advanced Diabetes Managers, having met certain eligibility and exam requirements. The American Association of Diabetes Educators advocates diabetes education that is provided by a diabetes educator and focuses on 7 self-care behaviors (ie, healthy eating, being active, monitoring, taking medication, problem solving, healthy coping, and reducing risks) that are essential for improved health status and greater quality of life. No economic studies were available that met this more restricted definition of diabetes education. Hence, this study adopted a very broad definition of diabetes education for its literature review. The strength of this decision is that more than 25 studies were identified as being relevant. The weakness is that the studies varied considerably in design, outcome metric, population studied, and their aims.

In summary, the review of the literature addresses economic and financial outcomes relating to diabetes education interventions that are supportive of diabetes education as a cost-effective intervention. One could posit that diabetes education reduces cost because it is guided by the best available science-based evidence; incorporates the needs, goals, and life experiences of the person with or at risk of diabetes; and supports the work of health care providers who treat these patients.

Most but not all published papers on the topic appear in Medline. Some of the studies are more robust than others. The inclusion criteria were broad, and hence it is not possible to grade the rigor of the studies and the importance of the findings of each. This study did, however, include findings from RCTs and a recent systematic review. Finally, it is not possible to identify the importance of the diabetes educator in the provision and outcomes of the programs in the study because of the broad definition of diabetes education that was used.

The findings indicate that the benefits associated with education on self-management and lifestyle modification for people with diabetes are positive and outweigh the costs associated with the intervention. More research is needed to validate that diabetes education provided by diabetes educators is cost-effective.

Implications/Relevance

- Behavior change, lifestyle modification, and self-management are crucial elements to the cost-effective management of chronic illnesses such as diabetes.
- For optimal comparisons, a standardized definition of diabetes education should be adopted for future economic studies.
- The benefits associated with diabetes education are positive and, based on the literature, outweigh the costs associated with the intervention.

References

1. Schoen C, Guterman S, Shih A, et al. Bending the curve: options for achieving savings and improving value in U.S. health spending, The Commonwealth Fund, December 2007. http://www.commonwealthfund.org/publications/publications_show.htm?doc_id=620087. Accessed January 29, 2008.
2. Anderson G. Chronic conditions: making the case for ongoing care. Johns Hopkins University. November 2007. http://www.fightchronicdisease.com/news/pfcd/documents/ChronicCareChartbook_FINAL.pdf. Accessed January 29, 2008.
3. American Diabetes Association. Economic costs of diabetes in the U.S. in 2007. Diabetes Care. 2008;31:1-20.
4. DeVol R, Bedroussian A, Charuworn A, et al. An unhealthy America: the economic burden of chronic disease—charting a new course to save lives and increase productivity and economic growth. Milken Institute. October 2007. http://www.milkeninstitute.org/pdf/chronic_disease_report.pdf. Accessed January 29, 2008.
5. American Association of Diabetes Educators. About diabetes education. http://www.diabeteseducator.org/DiabetesEducation. Accessed February 5, 2008.
6. Norris SL, Nichols PL, Caspersen CJ, et al. The effectiveness of disease and case management for people with diabetes: a systematic review. Am J Prev Med. 2002;22(suppl):15-38.
7. Norris SL, Lau J, Smith SJ, Schmidt CH, Engelgau MM. Self-management education for adults with type 2 diabetes: a meta-analysis of the effect on glycemic control. Diabetes Care. 2002;25:1159-1171.
8. Salber PR. How managed care organizations contribute to improved diabetes outcomes. Am J Managed Care. 2008;14:9-12.
9. Gary TL, Genkinger JM, Guallar E, Peyrot M, Brancati FL. Meta-analysis of randomized educational and behavioral interventions in type 2 diabetes. Diabetes Educ. 2003;29:488-501.
10. Balamurugan A, Ohsfeldt R, Hughes T, Phillips M. Diabetes self-management education program for Medicaid recipients: a continuous quality improvement process. Diabetes Educ. 2006;32:893-900.
11. Berg GD, Wadhwa S. Diabetes disease management in a community-based setting. Manag Care. 2002;11:45-50.
12. Burton WN, Connerty CM. Evaluation of a worksite-based patient education intervention targeted at employees with diabetes mellitus. J Occup Environ Med. 1998;40:702-706.
13. Chase HP, Pearson JA, Wightman C, Roberts MD, Oderberg AD, Garg SK. Modem transmission of glucose values reduces the costs and need for clinic visits. Diabetes Care. 2003;26:1475-1479.
14. Christensen NK, Williams P, Pfister R. Cost savings and clinical effectiveness of an extension service diabetes program. Diabetes Spectrum. 2004;17:171-175.
15. Cranor CW, Bunting BA, Christensen DB. The Asheville project: long-term clinical and economic outcomes of a community pharmacy diabetes care program. J Am Pharm Assoc. 2003;43:173-184.
16. De Weerdt, Visser AP, Kok GJ, van der Veen EA. Randomized controlled multicentre evaluation of an education programme for

insulin-treated diabetic patients: effects on metabolic control, quality of life and cost of therapy. Diabetes Med. 1991;8:338-345.
17. Diabetes cost savings legislation would save millions for Ohio insurance industry, business, and taxpayers in productivity, emergency room visits, and hospital stays. October 4, 2005 [cited January 7, 2008]. http://www.diabetes.org/uedocuments/10.4.05DCRA.pdf.
18. Eddy DM, Schlessinger L, Kahn R. Clinical outcomes and cost-effectiveness of strategies for managing people at high risk for diabetes. Ann Intern Med. 2005;143:251-264.
19. Fries JF, McShane D. Reducing need and demand for medical services in high-risk persons: a health education approach. West J Med. 1998;169:201-207.
20. Garrett DG, Bluml BM. Patient self-management program for diabetes: first-year clinical, humanistic, and economic outcomes. J Am Pharm Assoc. 2005;45:130-137.
21. Gilmer TP, O'Connor PJ, Manning WG, Rush WA. The cost to health plans of poor glycemic control. Diabetes Care. 1997;20:1847-1853.
22. Herman WH, Brandle M, Zhang P, et al. Diabetes Prevention Program Research Group: costs associated with the primary prevention of type 2 diabetes mellitus in the diabetes prevention program. Diabetes Care. 2003;26:36-47.
23. Herman WH, Brandle M, Zhang P, et al. Diabetes Prevention Program Research Group: within-trial cost-effectiveness of lifestyle intervention or metformin for the primary prevention of type 2 diabetes. Diabetes Care. 2003;26:2518-2523.
24. Katon W, Unutzer J, Fan M, et al. Cost effectiveness and net benefit of enhanced treatment of depression for older adults with diabetes and depression. Diabetes Care. 2006;29:265-270.
25. Keers JC, Groen H, Sluiter WJ, Bouma J, Links TP. Costs and benefits of a multidisciplinary intensive diabetes education program. J Eval Clin Pract. 2005;11:293-303.
26. Klonoff DC, Schwartz DM. An economic analysis of interventions for diabetes. Diabetes Care. 2000;23:390-404.
27. 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. 2002;346:393-403.
28. Menzin J, Langley-Hawthorne C, Friedman M, Boulanger L, Cavanaugh R. Potential short-term economic benefits of improved glycemic control. Diabetes Care. 2001;24:51-55.
29. Ragucci KR, Fermo JD, Wessell AM, Chumney ECG. Effectiveness of pharmacist-administered diabetes mellitus education and management services. Pharmacotherapy. 2005;25:1809-1816.
30. Rosenblum MS, Kane MP. Analysis of cost and utilization of health care services before and after initiation of insulin therapy in patients with type 2 diabetes mellitus. J Manag Care Pharm. 2003;9:309-316.
31. Rubin RJ, Dietrich KA, Hawk AD. Clinical and economic impact of implementing a comprehensive diabetes management program in managed care. J Clin Endocrinol Metab. 1998;83:2635-2642.
32. Shetty S, Secnik K, Oglesby AK. Relationship of glycemic control to total diabetes-related costs for managed care health plan members with type 2 diabetes. J Manag Care Pharm. 2005;11:559-564.
33. Sidorov J, Shull R, Tomcavage J, Girolami S, Lawton N, Harris R. Does diabetes disease management save money and improve outcomes? Diabetes Care. 2002;25:684-689.
34. Testa MA, Simonson DC. Health economic benefits and quality of life during improved glycemic control in patients with type 2 diabetes mellitus: a randomized, controlled, double-blind trial. JAMA. 1998;280:1490-1496.
35. Wagner EH, Sandhu N, Newton KM, McCulloch DK, Ramsey SD, Grothaus LC. Effect of improved glycemic control on health care costs and utilization. JAMA. 2001;285:182-189.
36. CDC Diabetes Cost-Effectiveness Group. Cost-effectiveness of intensive glycemic control, intensified hypertension control and serum cholesterol level reduction for type 2 diabetes. JAMA. 2002;287:2542-2551.
37. Ozminkowski RJ, Goetzel RZ, Smith MW, Cantor RI, Shaughnessy A, Harrison M. The impact of the Citibank, NA, health management program on changes in employee health risks over time. J Occup Environ Med. 2000;42:502-511.
38. Aldana SG. Financial impact of health promotion programs: a comprehensive review of the literature. Am J Health Promotion. 2001;15:296-320.
39. Department of Health and Human Services, Health Care Financing Administration. Federal Register, Part II; 42 CFR Parts 410, 414, 424, 480 and 498. Friday, December 29, 2000.