Medical Expenditures Associated With Diabetes Among Privately Insured U.S. Youth in 2007

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OBJECTIVE—To estimate, among privately insured youth in the U.S., medical expenditures associated with diabetes and the difference in medical expenditures between individuals with insulin-treated diabetes mellitus (ITDM) and with non-ITDM (NITDM).

RESEARCH DESIGN AND METHODS—Using the 2007 MarketScan commercial claims and encounter database, we analyzed data for 49,356 youth (aged ≤19 years) who were continuously enrolled in fee-for-service health plans. Youth with diabetes (cases) were identified from inpatient, outpatient, and pharmaceutical drug claims. Each case was matched with five controls (without diabetes) by age (±2 years), sex, census region, and urban versus rural residence. We used regression models to estimate medical expenditures in total and by component (inpatient, outpatient, and medication).

RESULTS—The predicted mean annual total per-person medical expenditures were $9,061 for youth with diabetes and $1,468 for those without, an excess of $7,593 for those with diabetes; of which, 43% was for prescription drugs. The predicted mean annual total expenditures were $9,333 for ITDM youth and $5,683 for NITDM youth, respectively, an excess of $3,650 for those with ITDM diabetes, of which 59% was for prescription drugs.

CONCLUSIONS—The excess medical expenditures associated with diabetes, ITDM in particular, among youth are substantial. Our estimates of excess expenditures can be used to assess the economic burden of diabetes overall and by diabetes treatment mode. Our estimated excess expenditure for NITDM may be used for evaluating the economic efficiency of interventions aimed at preventing type 2 diabetes in U.S. youth.

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Diabetes is one of the most prevalent chronic diseases among U.S. youth. In 2001, an estimated 1.8 per 1,000 individuals aged <20 years in the U.S. had diabetes (1). An increase in the incidence of type 1 diabetes, the most common form of diabetes in the young, has been reported in Europe and the U.S. (2,3). Furthermore, with increasing obesity rates in the young, type 2 diabetes, once considered an adult disorder, now occurs in adolescents, especially in minority populations (4).

Besides its adverse effects on an individual's health and quality-of-life, diabetes also imposes a staggering financial burden on the health care system. Numerous studies have estimated the medical costs of diabetes among adults or for the entire U.S. diabetic population (5–7). A few studies have also estimated the direct medical expenditures of diabetes among children and adolescents in European countries (8,9), as has one study in the U.S. (10). However, the U.S. study was based on a small sample of hospital patients.

Estimates of the direct medical costs attributed to diabetes among youth are essential to assess the financial burden of the disease and plan for future health care needs. In addition, because type 2 diabetes is potentially preventable (11), estimates of medical expenditures are needed to assess the full economic effect of programs aimed to prevent type 2 diabetes in youth.

Our study's objectives were to estimate *1*) the excess medical expenditures associated with diabetes, and *2*) the differences in medical expenditures for individuals with insulin-treated diabetes mellitus (ITDM) and non-ITDM (NITDM).

RESEARCH DESIGN AND METHODS

Data source

We analyzed data from the MarketScan Commercial Claims and Encounters Database (CCE) (MarketScan Database; Thompson Medstat, Ann Arbor, MI). Widely used to estimate the health expenditures of various illnesses—including diabetes among adults (6,12,13)—the CCE database annually compiles fully adjudicated and paid health insurance claims from more than 100 large employers and health plans. The claims come from several million individuals, including employees, their spouses, and dependents, who are covered by employer-sponsored private health insurance (14). The CCE includes patient-level data on inpatient, outpatient, and drug claims. All three can be linked through encrypted and unique enrollee identifiers (15).

Enrollee health plans are divided into fee-for-service (FFS) plans and fully or partially capitated plans. FFS plans include preferred provider organization (PPO) plans, exclusive provider organization plans, point-of-service plans, consumer-directed health plans, and indemnity plans. Fully or partially capitated plans include health maintenance organizations and point-of-service plans with capitation (15).

Study population

We restricted our analyses to 3,366,791 youth aged ≤19 years who were continuously enrolled in FFS health plans with prescription drug coverage from 1 January through 30 December 2007 (Fig. 1). We limited our analysis to individuals enrolled in FFS plans because their insurance claims represent actual payment for the services,

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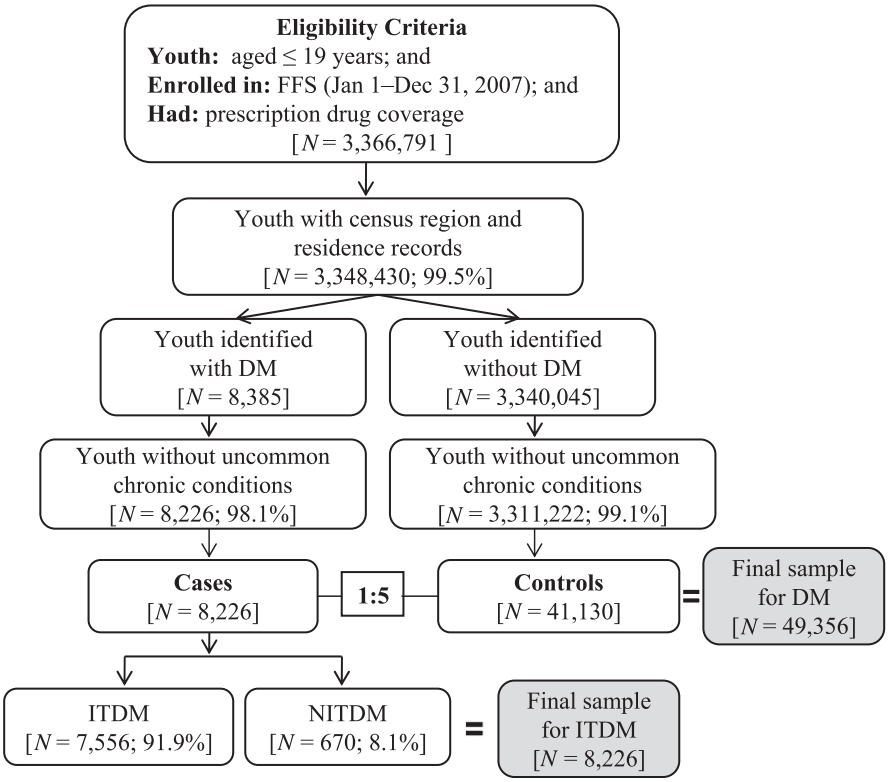

Figure 1—*Selection of study sample. DM, diabetes mellitus.*

whereas payment records in capitated plans often only reflect encounters (15). We excluded 0.5% of the youth because of missing records for census region (northeast, midwest, south, and west) or residence (rural vs. urban).

We identified an individual as having diabetes if the record showed *1*) at least two outpatient encounters that were at least 30 days apart, coded for diabetes as a primary or secondary diagnosis (16), or *2*) at least one inpatient admission coded for diabetes as a primary or secondary diagnosis, and *3*) at least one pharmaceutical drug claim filled for insulin or oral hypoglycemic agents, or both. The requirement for at least two outpatient encounters protected against inclusion of youth who were misdiagnosed at the first encounter and were later determined not to have diabetes (17). To indicate diabetes, we used the ICD-9-CM codes 250.00–250.93, 357.2, 362.0–362.02, and 366.41 in outpatient and inpatient claims (12,18) and the Therapeutic Class Codes of 172, 173, and 174 in drug claims. We identified 8,226 youth who had diabetes.

Because the presence of other chronic conditions could substantially influence health care expenditures, the model should account for these conditions. Among the 8,226 youth with diabetes, 4.6% had asthma, the most commonly reported chronic disease in youth, and we included data on these individuals. A total of 159 youth (<2%) had one or more of the following uncommon chronic conditions: congenital heart failure, hemiplegia, lymphoma, Down syndrome, autism, leukemia, congenital heart defects, and liver diseases. Because the number of observations for each of the uncommon chronic conditions was too small to produce a reliable estimated coefficient for that condition, we excluded data on these youth. Remaining in our sample were 8,226 youth with diabetes.

We used bootstrapping to estimate the SEs of predicted and excess mean expenditures. Bootstrapping the entire database of diabetes and without diabetic youth exceeded our computation capacity, so we used a case-control design to reduce the sample size. Each youth with diabetes (case subject) was directly matched one-to-one with five youth without diabetes (control subject), on the multiple variables: age (±2 years), sex, U.S. census region, and residence. For each case, control subjects were selected from a randomized subset of combination of matching variables without replacements. Each case-control matched set was identified as a unique cluster. Our analytic sample comprised 49,356 youth.

Data limitations precluded us from conclusively distinguishing type 1 and type 2 diabetes. We distinguished youth with diabetes by treatment mode (ITDM vs. NITDM). Those who had at least one prescription filled for insulin (Therapeutic Class Code of 172) were identified as having ITDM. By use of this method, we identified 7,556 diabetic youth who had ITDM. In contrast, remaining in our sample were 670 individuals with diabetes but without insulin prescriptions. These youth were considered to have NITDM.

Statistical analysis

We used *t* tests to assess differences in the means of sample characteristics and compared youth with diabetes and those without diabetes and youth with ITDM and those with NITDM.

Estimation of expenditures: comparing youth with and without diabetes. We used a two-part model (19,20) to estimate the excess medical expenditures associated with diabetes in total and by component: outpatient, inpatient, and drug expenditures. The two-part model was used because a large proportion of the nondiabetic youth had no medical expenditures, and among those who did, the medical expenditures were right-skewed (19).

In the first part of the two-part model, we estimated the probability that an individual would have a positive medical expenditure. We used a generalized estimating equation (GEE) with logit link and binomial distribution and accounted for the dependence within matched sets (clusters). In the second part, we estimated the level of expenditures among youth who had positive expenditures. Here, we used a GEE model with log link and γ distribution, again accounting for the dependence within the cluster. Because health plan type (PPO versus non-PPO) and the presence of asthma were not used in the case-control matching, we included both as covariates. The main exposure was a diagnosis of diabetes.

We calculated model-based predicted marginal medical expenditures by diabetes status. To estimate the predicted marginal medical expenditures associated with diabetes, the diabetes indicator variable was first set to 1 for all individuals and then again to 0 for all individuals. All other variables remained at their original

values. For both indicator sets, individual predicted values were calculated, and the predictions were averaged over all observations. The difference in the predicted mean expenditure between youth with and without diabetes was the excess-predicted expenditure associated with diabetes. We used 1,000 nonparametric bootstrap replications of clusters to calculate the SE of predicted and excess expenditures (21).

Estimation of expenditures: comparing youth by diabetes treatment mode. To estimate medical expenditures in total and by component associated with each of the two diabetes treatment modes (ITDM and NITDM), we used a two-part model to estimate the inpatient expenditures and only the second part of the two-part model to estimate the total, outpatient, and drug expenditures.

Estimation of the first part of the two-part model was not needed for estimating the total, outpatient, and drug expenditures because all youth with diabetes had positive expenditures for those components. In estimating the inpatient expenditures, similar to the model used for estimating expenditures for youth with or without diabetes in the first part, we used a logistic regression model to estimate the probability of a youth having a nonzero inpatient expenditure.

In the second part, we used a generalized linear model with log link and a γ distribution to estimate the expenditures among youth who had positive inpatient expenditures. In estimating the total, outpatient, and drug expenditures, we used a generalized linear model with log link and γ distribution among all youth with diabetes.

For all models, we included age, sex, U.S. census region, residence, health plan type (PPO vs. non-PPO), and the presence of asthma as covariates. The predicted mean medical expenditures for youth with ITDM and with NITDM and predicted excess expenditure associated with ITDM were estimated in the same way as for youth with diabetes versus without diabetes. We used 1,000 nonparametric bootstrap replications to calculate the SE of predicted and excess expenditures.

Using the model-based predicted mean annual expenditures, we calculated ratios of per capita annual medical expenditures in total and by component: expenditures for youth with diabetes divided by expenditures for those without diabetes, and expenditures for youth with ITDM divided by expenditures for those with NITDM.

All analyses were performed using STATA 10.1 software (StataCorp, College Station, TX). We considered results significant at $P < 0.05$.

RESULTS

Characteristics of the study population

Of the 49,356 youth, 15.2% had no medical expenditures, 18.0% had no outpatient expenditures, 95.9% had no inpatient expenditures, and 35.1% had no prescription drug expenses. Of those identified with diabetes, 91.9% were taking insulin, alone or combined with oral hypoglycemic agents, and 84.0% had not been hospitalized during the year.

The characteristics of the study population by diabetes status and treatment mode are summarized in Table 1. Among youth with diabetes, those with ITDM were significantly younger (12.7 vs. 14.8 years; $P < 0.05$) and less likely to be girls (47.7% vs. 67.5%; $P < 0.05$). Compared with youth with NITDM, those with ITDM were more likely to be from the west (13.3% vs. 16.7%; $P < 0.05$) and less likely to be from the south (52.1% vs. 42.8%; $P < 0.05$). The percentage of youth with asthma was significantly greater among those with NITDM than among those with ITDM (9.7% vs. 4.1%; $P < 0.05$).

Medical expenditures associated with diabetes

The predicted mean annual total medical expenditure was $9,061 for youth with diabetes and $1,468 for youth without diabetes, an excess of $7,593 among diabetic youth ($P < 0.05$; Table 2). The outpatient, inpatient, and drug expenditures were all significantly greater for diabetic youth than those without ($P < 0.05$). Regardless of diabetes status, outpatient expenditures (43 and 66% for those with or without diabetes, respectively) accounted for the largest share of the total expenditures, followed by prescription drugs (39 and 19%, respectively) and inpatient expenditures (18 and 15%, respectively). However, excess expenditures on prescription drugs accounted for the largest proportion of the excess total expenditures ($3,228; 43%), followed by excess expenditures on outpatient care ($2,970; 39%) and inpatient care ($1,406; 19%). For youth with diabetes, the predicted mean expenditures were $811 on diabetes supplies and $1,688 on medications (data not shown).

Medical expenditures for youth with ITDM and NITDM

The predicted mean total medical expenditure was $9,333 for youth with ITDM and $5,683 for those with NITDM, an excess of $3,650 ($P < 0.05$) for youth with ITDM (Table 2). The three component expenditures were all significantly greater for youth with ITDM than for youth with NITDM ($P < 0.05$). Regardless of treatment mode, the outpatient expenditures comprised the largest share of total expenditure (43 and 58%, respectively, for ITDM and NITDM youth), followed by prescription drugs (39 and 26%, respectively) and inpatient expenditures (18 and 17%, respectively). However, of the predicted excess total medical expenditure for youth with ITDM, predicted

Table 1—*Characteristics of study population by diabetes status and diabetes treatment mode*

	Cases	Controls	Diabetes treatment mode	
Variables	With diabetes	Without diabetes	ITDM	NITDM
n	8,226	41,130	7,556	670
Mean age, years	12.87 (0.05)	12.78 (0.02)	12.70* (0.05)	14.84* (0.12)
Sex: girls, %	49.28 (0.55)	49.28 (0.25)	47.67* (0.57)	67.46* (1.81)
Census region, %				
Midwest	30.46 (0.51)	30.46 (0.23)	30.72* (0.53)	27.61 (1.73)
South	43.54 (0.55)	43.54 (0.24)	42.79* (0.57)	52.09* (1.93)
West	16.42 (0.41)	16.42(0.18)	16.70*(0.43)	13.28*(1.31)
Urban residence, %	80.18 (0.44)	80.18 (0.20)	80.40 (0.46)	77.76 (1.61)
Non-PPO health plan, %	24.53 (0.47)	24.86 (0.21)	24.60 (0.50)	23.73 (1.64)
Asthma, %	4.55 (0.23)	4.36 (0.10)	4.09* (0.23)	9.70* (1.14)

Data are presented as mean (SE). *Statistically significant ($P < 0.05$) comparison of means between groups (youth with diabetes versus without diabetes, or ITDM versus NITDM).

Table 2—*Predicted mean annual medical expenditures (U.S. $) in 2007 for U.S. youth by diabetes status and treatment mode**

Diabetes status and treatment mode	Expenditure models			
	Total	Outpatient	Inpatient	Drug
Diabetes vs. without diabetes†				
With diabetes	9,061 (135)	3,939 (59)	1,628 (99)	3,505 (45)
Without diabetes	1,468 (29)	969 (21)	222 (16)	277 (6)
Excess: diabetes	7,593 (138)	2,970 (63)	1,406 (89)	3,228 (45)
Ratio	6.2	4.1	7.3	12.7
ITDM vs. NITDM‡				
ITDM	9,333 (132)	3,997 (57)	1,688 (89)	3,629 (44)
NITDM	5,683 (487)	3,300 (287)	976 (244)	1,492 (150)
Excess: ITDM	3,650 (509)	697 (295)	712 (256)	2,137 (157)
Ratio	1.6	1.2	1.7	2.4

*All excess expenditures are statistically significant ($P < 0.05$). Values in parentheses are bootstrap SE using 1,000 replications. Because of separate estimations of component models and rounding of values, the sum of predicted medical expenditures across the components do not necessarily sum to total expenditures. †Covariates in all models are: health plan (PPO vs. non-PPO) and presence of asthma. ‡Covariates in all models are: age, sex, census region, residence, health plan, and presence of asthma. Reference groups were as follows: boys, northeast region, rural residence, PPO health plan, and without asthma.

excess expenditures on prescription drugs accounted for the largest proportion ($2,137; 59%), followed by expenditures on inpatient ($712; 20%) and outpatient care ($697; 19%). The expenditure on diabetes supplies was $863 for ITDM and $82 for NITDM youth, and the expenditure for diabetes medication was $1,826 for ITDM and $228 for NITDM youth (data not shown).

CONCLUSIONS—The medical expenditures associated with diabetes in general and by diabetes treatment mode among U.S. youth are less known. Using administrative claims data from >3 million youth, we estimated that the excess mean total medical expenditure associated with diabetes among youth was $7,593 per year. Estimated mean annual total medical expenditures were $9,333 for ITDM youth and $5,683 for NITDM youth, an excess of $3,650 for those with ITDM. Our ITDM group included all youth with type 1 diabetes but probably also some with type 2. Youth with NITDM most likely have type 2 diabetes (4,22–25), therefore, our estimated medical expenditures for NITDM youth likely represent a lower bound for youth with type 2 diabetes receiving medications in the U.S.

We found that excess expenditures on prescription drugs contributed the most to the total excess medical expenditures associated with diabetes in youth. This contrasts with findings for the entire diabetic population, where hospitalization or inpatient expenditures contributed the most (5,8). However, our results of health care spending across components are consistent with the estimates for a closely comparable age group (≤14 years) in Sweden (8). Our relatively large expenditure on prescription drugs was mainly driven by a greater proportion of diabetic youth who required treatment with insulin, thus their greater expenses on insulin and diabetes supplies. This is consistent with findings in Sweden (8).

We found that among diabetic youth and regardless of treatment mode, the drug expenses are mainly driven by the expenses for medications. The expenses for diabetic supplies are likely underestimated because not all health insurance plans cover the costs of the diabetes supplies.

Our estimated level of per capita total medical expenditure attributable to diabetes of $7,593 is greater than a corresponding per capita estimate of $6,649 for the entire U.S. diabetic population in 2007 (5). Our estimated total medical expenditures ratio of those with diabetes compared with those without diabetes is also larger than that estimated for adults, which ranges from 2 to 5 (5,7). However, our estimated total medical expenditures ratio is lower than in the previously mentioned Swedish study (8). Our results are generally consistent with what has been previously reported: excess expenditure is higher in younger age groups, and the expenditures ratio between persons with or without diabetes tends to decrease with age (7,8). The higher excess expenditure in younger age groups may have been driven by costs for specialist visits, medications, and diabetes testing supplies (8). The higher medical expenditures ratio for youth may also have been driven by relatively lower medical expenditures for youth without diabetes than that for older populations without diabetes.

Our study has several limitations. First, our medical claim data are from enrollees in employer-sponsored health plans and without uncommon chronic conditions. The study population did not include individuals without health insurance coverage, those on Medicaid, and those identified with uncommon chronic conditions. Hence, the results may not be generalized to the U.S. youth population. Our sample only represents those enrolled in FFS plans and, therefore, may not reflect medical expenditures for those enrolled in capitated plans.

Second, the accuracy of our estimates is subject to diagnostic coding errors; however, the MarketScan database undergoes rigorous data quality checks, and less than 1% of all claims could not be verified (14).

Last, we could not estimate the excess expenditures by diabetes type because the MarketScan database does not provide sufficient information to differentiate type 1 from type 2 diabetes. We were also unable to correctly identify diabetic youth who were treated with diet and exercise only; therefore, our sample does not include this population.

Our study showed that the excess medical expenditures associated with diabetes in youth were substantial. Our estimates associated with diabetes (both ITDM and NITDM) can be used to estimate the economic burden of diabetes in youth in the U.S. The estimates of expenditure for NITDM can also serve as a lower bound to evaluate the benefits of type 2 diabetes prevention programs. Future research on estimation of costs among youth with diabetes not on medications would provide additional insights into the expenditure associated with diabetes among youth.

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