Medical Care Costs Associated With Long-term Weight Maintenance Versus Weight Gain Among Patients With Type 2 Diabetes

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OBJECTIVE

Weight loss is recommended for overweight patients with diabetes but avoidance of weight gain may be a more realistic goal. We calculated the 4-year economic impact of maintaining body weight versus gaining weight.

RESEARCH DESIGN AND METHODS

Among 8,154 patients with type 2 diabetes, we calculated weight change as the difference between the first body weight measure in 2010 and the last measure in 2013 and calculated mean glycated hemoglobin (A1C) from all measurements from 2010 to 2013. We created four analysis groups: weight change <5% and A1C <7%; weight gain ≥5% and A1C <7%; weight change <5% and A1C ≥7%; and weight gain ≥5% and A1C ≥7%. We compared change in medical costs between 2010 and 2013, adjusted for demographic and clinical characteristics.

RESULTS

Patients who maintained weight within 5% of baseline experienced a reduction in costs of about $400 regardless of A1C. In contrast, patients who gained ≥5% of baseline weight and had mean A1C ≥7% had an increase in costs of $1,473 ($P$ < 0.001). Those who gained >5% of their baseline weight with mean A1C <7% had a modest increase in costs ($387, NS).

CONCLUSIONS

Patients who gained at least 5% of their baseline body weight and did not maintain A1C <7% over 4 years experienced a 14% increase in medical costs, whereas those who maintained good glycemic control had a mean cost increase of 3.3%. However, patients who maintained weight within 5% of baseline had costs that were ∼5% lower than baseline. Avoidance of weight gain may reduce costs in the long-term.

Type 2 diabetes (T2D) is a chronic disease defined by hyperglycemia (1), and almost 90% of patients with T2D are affected by overweight or obesity (2). In addition to blood pressure and cholesterol, weight management and glycemic control are the cornerstones of diabetes care (3,4). Indeed, based primarily on the Look AHEAD trial that demonstrated the feasibility of achieving and maintaining weight loss in patients with diabetes, weight loss is recommended for most overweight patients with diabetes (5). Although mean weight loss of Look AHEAD participants who received

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the intensive lifestyle intervention (ILI) was 8.6% after 1 year, regain resulted in a mean loss of 4.7% at 4 years (6). Whereas 68% of ILI participants achieved a 5% weight loss at year 1, by year 8 that figure had fallen to 50.3% (7). Furthermore, Look AHEAD participants represented only about one-third of individuals who met prescreening criteria for the study; most of the other two-thirds declined participation. In clinical practice, therefore, the majority of patients with T2D are unlikely to attempt, achieve, and maintain significant weight loss; avoidance of weight gain may be a more realistic goal. We undertook the current study to determine the economic impact of maintaining body weight versus gaining weight over 4 years among free-living patients with T2D who did and did not maintain glycemic control during that period.

RESEARCH DESIGN AND METHODS

The study site was Kaiser Permanente Northwest (KPNW), an integrated medical system that provides health services in and around Portland, OR. We conducted an observational cohort study using comprehensive electronic medical records data that include frequent anthropometric measures, diagnoses, laboratory results, and pharmaceutical dispensings. The KPNW institutional review board approved the study with a waiver of informed consent.

Sample Selection

We identified all people with T2D diagnosed in 2010 or earlier and who were continuously enrolled in KPNW from January 2010 through December 2013 (n = 22,186). Patients were required to have at least one glycated hemoglobin (A1C) measurement in each year and to have at least one body weight measurement in 2010 and 2013 (n = 16,631). We excluded patients over age 85 years (n = 153) and those who had bariatric surgery (n = 77) or were diagnosed with malignant cancer (n = 4,417) or end-stage renal disease (n = 335) before 2013 because of the high costs associated with these conditions that also have significant impact on weight (remaining n = 11,649). We calculated weight change as the difference between the first body weight measure recorded in 2010 and the last measure recorded in 2013 and excluded 3,495 patients who lost >5% of their 2010 body weight to avoid the effects of other unintentional weight loss, producing a final study sample of 8,154. We stratified weight change by those who maintained weight within 5% of their 2010 measurement versus gained 5% or more. Mean A1C was calculated from all measurements recorded from 2010 through 2013. We stratified mean A1C over the entire study period using a glycemic control cut point of 7%, resulting in four analysis groups: weight change <5% and A1C <7%; weight gain ≥5% and A1C <7%; weight change <5% and A1C ≥7%; and weight gain ≥5% and A1C ≥7%.

Cost Analyses

We used calendar year 2010 to collect baseline data and calculated the change in annual medical costs as 2013 minus 2010 costs. Inpatient, outpatient, pharmacy, and total medical costs were calculated by year for each individual during their entire follow-up period. We based our costing method on procedures developed and validated by the KPNW Center for Health Research. This costing algorithm assigns an average cost per unit of service based on general ledger information. For outpatient costs, this method creates standard costs for office visits by specialty/department and type of clinician (MD vs. physician assistant/nurse practitioner). The number of visits per department per clinician type is multiplied by the appropriate unit cost. Pharmaceutical costs were based on retail prices within the service area. Hospitalization costs were calculated by multiplying the average daily cost per assigned diagnosis-related groups by the length of stay. Costs for medical services incurred at facilities not owned by KPNW were based on the amount paid to the non–plan provider. All costs were adjusted to 2014 dollars using the medical or pharmaceutical component of the Consumer Price Index.

Covariates

The statistical models included covariates for baseline costs, age, sex, race/ethnicity, duration of diabetes, smoking status, baseline systolic blood pressure (SBP), LDL cholesterol, and weight. We also assessed history (before 2011) of ischemic heart disease (ICD-9 codes 410–414.x), heart failure (ICD-9 428.x), retinopathy (362.01, 362.02, 362.83, and 379.23), neuropathy (250.6, 355.9, 356.9, 357.1, and 357.4), depression (296.x, 300.4, and 311), and chronic kidney disease (CKD) (585.x or last glomerular filtration rate prior to 2011 <60 mL/min, estimated from serum creatinine using the MDRD equation). We also controlled for use of specific antihyperglycemic agents (metformin, sulfonylureas, insulin, other oral agents, and other injectables), ACE inhibitors or angiotensin receptor blockers (ARBs), β-blockers, and statins in the baseline year.

Statistical Analyses

Medical costs are not typically normally distributed. Although log transformation can often normalize the data, we used simple ordinary least squares regression on untransformed medical costs to compare the change in annualized costs across weight change and glycemic control groups. Prior research in this setting demonstrated that ordinary least squares regression is as robust at predicting costs as more advanced techniques (8), and others have argued that the sample mean performs well and is unlikely to lead to inappropriate conclusions (9). Therefore, for ease of interpretation, we report mean change in costs adjusted for covariates listed above and compared adjusted costs using the LSMEANS options in PROC GLM (SAS version 9.4; SAS Institute, Cary, NC).

RESULTS

Of the 8,154 patients with T2D who met all inclusion/exclusion criteria for the study (Table 1), 31.3% (n = 2,553) maintained mean A1C <7% and experienced body weight change of <5%, and 6.8% (n = 557) maintained A1C <7% but gained 5% or more of their baseline body weight. Another 49.4% (n = 4,024) had a mean A1C ≥7% with a body weight change of <5%, and 12.5% (n = 1,020) had a mean A1C ≥7% with a body weight change of ≥5%. Patients who did not maintain A1C <7% were considerably younger, whereas those who gained weight were more likely to be women, have heart failure or depression, and to be using insulin.

Patients who did not maintain mean A1C <7% were significantly heavier at baseline regardless of whether they subsequently gained weight (Table 2). These patients also had significantly higher baseline comorbidities and costs. Mean weight gain among patients who gained weight and maintained glycemic control was ~20 pounds (9.9%), but those who did not maintain mean A1C <7% gained a mean of 23 pounds (10.5%).

Figure 1 displays the multivariable adjusted change in medical costs by resource and in total for each of the four analysis

Table 1—Characteristics of study sample

Baseline characteristic	Total sample	A1C <7%, weight change <5%	A1C <7%, weight gain ≥5%	A1C ≥7%, weight change <5%	A1C ≥7%, weight gain ≥5%
Sample size	8,154	2,553	557	4,024	1,020
Percent of total	100%	31.3%	6.8%	49.4%	12.5%
Age	54.3 (10.4)	58.6 (10.0)*†‡	56.3 (9.5)*†§	52.3 (10.0)†‡§	50.4 (9.8)*†§
Duration of diabetes (years)	7.2 (5.2)	5.7 (4.6)†‡	5.9 (4.8)†‡	7.9 (5.3)*‡§	8.6 (5.4)*†§
% men	54.0%	52.4%*†	47.6%‡	56.9%*‡§	49.9%†
African American	4.5%	4.0%	4.8%	4.9%	3.4%
Hispanic	6.4%	5.0%†	4.3%†	7.8%*§	5.8%†
Smoker	9.1%	8.3%*	11.7%§	9.1%	9.6%
LDL cholesterol (mg/dL)	101 (25)	101 (24)	102 (25)	100 (25)	100 (26)
SBP (mmHg)	130 (13)	130 (13)*†	128 (13)†‡§	131 (13)*§	131 (13)*
Diastolic blood pressure (mmHg)	73 (8)	72 (8)*†‡	71 (8)†‡§	74 (8)*§	74 (9)*§
Ischemic heart disease	20.9%	21.3%	21.5%	20.3%	21.7%
Heart failure	7.8%	7.2%*‡	10.8%†§	7.2%*‡	10.1%*§
Depression	32.1%	29.8%*‡	38.1%†§	31.8%*‡	35.7%†§
Retinopathy	15.1%	9.5%†‡	11.7%†‡	16.9%*‡§	23.4%*†§
Neuropathy	29.6%	25.5%*†‡	31.6%‡§	30.1%‡§	36.9%*‡§
Hypoglycemia	0.1%	0.0%	0.0%	0.1%	0.1%
CKD	19.8%	21.7%†	21.5%†	17.8%*‡§	21.8%†
ACE/ARB use	76.1%	75.0%	72.5%†‡	76.9%*	77.6%*
β-Blocker use	36.6%	39.8%†	39.3%†	33.8%*‡§	38.3%†
Insulin use	22.0%	9.0%*†‡	14.9%†‡§	26.2%*‡§	42.1%*†§
Statin use	77.0%	76.3%‡	79.7%	76.3%‡	79.6%†§
Metformin use	63.0%	50.9%†‡	48.8%†‡	71.0%*§	69.3%*§
Sulfonylurea use	36.3%	19.6%†‡	16.0%†‡	47.0%*§	47.2%*§
Other oral antidiabetic use	3.4%	1.5%†‡	1.6%†‡	4.5%*§	4.9%*§

Data are mean (SD) or percentage. *$P < 0.05$ compared with A1C <7% and weight gain ≥5%. †$P < 0.05$ compared with A1C ≥7% and weight change <5%. ‡$P < 0.05$ compared with A1C ≥7% and weight gain ≥5%. §$P < 0.05$ compared with A1C <7% and weight change <5%.

groups. After adjustment for baseline costs and demographic and clinical characteristics, patients who maintained weight within 5% of baseline experienced a reduction in costs of about $400 regardless of whether mean A1C was above or below 7%. In contrast, patients who gained >5% of their baseline weight and had a mean A1C ≥7% had an increase in costs of $1,473 (significantly different from both weight maintenance groups, $P < 0.001$). Those who gained >5% of their baseline weight but had a mean A1C <7% had a more modest increase in costs ($387) that was not statistically significantly different from the other groups.

The full models of change in medical costs by resource and in total are shown in Table 3. A diagnosis of heart failure was the single largest contributor to an increase in total costs ($3,705, $P < 0.001$),

Table 2—Baseline weight and weight change, mean A1C, and baseline costs

Baseline characteristic	Total sample	A1C <7%, weight change <5%	A1C <7%, weight gain ≥5%	A1C ≥7%, weight change <5%	A1C ≥7%, weight gain ≥5%
Baseline weight (pounds)	217 (53)	210 (52)	205 (51)	221 (53)	221 (55)
Baseline BMI (kg/m^2)	34.1 (7.3)	33.3 (7.3)	32.7 (7.0)	34.6 (7.2)	35.2 (7.7)
Weight change (pounds)	3.2 (12)	−1.4 (7.4)	19.8 (11.4)	−1.0 (6.2)	23.0 (14)
Weight change (%)	1.5% (5.6%)	−0.7% (2.6%)	9.9% (5.9%)	−0.5% (2.7%)	10.5% (6.4%)
Mean A1C	7.5% (1.1%)	6.5% (0.3%)	6.4% (0.4%)	8.1% (1.0%)	8.2% (1.0%)
Mean # of A1C values	8.0 (2.5)	7.1 (2.2)	7.1 (2.3)	8.5 (2.6)	9.1 (2.8)
Baseline costs					
Inpatient	$2,643	$3,133	$4,116	$2,041	$2,994
Outpatient	$3,924	$3,787	$4,724	$3,681	$4,794
Pharmacy	$2,266	$1,999	$2,949	$2,214	$2,764
Total	$8,833	$8,919	$11,789	$7,936	$10,552

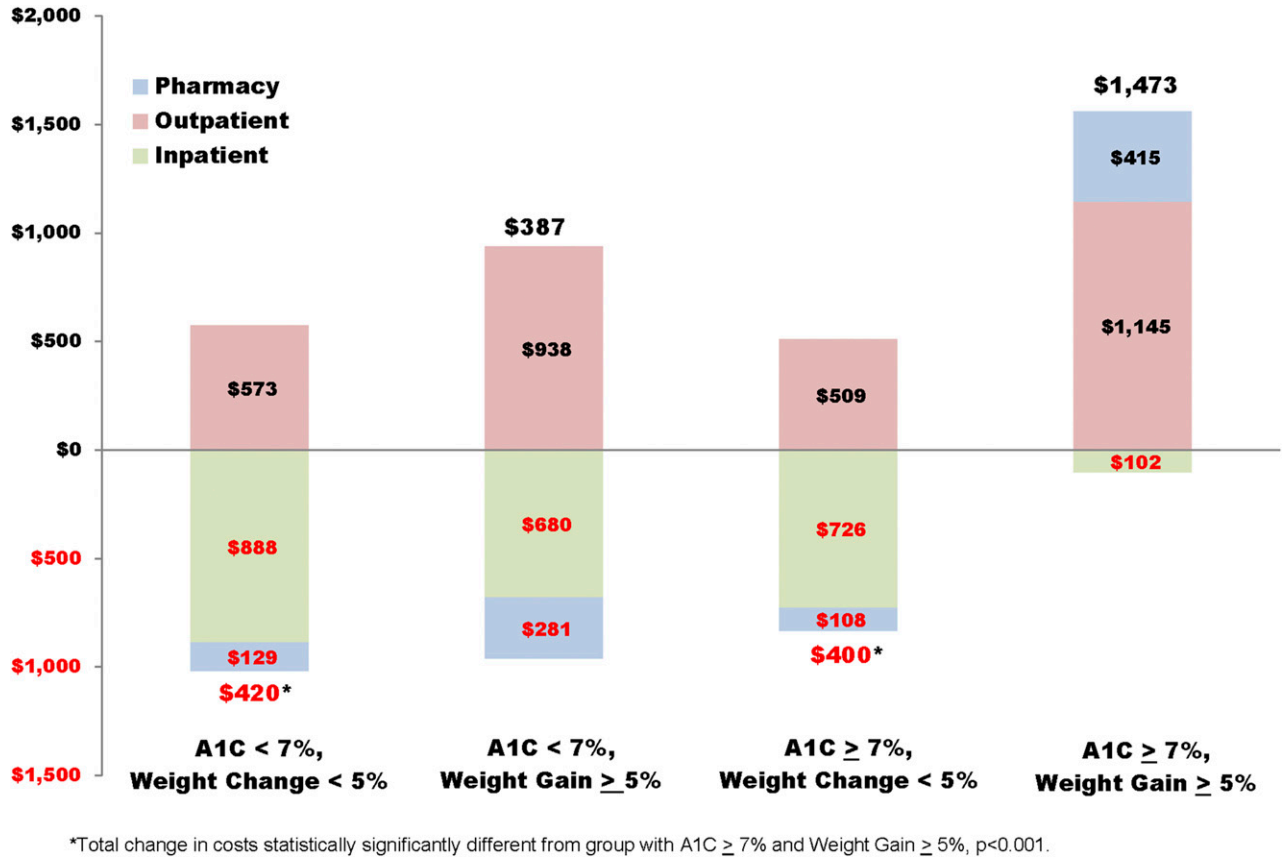

Figure 1—Change in annual medical costs calculated as costs in 2010 minus costs in 2013, by resource and in total. Data labels in red indicate lower costs in 2013 compared with 2010. Data labels in black indicate higher costs in 2013 vs. 2010.

followed by use of insulin ($2,670, $P <$ 0.001), depression ($2,489, $P <$ 0.001), and neuropathy ($2,392, $P <$ 0.001).

CONCLUSIONS

In this observational cohort study of 8,154 patients with T2D who did not lose >5% of their baseline weight over 4 years, we found that the majority of patients (81%) were able to maintain their weight within 5% of baseline, but a minority (38%) managed to maintain mean A1C of <7%. From a cost standpoint, however, weight gain was far more important than glycemic control. The combination of weight gain ≥5% and A1C ≥7% was a particularly expensive combination that resulted in a 14% increase in medical costs that were already ~20% higher at baseline than patients who did not gain weight. In fact, patients who maintained their baseline weight had an ~5% decline in baseline costs.

Our findings are consistent with previous studies evaluating shorter periods of weight change and medical costs. Bell et al. (10) reported that weight gain of >3% over 1–6 months was associated with a significant increase in 1-year all-cause costs of $3,400 compared with a weight-neutral cohort. In another study, patients who increased weight by a minimum of 1 pound over 6 months had mean total health care costs that were $1,719 higher than patients who did not gain weight (11). The current study is unique in its analysis of long-term weight maintenance and associated costs.

We limited our analyses to patients who maintained weight within 5 pounds of baseline, or gained weight of 5% or more over 4 years because substantial weight loss is often a marker for catastrophic illness. We could not attribute weight loss to any specific lifestyle intervention or even personal attempts to intentionally lose weight, including use of weight loss medications; use was extremely low and therefore impossible to assess. It is possible that pharmaceutically induced weight loss could provide economic benefit. In the Look AHEAD trial, the Diabetes Support and Education (control) group experienced mean weight loss of <1% over 4 years (6), remarkably similar to the percentage weight change of our two groups that did not gain weight. Thus, we believe our cohort represents a "usual care" group of typical patients living with diabetes. Although the Look AHEAD trial reported cost savings over 10 years among those who received the ILI compared with the control group, the difference in costs did not appear until about year 5 (12), despite significant differences in weight loss at year 4 (6). This suggests that our exclusion of patients with intentional weight loss does not impact the costs we report for patients who maintained their baseline weight. We also note that weight gain in an already heavy individual may be a marker of diabetes severity and therefore may not be a modifiable risk factor. We controlled for diabetes duration, use of antihyperglycemics, and other presence of comorbidities to account for differential disease burden.

Our other analysis variable, mean A1C <7% vs. ≥7% over 4 years, had little impact on change in costs. However, mean

Table 3—Parameter estimates (independent dollar contribution to change in costs) and *P* values from fully adjusted multivariable models of change in annual costs

	Inpatient costs		Outpatient costs		Pharmacy costs		Total costs	
	Parameter estimate	*P* value	Parameter estimate	*P* value	Parameter estimate	*P* value	Parameter estimate	*P* value
A1C <7%, weight change <5% (ref)	–	–	–	–	–	–	–	–
A1C ≥7%, weight change <5%	162	0.550	−64	0.661	22	0.823	20	0.958
A1C <7%, gained >5%	208	0.650	365	0.141	−152	0.358	807	0.216
A1C ≥7%, gained >5%	**786**	**0.044**	**572**	**0.007**	**544**	**<0.001**	**1,894**	**<0.001**
Baseline costs	**−1**	**<0.001**	**−1**	**<0.001**	**0**	**<0.001**	**−1**	**<0.001**
Age	13	0.304	7	0.301	**−13**	**0.006**	−15	0.416
Duration of diabetes	23	0.390	**54**	**<0.001**	**−23**	**0.020**	28	0.463
Male	−3	0.990	**–425**	**<0.001**	77	0.366	−436	0.193
African American	**−1,377**	**0.009**	−54	0.851	−185	0.331	**−1,571**	**0.037**
Hispanic	−882	0.053	−147	0.550	−135	0.408	**−1,363**	**0.035**
Smoker	**1,176**	**0.002**	198	0.338	199	0.149	**1,942**	**<0.001**
Baseline LDL cholesterol	4	0.363	−2	0.455	−1	0.666	−1	0.926
Baseline SBP	**23**	**0.010**	−6	0.215	4	0.258	**26**	**0.039**
Baseline weight	1	0.625	1	0.275	1	0.142	4	0.268
Ischemic heart disease	479	0.115	**521**	**0.002**	−189	0.084	**888**	**0.040**
Heart failure	**2,195**	**<0.001**	**840**	**<0.001**	297	0.058	**3,705**	**<0.001**
Depression	**699**	**0.004**	**732**	**<0.001**	**185**	**0.036**	**2,489**	**<0.001**
Retinopathy	497	0.137	148	0.410	−204	0.088	175	0.712
Neuropathy	323	0.208	**1,135**	**<0.001**	**233**	**0.012**	**2,392**	**<0.001**
Hypoglycemia	−3,035	0.381	1,918	0.304	844	0.497	826	0.867
CKD	47	0.874	**340**	**0.033**	−7	0.945	567	0.178
ACE/ARB use	−191	0.510	56	0.718	−59	0.568	−209	0.611
β-Blocker use	**720**	**0.005**	**355**	**0.010**	−3	0.974	**1,282**	**<0.001**
Insulin use	**1,072**	**<0.001**	310	0.071	**271**	**0.019**	**2,670**	**<0.001**
Statin use	−351	0.224	**−587**	**<0.001**	**−272**	**0.009**	**−966**	**0.018**
Metformin use	**−503**	**0.047**	8	0.951	−91	0.316	−566	0.115
Sulfonylurea use	416	0.100	−21	0.879	**233**	**0.011**	**745**	**0.038**
Other oral antidiabetic use	415	0.491	54	0.869	**−430**	**0.047**	655	0.445
Other injectable antidiabetic use	−2,229	0.610	2,543	0.281	2,084	0.185	4,457	0.473

Bold font indicates statistical significance, $P < 0.05$.

A1C in the ≥7% groups was 8.2%, which may not be high enough to affect costs. Furthermore, cardiovascular disease (CVD) is a major driver of medical costs in diabetes (13). Because the relationship between A1C and CVD risk is reportedly U-shaped (14,15), an association between costs and A1C would likely be mitigated by excess CVD-related costs at both the high and low ends of the A1C distribution.

Aside from weight gain, heart failure was associated with substantially greater health care costs in our study. Heart failure generates a substantial number of hospitalizations, and rehospitalization is common, making it an enormously expensive condition (16,17). Because heart failure is more common among people with diabetes of all ages (18), preventing heart failure could significantly impact the cost of diabetes.

Use of insulin was another variable that was a large contributor to change in health care costs. This may be due in part to the fact that medical costs are greater later in life (19,20), and in our setting, patients typically begin insulin use at ~65 years of age after ~9 years of living with diabetes (21). These patients are likely to have many more comorbidities, each of which would make an independent contribution to costs. Although we controlled for a number of diabetes-related comorbidities, insulin use may be a marker for greater overall disease burden, representing a multiplicative effect on costs of age, diabetes duration, and complications. However, insulin, as well as sulfonylureas, is known to cause weight gain (22–25), a fact that may have confounded the associations between weight gain and costs. We controlled for use of specific classes of antihyperglycemic agents in our analyses. Disentangling the association between disease burden, body weight, medical costs, and medications is beyond the scope of our report.

Strengths of our study include the ability to capture complete medical utilization, and therefore costs, and to do so for a sample size sufficient to compare medical costs despite high variability. However, the integrated health system in which the study was conducted uses information technology, including practice alerts, that may not be available in smaller group or independent practices. As an observational study, we cannot conclude that cost differences were caused by weight change or glycemic control. We relied on A1C and weight measurements that were taken in the course of clinical care rather than at regular protocol-defined intervals.

Although we included a large number of covariates, residual confounding could remain. As discussed above, we limited our analyses to patients who did not lose >5% of their baseline body weight, and we required participants to be continuously enrolled in the health plan for 4 years. Whether these factors impact generalizability is unknown.

In summary, we found that patients who gained at least 5% of their baseline body weight over 4 years had higher medical costs at baseline. Of those, patients who did not maintain A1C <7% over 4 years experienced an increase in medical costs of 14%, whereas those who did maintain good glycemic control had a mean cost increase of 3.3%. However, patients who maintained weight within 5% of baseline had costs that were ~5% lower than baseline. Avoidance of weight gain may result in meaningful cost reductions.

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