Using Clinical Information To Project Federal Health Care Spending

How Congress could use a diabetes spending projection model to help inform budget decisions.

by Elbert S. Huang, Anirban Basu, Michael J. O'Grady, and James C. Capretta

ABSTRACT: Complications from chronic illnesses often do not emerge for many years. Current federal cost projection methods are constrained by ten-year cost estimates, which capture increases in near-term intervention costs but not changes in long-term costs. Current methods also cannot easily capture the cost implications of changes in disease progression. Type 2 diabetes is a prime example of a chronic illness with long-term health and cost consequences. We present results from an epidemiologically based model that projects federal costs for diabetes under alternative policies, and we discuss the potential changes in the federal budget process needed to capture the full impact of these interventions. [Health Aff (Millwood). 2009;28(5):w978–90 (published online 1 September 2009; 10.1377/hlthaff.28.5.w978)]

THE HIGH COSTS ASSOCIATED WITH CARING FOR people with chronic diseases is one of the most pressing health policy issues in the United States today.[1] The baby-boom generation is entering its retirement years, and advanced age is associated with the development of several costly chronic illnesses. As a result, Medicare and other payers will be under tremendous financial pressure as costs rise from predictable demographic and epidemiological forces.

Current Practice, The Ten-Year Budget Window, And Diabetes

Forecasting future health care costs for the federal government is done primarily by the Office of the Actuary (OACT) at the Centers for Medicare and Medicaid Services (CMS) for the administration and by the Congressional Budget Office (CBO) for Congress. The CMS Office of the Actuary has lead responsibility for

Elbert Huang is an assistant professor of medicine in the Section of General Internal Medicine, University of Chicago (Illinois) School of Medicine. Anirban Basu is an assistant professor of medicine there. Michael O'Grady (MOGrady@UChicago.edu) is a senior fellow at NORC in Bethesda, Maryland, and principal of O'Grady Health Policy LLC in Chevy Chase, Maryland. James Capretta is a principal of Civic Enterprises LLC in Washington, D.C.

DOI 10.1377/hlthaff.28.5.w978

forecasting future spending for Medicare as part of the annual look at the program's finances by the Boards of Trustees. The CBO is charged by Congress with providing nonpartisan research on the costs of proposed and enacted legislation. Both the House and the Senate have rules requiring bills to be analyzed for cost implications by the CBO. CBO staff has broad flexibility to use professional judgment to set assumptions and analytical approaches when producing cost estimates for health legislation.

Both the CMS and the CBO regularly review the latest findings and data from clinical medicine and health services research to inform their projection methods and assumptions. For instance, the CBO released a detailed review of the literature on pharmaceutical care before the Medicare prescription drug legislation was passed. At that time, the CBO staff concluded that the evidence was insufficient to incorporate health status changes into its projection methodology when examining drug coverage legislation.[2] A similar CBO study was issued in 2002 on the effectiveness of disease management programs in Medicare.[3]

The CBO has also developed the capacity to make long-term budgetary projections, which are featured in a series of reports.[4] Findings from its long-term forecasts have been cited extensively by agency officials in congressional testimony and elsewhere, to better inform policymakers and the public about the dramatic growth in entitlement costs expected in the coming decades. To make these projections, the CBO has developed separate, long-term models for Social Security and health care costs.

CBO cost estimates for legislation related to programs such as Medicare and Medicaid have traditionally covered a period of ten-years—the so-called budgetary window.[5] In the past, concerns were raised that this practice contained a budgetary loophole. Legislation with minimal short-term costs could include built-in cost increases beyond ten years. To address this problem, Congress recently asked the CBO to monitor the cost effects of tax and entitlement legislation for the four succeeding decades beyond the first ten years.[6] Still, the reverse problem has not yet been addressed. Legislative initiatives that produce near-term costs but longer-term savings are only examined based on their ten-year cost impact.

For health policy directed at chronic illnesses, a near-term focus is problematic, as the natural history of disease progression often goes well beyond ten years. Thus, the full impact of policies intended to head off unnecessary expenses will not be in full view for policymakers with cost estimates stopping at year ten. The problem cuts both ways. A more complete accounting of the costs of a chronic-illness intervention would capture the potential offsetting costs of reductions in care for avoided or postponed complications, but it would also capture the increased spending associated with the chronically ill living longer lives.

Further, projection methodologies should have the capacity to capture health and cost effects of alternative policies for chronic illness. Although both the CBO and the CMS track closely the literature relevant to their projection assumptions,

to our knowledge neither agency has yet built a forecasting approach for any chronic condition or disease that uses reliable epidemiological data to project expected health and cost effects from alternative policy scenarios.

Type 2 diabetes is the prototypical example of a chronic condition with long-term health implications. The typical progression is from excessive body weight to pre-diabetes (impaired fasting glucose, impaired glucose tolerance), to type 2 diabetes, and ultimately to diabetes-related complications. Type 2 diabetes typically develops in middle-aged or older people, although it is an emerging issue for children and young adults as well.[7] The actual diagnosis of type 2 diabetes often is delayed by four to seven years from the time that glucose levels enter the diabetic range.[8] The complications of diabetes such as blindness and renal failure also take many years to appear. As a result, the positive effects of improved treatment often take decades to show clinically significant effects.[9]

Cost estimators are understandably cautious about crediting long-term savings, given the uncertain financial exposure for taxpayers. Although no projection can be foolproof, what is needed now is a concrete demonstration of how an epidemiological model could inform budget projections beyond ten years, with transparent methods and an acceptable level of reliability. We present such a model for type 2 diabetes here.

Description Of A Model For Projecting Diabetes Prevalence, Incidence, And Costs

During the past decade, the modeling of the natural history of diabetes and its treatments has advanced greatly with the availability of data from groundbreaking clinical trials such as the Diabetes Control and Complication Trial (DCCT) and the United Kingdom Prospective Diabetes Study (UKPDS).[10,11] Major diabetes models include the DCCT Research Group Type 1 diabetes model,[12] the type 2 diabetes model from the National Institute of Diabetes and Digestive and Kidney Diseases (NIDDK),[13] the model of diabetes complications from the Centers for Disease Control and Prevention (CDC) and Research Triangle International,[14] the UKPDS type 2 diabetes model,[15] the Sheffield model,[16] the CORE diabetes model,[17] the Eagle model,[16] and the Archimedes model.[18] Each simulates the natural history of major diabetes complications. The models' conclusions regarding future complication rates and the benefits of comprehensive diabetes care have been consistent over time, despite differences in model assumptions and inputs.[16] These models have been used to forecast the long-term costs of a cohort of patients with diabetes and its complications.

We set out to explore whether an epidemiologically based model of a chronic condition could provide insights to policymakers weighing the merits of policy scenarios. We developed the Diabetes Population Cost Model (DPCM), integrating a diabetes progression model with data already in the public domain that can be used to estimate population-level changes in diabetes risk factors over time.

A more detailed description of the structure and inputs of the DPCM will be available from a forthcoming publication.[19] In brief, we defined the prevalent type 2 diabetes population using data from the National Health and Nutrition Examination Survey (NHANES), modeled people's transitions across various body mass index (BMI) categories, and modeled the progression to (1) no diabetes, (2) undiagnosed diabetes, (3) diagnosed diabetes, and (4) death. Among those who developed diabetes, we modeled the development of diabetes-related complications using the UKPDS epidemiological models of diabetes complications.[15] The baseline costs of diabetes care came from published reports of the use of health services. The model aggregates estimates of individuals' health-state transitions and costs for the overall population over time. All costs are expressed in 2007 dollars. We incorporated CBO cost-growth assumptions in our analyses (2.4 percent real growth annually for ten years and 1.7 percent per year thereafter).[20]

Baseline Population And Cost Projections

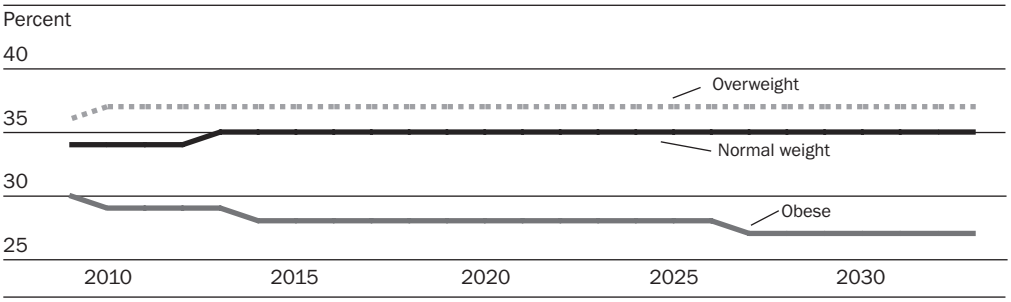
We found that by 2009, 19.5 million people will have diagnosed type 2 diabetes and 4.25 million people will have undiagnosed type 2 diabetes in the U.S. adult population ages 24–85. Over the next twelve years, the cohort of people with diabetes is expected to rise. This trend reflects the demographic shift under way with the aging of the baby-boom generation combined with increased prevalence of obesity. At the same time, the medical care system is screening continually for diabetes. Our diabetes screening rates are based on data from the 2005–2006 NHANES. The combined effect is an increase in diabetes cases and the successful identification of many of these cases by the medical system. This translates into a growing cohort of established diabetic cases and a slow pace of decline in cohorts of people with undiagnosed and newly diagnosed diabetes. By 2020, the sizes of these cohorts will reach 31.7 million, 3.7 million, and 2.5 million, respectively.

The Impact Of Changes In Obesity Prevalence

The increased prevalence of obesity during the past decade is well documented, as is the correlation between obesity and the risk of type 2 diabetes.[21] Exhibit 1 shows our estimates of changes in the percentages who are obese, overweight, and normal weight among people without diabetes—that is, the pool of potential new diabetics. The overall obesity distribution in this population is assumed to remain fairly stable over time, with about 65 percent being overweight or obese. Although overweight and obese subjects have greater hazards of progression to diabetes, growth in these categories will be small and therefore is not expected to contribute toward the growth in diabetes prevalence. This same leveling of the obesity trend is found in projections produced by the CDC for the entire U.S. population.[21]

For the immediate future, the rates of diabetes will reflect the increased obesity trends of the past decade. This will result in an increased incidence of new diabetes cases and a parallel increase in spending associated with those new cases. As

EXHIBIT 1
Projected Distribution Of Obese, Overweight, And Normal-Weight Non-Diabetic Populations, 2009–2033



SOURCE: Authors' modeling (projected) based on data from the National Health and Nutrition Examination Survey (NHANES). See also Note 20 in text.
NOTE: Obesity, overweight, and normal weight are determined by body-mass index (BMI).

Exhibit 1 highlights, the projected obesity trend and its impact on diabetes cases and spending are not expected to improve or worsen substantially during the next twenty-five years.

Spending On Diabetes And Its Complications

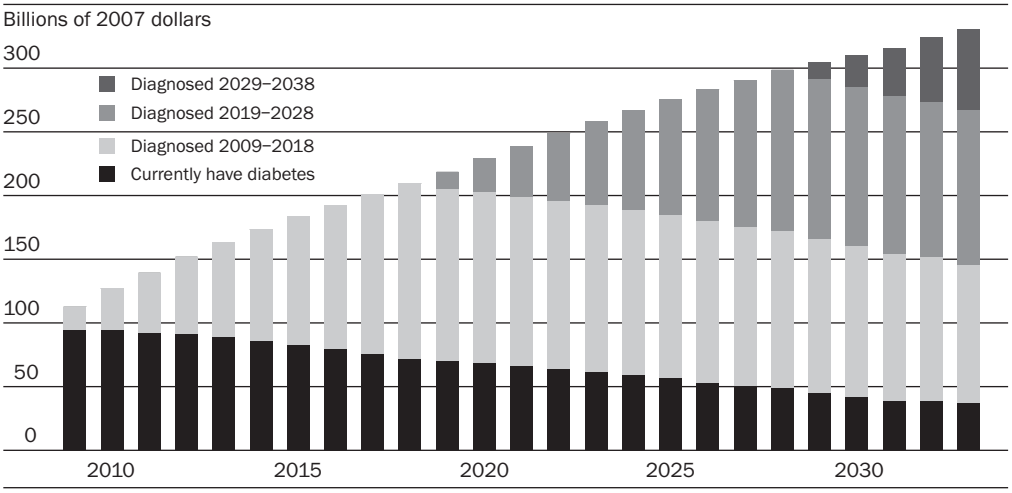
In conjunction with forecasts of diabetes population growth, we projected direct spending on care for diabetes and its complications for the next twenty-five years. Over that time frame, annual total spending is expected to increase steeply to approximately $336 billion, mainly because of the increasing size of the cohorts with diabetes (Exhibit 2). The projected real growth in direct spending for diabetes clearly exceeds current projections of growth in gross domestic product (GDP) for the foreseeable future (Exhibit 3). It also exceeds growth projections for Medicare spending in the next two decades; however, the two growth trends begin to converge in the third decade.

Policy Projections

In addition to providing insight into future cost projections, epidemiologically based models can inform decision making regarding possible alternatives to current policy. We modeled a prototypical intervention to improve the treatment of type 2 diabetes similar to current well-designed disease management programs. These programs intensify the treatment of people with diabetes. Nurses or diabetes educators typically take on the task of population management, which includes monitoring of risk-factor levels and recommending intensification of medications when necessary.[22]

For the policy simulation, we compared (1) the baseline total costs of diabetes care, (2) added program costs, and (3) the reestimated overall costs incorporating program costs and clinical benefits. The difference between the combination of cost categories 1 and 2 (combined) and category 3 represents the cost offset of the

EXHIBIT 2
Projected Direct Spending On Diabetes And Its Complications Among Different Diagnosis Cohorts, 2009–2033

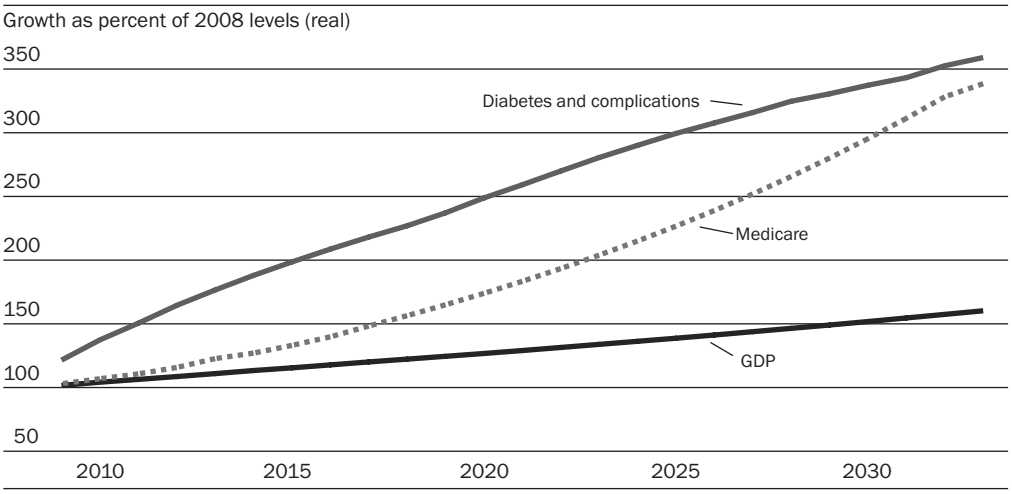


SOURCE: Derived from the authors' own analyses and computations.

intervention compared for ten- and twenty-five-year budget windows.

We assumed that annual program costs for each enrolled patient would be $424, based on an estimate of costs from prior studies of diabetes quality improvement programs.[23, 24] Additionally, with the program in place, the cost of diabetes care related to preventive medications and routine testing would increase by $600 per patient annually based on a micro-costing exercise,[25] thereby bringing the to-

EXHIBIT 3
Projected Real Growth In Direct Spending On Diabetes And Its Complications, Medicare Overall Spending, And U.S. Gross Domestic Product (GDP), 2009–2033



SOURCE: Derived from the authors' own analyses and computations.

tal annual cost per patient to $1,024.

Based on the peer-reviewed literature, we assumed that the intervention would lead to multiple improvements in diabetes care. Current clinical insight stresses that diabetes care encompasses both optimal cardiovascular prevention and glucose control. We estimated that the program would bring about an average reduction in glycosylated hemoglobin (A1c) of 0.81 percent and an average reduction in systolic blood pressure of 5 mm Hg. These two estimates are based on a meta-analysis of existing trials of chronic disease management programs (twenty-six glucose-lowering trials and thirteen blood pressure–lowering trials).[22] We also incorporated a reduction in total cholesterol of 20 mg/dl, a ten-percentage-point absolute increase in the use of angiotensin-converter enzyme (ACE) inhibitor (from 50 percent to 60 percent), and a ten-percentage-point absolute increase in use of aspirin (from 45 percent to 55 percent) based on the experience of the Health Disparities Collaborative, a four-year observational study of a quality improvement program in federally qualified community health centers.[26]

The program would enroll people ages 24–64 with existing type 2 diabetes. With each subsequent year, 60,000 to 100,000 representative individuals, among those who had existing diabetes and aged into the program or those who developed diabetes in this age range, would be enrolled. We expect that an actual program would target participation, instead of using a representative sample. We understand that using a representative sample may cause our costs to appear higher than they would be in practice, but we did not have enough data to simulate eligibility criteria. The diabetes improvement program would follow each enrolled patient for the rest of his or her life or to the end of the budget window, whichever came first. We also assumed that adherence to the program would persist over patients' lifetimes and affect their long-term risk of blindness, renal failure, lower-extremity amputation, and coronary heart disease. We know that actual adherence to such a program in real-world practice would not be 100 percent. Lower adherence would lessen the program's effectiveness but also would lessen the program's costs because of subject dropouts.

Exhibit 4 divides the treatment population into different age cohorts to illustrate the relative costs of different subpopulations. The size of the program budget and the number of people treated can be adjusted up or down based on available funding and other policy considerations. We selected the size of the treatment group based on an assumption that the budget for such a program would be unlikely to exceed $20 billion in gross spending over twenty-five years, or about $0.8 billion per year, on average, in 2007 dollars. This parameter also provides policymakers with the ability to control spending over time. For most of the age cohorts in the model, this translated into 60,000 randomly selected participants entering the program in each of the twenty-five years modeled.

Exhibit 4 illustrates a number of findings. First, the younger the subpopulation in the program, the greater the clinical benefits from treatment improvement. This

EXHIBIT 4
Diabetes Quality Improvement Intervention: Participation And Spending (Billions Of 2007 Dollars), By Nonelderly Cohort

Entry age cohort (years)	Number of patients entering treatment program each year	Baseline spending (no improvement intervention), billions	Improvement intervention spending, billions	New spending plus cost of intervention, billions	Net new spending, billions
25-year effects (2009–2033)					
24–30	60,000	$167	$21	$161	–$6
31–40	60,000	145	20	145	0
41–50	60,000	132	19	136	2
51–60	80,000	153	21	159	6
61–64	100,000	160	21	165	5
10-year effects (2009–2018)					
24–30	60,000	21.0	3.7	22.1	1.2
31–40	60,000	20.2	3.7	22.0	1.9
41–50	60,000	20.7	3.6	22.1	1.5
51–60	80,000	28.0	4.5	29.4	1.4
61–64	100,000	34.9	5.1	36.5	1.6

SOURCE: Derived from the authors' own analyses and computations.

translates into larger offsets against program costs. Second, for most age groups, the treatment improvement program will not save money but will generate a cost offset. The offset is generated by long-term reductions in the major complications of diabetes including blindness, kidney failure, lower-extremity amputations, stroke, and coronary heart disease. Third, a program that includes a range of cohorts could use the savings from the younger cohorts to partially subsidize the costs of older cohorts. The relationship between age and effectiveness of the program is consistent with prior studies of the long-term projected clinical effectiveness of diabetes treatments.[14] These results provide policymakers with a range of options in designing an actual program. By adjusting the combination of eligibility age and total program size, policymakers can adjust the program to meet budget constraints or other policy considerations.

The Impact Of The Budget Window

The results on the top half of Exhibit 4 are based on a twenty-five-year budget window, which enlarges program costs but also captures long-term cost offsets from complications avoided or delayed. The bottom half of Exhibit 4 displays results for the same improvement program using a traditional ten-year budget window. In the latter, there is no subgroup of patients with any cost savings from the intervention program. The cost offsets in the ten-year window are proportionally smaller than those in the twenty-five-year window. For example, in the ten-year window, the cost offset for enrollees ages 41–50 was $2.1 billion: $3.6 billion in gross spending minus $1.5 billion in net spending. This means that 58 percent of

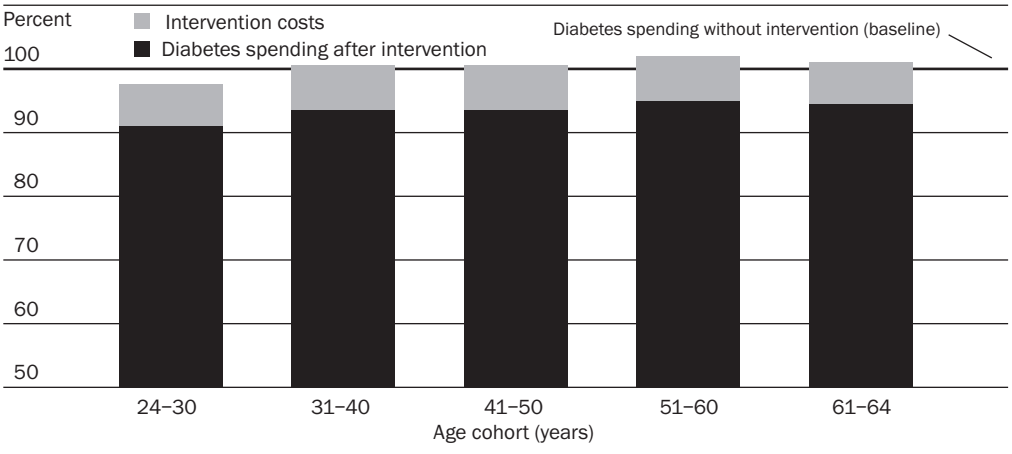
program costs were offset by reduced spending on diabetes and its complications. In the twenty-five-year window, the cost offset for the same age group was $17 billion, which represented an offset of 89 percent of program costs.

In Exhibit 5, baseline costs are compared to the combined costs of the intervention program and the reduced spending on diabetes care and complications. In general, the earlier the intervention the greater the offset, although the life expectancy of the different cohorts interacts with the onset of complications, causing slightly high costs among the cohort ages 51–60. Unless the program was limited to the youngest cohort, this intervention does not save money. However, it is clear from these simulations that a sizable proportion of intervention costs can be offset by reduced spending on diabetes care and complications—enough to make the intervention less costly than traditional budget modeling would indicate.

The Model's Output In Context

The cost projections produced by this epidemiologically based simulation model need to be understood in the context of the complexity of the health care system and in light of the model's limitations. The model projects the health care costs of alternative policies for addressing the management of diabetic cases. We assume that the additional costs of stepped-up treatment of diabetes would be financed with additional federal resources. In addition, the longer-term cost savings from reduced care of costly complications would also largely be reflected in less federal Medicare and Medicaid spending. However, some of the savings would also flow to other payers—namely, the states (in the case of Medicaid) and private payers such as employer-sponsored insurance plans for those whose

EXHIBIT 5
Twenty-Five-Year Spending On A Diabetes Quality Improvement Intervention Among Nonelderly Cohorts, As Percentage Of Spending Without Intervention



SOURCE: Derived from the authors' own analyses and computations.

health status improves before they become eligible for Medicare.

Further, the model looks at the direct costs of type 2 diabetes care—not the full use of health care services by diabetics. Reducing the costs associated with diabetes complications may increase the use of other health care services, particularly if diabetics live longer and develop other conditions.

Finally, the model does not include other potential federal cost consequences of an intensive diabetes management effort. For instance, if diabetes complications are reduced, there may be fewer applications for Social Security disability payments. On the other hand, a healthier diabetic population is projected to live longer, on average, which would mean added long-term costs for Social Security.

The model we present here, therefore, does not yet provide a complete assessment of the federal budgetary implications of the kind of diabetes intervention we have modeled. To do so would require taking each of the factors mentioned here more fully into account. It is possible, therefore, that the offsetting reductions from improved health status may be less when viewed exclusively from the perspective of the federal budget.

Budget Process Implications

Despite these limitations, this policy simulation illustrates the potential for epidemiologically based simulation models to inform the federal budget estimating process. Important progress has been made in our understanding of the natural history of chronic diseases such as diabetes, and clinical trials have produced vital insights into the effects and harms of common treatments. In type 2 diabetes, data from recent clinical studies have been integrated into simulation models of diabetes complications and costs. These models have been well studied and could be leveraged by cost estimators to consider as possible inputs into health care forecasting models. There are, in fact, already multiple federally sponsored efforts to advance modeling in cancer, HIV/AIDS, obesity, and neurological diseases, which could serve as the basis for future work in individual chronic conditions as well as in an integrated budget forecast. All of these models are constructed with publicly available data from clinical epidemiology and clinical trials.

If such data from clinical medicine are to be used, it is important to recognize that in some circumstances, using a ten-year cost projection is not long enough to fully capture the effects of many medical interventions. This is particularly true for diabetes, for which there are long delays in the development of the complications of the disease and for which interventions may bring about changes in observable intermediate measures only in the short term. These long time horizons for the natural history of the disease suggest that long-term thinking in terms of health care policy would produce better results.

Apart from consideration of the natural history of disease, it may be important to reconsider the traditional budgetary time frame simply because of the potential threat of long-term health care cost problems for the economy. As the CBO direc-

tor and the comptroller general of the United States have stated, the most important threat to the nation's economic strength over the long run is the coming escalation in governmental health care spending in Medicare and Medicaid.[20] Congress should be examining all kinds of policy options aimed at reducing the cost pressures in 2020 and 2030.

We recommend that under certain circumstances, the House and Senate Budget Committee chairs and ranking members be given the authority to request from the CBO twenty-five-year cost estimates for health care legislative provisions that are aimed at producing longer-term health status improvements. Although this would not be necessary for the vast majority of cost estimates produced by the CBO, it would improve the information available when Congress considers health legislation with implications for the treatment of a relatively small number of costly chronic illnesses.

To allow these longer-term estimates to be optimally useful in the legislative and budgetary process, Congress could also consider other modifications of the process, particularly to the pay-as-you-go rules. Under current practice, congressional legislation that changes entitlement programs or taxes is supposed to be, at a minimum, neutral to the federal budget deficit. Any net increase in entitlement spending over ten years, as estimated by the CBO, is expected to be offset by a tax increase, and any net tax reduction, by an entitlement spending decrease. Normally, if any legislation brought to the floor of either chamber that violates the "paygo" rule, any member has the right to raise an objection. That action has the potential to derail the legislation. However, "paygo" can be, and often has been, waived to allow consideration of legislation Congress deems to be too important to be held up by cost estimates showing a ten-year deficit increase. Even though it can be waived, "paygo" can serve to dissuade consideration of bills with costs because members know that the legislation could face a higher vote hurdle.

If the CBO found that a health care provision would actually produce health benefits beyond a ten-year window and potentially reduce costs below what they otherwise would be, the chair and ranking member of either chamber's Budget Committee could be given the authority to use that information to modify the "paygo" test. Several approaches might be considered for doing this, such as using an average cost for twenty-five years as the yearly costs incorporated into the "paygo" ten-year test. This alternative budget process should be available only if both the Democratic and Republican leaders of the Budget Committee agree to it.

One of the challenges associated with capturing savings from improved treatment or prevention efforts flows from Medicare's current design. The program generally pays at least a portion of the bill for whatever health services enrollees use, with no questions asked. Consequently, past efforts to reduce spending in a part of the program (for example, inpatient hospital care) by increasing the use of less expensive services in another part of the program (for example, home health) have not been successful because there has been no easy way to ensure that re-

duced pressure for hospitalization could be realized and captured by the program.

This dilemma may well be raised again in the context of treatment improvement efforts for chronic diseases. Some budgetary experts might observe that in Medicare's current design, it would be difficult to ensure that improved health outcomes would translate into reduced use of services, given the tendency for communities to make full use of potential supply.

One way to address this dilemma would be to give participants and providers a stronger financial incentive to capture potential savings from treatment improvement. Currently, there is great interest in examining ways to create financial incentives for physicians to take responsibility for overseeing care for those with expensive chronic illnesses.

The burden of common and chronic diseases such as diabetes will grow in the coming decades and have major impacts on both the lives of Americans and the financial viability of federal health care programs, especially Medicare. Policymakers must have the most reliable and relevant information available as they wrestle with these difficult issues. This study was undertaken to develop a new approach for estimating the incidence of type 2 diabetes and related health care costs in the future and to use it to stimulate a discussion on ways to improve the information base and process for policy making.

We realize that epidemiological modeling for federal cost projections is a new area, and its rigor needs to be tested and better understood before it is fully adopted. And we acknowledge that this type of modeling does not answer all questions. Models such as the one described in this paper will need to be constantly updated as new clinical insights emerge. Still, we believe that models that integrate clinical epidemiology and trial data would improve understanding among policymakers of the dynamics of disease progress and realistic expectations regarding the health and cost benefits of alternative scenarios.

Funding for this study was received from the National Changing Diabetes Program (NCDP) at Novo Nordisk Inc. The authors acknowledge the contributions of Dana Haza and Erin Byrne of the NCDP; internal reviewers, David Meltzer, University of Chicago, and Judith Wagner, CBO and IOM (retired); our NCDP reviewers, Gail Wilensky, Project HOPE; and John Bertko and Dana Goldman, RAND; and the anonymous Health Affairs *reviewers.*

NOTES

1. DeVol R, Bedroussian A. An unhealthy America: the economic burden of chronic disease. Santa Monica (CA): Milken Institute; 2007.
2. Antos JR, Spoor C. Issues in designing a prescription drug benefit for Medicare. Washington (DC): Congressional Budget Office; 2002.
3. Crippen D, Congressional Budget Office. Testimony on disease management in Medicare: data analysis and benefit design. Washington (DC): CBO; 2002.
4. Congressional Budget Office. The long-term budget outlook. Washington (DC): CBO; 2007.
5. 2 U.S. Code, secs. 602 and 658.
6. U.S. House of Representatives. Concurrent resolution on the budget for fiscal year 2009. Section 311 (a).

Washington (DC): U.S. Government Printing Office; 2008. House Report 110-659.

7. Lipton RB. Incidence of diabetes in children and youth—tracking a moving target. JAMA. 2007 Jun 27;297(24):2760–2.
8. Harris MI, Klein R, Welborn TA, Knuiman MW. Onset of NIDDM occurs at least 4–7 years before clinical diagnosis. Diabetes Care. 1992;15(7):815–9.
9. Holman RR, Paul SK, Bethel MA, Matthews DR, Neil HA. Ten-year follow-up of intensive glucose control in type 2 diabetes. N Engl J Med. 2008 Oct 9;359(15):1577–89.
10. The effect of intensive treatment of diabetes on the development and progression of long-term complications in insulin-dependent diabetes mellitus. N Engl J Med. 1993 Sep 30;329(14):977–86.
11. Intensive blood-glucose control with sulphonylureas or insulin compared with conventional treatment and risk of complications in patients with type 2 diabetes (UKPDS 33). Lancet. 1998 Sep 12;352(9131):837–53.
12. Lifetime benefits and costs of intensive therapy as practiced in the diabetes control and complications trial. JAMA. 1996 Nov 6;276(17):1409–15.
13. Eastman RC, Javitt JC, Herman WH, Dasbach EJ, Zbrozek AS, Dong F, et al. Model of complications of NIDDM. I. Model construction and assumptions. Diabetes Care. 1997 May;20(5):725–34.
14. 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 May 15;287(19):2542–51.
15. Clarke PM, Gray AM, Briggs A, Farmer AJ, Fenn P, Stevens RJ, et al. A model to estimate the lifetime health outcomes of patients with type 2 diabetes: the United Kingdom Prospective Diabetes Study (UKPDS) Outcomes Model (UKPDS no. 68). Diabetologia. 2004 Oct;47(10):1747–59.
16. Mount Hood 4 Modeling Group. Computer modeling of diabetes and its complications: a report on the Fourth Mount Hood Challenge Meeting. Diabetes Care. 2007 Jun;30(6):1638–46.
17. Palmer AJ, Roze S, Valentine WJ, Minshall ME, Foos V, Lurati FM, et al. The CORE diabetes model: projecting long-term clinical outcomes, costs, and cost-effectiveness of interventions in diabetes mellitus (types 1 and 2) to support clinical and reimbursement decision-making. Curr Med Res Opin. 2004 Aug;20 Suppl 1:S5–26.
18. Eddy DM, Schlessinger L. Validation of the Archimedes diabetes model. Diabetes Care. 2003 Nov;26(11):3102–10.
19. Huang ES, Basu A, O'Grady M, Capretta JC. Projecting the future diabetes population size and related costs for the United States. Diabetes Care. Forthcoming 2009.
20. Orszag P. Congressional Budget Office. Growth in health care costs. Testimony before the Committee on the Budget, 110th Congress, 2d sess. (Jan 31, 2008).
21. Homer J, Milstein B, Dietz W, Buchner DM, Majestic E. Obesity population dynamics: exploring historical growth and plausible futures in the U.S. Presented at: 24th International Conference of the System Dynamics Society; July 2006. Nijmegen, Netherlands.
22. Chodosh J, Morton SC, Mojica W, Maglione M, Suttorp MJ, Hilton L, et al. Meta-analysis: chronic disease self-management programs for older adults. Ann Intern Med. 2005 Sep 20;143:427–38.
23. Huang ES, Brown SE, Zhang JX, Kirchhoff AC, Schaefer CT, Casalino LP, et al. The cost consequences of improving diabetes care: the community health center experience. Jt Comm J Qual Patient Saf. 2008 Mar;34(3):138–46.
24. Sidorov J, Shull R, Tomcavage J, Girolami S, Lawton N, Harris R. Does diabetes disease management save money and improve outcomes? A report of simultaneous short-term savings and quality improvement associated with a health maintenance organization–sponsored disease management program among patients fulfilling Health Employer Data and Information Set criteria. Diabetes Care. 2002 Apr;25(4):684–9.
25. Crivera C, Suh DC, Huang ES, Cagliero E, Grant RW, Vo L, et al. The incremental costs of recommended therapy versus real world therapy in type 2 diabetes patients. Curr Med Res Opin. 2006 Nov;22(11):2301–11.
26. Huang ES, Zhang Q, Brown SE, Drum ML, Meltzer DO, Chin MH. The cost-effectiveness of improving diabetes care in U.S. federally qualified community health centers. Health Serv Res. 2007 Dec;42(6 Pt 1):2174–93.