

Diabetes Diagnosis, Resource Utilization, and Health Outcomes

Martin C. Gulliford, FFPH; Radoslav Latinovic, BSc;
and Judith Charlton, MSc

Objective: To determine the effect of a clinical diagnosis of diabetes mellitus (DM) on healthcare utilization and health outcomes.

Study Design: Cohort study.

Methods: A total of 197 United Kingdom family practices with 4974 subjects (mean age, 62.8 years; 52.2% men) with type 2 DM and 9948 matched nondiabetic control subjects. Healthcare utilization and the occurrence of complications were estimated from 2 years before to 2 years after the first clinical diagnosis of DM.

Results: From 24 months before the DM diagnosis, primary care consultations were increased in prediagnosis cases compared with controls (relative rate [RR], 1.31; 95% confidence interval [CI], 1.27-1.35), as were emergency and hospital care consultations, hospital specialist referrals, and prescription drug items. At diagnosis of DM, utilization of all forms of healthcare was increased (RR, 4.27; 95% CI, 4.17-4.36 for primary care consultations; RR, 2.49; 95% CI, 2.46-2.52 for prescription drug items). In the quarter following diagnosis, healthcare utilization was increased for acute myocardial infarction (RR, 6.29; 95% CI, 2.69-14.73), cerebrovascular disease (RR, 5.14; 95% CI, 3.37-7.84), ischemic heart disease (RR, 3.65; 95% CI, 2.77-4.80), and peripheral nerve disorders (RR, 5.01; 95% CI, 2.81-8.95). First diagnoses of myocardial infarction, cerebrovascular disease, and peripheral nerve disorders were increased during the period from 6 months before to 6 months after diagnosis.

Conclusions: Clinical diagnosis of DM is often the end of a process leading to established complications and is associated with greatly increased utilization of care. This adds to the justification of strategies for earlier detection of hyperglycemic states.

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Increasing evidence that type 2 diabetes mellitus (DM) may be prevented through lifestyle intervention¹ and drug therapy² has focused attention on events occurring before the diagnosis of type 2 DM. During the period before diagnosis, the onset of DM may be prevented or delayed in some subjects. However, there is continuing uncertainty concerning the justification for screening for type 2 DM or prediabetes.³ This uncertainty results in part from limited knowledge concerning the natural history of the period before the clinical diagnosis of DM. Studies⁴⁻⁶ have used electronic patient records to evaluate healthcare utilization during this period and showed that, in subjects who are later diagnosed as having DM, utilization of primary care consultations and prescription drug items is increased from up to 5 years⁴ to 8 years⁵ before the diagnosis compared with matched control subjects who never developed DM. The finding of increased utilization of medical care before the diagnosis of DM raises questions concerning the importance of the clinical diagnosis of DM. Is the clinical diagnosis of DM an incidental event of little consequence in the course of a slowly progressive condition that is already present? Alternatively, is the diagnosis of DM associated with a transition to a state with a higher rate of occurrence of adverse DM outcomes? To answer these questions, the present study compared utilization of medical care in a cohort of subjects with DM before, during, and after the clinical diagnosis of DM. We aimed to determine how the use of healthcare resources and the incidence of adverse health events changed following the clinical diagnosis of DM.

METHODS

A retrospective cohort study was implemented. Subjects diagnosed as having DM were compared with age-matched and sex-matched control subjects with respect to the utilization of medical care before and after the diagnosis of DM. The study was implemented using The Health Improvement Network, a database containing computerized medical records from family practices in the United Kingdom.^{7,8} The study was approved by the London Multi-centre Research Ethics Committee.

Practice and Patient Selection

Family practices were selected if they continuously provided data from January 1, 2001, to December 31, 2005.

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There were 1 283 429 patients 100 years or younger who were continuously registered with 197 family practices during this time. From this cohort, medical diagnostic codes for DM and prescriptions for oral hypoglycemic drugs or insulin were used to identify cases with DM. The DM diagnosis date was defined as the earlier of the first DM medical code or the first DM prescription date. Cases with DM were selected if their diagnosis date was between January 1, 2003, and December 31, 2003 (5635 cases), and if they were aged between 30 and 89 years at diagnosis (5091 cases). Two controls were selected for each case (matching for age, sex, and family practice) from among subjects who had never been diagnosed as having DM or prescribed oral hypoglycemic drugs or insulin. Twenty-two cases were excluded because there were insufficient matched controls. Finally, we included only 4974 patients who had never been diagnosed as having type 1 DM.

Data Analysis

For each case or control, we considered the 2 years preceding and the 2 years following the first clinical diagnosis of DM. Person-time of follow-up was divided into quarterly periods (91.3 days each) for analysis. Records were censored if subjects died or ended their registration with the practice after the diagnosis. For each subject, medical events of interest were counted by quarter. These included primary care consultations, emergency care consultations, hospital admissions, referrals to and consultations with hospital specialists (referred to as hospital specialist referrals), and prescription drug items. Emergency care consultations included urgent visits by a physician to the patient's home and referrals or attendances at hospital accident and emergency departments. Emergency care consultations and hospital admissions were combined for presentation. The data are coded using Read code clinical terms.⁹ Medical events associated with Read codes for ischemic heart disease, acute myocardial infarction, cerebrovascular disease, and peripheral nerve disorders were identified separately. Details of the codes used are available from the author.

To avoid double counting, a maximum of 1 event of each type was counted on 1 day. The rate of occurrence of each type of event per person-year was estimated by quarter for cases and controls. The relative rates (RRs) and associated 95% confidence intervals (CIs) were estimated using random-effects Poisson regression analysis, with the identifier for each triplet of case and 2 controls as the random effect and the time at risk as included as the exposure for each subject. Models were fitted using version 9 of STATA.¹⁰ In the next stage of the analysis, medical events were counted for different conditions, and results are presented for ischemic heart disease, acute myocar-

dial infarction, cerebrovascular disease, and peripheral nerve disorders. In condition-specific analyses, medical events were combined for primary care consultations, emergency care consultations, hospital admissions, and hospital specialist referrals. Initially, all events were considered, and then first events in subjects previously free from the diagnostic grouping were evaluated separately.

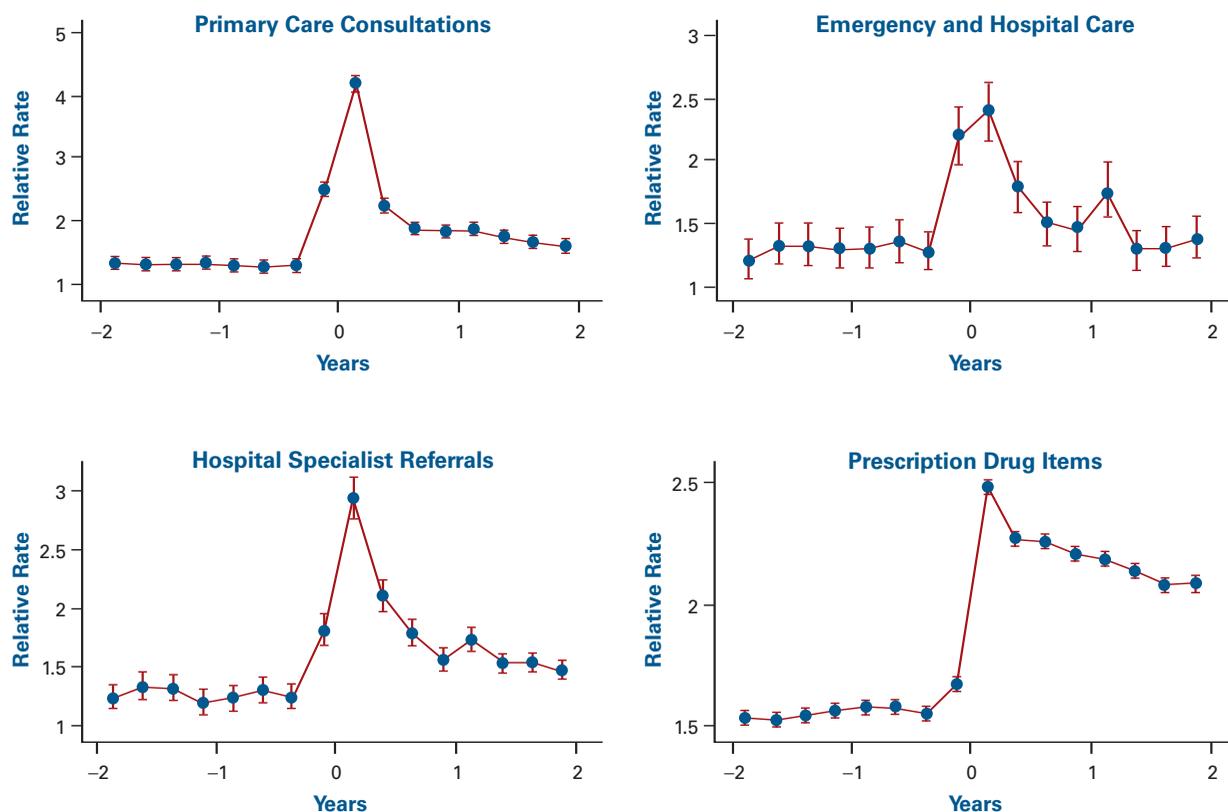
RESULTS

Data were analyzed for 4974 subjects (mean age, 62.8 years [age range, 30-89 years]; 52.2% men), drawn from 197 family practices, who were diagnosed as having type 2 DM during 2003. There were 9948 control subjects, never diagnosed as having DM, who were matched for age, sex, and family practice.

Figure 1 shows the utilization of healthcare before and after the diagnosis of DM compared with that of nondiabetic control subjects. In the quarter from 24 to 22 months before the diagnosis of DM, the RRs were 1.31 (95% CI, 1.27-1.35) for primary care consultations, 1.23 (95% CI, 1.08-1.39) for emergency and hospital care, 1.24 (95% CI, 1.14-1.35) for hospital specialist referrals, and 1.55 (95% CI, 1.52-1.57) for prescription drug items. The relative excess of medical care utilization continued through the prediagnosis period and then showed a marked increase, reaching a maximum in the quarter following diagnosis of DM. At this time, the RR for primary care consultations was 4.27 (95% CI, 4.17-4.36) times higher than that for controls; the RRs were 2.41 (95% CI, 2.18-2.66) times higher for emergency and hospital care, 2.97 (95% CI, 2.79-3.16) times higher for hospital specialist referrals, and 2.49 (95% CI, 2.46-2.52) times higher for prescription drug items. By 22 to 24 months after diagnosis, utilization of medical care had declined but remained higher than that in controls and higher than that in the prediagnosis period. Compared with controls, the RRs for cases were 1.64 (95% CI, 1.60-1.68) for primary care consultations, 1.42 (95% CI, 1.26-1.59) for emergency and hospital care, 1.50 (95% CI, 1.42-1.57) for hospital specialist referrals, and 2.10 (95% CI, 2.08-2.13) for prescription drug items. **Table 1** gives the absolute rates and RRs of healthcare utilization for 3 broad periods before, during, and after the diagnosis of DM confirming these findings.

Figure 2 shows the RRs of healthcare utilization events, combined across various types of care, for 4 different conditions. These analyses of healthcare utilization for specific groups of conditions showed that utilization of medical care was increased from 24 to 22 months before DM diagnosis for

■ **Figure 1.** Relative Rates of Utilization of Healthcare Before and After Diagnosis of Diabetes Mellitus Compared With Nondiabetic Control Subjects by Quarter



Data are given as relative rate (95% confidence interval).

ischemic heart disease (RR, 2.13; 95% CI, 1.60-2.84) but not for acute myocardial infarction (RR, 1.33; 95% CI, 0.47-3.75), cerebrovascular disease (RR, 1.00; 95% CI, 0.57-1.76), or peripheral nerve disorders (RR, 1.33; 95% CI, 0.68-2.62). There were statistically significant peaks in the utilization of care for these conditions at the time of diagnosis. In the quarter following diagnosis of DM, the RRs were 3.65 (95% CI, 2.77-4.80) for ischemic heart disease events, 6.29 (95% CI, 2.69-14.73) for acute myocardial infarction, 5.14 (95% CI, 3.37-7.84) for cerebrovascular disease, and 5.01 (95% CI, 2.81-8.95) for peripheral nerve disorders. However, utilization of care for these conditions declined to levels similar to those of controls by 22 to 24 months after diagnosis (RR, 1.05; 95% CI, 0.70-1.58 for ischemic heart disease; RR, 2.01; 95% CI, 0.41-9.96 for acute myocardial infarction; RR, 1.47; 95% CI, 0.81-2.65 for peripheral nerve disorders; and RR, 1.64; 95% CI, 0.93-2.87 for cerebrovascular disease). **Table 2** summarizes how, in the period from 6 months before to 6 months after diagnosis, the absolute rates and RRs of new diagnoses of each condition were statistically significantly elevated.

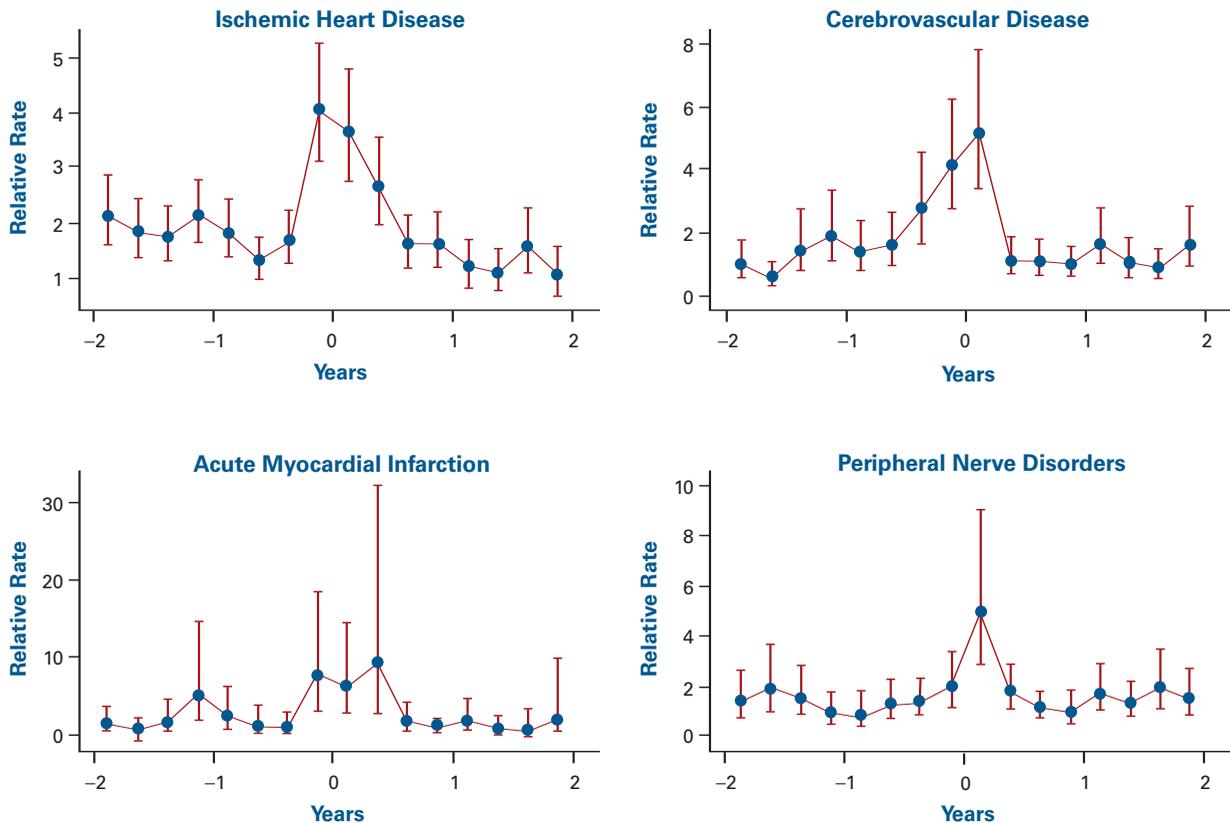
New ischemic heart disease and peripheral nerve disorder events were increased in the postdiagnosis period, but cerebrovascular disease events and acute myocardial infarctions were not.

DISCUSSION

We hypothesized that the clinical recognition of DM may be an event of limited significance in the course of a condition that is already present. Our results show that this is not the case. A clinical diagnosis of DM is associated with a profound increase in healthcare utilization and with increased occurrence of newly diagnosed ischemic heart disease, acute myocardial infarction, cerebrovascular disease, and peripheral nerve disorders. A clinical diagnosis of DM is a costly occurrence in terms of healthcare resource utilization and associated adverse health outcomes of DM. However, the nature of the interaction between health services and affected individuals is complex. The occurrence of illness may lead to contacts with health services at which DM may be diagnosed.

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Figure 2. Relative Rates of Utilization of Healthcare for Diabetes Mellitus (DM) Complications Before and After Diagnosis of DM Compared With Nondiabetic Control Subjects by Quarter



Data are given as relative rate (95% confidence interval).

Table 1. Relative Rates of Utilization of Healthcare Before, During, and After Diagnosis of Diabetes Mellitus Compared With Nondiabetic Control Subjects

Condition	Group	Events From 24 to ≥6 mo Before Diagnosis		Events From <6 mo Before to ≥6 mo After Diagnosis		Events From 6 to ≤24 mo After Diagnosis	
		Absolute Rate per Person-Year	RR (95% CI)	Absolute Rate per Person-Year	RR (95% CI)	Absolute Rate per Person-Year	RR (95% CI)
Primary care consultations	Cases	5.19	1.32 (1.31-1.34)	11.55	2.61 (2.58-2.64)	8.82	1.85 (1.83-1.87)
	Controls	3.92	—	4.42	—	4.79	—
Emergency and hospital care	Cases	0.34	1.32 (1.26-1.39)	0.53	1.92 (1.82-2.03)	0.38	1.52 (1.44-1.59)
	Controls	0.26	—	0.28	—	0.26	—
Hospital specialist referrals	Cases	0.71	1.28 (1.23-1.32)	1.37	2.11 (2.04-2.18)	1.93	1.66 (1.62-1.69)
	Controls	0.56	—	0.65	—	1.17	—
Prescription drug items	Cases	28.2	1.57 (1.56-1.58)	41.9	2.02 (2.00-2.03)	53.3	2.24 (2.23-2.25)
	Controls	18.0	—	20.8	—	24.0	—

RR indicates relative rate; CI, confidence interval.

■ **Table 2.** New Diagnoses by Broad Groups of Conditions and Periods

Condition	Group	Events From 24 to ≥6 Mo Before Diagnosis		Events From <6 Mo Before to ≤6 Mo After Diagnosis		Events From 6 to ≤24 Mo After Diagnosis	
		No. (%) of First Events	RR (95% CI)	No. (%) of First Events	RR (95% CI)	No. (%) of First Events	RR (95% CI)
Ischemic heart disease	Cases	100 (2.49)	1.73 (1.34-2.25)	137 (3.46)	4.44 (3.33-5.93)	57 (1.54)	1.58 (1.13-2.21)
	Controls	128 (1.45)	—	71 (0.81)	—	86 (1.01)	—
Cerebrovascular disease	Cases	34 (0.88)	1.25 (0.82-1.91)	80 (2.17)	3.80 (2.66-5.43)	30 (0.87)	1.11 (0.72-1.71)
	Controls	61 (0.71)	—	49 (0.59)	—	66 (0.81)	—
Acute myocardial infarction	Cases	20 (0.52)	1.95 (1.07-3.55)*	40 (1.08)	6.35 (3.49-11.55)	10 (0.29)	0.87 (0.43-1.79)*
	Controls	23 (0.27)	—	15 (0.18)	—	28 (0.34)	—
Peripheral nerve disorders	Cases	50 (1.07)	1.53 (1.06-2.21)	61 (1.31)	2.33 (1.61-3.35)	64 (1.40)	1.79 (1.28-2.50)
	Controls	67 (0.70)	—	54 (0.57)	—	76 (0.80)	—

RR indicates relative rate; CI, confidence interval. Denominators for percentages were obtained after excluding subjects previously diagnosed as having the condition.
*Convergence criterion not achieved.

Conversely, a diagnosis of DM may lead to the detection of comorbid conditions that were already present. In either case, there will be delivery of needed care for treatment of present conditions and prevention of future complications. Clinical practice recommendations for good-quality DM care require that utilization of care is increased to facilitate assessment for complications and intervention to control hyperglycemia, hypertension, and lipid disorders. Therefore, even when diabetic complications are not present, some increase in utilization of care around the time of DM diagnosis may be anticipated. Furthermore, there may be subgroups of patients in whom the occurrence of complications, or the increase in utilization of care associated with DM diagnosis, is more or less evident.

Comparison With Other Studies

There have been few epidemiological studies of DM diagnosis; most studies regard a diagnosis of DM as an end point or as an entry criterion. Type 2 DM is believed to be an evolving process from normal glucose tolerance, first to impaired fasting or nonfasting glucose tolerance, and then to DM, with the degree of hyperglycemia increasing over time.¹¹ Epidemiological findings indicate that up to 35% of subjects with newly diagnosed type 2 DM may already show signs of diabetic retinopathy.¹² This suggests that by the time a diagnosis is made, metabolic abnormalities may have been present for several years.¹³ Some 29% or more of prevalent cases of DM are undiagnosed.¹⁴ In the Nurses' Health Study,¹⁵ women who later developed type 2 DM had an age-adjusted

RR of myocardial infarction of 3.75 (95% CI, 3.10-4.53) compared with subjects who remained free of DM. The age-adjusted RR of stroke was 2.53 (95% CI, 1.94-3.31). Coronary heart disease risk is increased in subjects with prediabetes¹⁶ or with metabolic syndrome.¹⁷ The present study shows that the time of diagnosis of DM is associated with increased utilization of healthcare for ischemic heart disease, cerebrovascular disease, and peripheral nerve disorders. In a previous analysis, an increased incidence of carpal tunnel syndrome was observed in the prediabetic period.¹⁸ The present analyses evaluated all healthcare utilization associated with peripheral nerve disorders and showed that there was a statistically significant excess of healthcare utilization for peripheral nerve disorders at the time of diagnosis of DM, as well as increased incidence in the prediabetic period.

Strengths and Limitations of the Study

This was a population-based study among a large number of family practices drawn from across the United Kingdom. The large sample size yielded precise estimates. Cases and controls were matched for age, sex, and family practice, but unmeasured variables such as cigarette smoking, obesity, and individual-level socioeconomic status may have accounted for observed differences. Smoking,^{19,20} obesity,^{21,22} and lower socioeconomic status²³ are associated with an increased frequency of DM and, in some studies,^{24,25} with greater utilization of primary care services. However, these characteristics may be causally associated with prediabetes and DM and are not true confounders.

Implications for Chronic Illness Care

The present results reveal the diagnosis of DM to be the end of a process as much as a beginning. In revealing the morbidity and costs associated with clinical diagnosis of DM, the present data add to the evidence suggesting that strategies for early detection of DM and prediabetes may be justified. The American Diabetes Association position statement on DM screening acknowledged that there was no direct evidence from randomized controlled trials to support a policy of DM screening but argued that “there is sufficient indirect evidence to justify opportunistic screening in a clinical setting of individuals at high risk”^{3(p513)} and that “clinicians should be vigilant in evaluating clinical presentations suggestive of diabetes.”^{3(p513)} Case finding may be most cost-effective in those who are hypertensive or obese.²⁶ The present data raise a concern that an earlier diagnosis of DM may extend the period during which healthcare costs are incurred. However, findings from a modeling study²⁶ suggest that the costs of screening and early intervention may be offset by reduced future costs of treating DM complications, but this result depends on achieving good control of intermediate outcomes over time. Future research should determine whether the immediate costs associated with screen-detected DM are less than those following clinical diagnosis.

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Author Affiliations: From King's College London, Public Health Sciences, London, UK.

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Address correspondence to: Martin C. Gulliford, FFPH, King's College London, Public Health Sciences, Capital House, 42 Weston St, London, UK, SE1 3QD. E-mail: martin.gulliford@kcl.ac.uk.

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Take-away Points

This study aimed to evaluate the ways in which a clinical diagnosis of DM is associated with healthcare utilization and the occurrence of clinical complications of DM.

- Previous studies show that healthcare utilization is increased for several years before DM is recognized clinically.
- The use of primary care, emergency, and hospital resources is greatly increased around the time of DM diagnosis, with a more moderate increase in healthcare utilization sustained over time.
- Excess resource utilization at the time of diagnosis is in part associated with increased cardiovascular events at the time of clinical DM diagnosis.

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