

Switching from Multiple Daily Injections to CSII Pump Therapy: Insulin Expenditures in Type 2 Diabetes

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As the prevalence of diabetes rises in the United States, managing the costs associated with treating the disease and its complications is a vexing issue for government and commercial payers. According to 2011 data from the CDC, 25.8 million Americans have diabetes, representing 8.3% of the population. The total cost of diagnosed diabetes reached \$174 billion in the United States in 2007: \$116 billion was direct medical expenditures, and \$58 billion was indirect costs tied to disability, work loss, and premature mortality.¹

As 90% to 95% of diagnosed cases of diabetes are type 2 diabetes mellitus (T2DM), stakeholders are seeking solutions to its increasing incidence.² Complementing pharmacologic and traditional insulin treatments is the continuous subcutaneous insulin infusion (CSII) device, commonly known as the insulin pump. CSII pump therapy is an option for the T2DM population, but it has largely been the domain of the type 1 diabetes mellitus (T1DM) population.³⁻⁵ In a 2008 article, Pickup et al noted that limited work has been conducted on the use of CSII pump therapy in patients with T2DM and that more clinical studies are needed.⁶ More recently, a 2010 consensus statement from the American Association of Clinical Endocrinologists made a similar observation.⁷ Research by Reznik and Cohen stated that use of the CSII pump is a fairly recent therapy for T2DM as compared with T1DM, and few countries allow for reimbursement in patients with T2DM.⁸

The relatively small use of CSII pump therapy among patients with T2DM may reflect the fact that the effectiveness of the pump, compared with multiple daily injections (MDIs) of insulin, has not been well established for this population.⁹ Few randomized clinical trials or systematic reviews have been conducted comparing the clinical efficacy of the 2 treatments in this population, and results are inconclusive.¹⁰ While some studies have found CSII pump therapy superior to MDI therapy in terms of reducing glycated hemoglobin¹¹ and providing better metabolic control,¹² others have reported no statistically significant differences between the two.¹³⁻¹⁵

ABSTRACT

Objectives

To identify variations in expenditures and utilization of insulin and other antidiabetes medications by comparing patients with type 2 diabetes mellitus using continuous subcutaneous insulin infusion (CSII) pump therapy versus multiple daily injection (MDI) therapy.

Study Design

Truven Health Analytics MarketScan Commercial Claims and Encounters Database and Medicare Supplemental Database for 2006 to 2010 were used in a difference-in-differences approach that took advantage of variation in the timing of the switch from MDI therapy to CSII pump therapy.

Methods

Continuous users of MDI therapy throughout the study period were compared with those who switched to the CSII pump therapy during this period. Specifications included: coefficient estimates from cross-sectional ordinary least squares (OLS) regressions with: 1) no additional controls, 2) controls for patient demographics and comorbidities, and 3) patient fixed effects. Propensity score matching at baseline mitigated concerns regarding patient selection bias.

Results

While insulin expenditures rose during the study period, switching to CSII pump therapy led to sizable reductions in insulin expenditures. This reduction in insulin expenditures due to switching varied between \$657 (standard error [SE] \$126; $P < .01$) and \$1011 (SE \$250.60; $P < .01$) per year.

Conclusions

This study demonstrated a significant reduction in insulin expenditures among MDI patients who switched to CSII pump therapy at various times throughout the study period.

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One obstacle to greater CSII pump therapy in patients with T2DM is the challenging set of Medicare guidelines for reimbursement. Specifically, Medicare beneficiaries must demonstrate substantial evidence of insulin deficiency, such as a documented fasting C-peptide level $\leq 110\%$ (or $\leq 200\%$ if renal insufficiency is present) at the lower limit of normal of the laboratory's measurement method with a concurrent fasting blood glucose ≤ 225 mg/dL, 6 months of MDI therapy, and other clinical factors.^{16,17} An estimated 26.9% of the Medicare population has diagnosed or undiagnosed T2DM¹; yet, possibly due to reimbursement restrictions, insulin pump usage in this T2DM cohort remains limited.

As payers continually seek to contain costs related to the growing T2DM population, finding ways to reduce spending could be meaningful. One way may be by lowering the insulin deficiency requirement. Only a few studies have examined this possibility. However, in a study of 56 insulin-naïve T2DM patients, Edelman et al found that for those who switched to CSII pump therapy, after 16 weeks, the mean and SD total daily insulin dose was 95 ± 59 U and there was significant improvement in glycemic control.¹⁸ Wolff-McDonagh et al performed an evaluation of insulin use in 15 adults with poorly controlled T2DM.¹⁹ Before CSII pump therapy initiation, patients had been using MDI therapy for at least 1 year with or without oral glucose-lowering and/or sensitizing agents. Once CSII pump therapy use began, a significant reduction in basal insulin use was found at 1 year. Over a hypothetical, projected 4-year period, subjects requiring more than 150 units daily realized a savings of \$12,274 in insulin and CSII pump therapy costs compared with MDI therapy. However, subjects in the moderate and low-use insulin group had an increase in costs.

The primary objective of this study was to identify the impact of switching from MDI therapy to CSII pump therapy on insulin and other antidiabetes medication expenditures in individuals with T2DM. As this study assesses changes in expenditures linked to utilization of insulin and other antidiabetes medications, any differences among the cohorts could have reimbursement implications for payers.

METHODS

Data Source

This study analyzed data from the US MarketScan Commercial Claims and Encounters Database and Medicare Supplemental Database from Truven Health Analyt-

Take-Away Points

The primary objective of this study was to identify the impact of switching from multiple daily injections (MDIs) to continuous subcutaneous insulin infusion (CSII) pump therapy on insulin and other antidiabetic medication expenditures in individuals with type 2 diabetes mellitus.

- This study demonstrated a significant reduction in insulin expenditures among MDI patients who switched to CSII pump therapy throughout the study period.
- While insulin expenditures rose during the study period (as shown in Figure 1), switching to CSII pump therapy led to sizable reductions in insulin expenditures.
- This reduction in insulin expenditures due to switching varied between \$657 (SE \$126; $P < .01$) and \$1011 (SE \$250.60; $P < .01$) per year.

ics (New York, New York).²⁰ The MarketScan databases are constructed of de-identified patient-level records from 170 million unique patients, collected since 1995 from health plans, employers, and state Medicaid agencies. In particular, they include data from 300 contributing employers and 25 contributing health plans, and have been used in a variety of diabetes-related studies.²¹⁻²³

A protocol describing the study objectives, criteria for patient selection, data elements of interest, and statistical methods were submitted to the New England Institutional Review Board (NEIRB) and were deemed exempt from review (NEIRB #12-348).

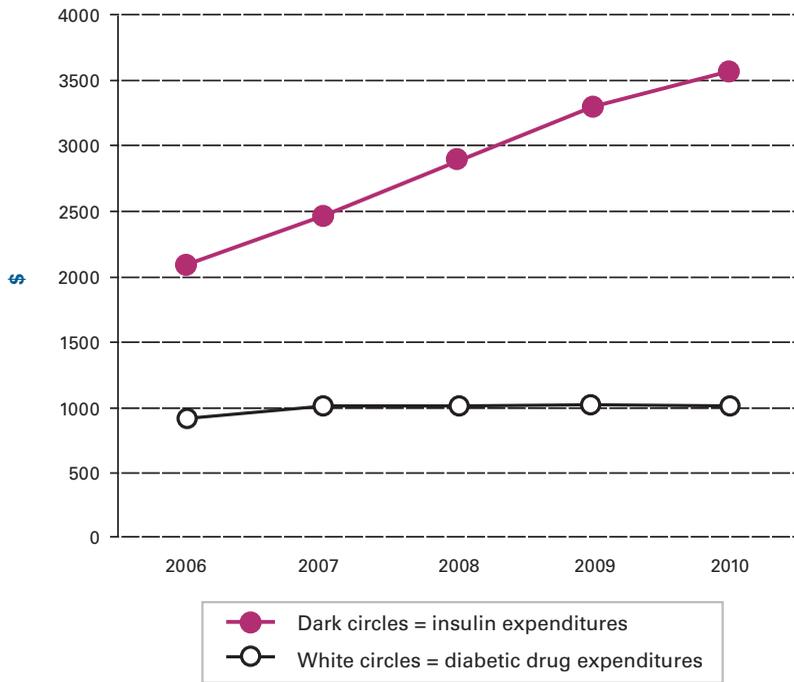
Study Population

Patient-level data were extracted from the 2 MarketScan databases, covering the period between January 2006 and December 2010. There were 3,825,352 patients with commercial insurance and 1,215,141 patients with Medicare who were identified by an algorithm as T1DM or T2DM patients. To be included in the analysis, T2DM patients had to be continuously enrolled in a health plan and have prescription drug coverage for the entire sample period.

For each year, patients were classified as either MDI therapy ($n = 6372$) or CSII pump therapy ($n = 181$) patients. MDI patients were those having a record of 2 or more rapid- or short-acting insulin prescriptions as well as 2 or more long-acting insulin prescriptions in each year. CSII pump therapy patients were identified as having the following Healthcare Common Procedure Coding System codes: E0784 (durable pump) or A9274 (disposable pump), along with CSII pump therapy supplies A4230, A4232, and A4231. Patients with continuous insulin pump use for the entire time period were excluded ($n = 1455$). In this analysis, expenditures include insulin and antidiabetic medications only; insulin supplies are not included in expenditures.

Once the mode of treatment was identified, patients were divided into cohorts based on their mode of insulin

■ **Figure 1.** Mean Annual Expenditures on Insulin and Antidiabetes Medications: 2006 to 2010



Insulin expenditures are shown to rise consistently each year over the 5-year study period, whereas antidiabetes medication expenditures essentially remain flat.

use. Of particular interest were patients classified as users of MDI therapy for all 5 sample years (*continuous MDI patients*) as well as patients classified as users of MDI in 2006 who switched to CSII pump therapy by 2010 (*switchers*). The switchers group included 4 switching patterns based on the year in which the switch occurred. The final sample contained 4490 commercially insured and 2063 Medicare patients classified as T2DM patients with continuous health plan and prescription coverage for all 5 years. Of these 6553 patients, 6372 were continuous MDI patients and 181 were switchers. No switchers were available among Medicare patients since the Medicare coverage policy effectively restricts pump access for T2DM patients.

Statistical Analysis

To study the impact of switching from MDI to CSII pump therapy on insulin expenditures and other antidiabetes medications expenditures, the following regression model specification was used:

$$\Delta EXP_{it} = \beta_1 + \beta_2 \times Switch_i + \beta_3 \times Year_t + \beta_4 \times [Switch_i \times Pump_{it}] + g \times X_{it} + e_{it}$$

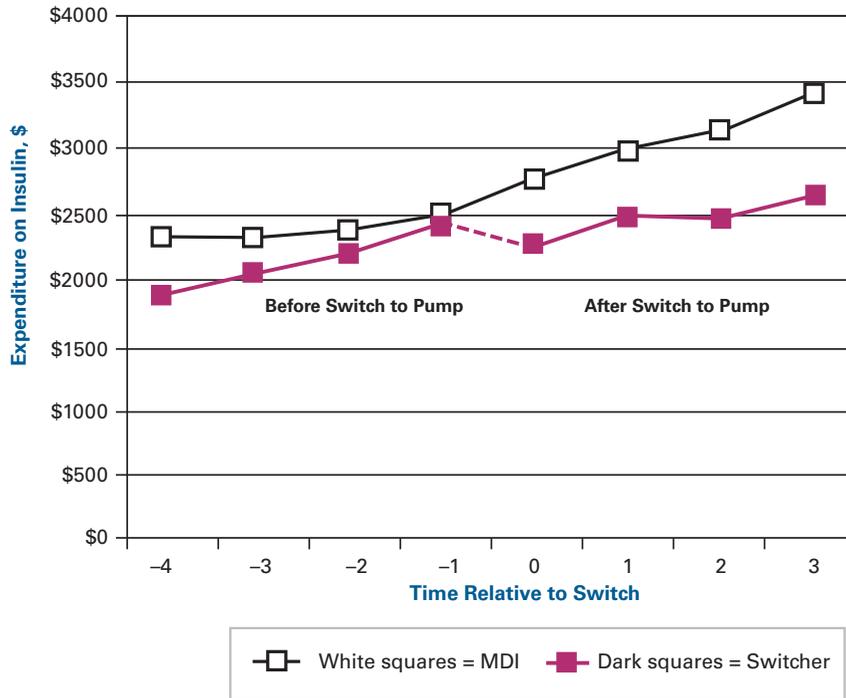
This specification, frequently used in economics and health services research, compares T2DM patients in the year following the switch with both themselves prior to the switch and with patients who stayed on MDIs in that

year (the control group). Since patients switched in different years, the *control* group consisted of patients who never switched (continuous MDI patients) and patients who switched in subsequent years (switchers).

The dependent variable, EXP_{it} , corresponds to 2 distinct dependent variables: the change in annual insulin-related expenditures and the change in annual expenditures for other antidiabetes medications. $Switch_i$ is an indicator variable equal to 1 for patients in the switchers category and 0 for nonswitchers. This indicator is designed to capture differences between continuous MDI patients and switchers even in periods when both groups are on MDIs. Since the effect of switching is identified from its timing, it is crucial to control for overall trends affecting all patients in the sample. $Year_t$ captures such longitudinal effects. $[Switch_i \times Pump_{it}]$ is an interaction-based time indicator for patient i (equal to 1 in the year post switching and 0 in pre-switching periods). This indicator is designed to capture differences between the pre and post periods for each individual switcher. This interaction of timing and treatment captures the effect of switching from MDI therapy to CSII pump therapy on patient drug expenditures. A negative and significant b_4 would imply a reduction in drug expenditures associated with switching from MDI therapy to CSII pump therapy.

Propensity score matching was used to select a subset of patients for analysis that would be as similar as possible

■ **Figure 2.** Insulin Expenditure (by year) Relative to the Year of Switch



MDI indicates multiple daily injection.

Figure shows that MDI patients who ultimately switch to CSII pump therapy (dark squares) and those who stay on MDIs (white squares) have similar expenditure trends (left side of figure). Those patients who switch to CSII pump therapy diverge from the trend with relatively stable expenditures 3 years after the switch to CSII pump therapy.

to each other. Since not all 181 patients who switched were similar in terms of clinical covariates to those who did not switch, we were able to match 177 patients using propensity scores generated from a multivariable logistic regression with stepwise selection. Propensity scores from the same multivariable logistic regression without stepwise selection were used to match an additional 151 pairs. In this regression, all variables remained in the model regardless of their significance level.

RESULTS

Clinical and demographic characteristics of the study population at baseline are summarized for continuous MDI patients and switchers (Table 1). This comparison was performed for the entire sample (n = 6553) and the 2 matched samples, 151 pairs in Table 1 and 177 pairs in eAppendix Table A (available at www.ajmc.com). In the entire population, continuous MDI patients were more likely than switchers to be older (aged 56.2 vs 43.1 years), female (43% vs 41%), and have certain comorbidities, such as heart failure (7% vs 2%) and hypertension (38% vs 20%). Differences in comorbid conditions between Medicare

patients and younger patients mostly disappeared in the matched samples. Antidiabetes medication expenditures for patients with T2DM between 2006 and 2010 were fairly flat, but the average patient experienced a 70% increase in insulin expenditures during the same period (Figure 1).

The data were analyzed using 4 different empirical strategies, and 4 corresponding samples, using the difference-in-differences approach. Switchers were compared with all continuous MDI patients (first panel of Table 2). A second comparison was made in which switchers were compared with those who changed to CSII pump therapy in subsequent years (second panel of Table 2). Two subsets were analyzed, 1 based on propensity score matching without stepwise selection such that all variables remained in the model regardless of their significance level, the result of which appears in the third panel of Table 2. Stepwise selection was used to generate propensity scores that were then used to match the second subset (eAppendix tables). Similar to the first 2 samples, in the matched analysis, the control group consisted of switchers who changed to CSII pump therapy in subsequent years.

For each of the 4 samples, results are reported from 3 different specifications. In Table 2, columns marked [1] re-

Table 1. Summary Statistics for Patient Demographics in Baseline Period (2006)

	5-Year MDI					
	All Patients		Aged 65 years and over n = 2,063	Aged under 65 years n = 4,490	All Patients Matched	
	5-Year MDI n = 6,372	Switcher n = 181			5-Year MDI n = 151	Switcher n = 151
Demographics						
Mean age, y (SD)	56.2 (13.7)	43.1 (11.4)	71.7 (5.7)	48.8 (9.5)	44.3 (11.9)	43.9 (11.0)
Male	57%	59%	56%	58%	60%	59%
Female	43%	41%	44%	42%	40%	41%
Clinical characteristics						
Skin cancer	2.6%	1.1%	5.5%	1.2%	2.0%	1.3%
Colon cancer	0.3%	0.0%	6.3%	0.2%	0.0%	0.0%
Lung cancer	0.3%	0.0%	0.4%	0.2%	0.0%	0.0%
GERD	3.6%	1.7%	4.2%	3.2%	0.0%	2.0%
Gastritis	2.4%	1.1%	3.6%	1.8%	0.0%	6.6%
Gastric ulcer	0.3%	0.0%	0.4%	0.2%	0.0%	0.0%
Diverticulitis	0.6%	0.0%	0.9%	0.4%	0.0%	0.0%
Kidney stones	1.8%	1.1%	1.4%	1.9%	0.7%	0.0%
Depression	5.2%	9.4%	2.4%	6.7%	6.6%	5.3%
Heart failure	6.8%	2.2%	12.5%	4.1%	0.7%	2.0%
Myocardial infarction	1.9%	0.6%	2.9%	14.0%	0.0%	0.7%
Stroke	1.4%	0.0%	2.9%	0.7%	0.0%	0.0%
Hypertension	37.8%	19.9%	42.9%	34.7%	21.2%	19.9%
Irritable bowel syndrome	0.7%	0.6%	0.5%	0.8%	0.7%	0.7%
Osteoarthritis	11.8%	6.1%	19.1%	8.3%	7.3%	6.0%
Asthma	4.0%	2.8%	3.6%	4.6%	0.7%	0.7%
COPD	5.0%	1.7%	2.7%	9.8%	1.3%	1.3%
Insulin expenditures, \$ (SD)	2089 (1270)	1832 (962)	1965 (1160)	2148 (1316)	1936 (1082)	1821 (977)
Antidiabetes medication expenditures, \$ (SD)	934 (946)	979 (1008)	892 (870)	956 (982)	895 (1201)	862 (908)

COPD indicates chronic obstructive pulmonary disease; GERD, gastroesophageal reflux disease; MDI, multiple dose injection.

port the first specification, the coefficient estimates from cross-sectional ordinary least squares (OLS) regressions with no additional controls. The columns marked [2] report the second specification, the coefficient estimates from a saturated cross-sectional OLS regression with controls for patient demographics and comorbidities. The columns marked [3] reports the third specification, the coefficient estimates from OLS regressions with patient-fixed effects to control for time-invariant individual heterogeneity.

Expenditures on insulin. Figure 2 shows the trend in expenditures on insulin before and after the switch to CSII pump therapy for the matched group of MDI-only and MDI-to-CSII pump therapy switchers. The x-axis reflects years of switch to CSII pump therapy, with negative

numbers reflecting years prior to switch, positive numbers reflecting years post switch, and zero being the year of the switch (represented by dashed line). Since MDI-only patients do not have a “switch year,” the corresponding calendar years for each matched pair was used, such that each pair of matched patients span the same interval on the x-axis. The expenditures on insulin in the MDI-only group are similar in trend and magnitude to those shown in Figure 1; however, insulin expenditures for switchers drop in the switch year and exhibit a slower increase in the post switch period relative to MDI-only patients. Switching from MDI therapy to CSII pump therapy led to sizable reductions in insulin expenditures among the 3 groups (Table 2).

Table 2. Multivariate Results: Expenditures on Insulin and Antidiabetes Medications

Variables	Switcher and Continuous						Switcher and Matched		
	MDI Patients: Change in Insulin Expenditure (\$)			Switcher Patients Only: Change in Insulin Expenditure (\$)			Continuous MDI Patients: Change in Insulin Expenditure (\$)		
	[1]	[2]	[3]	[1]	[2]	[3]	[1]	[2]	[3]
Switch × Pump	-500.6^a	-533.8^a	-656.8^a	-493.3^a	-526.1^a	-1,011^a	-557.4^a	-609.9^a	-868.6^a
	[79.42]	[79.55]	[126.0]	[122.7]	[126.7]	[250.6]	[92.52]	[92.91]	[150.9]
Year	-36.33 ^a	-38.12 ^a	-32.06 ^a	-93.06	-132.4 ^b	84.08	-51.46 ^a	-49.89	-4.334
	[5.915]	[5.950]	[6.310]	[61.81]	[65.66]	[131.6]	[30.63]	[30.95]	[38.97]
R²	0.003	0.009	0.198	0.058	0.147	0.455	0.04	0.102	0.325
Demographics & Comorbidities		✓	✓		✓	✓		✓	✓
Fixed Effects			✓			✓			✓

Variables	Switcher and Continuous						Switcher and Matched		
	MDI Patients: Change in Antidiabetes Medication Expenditure (\$)			Switcher Patients Only: Change in Antidiabetes Medication Expenditure (\$)			Continuous MDI Patients: Change in Antidiabetes Medication Expenditure (\$)		
	[1]	[2]	[3]	[1]	[2]	[3]	[1]	[2]	[3]
Switch × Pump	-195.0^c	-227.4^b	-38.76	-295	-243.6	-89.65	-36.93	-37.62	270.9
	[105.4]	[105.9]	[185.1]	[194.0]	[209.5]	[433.4]	[140.5]	[151.2]	[270.6]
Year	-17.92 ^b	-17.53 ^b	-56.64 ^a	48.25	12.22	-94.57	-49.45	-39.82	-101.4
	[7.538]	[7.582]	[8.810]	[94.15]	[104.8]	[213.3]	[48.10]	[51.38]	[71.62]
R²	0.001	0.008	0.281	0.018	0.304	0.745	0.004	0.109	0.471
Demographics & Comorbidities		✓	✓		✓	✓		✓	✓
Fixed Effects			✓			✓			✓

MDI indicates multiple daily injections.
^aP < 0.01.
^bP < 0.05.
^cP < 0.1.
Columns marked [1] report the coefficient estimates from cross-sectional ordinary least squares (OLS) regressions with no additional controls. Columns marked [2] report the coefficient estimates from a saturated cross-sectional OLS regression with controls for patient demographics and comorbidities. Columns marked [3] report the coefficient estimates from OLS regressions with patient fixed-effects to control for time-invariant individual heterogeneity. Switcher and matched continuous MDI patients cohort included the same variables in the regression without stepwise selection, so that all variables remained in the model regardless of significance. This match yielded 151 pairs with propensity scores matched to at least .001 (matching to .0001 in this case brought the yield down to 126). SE in brackets. Bold "Switch × Pump" values indicate the key result. A "✓" notes which model specification is shown.

Expenditures on antidiabetes medications. The results of comparison of expenditures on antidiabetes medications are shown in Table 2. Across the 3 specifications, the coefficient estimates, while almost always are negative, did not consistently reach statistical significance.

DISCUSSION

This study used claims data to demonstrate a significant reduction in insulin expenditures among MDI patients who switched to CSII pump therapy at various times over

the study period. This result is particularly meaningful as expenditures for insulin continued to rise over the study's 5-year timeline. In the entire population, the mean annual expenditures for insulin among 5-year continuous MDI patients were \$2089 (SD \$1270) compared with \$1832 (SD \$962) for patients who switched from MDI therapy to CSII pump therapy.

To determine if the CSII pump therapy offered any cost advantage, rigorous data analyses were conducted using 4 samples: switcher patients only, switchers and continuous MDI patients, and 2 propensity matched cohorts. For

each of the 4 samples, results were reported from 3 different specifications. The effects for all 12 specifications on a reduction in insulin expenditures were statistically significant at the 1% level.

Between the 2 matched cohorts, findings were similar in terms of lower insulin expenditures across all 3 specifications. In the OLS specification (column [1]), reductions in insulin expenditures for the Switch \times Pump variable were \$557 in matched and \$505 in the stepwise match (eAppendix Table B). In the model that included demographics and comorbidities, reductions of \$610 in insulin expenditures were found in the matched sample.

The volume of literature addressing the impact of the insulin pump on expenditures reduction is modest, but some do suggest that the greatest cost impact of CSII pump therapy is tied to high insulin use. In a study by David et al, the value of CSII pump therapy increased with the amount of insulin required.²⁴ That analysis showed that for those taking ≥ 169 units of insulin daily (90th percentile), savings were realized with CSII pump therapy use due to lower insulin and antidiabetes medication use. Similarly, in the Wolff-McDonagh study of insulin use in patients with poorly controlled T2DM, the cohort requiring more than 150 units daily, the highest users, would realize a savings projected over 4 years of \$12,274 on insulin and CSII pump therapy costs as compared with MDI therapy, whereas subjects in the moderate and low-use insulin group would see their costs increase.¹⁹

This study adds to the literature by providing a detailed expenditure comparison among sizeable groups of patients with T2DM. Although 97% of the sample was continuous MDI users, the study construct allowed for more than 150 matched pairs of MDI users and switchers in 2 cohorts in which time variation was considered. Also, a control group was created in which switchers were compared with themselves prior to the switch and to those who remained on MDIs. The effect of switching was identified from its timing, and the Switch \times Pump variable captured differences between the pre and post periods for each individual switcher. The lowering of insulin expenditures as demonstrated by this variable indicates that switching to CSII pump therapy has real impact regardless of when the switch takes place.

The main concern with comparing continuous MDI patients and switchers was that patients who did not switch over the sample period might be clinically different than those switching to CSII pump therapy. Some of these differences may be time-invariant and observable at the baseline period, such as patient demographics and comorbid conditions, while other differences may be time-

invariant and unobservable to the researcher, and some may vary over time as switchers may experience disease progression different from that of continuous MDI patients. To address these concerns, a variety of empirical strategies were used, including propensity score matching on clinical dimensions in the baseline period and patient-fixed effects specification.

Using this 5-year panel data source has significant advantages over using pure cross section data or repeated cross-sections, as these data allow for more reliable estimates with less restrictive assumptions and, most importantly, test more refined behavioral models. Specifically, the strength of the panel data assists in focusing on dynamic switching behavior as the source of variation in expenditures on insulin and other antidiabetes medications. Matching patients on demographic and clinical profiles provides a way of adjusting for selection bias in observational studies. This analysis matched patients with similar clinical characteristics at baseline; therefore, the matched cohorts with similar clinical profiles provided a more homogeneous basis from which to infer the effect of switching.

Limitations

This study had several limitations. Switching may not be random; unobserved changes in patient comorbidities, physician practice patterns, physician or hospital quality, or other factors could explain switching from MDI therapy to CSII pump therapy. The use of claims data did not allow for analysis of pre and post switching glycated hemoglobin data, duration of diabetes, or body mass index. Also, it was not possible to directly distinguish basal from bolus insulin and their ratio. Given the current coverage policy, there were no Medicare patients in the switchers group.

Similar potential vulnerabilities apply to identification of switchers from MDI therapy to CSII pump therapy use, but the rigorous selection criteria used to identify patients with T2DM were designed to control for this bias. While any remaining anomalies could reduce the precision of the estimates, their impact on the magnitude of the estimates should be minimal provided they were distributed randomly across the entire study population.

CONCLUSION

Using 4 different empirical strategies and corresponding samples, this study demonstrated a significant reduction in insulin expenditures among MDI patients with T2DM who switched to CSII pump therapy throughout the study

period. Similar reductions in expenditures were not found for other antidiabetes medications. This analysis suggests that CSII pump therapy in patients with T2DM may help reduce the utilization of insulin, as evidenced by the reduction in insulin expenditures among patients with T2DM who switch from MDI therapy to CSII pump therapy.

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Authorship Information: Concept and design (GD, MG, CG, JS, SE); acquisition of data (MG, CG); analysis and interpretation of the data (GD, CG, JS, SE); drafting of the manuscript (GD, CG, JS, SE); critical revision of the manuscript for important intellectual content (GD, CG, JS, SE); statistical analysis (GD); obtaining funding (MG); administrative, technical, or logistic support (MG); supervision (MG).

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eAppendix Table A. Summary Statistics for Patient Demographics in Baseline Period for Second Matched Cohort

	All Patients Matched	
	5 Year MDI	Switcher
	n = 177	n = 177
Demographics		
Mean age (Std. Dev.)	43.4 (11.1)	43.4 (11.1)
Male	54%	60%
Female	46%	40%
Clinical characteristics		
Skin cancer	1.1%	1.1%
Colon cancer	0.0%	0.0%
Lung cancer	0.0%	0.0%
GERD	1.1%	1.7%
Gastritis	2.3%	1.1%
Gastric ulcer	0.0%	0.0%
Diverticulitis	0.0%	0.0%
Kidney stones	0.0%	1.1%
Depression	7.9%	7.9%
Heart failure	1.1%	2.3%
Myocardial infarction	1.1%	0.6%
Stroke	0.6%	0.0%
Hypertension	20.3%	20.3%
Irritable bowel syndrome	0.6%	0.6%
Osteoarthritis	6.22%	6.22%
Asthma	3.90%	2.80%
COPD	1.13%	1.69%
Insulin expenditures (Std. Dev.)	2,025 (1,378)	1,844 (968)
Antidiabetes drug expenditures (Std. Dev.)	763 (921)	984 (1,019)

COPD indicates chronic obstructive pulmonary disease; GERD, gastroesophageal reflux disease; MDI, multiple dose injection.

eAppendix Table B. Multivariate Results for Expenditures on Diabetic Drugs and Insulin Cost for Stepwise Matched Cohort

VARIABLES	Switcher and Matched Continuous MDI Patients (Stepwise Match)					
	Change in Antidiabetes Medication Expenditure (\$)			Change in Insulin Cost (\$)		
	[1]	[2]	[3]	[1]	[2]	[3]
Switch × Pump	– 235.9^b [116.5]	–196.7 [124.1]	4.361 [209.8]	–505.1^a [89.49]	–545.3^a [90.71]	–815.5^a [152.0]
Year	5.734 [38.51]	13.63 [39.69]	3.693 [50.88]	–29.88 [29.56]	–28.08 [30.14]	27.98 [39.12]
R ²	0.011	0.111	0.485	0.029	0.058	0.258
Demographics & Comorbidities		✓	✓		✓	✓
Fixed Effects			✓			✓

MDI indicates multiple dose injection.

^a*P* < .01.

^b*P* < .05.

Stepwise match included age, gender, and all comorbid variables in a logistic regression with stepwise selection (entry and exit *P* values of .10) to generate propensity scores. This match yielded 177 pairs (of 181 possible switchers) with propensity scores matched to at least .0001.

Columns labeled [1] report the coefficient estimates from cross-sectional ordinary least squares (OLS) regressions with no additional controls.

Columns labeled [2] report the coefficient estimates from a saturated cross-sectional OLS regression with controls for patient demographics and comorbidities.

Columns labeled [3] report the coefficient estimates from OLS regressions with patient fixed-effects to control for time-invariant individual heterogeneity.

SE in brackets.

Bold “Switch × Pump” values indicate the key result.

A “✓” notes which model specification is shown.