NIH Public Access
Author Manuscript
Am J Pharm Benefits. Author manuscript; available in PMC 2013 December 28.

Published in final edited form as:
Am J Pharm Benefits. 2013 ; 5(2): 59–64.

Association Between Sustained Glycated Hemoglobin Control and Healthcare Costs

DT Juarez[1], **R Goo**[1], **S Tokumaru**[1], **T Sentell**[2], **JW Davis**[3], and **MM Mau**[4]

[1]College of Pharmacy, University of Hawai'i at Hilo

[2]Department of Public Health Sciences, John A. Burns School of Medicine, Honolulu, Hawai'i

[3]Department of Biostatistics & Data Management Core, John A. Burns School of Medicine, Honolulu, Hawai'i

[4]Native Hawaiian Health, John A. Burns School of Medicine, Honolulu, Hawai'i

Abstract

Objective—To examine the relationship between sustained glycemic control and health care costs among patients with diabetes with an initial hemoglobin A1c≥9%.

Study Design/Methods—We conducted a retrospective analysis of administrative data from patients with diabetes and initial poor HbA1c control enrolled in a large health plan in Hawai'i (n=1304). We used propensity scores to identify a comparable cohort based on age, gender, type of coverage, diabetes duration, number of medications, location of residence, comorbidity conditions, and morbidity level. We examined the relationship between reduced A1c values and costs in the same year as well as the impact of achieving sustained A1c control (at < 7%)for three years on changes in health care costs using generalized linear models.

Results—In cross-sectional comparisons, the average annual direct medical costs for patients withHbA1c less than 7% was $14,821 compared to $12,108 for the matched sample of patients with A1c greater than or equal to 7%, for a difference of $2,713 95%CI[$285, $5,140]. In contrast, when we examined the change in cost from 2006 to 2009 for patients who had sustained levels of A1c at <7% for all three years, we found that total cost care for patients with sustained control decreased by $2,207 compared to a $3,006 increase for patients without sustained control, for a difference of −$5,214, 95%CI[−$10,163, −$264].

Conclusion—Our study suggests that while reducing hemoglobin A1c levels to target goals may not immediately result in cost reductions, sustained A1c control were associated with lower costs in a three-year time frame.

Keywords

glycemic control; diabetes mellitus; health care costs; quality of care

Diabetes is one of the most common and costly diseases, affecting 25.8 million people or 8.3% of the U.S. population.[1] Diabetes is also the seventh leading cause of death in the U.S. and can result in serious health complications including heart disease, stroke, kidney failure, blindness, and lower-extremity amputations. In 2007, the estimated diabetes cost in the U.S. was $1.7 billion, with direct medical expenditures for people with diabetes averaging nearly 2.4 times that of those without the disease.[1]

Hemoglobin A1c (HbA1c) is one of the most common measurements used in the assessment of glycemic control and is thought to reflect the average glycemic control over several months[2] and predict the occurrence of diabetes related complications.[3] The most recent

NIH-PA Author Manuscript
NIH-PA Author Manuscript
NIH-PA Author Manuscript

NIH-PA Author Manuscript

NIH-PA Author Manuscript

NIH-PA Author Manuscript

guidelines put forth by the American Diabetes Association (ADA) recommend lowering HbA1c to below or around 7%.[4] This recommendation was based on findings from multiple trials performed in both type 1 and type 2 diabetic patients demonstrating significant decreases in microvascular and neuropathic complications associated with reductions in HbA1c.[5–7] In addition to the microvascular benefits of intensive glycemic control, both the Diabetes Control and Complications Trial Research Group(DCCT) and UK Prospective diabetes study (UKPDS) demonstrated the potential of intensive glucose control to lower the risk of cardiovascular events.

The percent of diabetic patients with poor glycemic control (A1C >9.0%) fell from 21.0% in 1999–2000 and 17.8% in 2001–2002 to 12.4% in 2003–2004.[8] Despite these encouraging trends, many patients still struggle to achieve and/or sustain optimal glycemic control over extended periods of time (i.e. years).

Some prior evidence suggests that having a hemoglobin HbA1c<7% is associated with lower costs of medical care;[9–13] however, many of these studies examine cross-sectional relationships that may be confounded by severity of disease. While all studies require a diagnosis of diabetes, there may be some false positives (i.e. people with a diagnosis and HbA1c<7% who do not really have diabetes). Also, some people have diabetes of low severity and would not be expected to have high costs. To address these issues, our study starts with a sample of patients with poor initial control (HbA1c≥9%) and uses propensity score matching to define a comparable cohort.

The purpose of this study was to examine the relationship between sustained glycemic control and total direct health care costs among patients with diabetes with an initial HbA1c greater than or equal to 9%. Specifically, this study sought to test the hypothesis that lowering HbA1cfrom above 9% to below 7%, and sustaining this level, reduces health care costs among patients with diabetes mellitus.

Methods

We conducted a retrospective analysis of administrative data from patients with diabetes enrolled in a large health plan in Hawai'i. To be included in the study, patients needed to meet the following criteria (1) be identified as having diabetes, by either having 2 or more claims for type 2 diabetes in medical claims (*International Classification of Diseases, Ninth Revision, Clinical Modification* [ICD-9-CM] codes 250.xx) or had at least 1 prescription for an oral hypoglycemic agent and/or insulin; 2) be at least 18 but under 75 years old; (3)be enrolled with medical and drug coverage; (4) have at least 1 HbA1c value at >9% in 2006. This level was chosen because the National Committee on Quality Assurance's Healthcare Effectiveness Data and Information Set (HEDIS) uses a level of 9% to indicate poor HbA1c control.

Patient information including age, sex, isle of residence and type of coverage (HMO, preferred provider organization [PPO], Medicare cost contract) was obtained from administrative data. Patient morbidity level was determined by using *International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9-CM)* codes according to the Johns Hopkins Adjusted Clinical Group methodology; levels of 4 or 5 on the 5-point scale were considered high morbidity.[14] In addition, using disease management algorithms, we created dichotomous variables to identify patients with coronary artery disease and congestive heart failure as these are conditions known to be prevalent in patients with diabetes and to increases costs. Diagnoses of diabetes, coronary artery disease and congestive heart failure were confirmed whenever possible through contact of members and their physicians. A physician's confirmation was required to exclude false positives.

NIH-PA Author Manuscript

NIH-PA Author Manuscript

NIH-PA Author Manuscript

During the baseline year 2006, we identified all patients with diabetes who had a HbA1c level>9% (n=4,667 out of 56,921 patients with diabetes). For each subsequent year (2007–2009), we calculated mean HbA1c levels for these patients. We used propensity scores[15] to identify a comparable control cohort for those with HbA1c<7% in year 2007 using demographic and utilization data, including age, gender, isle of residence, type of insurance coverage, comorbid conditions, diabetes duration, number of distinct medications, and morbidity level. We conducted cross sectional analyses, comparing the average annual direct medical costs of patients with mean HbA1c<7% compared to those who did not meet this glycemic level for the matched sample (n=4093 observations for 1304 individuals).

For longitudinal analyses, we created a dichotomous variable indicating whether or not the patient had sustained HbA1c control at target levels (A1c<7%) for all three years (2007–2009). Of the 1304 individuals in the matched sample, 518 were enrolled, had HbA1c values for all four years (2006 through 2009), and were included in the longitudinal analyses of cost change.

We calculated average baseline costs of care (2006) for these patients and subsequent average annual costs in years 2007 through 2009using medical claims data. Costs included direct medical expenses paid by the health plan. We analyzed total costs and cost broken into cost categories: facility, physician services, and pharmaceutical. All costs in the study were adjusted to constant 2009 dollars using the medical care component of the Consumer Price Index.

For samples matched using propensity scores, we compared costs, total and by category, in a given year for patients with HbA1c levels less than 7% to those with higher HbA1c levels. We also examined differences in cost changes for those who were able to sustain levels of HbA1c less than 7% for three years compared to those who had HbA1c levels higher than 7% for at least one year.

Next, to account for year and baseline costs, we used generalized estimating equations with robust standard errors to compare annual average health care costs by cost category for patients at recommended levels (HbA1c level<7%) to those of patients with HbA1c levels at or above 7% for the matched groups.[16] Interaction terms between year and HbA1c level were included to account for differences in the relationship over time.

Generalized linear models with a negative binomial distribution and log link were used to examine the relationship between sustained control (HbA1c<7% for three years) and direct medical costs according to cost category (total, inpatient facility, physician services, and pharmaceutical)in year 2009, adjusting for baseline costs. Inpatient costs included costs of all facilities, such as hospitals and long term care institutions. Physician services included both inpatient and outpatient physician reimbursement. Institutional Review Board approval was obtained from the University of Hawai'i. All analyses were conducted in Stata v. 11 (StataCorp. 2009. *Stata Statistical Software: Release 11*. College Station, TX: StataCorp LP).

Results

Of members with HbA1c≥9% in 2006 (n=4667), the percentage of members able to achieve mean HbA1c levels of less than 7% were 10.0% in 2007, 12.7% in 2008 and 13.3% in 2009. Only 3.6% of members with HbA1c>9% in the baseline year were able to reduce their HbA1c level to goal (<7%) and sustain this level for three years.

While there were significant differences in 2007 between those achieving an HbA1c level of 7% in the unmatched sample(n=4667)in terms of age, isle of residence, type of coverage and

NIH-PA Author Manuscript

NIH-PA Author Manuscript

NIH-PA Author Manuscript

duration of diabetes, there were no significant differences in demographic characteristics and utilization for the groups matched using propensity scores(n=1304, Table 1).

For the matched sample in 2007, the mean age of those with HbA1c<7% was 54 +0.53, while the mean age for those not at recommended levels was 54 + 0.41. Forty-three percent of patients in both groups were female (Table 1). Most patients were in the PPO (67% of those with A1c<7% and 66 % of those with A1c>7%). The average duration of diabetes was 6.9 years for both groups and patients in both groups were taking nine distinct medications a year on average. Approximately 44% of patients at target had high morbidity compared to 41% of those with A1c≥7%. Thirteen percent of patients in both groups had congestive heart failure, while 23% of patients with A1c<7% had a history of coronary artery disease compared to 24% of patients not at recommended A1c levels. This suggests that the propensity matching was successful in creating groups that were similar on observable characteristics.

Difference in Average Costs and Cost Change

In cross-sectional comparisons, the average annual costs for patients with an A1c<7% was $14,821 compared to $12,108 for the matched sample of patients with A1c≥7% for a difference of $2,713 95%CI[$285, $5,140] (Table 2). In contrast, when we examined the change in cost from 2006 to 2009 for patients who had sustained levels of A1c at <7% for all three years, we found that total cost care for patients with sustained control decreased by $2,207 compared to a $3,006 increase for patients without sustained control, for a difference of −$5,214,95%CI[−$10,163, −$264].

Negative Binomial Regression Results

Our negative binomial results (Table 3) are consistent with findings in Table 2. In the panel data analyses, costs were higher for patients with mean A1c<7% compared to those with higher mean A1c values. For total costs, the risk ratio was estimated at IRR=1.35, 95%CI[1.28, 1.44]. These results were consistent across all cost categories (Table 3).

In contrast, examining the impact of duration of A1c control on cost, we found that patients who had 3 years of sustained hemoglobin A1c control (at levels of less than 7%) had smaller cost increases than patients without sustained control [IRR=0.71, 95%CI(0.59, 0.86), Table 3]. Cost ratios of patients with sustained control were significantly less than one for all cost categories except for pharmaceutical costs, which did not differ between groups.

Discussion

Less than 4% of the study population who had poor glycemic control in 2006 (HbA1c>9%) were able to reduce their HbA1c level to less than 7% and sustain this level for three years (2007–2009); however, achievement and maintenance of glycemic control was associated with lower total health care costs in 2009. To our knowledge, our study is the first to examine the impact of sustained HbA1c control on costs and to use propensity score matching to minimize potential confounding.

While cost increases in pharmaceutical treatment were similar in both groups, cost reductions were found for the group with sustained HbA1c control in both physician services and inpatient categories. Prior evidence has shown that complications are key drivers of the direct medical costs in patients with diabetes.[17] Hence, part of the reduced costs seen in our study following sustained glycemic control may be due to reduced incidence of diabetes complications and morbidity.

NIH-PA Author Manuscript

NIH-PA Author Manuscript

NIH-PA Author Manuscript

Our analyses of panel data reveal, however, that these cost savings are not immediate. In our study, during any given year that patients achievedHbA1c levels of <7%, their costs were significantly higher than patients with HbA1c≥7%. We acknowledge that even though cost changes (2009–2006) were more than $5000 less in the group that sustained good glycemic control, some of these savings could be counterbalanced by cost increases in intervening years, as it may take additional physician visits and medications to achieve this control. The costs are immediate but the benefits may take years to be realized. Even so, it is likely that costs will continue to be lower in subsequent years if patients maintain glycemic control.

These findings contrast with several prior studies that have found short-term cost savings. Shetty and colleagues divided a cohort of patients with diabetes in a managed care setting into two groups, those at the target HbA1c level (≤7%) and those above the target HbA1c level (>7%), and examined cost savings after one-year follow up.[11] They found substantial cost savings of 32% for patients at target. In another study, grouping patients with type 2 diabetes by glycemic control (good [HbA1c ≤ 7%], fair [> 7% to ≤ 9%], and poor [> 9%]), Oglesby et al. (2006) found diabetes related costs to be 16% lower for patients with good control than fair control and 20% lower than for patients with poor control.[12] Similarly, Gilmer and colleagues (1997) examined medical charges related to HbA1c and found that after controlling for demographics and cardiovascular disease, costs increased by 30% as HbA1c increased from 6 to10%.[13]

Our findings of increased costs for the patients with HbA1c<7% within a year differed from the results of these prior studies. We believe the main difference was that we required patients to have elevated HbA1c levels (>9%) at baseline while these other studies did not. Hence, they may have had patients with fairly “normal” HbA1c levels even without treatment in their “at target” group. It may also be that initial interventions for patients with poor control that drive up immediate costs were not evaluated in these cross-sectional cohort studies but were seen for our patients who were initially in poor control.

A subsequent study by Gilmer et al. (2005) reported that in a large Minnesota health plan, higher HbA1c in patients with either type 1 or type 2 diabetes predicted higher three-year total health care costs for patients with HbA1c > 7.5%.[18] This study differed from ours in that it did not examine the impact of changes in HbA1c levels. Both Gilmer studies emphasized that cardiovascular disease was a stronger predictor of costs than glycemic control. We did not examine the association between cardiovascular disease and costs in our study.

In a recent study, Menzin et al. examined a cohort of patients with diabetes in a managed care setting.[19] The investigators found the odds of having at least one diabetes-related hospitalization were not significantly associated with higher mean HbA1c except for patients with mean HbA1c of at least 10%. They did find that for hospitalized patients, mean costs were higher among patients with higher mean HbA1c levels. However, because they did not examine total costs of care or changes in costs related to changes in HbA1c levels, we cannot directly compare their findings to ours.

A study by Wagner and colleagues was the most similar to ours in that it focused on changes in cost related to changes in HbA1c levels. They examined data for diabetic patients enrolled in a staff model HMO in the mid-1990s.[20] The investigators defined improvement as having at least a 1% decrease in HbA1c levels. They found costs of the improved group were lower each subsequent year but differences were only statistically significant for those with baseline HbA1c levels≥10%. Our study design differed from theirs in that we examined costs for patients who dropped their HbA1c levels from >9% to <7%. Hence, we required a

NIH-PA Author Manuscript

NIH-PA Author Manuscript

NIH-PA Author Manuscript

higher level of improvement (2 percentage point reduction) as well as sustained control and found that those with HbA1c>9% experienced significant cost reductions.

Our study may underestimate potential savings from HbA1c reduction to target levels. Tissue damage from inadequate glycemic control may not be promptly overcome or mitigated. Clinical trials have demonstrated that approximately 8 years are needed to realize fully all of the microvascular benefits of glycemic control.[21] The UKPDS demonstrated that maintaining a lower HbA1c (7%) over 10 years is associated with a substantial risk reduction in microvascular complications.[7] Hence, further risk reduction and cost savings may be observed within an extended study period (8–10 years).

This study had several limitations. First, the study was conducted on enrollees of a single health plan in Hawaii. The percent of patients in poor control (HbA1c>9%) in 2006 (at 8%) was lower than the national average, so our may not be generalizable to other areas or uninsured populations. Second, we only estimated direct medical costs covered by the health plan. Free drug samples distributed by physicians, use of aspirin, and other non-covered costs would not be included in our analyses. Adding indirect measures, such as productivity gains and decreased absenteeism, would most likely have increased the cost savings for the group with sustained glucose control.[22] We were also not able to separate out diabetes-specific costs.

Third, we relied on administrative data from a health plan to identify patients with diabetes and to estimate costs. The issue with false positives arising from claims data identification is diminished in our study as we required a diagnosis of diabetes and an HbA1c value greater than 9% at baseline. Fourth, this study also did not examine the quality of life implications which could be substantial. Fifth, only 3% of patients were able to achieve target level HbA1c for three years. This group may have been different in other ways. For instance, they may have eaten healthier diets, smoked less, and exercised more than those not able to sustain control. These factors may have been as important to sustained glycemic control as medical interventions but the costs would have primarily been absorbed by the patients and they were unmeasured in this study. Future research is needed that takes a more comprehensive approach to measuring factors that might contribute to cost changes.

Conclusion

In our study of 1304 managed care enrollees with poor initial HbA1c control, we found that patients who were able to achieve target goals had lower costs after three years compared to patients not able to sustain these target levels.

Quality indicators for health plans and physicians often include some measure of HbA1C screening or the reaching of target levels. Our study suggests that while achieving these target goals may not immediately result in cost reductions, sustained A1c control is associated with lower costs in a three-year time frame, suggesting that efforts to support and reward physicians and health plans for achieving these target goals may be a good investment in the intermediate-term.

Acknowledgments

Funding Source:

This publication was made possible by awards P20MD000173 and S21MD999228 from the National Center on Minority Health and Health Disparities and ARRA grant 3P20MD000173-09S1 from the National Institute on Minority Health and Health Disparities. The content is solely the responsibility of the authors and does not necessarily represent the official views of the National Center on Minority Health and Health Disparities or the National Institutes of Health.

NIH-PA Author Manuscript

NIH-PA Author Manuscript

NIH-PA Author Manuscript

References

1. Centers for Disease Control and Prevention. National diabetes fact sheet: national estimates and general information on diabetes and prediabetes in the United States, 2011. Atlanta, GA: U.S. Department of Health and Human Services, Centers for Disease Control and Prevention; 2011.
2. Sacks DB, Arnold M, Bakris G, et al. Executive summary: guidelines and recommendations for laboratory analysis in the diagnosis and management of diabetes mellitus. Clin Chem. 2011 Jun; 57(6):793–8. [PubMed: 21617153]
3. Stratton IM, Adler AI, Neil HA, et al. Association of glycemia with macrovascular and microvascular complications of type 2 diabetes (UKPDS 35): prospective observational study. BMJ. 2000; 321:405–412. [PubMed: 10938048]
4. Executive Summary: Standards of Medical Care in Diabetes- 2011. Diabetes Care. 2011; 34(1):S12–S61.
5. The Diabetes Control and Complications Trial Research Group. The effect of intensive treatment of diabetes on the development and the progression of long-term complications in insulin-dependent diabetes mellitus. N Engl J Med. 1993; 329:977–86. [PubMed: 8366922]
6. UK Prospective Diabetes Study (UKPDS) Group. 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; 352:837–53. [PubMed: 9742976]
7. UK Prospective Diabetes Study (UKPDS) Group. Effect of intensive blood-glucose control with metformin on complications in overweight patients with type 2 diabetes (UKPDS 34). Lancet. 1998; 352:854–856. [PubMed: 9742977]
8. Hoerger TJ, Segel JE, Gregg EW, Saaddine JB. Is glycemic control improving in U.S adults? Diabetes Care. 2008; 31:81–86. [PubMed: 17934153]
9. Menzin J, Langley-Hawthorne C, Friedman M, Boulanger L, Cavanaugh R. Potential short-term economic benefits of improved glycemic control: a managed care perspective. Diabetes Care. 2001; 24:51–55. [PubMed: 11194241]
10. Stephens JM, Botteman MF, Hay JW. Economic Impact of Antidiabetic Medications and Glycemic Control on Managed Care Organizations: A Review of the Literature. J Manag Care Pharm. 2006; 12(2):130–42. [PubMed: 16515371]
11. Shetty S, Secnik K, Oglesby A. 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(7):559–64. [PubMed: 16137213]
12. Oglesby AK, Secnik K, Barron J, Al-Zakwani I, Lage MJ. The association between diabetes-related medical costs and glycemic control: a retrospective analysis. Cost Eff Resour Alloc. 2006; 4:1. Available at: http://www.ncbi.nlm.nih.gov/pmc/articles/PMC1369002/pdf/1478-7547-4-1.pdf. [PubMed: 16412255]
13. Gilmer TP, O'Connor PJ, Manning WG, Rush WA. The cost to health plans of poor glycemic control. Diabetes Care. 1997; 20:1847–53. [PubMed: 9405905]
14. Clark DO, Von Korff MV, Saunders K, Baluch WM, Simon GE. A chronic disease score with empirically derived weights. Med Care. 1995; 33:783–795. [PubMed: 7637401]
15. Stuart EA. Matching methods for causal inference: A review and a look forward. Stat Sci. 2010 Feb 1; 25(1):1–21.10.1214/09-STS313 [PubMed: 20871802]
16. Blough DK, Madden CW, Hornbrook MC. Modeling risk using generalized linear models. J Health Econ. 1999; 18(2):153–71. [PubMed: 10346351]
17. Pelletier EM, Smith PJ, Boye KS, et al. Direct medical costs for type 2 diabetes mellitus complications in the US commercial payer setting: a resource for economic research. Appl Health Econ Health Policy. 2008; 6(2–3):103–12. [PubMed: 19231904]
18. Gilmer TP, O'Connor PJ, Rush WA, et al. Predictors of health care costs in adults with diabetes. Diabetes Care. 2005; 28(1):59–64. Available at: http://care.diabetesjournals.org/content/28/1/59.full.pdf+html. [PubMed: 15616234]
19. Menzin J, Korn JR, Cohen J, et al. Relationship Between Glycemic Control and Diabetes-Related Hospital Costs in Patients with Type 1 or Type 2 Diabetes Mellitus. J Manag Care Pharm. 2010; 16(4):264–75. [PubMed: 20433217]

NIH-PA Author Manuscript

NIH-PA Author Manuscript

NIH-PA Author Manuscript

20. Wagner EH, Sandhu N, Newton KH, McCulloch DK, Ramsey SD, Grothaus LC. Effect of improved glycemic control on health care costs and utilization. JAMA. 2001; 285(2):182–89. [PubMed: 11176811]

21. Holman R, Paul S, Bethel M, Matthews D, Neil H. 10-Year Follow-up of Intensive Glucose Control in Type 2 Diabetes. N Engl J Med. 2008; 359(15):1577–1589. [PubMed: 18784090]

22. 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; 280:1490–96. [PubMed: 9809729]

NIH-PA Author Manuscript

NIH-PA Author Manuscript

NIH-PA Author Manuscript

Bullet points

- In cross-sectional analyses, costs were higher for patients who reduced their HbA1c levels from greater than 9% to <7%.
- Among patients with initially poor glycemic control (HbA1c>9%), those who reduced their HbA1c to <7% and sustained this level for three years had lower health care cost increases than other patients.
- This suggests that efforts to improve glycemic control for patients in poor control may want to emphasize the potential benefit of sustaining good control.

NIH-PA Author Manuscript NIH-PA Author Manuscript NIH-PA Author Manuscript

Table 1

Demographic Characteristics With (n=1304) and Without (n=4667) Propensity Score Matching, in Year 2007.

Variable	Entire Unmatched Cohort			Propensity Matched Cohort		
	A1c<7% (n=450)	A1c>7% (n=4,217)	p-value	A1c<7% (n=450)	A1c>7% (n=854)	p- value
Age category						
Age 35–49 (%)	25%	27%	0.03	25%	26%	0.33
Age 50–64 (%)	55%	50%	0.001	55%	52%	0.127
Age 65–74(%)	17%	17%	0.712	17%	17%	0.749
Sex (% female)	43%	44%	0.221	43%	43%	0.961
Island						
Hawaii (%)	19%	16%	0.003	19%	17%	0.321
Maui (%)	10%	9%	0.420	10%	9%	0.294
Kauai (%)	7%	7%	0.260	7%	8%	0.509
Oahu (%)	63%	66%	0.011	63%	65%	0.345
Type of insurance coverage						
PPO (%)	67%	67%	0.609	67%	66%	0.798
Medicare cost contract (%)	10%	7%	<0.001	10%	11%	0.471
High morbidity[1] (%)	44%	40%	<.0001	44%	41%	0.055
Diabetes duration [Mean (SD)]	6.9 years	8.0 years	<0.001	6.9 years	6.9 years	0.634
Number of distinct medications [Mean (SD)]	9.03	8.95	0.677	9.03	8.87	0.550
Comorbid conditions						
Coronary Artery Disease (%)	23%	24%	0.190	23%	24%	0.459
Congestive Heart Failure (%)	13%	12%	0.455	13%	13%	0.747

[1]High morbidity was defined according to the Johns Hopkins Adjusted Clinical Group methodology; levels of 4 or 5 on the 5-point scale were considered high morbidity.

NIH-PA Author Manuscript

NIH-PA Author Manuscript

NIH-PA Author Manuscript

Table 2

Average Annual Cost and Cost Change For Matched Samples.

Average Annual Costs Related to A1c Level				
A1c<7% (n=450)	A1c≥7% (n=854)	Cost Difference	T-stat	95% Confidence interval[+]
$14,821	$12,108	$2,713	2.16	[$ 285, $5,140]
Cost change (2009 – 2006) Related to Sustained A1c Control				
A1c<7% for 3 years (n=169)	A1c≥7% for at least 1 year (n=349)	Difference in Cost Change	T-stat	95% Confidence interval[+]
−$2,207	$3,006	−$5,214	−2.23	[−$10,163, −$264]

[+]Confidence intervals obtained through bootstrapping.

NIH-PA Author Manuscript

NIH-PA Author Manuscript

NIH-PA Author Manuscript

Table 3

Negative Binomial Results For Each Cost Category for Matched Samples.

Model 1: Relative cost of members with A1c<7% compared to members with A1c≥7% in a given year (n=4093 observations for 1304 individuals), adjusted for year.			
Type of Cost	**Relative Costs**	**95%CI**	**p-value**
Total	1.35	1.28, 1.44	<0.001
Facility	1.41	1.32, 1.50	<0.001
Physician services	1.30	1.23, 1.36	<0.001
Drug	1.24	1.17, 1.31	<0.001
Model 2: Relative cost in year 2009 for patients with three years (2007–2009) of A1c<7% compared to members with A1C≥7% for at least one of those years adjusted for baseline costs (n=518).			
Type of Cost	Relative Costs	95%CI	p-value
Total	0.71	0.59, 0.86	<0.001
Facility	0.68	0.56, 0.82	<0.001
Physician services	0.81	0.67, 0.98	0.03
Drug	0.99	0.83, 1.2	0.99