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RESEARCH ARTICLE

Cost Implications to Health Care Payers of Improving Glucose Management among Adults with Type 2 Diabetes

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Objective. To assess the cost implications to payers of improving glucose management among adults with type 2 diabetes.
Data Source/Study Setting. Medical-record data from the Community Quality Index (CQI) study (1996–2002), pharmaceutical claims from four Massachusetts health plans (2004–2006), Medicare Fee Schedule (2009), published literature.
Study Design. Probability tree depicting glucose management over 1 year.
Data Collection/Extraction Methods. We determined how frequently CQI study subjects received recommended care processes and attained Health Care Effectiveness Data and Information Set (HEDIS) treatment goals, estimated utilization of visits and medications associated with recommended care, assigned costs based on utilization, and then modeled how hospitalization rates, costs, and goal attainment would change if all recommended care was provided.
Principal Findings. Relative to current care, improved glucose management would cost U.S.$327 (U.S.$192–711 in sensitivity analyses) more per person with diabetes annually, largely due to antihyperglycemic medications. Cost-effectiveness to payers, defined as incremental annual cost per patient newly attaining any one of three HEDIS goals, would be U.S.$1,128; including glycemic crises reduces this to U.S.$555–1,021.
Conclusions. The cost of improving glucose management appears modest relative to diabetes-related health care expenditures. The incremental cost per patient newly attaining HEDIS goals enables payers to consider costs as well as outcomes that are linked to future profitability.

Key Words. Quality of health care, cost and cost analysis, cost–benefit analysis, diabetes mellitus

Managing blood glucose well is fundamental to caring for people with type 2 diabetes mellitus. According to recent data from the United Kingdom Prospective Diabetes Study (UKPDS), people randomized to tighter control (mean hemoglobin A1c [HbA1c] 7.0 percent) for 10 years have a 15–33 percent lower

risk of myocardial infarction and a 13–27 percent lower risk of death long term than those receiving conventional care (HbA1c 7.9 percent) (UKPDS Group 1998; Holman et al. 2008). Yet in the 2003 Community Quality Index (CQI) study, the most comprehensive assessment of quality of care to date, U.S. adults received only 45 percent of the essential care processes recommended for diabetes. HbA1c testing, follow-up visits, and medication adjustments were substantially underused (McGlynn et al. 2003). Given 17.5 million people in the United States have been diagnosed with diabetes, rectifying this shortfall in quality may have substantial effects on health and health care expenditures nationally (American Diabetes Association [ADA] 2008a).

Although people with diabetes benefit from improved care, public and private health care payers are likely to be interested in quantifying the associated expenditures. Payers play major roles in ameliorating deficits in quality of care and can align financial incentives with improvement. For example, the National Committee on Quality Assurance's Health Care Effectiveness Data and Information Set (HEDIS) enables health plans to monitor and report the quality of the care their enrollees receive. Ninety percent of health plans participate in the HEDIS program and employers consider HEDIS scores in health care purchasing decisions (National Committee for Quality Assurance 2008).

Despite the role that payers play in improving care, costs and benefits of interest to payers have received limited attention. For type 2 diabetes, the cost-effectiveness of tight glucose control over the long term has been well established from the societal perspective (The Diabetes Control and Complications Trial Research Group 1996; Gray et al. 2000; Clarke et al. 2001, 2005; CDC Diabetes Cost-effectiveness Group 2002; Gray and Clarke 2008; Kahn et al. 2008). Several studies have estimated the financial effects of reducing HbA1c and diabetes-related complications over one or more decades (Wagner et al. 2001; Caro, Ward, and O'Brien 2002; Minshall et al. 2005; Huang et al. 2007; Kahn et al. 2008; Eggleston et al. 2009). However, private payers are more

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likely to be concerned about short-term costs and benefits, such as the cost of enabling additional patients to achieve HEDIS goals, because enrollee turnover is substantial (Cunningham 2000). Reducing the average HbA1c to 7 percent nationwide would eliminate U.S.$65.4 billion (inflated to 2009) in medical expenditures for diabetes-related complications over 20 years—but only 20 percent of the savings would occur within 5 years (Minshall et al. 2005). Longer-term savings may be relevant to payers with low turnover rates, such as public payers, but much of the U.S. population has private insurance.

Consequently, this analysis sought to estimate the incremental per-patient cost and cost-effectiveness *to payers* of consistently providing the basic elements of glucose management to U.S. adults with established type 2 diabetes mellitus. We focused on process-of-care criteria because they identify specific care processes that are associated with improved outcomes, quality improvement efforts can improve adherence to the criteria, and the costs of adherence are readily quantifiable (Brook, McGlynn, and Cleary 1996). Taking the payer perspective influenced our time horizon (1 year) and measure of cost-effectiveness (cost per patient newly attaining HbA1c goals). We based our analysis on the CQI study because it represents the only nationally representative data on the quality of care processes for diabetes to date. Using that data, we identified care processes that are recommended for individual patients, assessed how frequently those processes were provided, and determined how often patients attained treatment goals. We then modeled how direct costs to payers and goal attainment would change if all recommended care processes were provided.

METHODS

To achieve our study objective, we compared the costs and proportions of diabetic individuals attaining treatment goals between a "status quo" scenario (glucose management in the CQI study) and an "improved care" scenario (100 percent provision of recommended care processes). The analysis involved the following steps: (1) selecting quality-of-care criteria; (2) developing a probability model; (3) applying the model to the CQI study population (status quo scenario); (4) estimating the effects of complete adherence to the process-of-care criteria on HbA1c outcomes (improved care scenario); (5) estimating utilization and costs under both scenarios; (6) calculating costs and cost-effectiveness ratios; and (7) performing sensitivity analyses. Costs are represented in 2009 U.S. dollars. Appendix SA2 contains additional detail.

Quality-of-Care Criteria

Recommended care processes, timeframes, and treatment goals were drawn from 2010 ADA standards (ADA 2010), 2010 HEDIS measures, and other sources (Table 1). We used multiple HbA1c goals because this is consistent with the HEDIS measures and reflects the fact that intensive blood glucose control may not be optimal for certain patients.

Probability Model

The probability model depicted major considerations involved in managing blood glucose among patients with existing type 2 diabetes over a 1-year "modeling period," including the recommended care processes and HbA1c outcomes from Table 1. Sequential branch points in the probability model included the following: (1) taking antihyperglycemic medications before the

Table 1: Quality of Care Criteria Used in Model

Name	*Criterion*	*References*
Process-of-care		
HbA1c testing	Patients with diabetes should have HbA1c assessed every 6 months	McGlynn et al. (2003); Martirosyan et al. (2008); American Diabetes Association (2010)
Medication initiation*	Patients with diabetes who are not taking antihyperglycemic medications should be started on them within 3 months of having an HbA1c value $\geq$ 8%	McGlynn et al. (2003); Kerr et al. (2004); Aron and Pogach (2008); Martirosyan et al. (2008); American Diabetes Association (2010)
Medication adjustment*	Patients with diabetes who are taking antihyperglycemic medications should have a medication adjustment within 3 months of having an HbA1c value $\geq$ 8%	McGlynn et al. (2003); Kerr et al. (2004); Aron and Pogach (2008); Martirosyan et al. (2008); American Diabetes Association (2010)
Outcome		
Better than poor control	HbA1c $\leq$ 9%	National Committee for Quality Assurance (2008)
Adequate control	HbA1c $<$8%	National Committee for Quality Assurance (2008); American Diabetes Association (2010)
Intensive control	HbA1c $<$7%	National Committee for Quality Assurance (2008); American Diabetes Association (2010)

*We examined the effect of using 5 months instead of 3 months and found a small difference in adherence rates, which was within the ranges we used in sensitivity analyses.

modeling period (yes or no), (2) receipt of an initial HbA1c test within the recommended interval ($\leq$ 180 days, $>$180 days, no tests), (3) first HbA1c test result $\geq$ 8 percent (yes or no), (4) if that result was $\geq$ 8 percent, medication initiation or adjustment within the recommended interval (yes or no), (5) receipt of a follow-up HbA1c test within the recommended interval ($\leq$ 180 days, $>$180 days, no tests), and (6) HbA1c outcome at the end of the modeling period (3 iterations: $<$7 percent versus $\geq$ 7 percent, $<$8 percent versus $\geq$ 8 percent, and $\leq$ 9 percent versus $>$9 percent). A cycle of recommended HbA1c testing, medication changes, and repeat testing takes up to 1 year.

Status Quo Scenario

Clinical parameters for this scenario (Table 2) were based on data from the CQI study. Random-digit-dial telephone surveys identified 6,712 adults from 12 metropolitan areas (round 1) and a national sample of 7,598 adults (round 2). In both rounds, trained nurses collected data from medical records in up to two 2-year waves per patient from 1996 to 2002 (McGlynn et al. 2003). Data from outpatient physician visits included laboratory tests, medication changes, and lifestyle counseling. For the current study, subjects included 821 adults with type 2 diabetes at the start of one of the 2-year waves. We obtained the first available 2-year wave of data for each subject and selected the first year of the wave as the "modeling period." The RAND Human Subjects Protection Committee exempted this study.

For each individual subject, we based the receipt of HbA1c tests within 180 days on his/her average HbA1c testing frequency over the 2-year wave period, rather than on whether he/she actually received an HbA1c test within the first 180 days of the modeling period, for the following reason. When applying early versions of the probability model to the CQI data, we observed substantial inter- and intra-patient variability in HbA1c testing frequency. Failing to account for such variability would exaggerate costs for the status quo scenario because many patients whose testing interval is usually longer than 180 days would by chance have a test during the first 180 days of the modeling period.

We based HbA1c outcomes on the test results closest to the end of the modeling period; that is, the last test in the first year or first test in the second year of the 2-year wave period. For patients without a second test during the wave period, we used the result of their first test to impute their HbA1c outcome. For patients without any tests, we imputed HbA1c outcomes based on the first tests from the population tested at $<$180-day intervals.

Table 2: Model Parameters, Base Case Values, and Ranges Used in Sensitivity Analyses (SA)

Model Parameters	*Base Case*	*Range for SA**	*References*
Clinical parameters, status quo scenario			
Patients on antihyperglycemic medications at start of modeling period	32%	32–82%	Rodondi et al. (2006); Hoerger et al. (2008)
Adherence to HbA1c testing criterion: predicted mean time between HbA1c tests over 2 years[†]			Kerr et al. (2004); Hoerger et al. (2008)
≤ 180 days	15–20%	15–60%	
>180 days	55–56%	45–56%	
No HbA1c tests	24–30%	14–30%	
Patients with time between HbA1c tests ≤ 180 days			
First HbA1c ≥ 8%[†]	22–25%		Saaddine et al. (2002); Rodondi et al. (2006); Saaddine et al. (2006); Hoerger et al. (2008)
Adherence to medication initiation & adjustment criteria			Rodondi et al. (2006); Schmittdiel et al. (2008)
Medications initiated when first HbA1c ≥ 8%	79%	79–99%	
Medications adjusted when first HbA1c ≥ 8%	58%	58–78%	
Patients with time between HbA1c tests >180 days			
First HbA1c ≥ 8%[†]	37–50%		Saaddine et al. (2002); Rodondi et al. (2006); Saaddine et al. (2006); Hoerger et al. (2008)
Adherence to medication initiation & adjustment criteria			Berlowitz et al. (2005); Rodondi et al. (2006); Schmittdiel et al. (2008)
Medications initiated when first HbA1c ≥ 8%	24%	24–44%	
Medications Adjusted When First HbA1c ≥ 8%	29%	29–49%	
HbA1c outcomes at end of modeling period			
Mean HbA1c including imputed values	7.8%		
Mean HbA1c for patients with tests	6.8%		

continued

Table 2. *Continued*

Model Parameters	*Base Case*	*Range for SA**	*References*
Distribution of HbA1c for patients with tests			
HbA1c ≥ 8%	38%		Hoerger et al. (2008)
HbA1c 7% to <8%	24%		
HbA1c <7%	38%		
Distribution of imputed values			Rossi et al. (2008)
HbA1c ≥ 8%	37–50%	17–50%	
HbA1c 7% to <8%	13–21%	13–31%	
HbA1c <7%	37–42%	37–52%	
Supplemental analysis: severe hyper- & hypoglycemia‡			
Severe hypoglycemic events, annual rate	0.02–0.78%		Bolen et al. (2007); Bodmer et al. (2008); Kelly et al. (2009)
Severe hyperglycemic events, annual rate	0.36–1.34%		Wang et al. (2009)
Clinical parameters, improved care scenario			
Adherence to HbA1c testing criterion: time between tests ≤ 180 Days	100%		
Adherence to medication initiation & adjustment criteria	100%		
Assumed decline in HbA1c due to improved care			UK Prospective Diabetes Study (UKPDS) Group (1998); Shojania et al. (2006)
Status quo HbA1c ≥ 10%	−1%	−2.5–0.5%	
Status quo HbA1c ≥ 8% to <10%	−1%	−1–0.5%	
Status quo HbA1c 7% to <8%	−0.5%	−0.5–0%	
HbA1c outcomes at end of modeling period			
Mean HbA1c including imputed values	7.5%	7.2–7.7%	
Mean HbA1c for patients with tests	6.4%	6.2–6.5%	
Supplemental analysis: severe hyper- & hypoglycemia			
Severe hypoglycemic events, annual rate	0.04–2.34%		Duckworth et al. (2008); Kelly et al. (2009)
Severe hyperglycemic events, annual rate	0.52–0.62%		Wang et al. (2009)
Costs of glucose management, both scenarios (2009 U.S. dollars)			

Associated with each HbA1c test			
1 level 2 physician visit (CPT 99212)	U.S.$37.15		Medicare Physician Fee Schedule Look-Up [database online] (2009)
1 HbA1c laboratory test (CPT 83036)	U.S.$14.17		Medicare Clinical Laboratory Fee Schedule [database online] (2009)
Associated with medication initiation and adjustment			
1 level 4 physician visit (CPT 99214)	U.S.$92.33		Medicare Physician Fee Schedule Look-Up [database online] (2009)
Daily medication costs	U.S.$3.56	U.S.$1.42–U.S.$9.13	Alexander et al. (2008); Kahn et al. (2008)
Supplemental analysis: severe hyper- & hypoglycemia			
Associated with each severe hypoglycemic event, level 5 physician visit (CPT 99215 or 99285)	U.S.$124.79–170.23		Medicare Physician Fee Schedule Look-Up [database online] (2009)
Associated with each severe hyperglycemic event, hospitalization	U.S.$14,501–U.S.$21,775		Kim (2007); U.S. Department of Labor: Bureau of Labor Statistics (2007)

*Sensitivity analysis ranges were tailored to the base case value for each specific branch of the probability model and varied in a comparable fashion across the branches.

†In the probability model, patients were initially stratified by whether they were on antihyperglycemic medications or not at study entry; the range of base case values refers to these two groups.

‡See Appendix SA2 for details.

Improved Care Scenario

We used the same probability model to represent the improved care scenario but made two additional assumptions. First, we assumed that adherence to the process-of-care criteria increased to 100 percent. Second, we assumed that individual subjects' HbA1c outcomes at the end of the modeling period improved as described in Table 2. Under these assumptions, the mean HbA1c for the study population declined by 0.4 percent with improved care (0.3–0.6 percent in sensitivity analyses). Quality improvement strategies typically reduce mean HbA1c by 0.4 percent, varying from 0.2 percent to 0.8 percent across strategies, and the UKPDS reduced it by 0.9 percent (Huang et al. 2007).

Utilization and Costs of Glucose Management

Physician Visits. We assumed that each HbA1c test and each medication initiation/adjustment involved one physician visit. Although in practice physicians handle some tests and medication changes by telephone or during visits for other conditions, we counted these as diabetes visits because compensation would be an incentive for providing the care. We assigned current procedural terminology (CPT) codes to visits based on the complexity of the care, and costs to CPT codes using the Medicare Physician Fee Schedule [database online] (2009).

Laboratory Tests. In the status quo scenario, we assumed that each subject's number of HbA1c tests equaled 365 divided by his/her average HbA1c testing frequency. In the improved care scenario, we assumed that all subjects had at least two tests. Cost per test was from the Medicare Clinical Laboratory Fee Schedule [database online] (2009).

Medications. The CQI data contained information on medication initiation and adjustment but not on utilization (such as filling prescriptions) or expenditures. We sought to base medication costs on actual population-based expenditures, rather than average wholesale prices or drug prices from retail pharmacies, because the latter two data sources ignore negotiated price discounts and patient nonadherence. We needed a dataset that included diagnosis codes so that we could identify people with diabetes, and drug names so that we could identify antihyperglycemic medications. Consequently, we obtained pharmacy claims data for 40,000 nonelderly adults with diabetes who were continuously enrolled in four health plans in

Massachusetts from 2004 to 2006. We then calculated the average cost to payers of antihyperglycemic medications and associated supplies per patient per day. The resulting estimates are similar to those from studies contemporaneous to the CQI study (Brown et al. 1999; Minshall et al. 2005). Sensitivity analyses considered a range based on expenditures and prices in prior studies.

In the status quo scenario, we assumed that people taking medications before the modeling period had 365 days of medication utilization, and people initiated on medications during the modeling period had 182 days. In the improved care scenario, we assumed 365 days for all patients treated with medications.

Hyper- and Hypoglycemic Events. Severe hyper- and hypoglycemia sometimes result in urgent physician visits, emergency department visits, and hospitalization. Because the CQI data did not include hospitalization data, we considered hyper- and hypoglycemic events in a supplemental analysis based on published literature (see Appendix).

Calculating Costs and Incremental Cost-Effectiveness Ratios (ICERs)

We determined the proportions of subjects attaining HbA1c goals for both the status quo and improved care scenarios. We then used the probability model to calculate costs for each scenario (sum of costs weighted by the probabilities of occurrence). Finally, for each HbA1c goal, we calculated ICERs, defined as incremental costs per individual newly attaining that goal ($[\text{cost}_{\text{improved care}} - \text{cost}_{\text{status quo}}]/[\text{proportion at goal}_{\text{improved care}} - \text{proportion at goal}_{\text{status quo}}]$). Analyses were performed in the *R* programming language.

Sensitivity Analyses

We used available literature to determine plausible ranges for model parameters and then performed a Monte Carlo sensitivity analysis. For each variable, we randomly sampled from within the range and assumed a uniform distribution of probabilities.

RESULTS

Summary of Adherence to Process-of-Care Criteria in Status Quo Scenario

Among diabetic patients in the CQI study, 17 percent had an average HbA1c testing frequency of $\leq$ 180 days, 55 percent received tests less frequently, and

28 percent received no tests. Among patients who received tests on time, 23 percent had an initial HbA1c result $\geq$ 8 percent and, of these individuals, 69 percent underwent medication initiation or adjustment when recommended. Among those who received HbA1c tests less frequently, 41 percent had initial HbA1c results $\geq$ 8 percent and, of these individuals, 26 percent had medications initiated or adjusted when recommended.

Per-Patient Costs, Proportion Achieving Goals, and ICERs

Table 3 shows the per-patient annual costs and percentages of patients achieving goals under both scenarios. Under the status quo scenario, the total cost of recommended care per patient annually was U.S.$503.38, which included U.S.$432.30 for medications, U.S.$58.21 for physician visits, and U.S.$12.87 for laboratory tests; hyper- and hypoglycemic events cost an additional U.S.$124.82–268.79. For the improved care scenario, the total cost of

Table 3: Cost-Effectiveness of Providing All Basic Recommended Care Processes Pertaining to Blood Glucose Management

Treatment Goal	*Annual Per-Patient Costs**	*Percentage of All Patients Achieving Goal*	*Incremental Cost Per Patient Newly Achieving Goal*
Goal defined as HbA1c <7%			
Status quo scenario	U.S.$503.38	37%	—
Improved care scenario	U.S.$830.39	51%	—
Difference between scenarios	U.S.$327.01	14%	U.S.$2,336
Goal defined as HbA1c <8%			
Status quo scenario	U.S.$503.38	62%	—
Improved care scenario	U.S.$830.39	72%	—
Difference between scenarios	U.S.$327.01	10%	U.S.$3,270
Goal defined as HbA1c $\leq$ 9%			
Status quo scenario	U.S.$503.38	79%	—
Improved care scenario	U.S.$830.39	85%	—
Difference between scenarios	U.S.$327.01	6%	U.S.$5,450
Goal defined as moving from above to below any of the thresholds			
Difference between scenarios	U.S.$327.01	29%	U.S.$1,128

*The improved care scenario involved providing 100% of basic recommended care processes. Because these care processes do not depend on the HbA1c goal selected, costs are the same across all three goals.

recommended care was U.S.$830.39, which included U.S.$682.91 for medications, U.S.$116.96 for physician visits, and U.S.$30.52 for laboratory tests; hyper- and hypoglycemic events cost an additional U.S.$94.01–102.80. The incremental cost (i.e., difference between the scenarios) was U.S.$327.01, varied from U.S.$191.50 to U.S.$710.80 in sensitivity analyses primarily due to medication costs, and declined to U.S.$161.02–296.10 (by U.S.$30.82–166.00) when hyper- and hypoglycemic events were included.

Per patient newly attaining HEDIS goals, the incremental cost was: HbA1c <7 percent, U.S.$2,336; HbA1c <8 percent, U.S.$3,270; HbA1c ≤ 9 percent, U.S.$5,450; any one of the three goals, U.S.$1,128 (Table 3). Because the basic recommended care processes do not vary across the three goals, costs remain the same. As the HbA1c goals rise, the ICERs increase because the proportions of patients newly attaining goals decline.

Table 4 shows results of sensitivity analyses. Including hyper- and hypoglycemic events and assumptions about medication costs had the largest effects on results. The incremental cost of newly attaining any one of the HEDIS goals fell from U.S.$1,128 to U.S.$555–1,021 when hyper- and hypoglycemic events are included.

DISCUSSION

Our analysis adds to the existing literature addressing the cost of improving quality of care for diabetes in two important ways. First, our work explicitly focuses on the cost implications of improved quality of care from the health care payer perspective. Second, the analysis uses a nationally representative sample to estimate the direct health care expenditures associated with improving glucose management, for which recent data have been limited.

Among adults with type 2 diabetes from the CQI study, we observed substantial underuse of HbA1c testing and medication adjustment. Ensuring that 100 percent of these essential care processes are provided would increase annual health care expenditures by U.S.$327 per person with diabetes, largely due to greater use of antihyperglycemic medications. HEDIS scores would improve for 29 percent of patients with diabetes, and payers would spend U.S.$1,128 on additional health care services per person with an improved score (U.S.$555–1,021 if hospitalizations for glycemic crises decline).

In addition to greater utilization of health care services, quality improvement programs and incentive payments to providers can also affect the costs and clinical outcomes associated with improving glucose management.

Table 4: Results of Sensitivity Analyses for Goal HbA1c <8%

	Status Quo Parameters		*Improved Care Parameters*		
	Annual Per-Patient Costs	*Percentage of All Patients Achieving Goal*	*Annual Per-Patient Costs*	*Percentage of All Patients Achieving HbA1c < 8%*	*Incremental Cost Per Patient Newly Achieving HbA1c < 8%*
Clinical parameters					
Adherence to HbA1c testing criterion	U.S.$503.38–U.S.$595.82	62%–63%	—	—	U.S.$2,606–U.S.$3,270
Adherence to medication initiation/adjustment criteria	U.S.$503.38–U.S.$534.21	62%–63%	—	—	U.S.$3,270–U.S.$3,291
Imputed outcomes for patients without HbA1c tests	U.S.$503.38	62%–67%	—	—	U.S.$3,270–U.S.$6,540
Assumed decline in HbA1c due to improved care	—	—	—	68–77%	U.S.$2,180–U.S.$5,450
Cost parameters					
Daily medication costs	U.S.$235.06–U.S.$1205.5	62%	U.S.$438.30–U.S.$1916.3	72%	U.S.$2,032–U.S.$7,108
All parameters, range of differences between scenarios*	—	—	U.S.$191.50–U.S.$710.80	6–15%	U.S.$1,277–U.S.$11,847
Supplemental analysis: costs of severe hyper- and hypoglycemia	U.S.$628.20–U.S.$772.17	62%	U.S.$924.31–U.S.$937.12	72%	U.S.$825–U.S.$2,961

*Except for costs of severe hyper- and hypoglycemia.

Myriad quality improvement strategies have been attempted for diabetes, but the costs of implementation and oversight (as opposed to health services) have been reported in few studies (Shojania et al. 2006). Some disease-management and patient-education programs cost U.S.$481–1,500 and the UKPDS implementation program cost U.S.$321 per patient annually (all inflated to 2009 dollars) (Sidorov et al. 2002; Clarke et al. 2005; Keers et al. 2005; Rothman et al. 2006; Currency Converter for 164 Currencies [database online] 2008). In one pay-for-performance program that paid physicians incentives equaling 1.5–7.5 percent of fees, monitoring of HbA1c tests increased substantially and hospitalization rates declined (Chen et al. 2010). However, the effectiveness of pay for performance remains unclear overall and it can have unintended consequences (McDonald and Roland 2009). Restructuring physician payment systems could align reimbursement with the resources involved in monitoring HbA1c testing and titrating medications; costs would depend on how these activities are valued. Summarizing the available information on the cost of improving glucose management, the total incremental cost of essential care processes, quality improvement programs, pay-for-performance incentives (U.S.$8–57 based on 1.5–7.5 percent of average diabetes-attributable outpatient physician costs), and hospitalizations for glycemic crises would be U.S.$490–1,853 annually per person (ADA 2008b). Average per-patient diabetes-attributable health care expenditures for those older than 45 are U.S.$5,450–10,400 (inflated to 2009) (ADA 2008b); therefore, providing 100 percent of essential care processes would represent a 3–6 percent increase and the total incremental cost would represent a 4.7–34 percent increase.

Two additional factors could also affect the costs and outcomes associated with glucose management: payers' pharmacy benefit management programs and patients' adherence to recommended care. Pharmacy benefit programs have the potential to influence which diabetes medications patients receive and also whether patients choose to fill prescriptions (Austvoll-Dahlgren et al. 2008). Because the data we used included many brand-name prescriptions, medication costs could be lower and adherence higher if more generics are used. Poor adherence to recommended testing and medication therapy by patients is common and associated with both worse HbA1c levels and higher health care expenditures (Balkrishnan et al. 2003; Cramer 2004; Karter et al. 2004; Rubin 2005; Sokol et al. 2005). On the other hand, one study found that uncontrolled HbA1c levels are more commonly due to provider failures to intensify treatment than patient nonadherence (Schmittdiel et al. 2008). Our cost estimates accounted for patient nonadherence in two ways. First, we based medication costs on actual pharmacy expenditures

rather than medication prices. Second, assumptions about the effect of improving care processes on HbA1c values were well within the range of documented effects of quality improvement interventions.

Although insurers often pay for the additional care processes that patients receive when quality is improved, researchers seldom examine the financial and health effects that are most relevant to payers. Indeed, the general public in the United States may be uncomfortable with the idea of payers conducting business-case analyses for any service, including quality improvement efforts. Yet payers often do consider cost-effectiveness when deciding which services to cover (Luce 2005). Because the interests of payers and society might sometimes be misaligned, it is important for public policy makers to examine short-term cost-effectiveness to payers as well as long-term cost-effectiveness to society. For glucose management, the potential differences between the payer and societal perspectives are particularly relevant to the Medicare program. A third of people with diabetes are age 65 or older and diabetes-attributable health care expenditures for this age group reached U.S.$65 billion in 2007 (ADA 2008a). Because diabetes is often diagnosed in late middle age, receiving poor versus adequate glucose management early on has the potential to affect Medicare expenditures a decade or more later. Consequently, private health care payors' policies regarding quality-of-care today can influence future Medicare expenditures.

Health care payers can apply our results in a manner analogous to how policy makers apply cost-effectiveness analyses performed from the societal perspective (Stokey and Zeckhauser 1978). First, a payer can determine whether the additional expenditures are within its budget. Next, the payer may consider whether improving glucose management is a good value. When assessing value, policy makers generally consider lifetime costs and health effects, and can, in theory, set a maximum acceptable cost per quality adjusted life year (e.g., U.S.$50,000). For payers, the incremental cost per patient newly attaining a HEDIS goal is a more useful metric of cost-effectiveness because it enables payers to consider costs as well as an outcome linked to future profitability. If a payer can predict the potential effect of raising its HEDIS scores on future enrollment and, in turn, the relationship between enrollment and profitability, it can determine whether the anticipated expenditures for improved glucose management may be balanced by an equal or greater rise in profits. Alternatively, a payer can judge subjectively whether a particular per person with an improved HEDIS score is a good value.

Other recent studies have examined the cost-effectiveness of improving quality of care for diabetes from the societal perspective. Using NHANES data

for 1998–2004 and the Archimedes model, Kahn et al. (2008) found that the maximum feasible attainment of HEDIS goals for diabetes over 30 years would cost U.S.$56,666/QALY (inflated to 2009). Kahn and colleagues also estimated that increasing the attainment of HbA1c <7 percent from 42 percent to 60 percent of the 5.7 million U.S. adults with diabetes would prevent 652,000 myocardial infarctions and add 15 million years of life nationally (Saaddine et al. 2006; Kahn et al. 2008). A second recent study evaluated a program that improved the management of blood glucose, cardiovascular risk factors, and microvascular complications at a national network of community health centers in 1998–2002. Using data from this program and the Eastman model, Huang et al. (2007) predicted that retinopathy, blindness, end-stage renal disease, and coronary artery disease would decline significantly and that the cost-effectiveness ratio would be U.S.$40,439/QALY (inflated to 2009) from the societal perspective.

Although we did not examine cost-effectiveness from the societal perspective, our analysis provides specific data on the direct cost of improving glucose management, which was lacking in these two prior publications. The study by Kahn and colleagues merely assumed that the additional care processes would cost U.S.$4,142 per patient annually (inflated to 2009), which substantially exceeds our estimate of U.S.$327. In the UKPDS, costs related to health care services were about U.S.$300–1,500 greater for intensive than conventional management (inflated to 2009 dollars) (Gray et al. 2000; Clarke et al. 2001, 2005; CDC Diabetes Cost-effectiveness Group 2002; Currency Converter for 164 Currencies [database online] 2008). Because our analyses and Kahn's are both from the same period and based on national samples, we used our estimate of the direct costs to recalculate Kahn's cost-effectiveness ratio, which then declined to U.S.$44,869/QALY.

Clearly, improving quality of care for diabetes represents an excellent value from the societal perspective. Payers may also believe it to be a good value from their perspective, given the small increase in annual costs involved and the incentives created by the HEDIS program. Indeed, payers' widespread use of disease management programs suggests that they already believe this.

Our data have several limitations. Since the CQI study began, more patients are on antihyperglycemics and mean HbA1c levels have declined (Saaddine et al. 2006; Alexander et al. 2008). Sensitivity analyses modeled these trends by increasing, for the status quo scenario, the percentage of patients receiving recommended HbA1c tests and medication adjustments. Given our analysis included only 821 people, findings may not be

representative; however, we did draw from a national sample and included other large studies in sensitivity analyses. Our estimate of medication expenditures was based on four health plans in one state, but it is within a wide range reported in prior studies. A strength of our analysis is that we used actual medication expenditures, rather than average wholesale prices, to account for negotiated price discounts and patient nonadherence. Lastly, we did not distinguish the perspectives of public and private payers.

In conclusion, ensuring that people with diabetes receive 100 percent of the essential care processes pertaining to glucose management will generate modest increases in total annual per-patient health care expenditures attributable to diabetes. Our results enable payers to consider short-term costs and outcomes that are important from their perspective.

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SUPPORTING INFORMATION

Additional supporting information may be found in the online version of this article:

Appendix SA1: Author Matrix.
Appendix SA2: Cost Implications of Improving Blood Glucose Management among U.S. Adults.

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