Type 2 Diabetes: Incremental Medical Care Costs During the 8 Years Preceding Diagnosis

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OBJECTIVE — To describe and analyze medical care costs for the 8 years preceding a diagnosis of type 2 diabetes.

RESEARCH DESIGN AND METHODS — From electronic records of a large group-model health maintenance organization (HMO), we ascertained the medical care costs preceding diagnosis for all members with type 2 diabetes who were newly diagnosed between 1988 and 1995. To isolate incremental costs (costs caused by the future diagnosis of diabetes), we subtracted the costs of individually age- and sex-matched HMO members without impending diabetes from the costs of members who were destined to receive this diagnosis. We also compared these prediagnosis costs with the first 3 years of postdiagnosis costs.

RESULTS — An economic burden from impending diabetes is apparent for at least 8 years before diagnosis, beginning with costs for outpatient and pharmacy services. Diabetes-associated incremental costs (costs of type 2 diabetic patients minus matched costs of nondiabetic patients) averaged $1,205 per type 2 diabetic patient per year during the first eight prediagnostic years, including $1,913 each year for the 3 years preceding diagnosis. In the year immediately preceding diagnosis, incremental costs were equivalent to those observed in the second and third years after diagnosis.

CONCLUSIONS — Incremental costs of diabetes begin at least 8 years before diagnosis and grow at an accelerating rate as diagnosis approaches and immediately after diagnosis. These incremental costs span the full range of medical services. Furthermore, the majority of these costs are for conditions not normally associated with diabetes or its complications.

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Type 2 diabetes is typically asymptomatic early in its course. Consequently, diabetes may exist and its complications may occur before diabetes is recognized (1). Type 2 diabetes also arises within a larger matrix of risk factors for cardiovascular and other diseases, including hypertension, dyslipidemia, and obesity. Some people eventually found to have diabetes will experience ill health and undergo therapy to control risk factors before the recognition of their diabetes.

Many authors have published point estimates of the annual cost of diabetes (2–13). We recently described the time pattern of incremental costs over the first 8 years after diagnosis in a population with known dates of recognition of type 2 diabetes (14). No studies have yet examined the time pattern of costs leading up to diagnosis. Our earlier study indicated that the first year after diagnosis was more expensive than any of the next 5 years. In all 8 years after diagnosis, however, incremental costs were considerably higher for type 2 diabetic patients than for otherwise similar nondiabetic patients. Do these higher incremental costs continue a pattern established before diagnosis, or do they arise from postdiagnostic preventive services and complications? To address this question, we analyzed 8 years of data before, and 3 years of data after, the diagnosis of type 2 diabetes in a large stable representative HMO population.

RESEARCH DESIGN AND METHODS

Research setting

The subjects of this study were members of a long-established nonprofit group-model HMO, Kaiser Permanente Northwest Division (KPNW). KPNW provides comprehensive prepaid coverage to ~20% of the Portland, Oregon, population (an average of 400,000 people during the period of this study). Subscribers resemble the area population as a whole (15).

All members of KPNW have access to the complete range of medically necessary clinical services. The organization maintains electronic databases containing information on inpatient admissions, pharmacy dispenses, outpatient visits, laboratory tests, and outside claims and referrals. All of these databases are linked through the unique health record number that is given to each member at the time of his or her first enrollment in the health plan.

Analysis population

Subjects were identified with diabetes by the following: *1*) purchasing any medications used to treat diabetes from a KPNW pharmacy; *2*) making purchases of blood sugar testing supplies from a KPNW pharmacy, with confirmation of the diagnosis by an endocrinologist; *3*) enrolling in diabetes education classes or receiving services from medical office diabetes educators; or *4*) leaving an acute care hospital with a discharge diagnosis indicating diabetes. At the request of patients or their clinicians, members who do not have diabetes may be removed from the registry after review and approval by an endocrinologist.

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Abbreviations: CHR, Kaiser Permanente Center for Health Research; HMO, health maintenance organization; KPNW, Kaiser Permanente Northwest Division; NWP, Northwest Permanente Medical Group.
A table elsewhere in this issue shows conventional and Système International (SI) units and conversion factors for many substances.

Table 1—*Number of pairs of subjects by cohort and year before diagnosis*

	Years since diagnosis										
Cohort	−8	−7	−6	−5	−4	−3	−2	−1	1	2	3
1988								1,025	924	851	791
1989							858	978	873	796	729
1990						872	973	1,128	978	903	833
1991					796	870	967	1,114	968	896	819
1992				778	858	933	1,038	1,143	1,007	917	841
1993			798	871	950	1,056	1,157	1,281	1,160	1,052	995
1994		756	826	911	1,010	1,088	1,184	1,318	1,171	1,096	1,036
1995	869	962	1,055	1,155	1,228	1,306	1,386	1,534	1,369	1,272	1,206
Total	869	1,718	2,679	3,715	4,842	6,125	7,563	9,521	8,450	7,783	7,250

Data are *n*.

Our analysis population consisted of all registrants who were newly diagnosed with type 2 diabetes between 1 January1988 and 31 December1995. To identify newly diagnosed patients, we selected all registrants who had 12 full months of health plan eligibility before entry into the registry (on average, study participants had >13 years of eligibility before diagnosis). We defined these individuals as incident cases and assumed that their registry entry date was their date of diagnosis. We limited the study population to patients with probable type 2 diabetes by excluding patients diagnosed before 45 years of age if they had purchased insulin sooner than 2 years after diagnosis.

For each study subject, we calculated duration of disease, starting from the day of diagnosis and counting backward or forward in 365-day intervals. Therefore, in this report, "year −1" refers not to a calendar year but to the first 365 days preceding diagnosis; "year −2" refers to the second 365-day period preceding diagnosis, and so on. "Year 1" refers to the first 365-day period after diagnosis. Registrants were included in analyses only for a diagnosis year during which they belonged to the HMO for a full 12 months. Thus, if a registrant joined the health plan 2.5 years before diagnosis, we analyzed data from diagnosis years −1 and −2 but not for his or her first half year of membership.

Using this method, a person diagnosed in 1995 could contribute up to 8 years of prediagnosis data and up to 3 years of postdiagnosis data, a person diagnosed in 1994 could contribute up to 7 prediagnosis years and 3 postdiagnosis years, and so on, back to patients diagnosed in 1988, who could contribute only 1 year of prediagnosis data (Table 1). Sample sizes are therefore larger for the years closer to diagnosis.

For each study subject in each diagnosis year, we selected a KPNW member without any evidence of diabetes to serve as a control subject. Control subjects were individually matched with study subjects on year of birth, sex, and duration of health plan membership. The matching algorithm assured random assignment within these strata.

Utilization data and costs

For this report, we retrieved the electronic utilization records for the following: *1*) acute hospital admissions to KPNW and non-KPNW hospitals; *2*) ambulatory visits to primary care, specialty care, and emergency clinicians; *3*) pharmaceuticals and supplies dispensed by KPNW outpatient pharmacies; and *4*) ambulatory services provided by non-KPNW individuals and institutions. We did not attempt to ascertain the use of medical services for which the health plan did not pay. We excluded from this report all costs that occurred on the day of diagnosis as well as the costs of hospitalizations during which diabetes was diagnosed.

We recently described our determination of unit costs in detail (16). The Kaiser Permanente Center for Health Research (CHR) has developed a system for assigning costs to inpatient services provided in hospitals owned by KPNW based on the Kaiser Permanente's annual Medicare Cost Report (17). For outpatient visits to KPNW clinicians, we used cost coefficients obtained by an internal 1993 study that estimated aggregate visit costs based on salaries by specialty, clinician type (MD, physician assistant, or nurse practitioner), minutes-per-visit by specialty, overhead costs per specialty, and per-visit cost of laboratory services per specialty. To calculate visit costs, we multiplied the relevant coefficient by the total number of visits per specialty department and provider type. This approach somewhat underestimates ambulatory visit costs for diabetic patients, who tend to require more physician time per visit and more laboratory testing than the average patient.

Of inpatient and outpatient costs, ~30% were for services purchased by the Northwest Permanente Medical Group (NWP) from community providers. We based the cost of these services on the amount Kaiser Permanente actually paid to vendors and combined these costs with the costs of internally produced care. We were unable to assess costs not authorized or paid by NWP (out-of-plan costs).

We report costs of drugs and related supplies at their approximate local retail cost at the time of purchase, adjusted to 1998 prices using the pharmaceutical component of the U.S. Medical Price Index (18). Drug cost data are continuously maintained and updated in the KPNW pharmacy-dispensing database for each dosage and the form of each compound. All inpatient and outpatient costs are also reported in 1998 dollars, using cost coefficients derived from 1993 cost data, adjusted for inflation using the U.S. Medical Price Index (18).

Our economic perspective was that of the medical insurer; we ignored costs other than those incurred as the result of covered medical services utilization. To calculate net incremental costs for patients who would receive a diabetes diagnosis in the future, we subtracted the costs experienced by matched control patients from the costs experienced by patients who in the future would be diagnosed with type 2 diabetes: thus, costs of type 2 diabetic patients minus costs of nondiabetic patients equals incremental costs of patients with types 2 dia-

Table 2—*Annual cost per person, by type and year before diagnosis (U.S. dollars 1998)*

	Inpatient costs			Outpatient costs		
Year	Total	Incremental	Control	Total	Incremental	Control
−8	$1,164 ± 186	−$9* ± 280	$1,173 ± 205	$1,131 ± 56	$324 ± 66	$807 ± 37
−7	$1,735 ± 226	$751 ± 246	$984 ± 104	$1,146 ± 40	$339 ± 49	$807 ± 28
−6	$1,330 ± 101	$124* ± 155	$1,206 ± 122	$1,090 ± 29	$277 ± 34	$813 ± 20
−5	$1,738 ± 104	$206* ± 154	$1,532 ± 114	$1,202 ± 26	$355 ± 31	$847 ± 18
−4	$1,901 ± 113	$438 ± 160	$1,463 ± 116	$1,21 ± 22	$317 ± 29	$902 ± 20
−3	$2,177 ± 115	$755 ± 142	$1,422 ± 83	$1,308 ± 22	$403 ± 27	$905 ± 16
−2	$2,330 ± 101	$849 ± 121	$1,481 ± 69	$1,378 ± 20	$451 ± 24	$927 ± 14
−1	$3,572 ± 128	$1,997 ± 143	$1,575 ± 65	$1,604 ± 22	$652 ± 25	$952 ± 14
Total	$15,947	$5,111	$10,836	$10,078	$3,118	$6,960
Average	$1,993	$639	$1,355	$1,260	$390	$870
SD	$747	$636	$209	$168	$119	$58
	Pharmacy costs			Total costs		
−8	$375 ± 35	$156 ± 38	$219 ± 15	$2,670 ± 227	$471* ± 321	$2,199 ± 224
−7	$385 ± 34	$170 ± 35	$215 ± 10	$3,266 ± 245	$1,260 ± 270	$2,006 ± 121
−6	$391 ± 21	$155 ± 22	$236 ± 8	$2,811 ± 120	$556 ± 175	$2,255 ± 131
−5	$403 ± 13	$150 ± 14	$253 ± 8	$3,343 ± 120	$711 ± 171	$2,632 ± 124
−4	$430 ± 16	$151 ± 17	$279 ± 8	$3,550 ± 125	$906 ± 175	$2,644 ± 124
−3	$472 ± 16	$184 ± 18	$288 ± 7	$3,957 ± 127	$1,342 ± 156	$2,615 ± 92
−2	$511 ± 15	$203 ± 16	$308 ± 6	$4,21 ± 114	$1,503 ± 136	$2,716 ± 77
−1	$568 ± 14	$245 ± 15	$323 ± 6	$5,744 ± 141	$2,894 ± 157	$2,850 ± 73
Total	$3,535	$1,414	$2,121	$29,560	$9,643	$19,917
Average	$442	$177	$265	$3,695	$1,205	$2,490
SD	$69	$33	$41	$979	$780	$296

Data are means ± SEM unless otherwise indicated. *Incremental costs are not statistically significant from zero, $P < 0.05$.

betes. This case-control method allowed us to estimate all the incremental costs of care, not just the costs known to be related to diabetes or its predictors, and to eliminate costs that would have occurred in the absence of future diabetes. It also provided a further control against secular changes in processes of care, prices, and productivity.

RESULTS — Our study population averaged 60.1 years of age in the year before diagnosis. The group providing data for the eighth prediagnostic year averaged 54.8 years of age at the beginning of their eighth prediagnosis year. In year −1, 47.2% of the cohort were women compared with 50.6% in year −8.

For at least 7 years before the diagnosis of diabetes, the total direct medical care costs incurred by patients who were destined to receive the diagnosis of type 2 diabetes significantly exceeded costs for age-, sex-, and eligibility-matched patients without a future diabetes diagnosis. Over the 8-year prediagnosis period, incremental costs averaged $1,205 (± $780) per person per year in 1998 dollars (Table 2). Incremental costs accelerated in the last 3 years before diagnosis. In the final year before diagnosis, incremental costs were nearly double those of the previous year. Control costs grew much more gradually during the study period. Therefore, year-to-year changes in the total costs of patients who were to be diagnosed with diabetes, which more than doubled between years −8 and −1, were mostly driven by the incremental portion of these costs.

Inpatient costs accounted for the majority (53%) of the total incremental costs over the prediagnosis years but showed more year-to-year variation than outpatient and pharmaceutical costs. However, for all 8 years before diagnosis, annual incremental outpatient and pharmacy costs were significantly greater for patients who were to receive a diabetes diagnosis. Incremental outpatient costs doubled over the prediagnosis study period, and incremental pharmacy costs grew 57% (from $156 to $245/year).

Outpatient costs for patients who would receive a diabetes diagnosis grew gradually over years −8 through −2, but jumped 16%, from $1,378 to $1,604/person in the year just before diagnosis. In the control group, outpatient costs remained relatively flat over the entire 8 years, growing by a total of just 18%.

The most costly single class of drugs was antihypertensive agents, with an incremental increase of $48/person per year (Table 3). Together with the other major classes used in cardiovascular treatment and prevention—antihyperlipidemics ($10/person per year, incremental) and other cardiovascular drugs ($20/person per year, incremental)—antihypertensive costs grew steadily during the study period. However, all other incremental drug costs (costs for drugs other than those used to treat hypertension, hyperlipidemia, and cardiovascular disease) accounted for more incremental expenditures than any other class ($896/person per year; 54% of all incremental drug costs).

In Fig. 1, total incremental costs for the 5 years preceding diagnosis are displayed in sequence with costs during the first 3 years after diagnosis. Incremental costs in the year immediately after diabetes diagnosis (year 1) were 41% higher than costs in either the year before or the year after that first postdiagnosis year. Incremental costs doubled in

Table 3—*Annual pharmacy costs per person by drug type and year before diagnosis (U.S. dollars 1998)*

	Antihyperlipidemics costs			Antihypertensives costs		
Year	Total	Incremental	Control	Total	Incremental	Control
−8	$17 ± 4	$9 ± 5	$8 ± 3	$85 ± 7	$40 ± 9	$45 ± 5
−7	$16 ± 3	$9 ± 3	$7 ± 2	$87 ± 5	$44 ± 6	$43 ± 3
−6	$20 ± 2	$10 ± 3	$10 ± 2	$91 ± 4	$46 ± 5	$45 ± 3
−5	$21 ± 2	$10 ± 3	$11 ± 2	$97 ± 3	$52 ± 4	$45 ± 2
−4	$23 ± 2	$8 ± 3	$15 ± 2	$97 ± 3	$48 ± 3	$49 ± 2
−3	$28 ± 2	$11 ± 3	$17 ± 2	$100 ± 2	$49 ± 3	$51 ± 2
−2	$31 ± 2	$12 ± 2	$19 ± 1	$103 ± 2	$52 ± 3	$51 ± 2
−1	$33 ± 2	$14 ± 2	$19 ± 1	$106 ± 2	$54 ± 2	$52 ± 1
Total	$189	$83	$106	$766	$385	$381
Average	$24	$10	$13	$96	$48	$48
SD	$6	$2	$5	$7	$5	$4
	Other cardiovascular costs			All other costs		
Year	Total	Incremental	Control	Total	Incremental	Control
−8	$34 ± 5	$17 ± 7	$17 ± 5	$238 ± 32	$89 ± 35	$149 ± 13
−7	$40 ± 4	$19 ± 5	$21 ± 3	$243 ± 33	$100 ± 34	$143 ± 8
−6	$38 ± 3	$15 ± 4	$23 ± 3	$242 ± 20	$84 ± 20	$158 ± 6
−5	$43 ± 3	$16 ± 4	$27 ± 2	$241 ± 11	$71 ± 12	$170 ± 6
−4	$46 ± 2	$16 ± 3	$30 ± 2	$261 ± 14	$75 ± 16	$186 ± 7
−3	$54 ± 2	$22 ± 3	$32 ± 2	$288 ± 15	$99 ± 16	$189 ± 5
−2	$59 ± 2	$25 ± 3	$34 ± 2	$315 ± 14	$11 ± 15	$205 ± 5
−1	$63 ± 2	$31 ± 2	$32 ± 2	$358 ± 13	$138 ± 13	$220 ± 5
Total	$377	$161	$216	$2,186	$766	$1,420
Average	$47	$20	$27	$273	$96	$178
SD	$10	$6	$6	$44	$22	$27

Data are means ± SEM. All incremental costs are statistically significant from zero, $P < 0.05$.

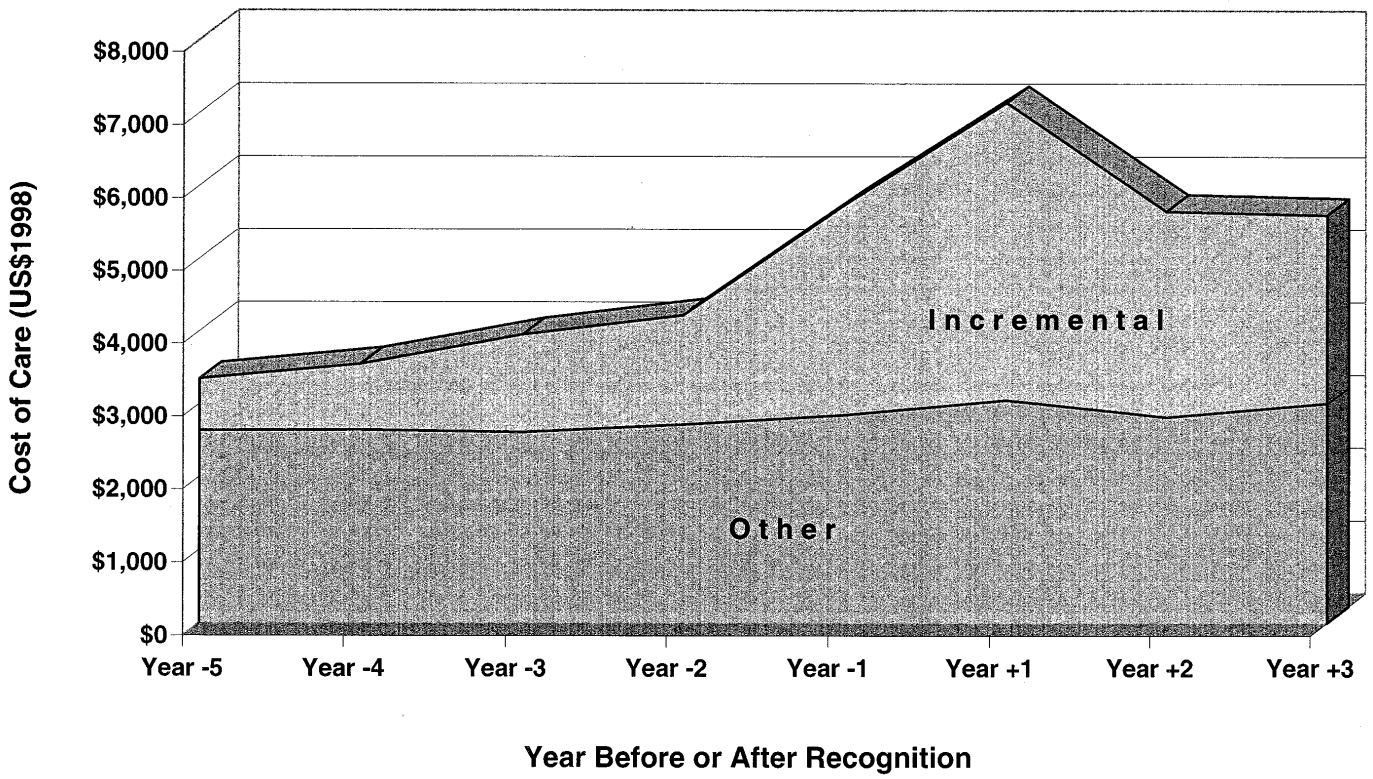

Figure 1—*Annual incremental and total health care costs per person with type 2 diabetes 5 years before and 3 years after recognition.*

the year just before recognition of diabetes, after rising relatively slowly and steadily over 7 of the 8 years preceding recognition. In the year immediately after diagnosis, incremental costs were nearly triple what they had been just 2 years earlier.

CONCLUSIONS — The challenge in estimating disease-specific incremental costs is to identify the net costs that would not have been incurred had the disease not been present or had the diagnosis not been made. In this article, we estimated net incremental costs of care for 8 years before a diagnosis of type 2 diabetes by subtracting the costs incurred by matched control subjects from the costs of patients who would later be diagnosed with type 2 diabetes. This case-control method, developed by us (19) and also used by Selby et al. (12), is particularly useful in diabetes because much of the excess use caused by diabetes is not explicitly recognized as such in medical and billing records. Because the period of study in this report preceded diagnosis, none of the excess use was formally recognized as being associated with diabetes at the time that it occurred. Thus, the case-control approach may be the only suitable method for the identification of costs before diagnosis. The case-control method also ensures that cases and control subjects are equally exposed to changes in exogenous factors (e.g., as input prices, practice style, utilization controls, surveillance practices). During the 8 years before diagnosis of diabetes, our study shows that patients destined to have diabetes consume significantly more medical care resources than control subjects.

Expenditures to prevent cardiovascular disease prominently contributed to health care costs in the years leading up to the recognition of type 2 diabetes. Pharmaceuticals used to treat hypertension, hyperlipidemia, and other cardiovascular risk factors accounted for nearly half (46%) of the overall incremental pharmacy costs that were associated with a future diagnosis of diabetes. However, hospital discharges with a primary diagnosis of cardiovascular disease accounted for only 11% of total diabetes-associated hospital costs (data not shown).

We have previously reported that diabetic patients experience significantly increased use of most classes of medications, not just those used to treat diabetes and its microvascular and macrovascular complications (14,19). This pattern describes the prediagnosis period as well, when the majority of drug costs were for noncardiovascular and, of course, non–glycemia-related agents. Even more dramatically, 78% of the incremental inpatient costs occurred during admissions caused by conditions seemingly unrelated to diabetes or its complications. These findings tend to rule out unrecognized uncontrolled diabetes as a major explanation for increased costs before diagnosis.

One possible explanation for higher incremental costs across-the-board is obesity. A recent study in this setting determined that BMI was an important predictor of future medical care costs in a cohort without a history of coronary heart disease, stroke, or cancer (20). This finding persisted when subjects with evidence of diabetes or hypertension were removed from the analyses. Although we lacked data on obesity in the current study, the well-established association between obesity and diabetes suggests that obesity may at least partially explain the increased costs in patients with prediabetes.

Another explanation consistent with the data is that, in the absence of a formal diabetes screening program, increased contact with the medical care system causes the diagnosis of diabetes. Figure 1 illustrates how medical resource use grows rapidly just before diagnosis and falls off afterward. Most of this growth and most of the decrease is attributable to inpatient care, although the actual diagnosis of diabetes rarely occurred during an admission in our data. Moreover, the postdiagnosis decrease would haver been greater if not for the postdiagnostic appearance of drugs, supplies, and visits for the treatment of hyperglycemia (data not shown). Both drug costs and visits costs doubled between years −1 and +1.

Increased exposure to medical care could "cause" diabetes through a variety of mechanisms. Increased contact with health professionals multiplies the opportunities for diabetes to be considered and diagnostic tests to be performed. In addition, however, serious medical conditions create physiological changes that may trigger metabolic decompensation in susceptible patients. Major illness episodes also create psychological stress and precipitate depression. Our data support the hypothesis that diabetes is often induced by deteriorating health and increased contact with the medical care system. More research is needed to better understand the circumstances surrounding the diagnosis of type 2 diabetes.

At least 8 years before their diagnosis, patients with type 2 diabetes begin incurring greater health care costs than similar patients without diabetes. These costs rise dramatically once diabetes is about to be recognized. An important topic for further research will be to examine whether this spike in costs is the currently unrecognized physiological result of diabetes and its complications or the result of ill health and the psychological stress and medical attention that accompany it.

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