The Impact of Cardiovascular Disease on Medical Care Costs in Subjects With and Without Type 2 Diabetes

GREGORY A. NICHOLS, PHD
JONATHAN B. BROWN, MPP, PHD

OBJECTIVE — We examined whether cardiovascular disease (CVD) affects medical care costs differently in subjects with and without diabetes and explored the impact of CVD on costs across the dimensions of age and diabetes duration.

RESEARCH DESIGN AND METHODS — We compared the prevalence of CVD and medical care costs for subjects with and without CVD in all 16,180 full-year health maintenance organization members in 1999 who had been diagnosed with type 2 diabetes and in control members matched by year of birth and sex. We ascertained diagnoses from the Kaiser Permanente Northwest Region's electronic ambulatory medical record and from hospital discharge datafiles. Utilization from these and other data systems were multiplied by unit costs.

RESULTS — CVD was 76% more prevalent in subjects with diabetes, but the risk ratios of more severe forms of CVD were even greater. Risk ratios for CVD were greatest in younger subjects. Cost profiles for subjects with both CVD and diabetes differed markedly from those with diabetes but without CVD. In the latter group, costs grew steadily with age, whereas in the former group, costs peaked in the 55- to 64-year age group before declining with age.

CONCLUSIONS — The types of CVD present in diabetic patients are more likely to be more severe and therefore more costly than in similar subjects without diabetes. CVD also disproportionately affects younger diabetic subjects. Finally, when CVD is present in diabetes, more costs occur earlier in life as well as earlier in the course of diabetes.

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Numerous studies have shown that patients with type 2 diabetes have substantially greater medical care use and cost than patients without diabetes (1–12). Several studies have also established that cardiovascular disease (CVD) in these patients accounts for a large proportion of these costs (10,13–16). We recently demonstrated that the excess costs of diabetes begin up to 8 years before diagnosis and that CVD was responsible for a significant portion of the prediagnostic costs (17). However, research thus far has not gone much beyond the quantification of costs of CVD and diabetes.

To more fully understand how CVD contributes to diabetes costs, we calculated costs for 16,180 subjects with diabetes, both with and without CVD. We compared these costs with costs for an age- and sex-matched nondiabetic control group, also with and without CVD. Then, in addition to studying the distributions of the components of costs in each group, we examined how age and duration of diabetes interacted with diabetes- and CVD-associated costs.

RESEARCH DESIGN AND METHODS

Research setting
The study site was Kaiser Permanente Northwest (KPNW), a not-for-profit group model health maintenance organization (HMO) that had ~450,000 members during the study period (1999). Subscriber demographics were similar to the area population as a whole, with non-Hispanic whites representing ~90% of the population and 10% comprised of African-Americans, Asians/Pacific Islanders, Native Americans, and subjects of Hispanic descent (18). A total of 18.5% of KPNW members were eligible for Medicare (>64 years of age), and ~8% were Medicaid members. The diabetes registry used in this report has been described elsewhere (11,19).

The organization maintains administrative and clinical 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 each member receives at the time of his or her first enrollment in the health plan.

Subjects and characteristics
For this study, we selected all 16,180 members in the diabetes registry who had type 2 diabetes and 12 full months of HMO eligibility in 1999. Using a method that assured random assignment, we used age and sex to match these subjects with 16,180 control members without diabetes who also had 12 full months of KPNW eligibility in 1999. We obtained age and sex information from HMO membership records. Analysis of diabetes duration was restricted to the 82% of diabetic subjects for whom date of diagnosis was known.

From the Center for Health Research, Portland, Oregon.
Address correspondence and reprint requests to Gregory A. Nichols, PhD, Center for Health Research, 3800 N. Interstate Ave., Portland, OR 97227-1110. E-mail: greg.nichols@kpchr.org.
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Abbreviations: CVD, cardiovascular disease; HMO, health maintenance organization; KPNW, Kaiser Permanente Northwest.
A table elsewhere in this issue shows conventional and Système International (SI) units and conversion factors for many substances.

Table 1—*Prevalence of CVD by diabetes status*

	Diabetic subjects	Control subjects	Risk ratio (diabetes:control)	95% CI
n	16,180	16,180	—	—
Acute myocardial infarction	2.5	0.9	2.78	2.27–3.30
Other ischemic heart disease	18.1	8.2	2.21	2.07–2.34
Angina	6.3	3.1	2.03	1.86–2.30
Congestive heart failure	9.5	3.5	2.71	2.45–2.95
Dysrhythmia	9.8	7.3	1.34	1.25–1.44
Other CVD	7.7	5.2	1.48	1.37–1.62
Multiple CVD diagnoses	14.2	6.7	2.12	1.97–2.26
At least one CVD diagnosis	31.2	17.9	1.74	1.68–1.82

Data are % unless otherwise indicated.

CVD diagnoses

KPNW has used an electronic ambulatory medical record since 1996. This record includes up to 20 ICD-9-CM–coded diagnoses for each patient contact. It also includes an electronic problem list of unlimited length. For both diabetic and control subjects, we searched the problem list and all contact diagnoses between 1996 and 1999 for evidence of CVD (see APPENDIX for list of ICD-9-CM codes). We also searched the 1987–1999 electronic database of discharge abstracts, which includes up to nine ICD-9-CM–coded diagnoses for each inpatient stay.

Ascertainment of costs

The Kaiser Permanente Center for Health Research has developed a system for assigning dollar costs to inpatient services provided in hospitals owned by KPNW and based on the HMO's annual Medicare Cost Report (20). We recently described our determination of unit costs in detail (16). 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 subjects with diabetes, who tend to require more physician time per visit and more laboratory testing than the average patient.

Approximately 30% of inpatient and outpatient costs during the study period were for services purchased by the Northwest Permanente Medical Group from community providers. We based the cost of these outside services on the amount Kaiser actually paid to vendors and combined these costs with the costs of internally produced care. Kaiser paid some vendors based on capitation agreements. In these cases, we derived unit costs by calculating an average cost per unit of use from data describing all units of use and all payments in the relevant calendar years. We were unable to assess costs not authorized or paid by Northwest Permanente (out-of-plan costs).

Because the cost and availability of drugs are subject to change, we report costs of drugs and related supplies at their approximate local retail cost at the time of purchase, adjusted to 1999 prices using the pharmaceutical component of the U.S. Medical Price Index (21). Drug cost data are continuously maintained and updated in the KPNW pharmacy–dispensing database for each dosage and form of each compound.

All inpatient and outpatient costs are also reported in 1999 dollars. Note that these unit cost coefficients represent average production costs, not charges based on revenue goals or reimbursement limits.

RESULTS— The prevalence of CVD was nearly 75% greater (risk ratio 1.74, 95% CI 1.68–1.82) in subjects with diabetes than in the age- and sex-matched nondiabetic control group (Table 1). For acute myocardial infarction and congestive heart failure, relative prevalences were even higher (2.78, range 2.27–3.30 and 2.71, 2.45–2.95, respectively). Subjects with diabetes were more than twice

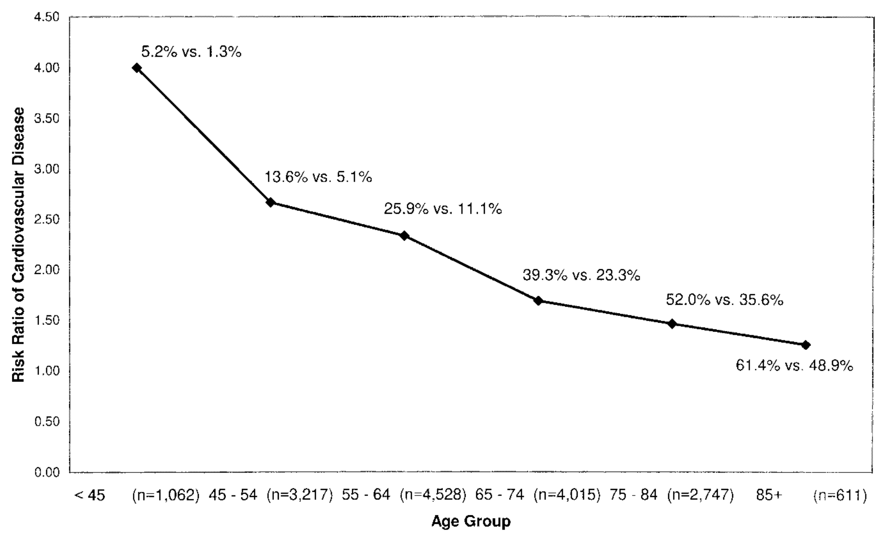

Figure 1—*Diabetes-to-control group risk ratio of CVD by age group.*

Table 2—*Characteristics by diabetes and CVD Status*

	Nondiabetic control group			Diabetic group		
	No CVD	CVD	Total	No CVD	CVD	Total
n	13,286	2,894	16,180	11,130	5,050	16,180
Age group (years)						
<45	7.9	0.5	6.6	9.1	1.1	6.6
45–54	23.0	5.6	19.9	25.0	8.7	19.9
55–64	30.3	17.4	28.0	30.1	23.3	28.0
65–74	23.2	32.3	24.8	21.9	31.3	24.8
75–84	13.3	33.8	17.0	11.8	28.3	17.0
≥85	2.4	10.3	3.8	2.1	7.4	3.8
Mean age (years)	61.2	71.9	63.1	60.2	69.5	63.1
Women	50.3	39.7	48.4	51.2	42.3	48.4

Date are % unless otherwise indicated.

as likely to have multiple CVD diagnoses (2.12, 1.97–2.26).

CVD prevalence increased with age among subjects both with and without diabetes (Fig. 1). However, the diabetes-associated relative risk (RR) of CVD decreased as age increased. In the youngest age group (<45 years of age), 5.2% of the diabetic subjects but only 1.3% of the control subjects had CVD (RR 4.00, range 2.20–7.02). In the oldest age group (≥85 years of age), 61.4% of subjects with diabetes and 48.9% of control subjects had CVD, a RR of 1.26 (1.13–1.39).

Although matching subjects with diabetes to nondiabetic control subjects assured identical age and sex among these two groups in the aggregate, Table 2 shows that subjects with diabetes and CVD were nearly 2 years younger than control subjects with CVD (69.5 vs. 71.9 years, $P < 0.001$). Nearly one-half of all subjects were women (48.4%), but in both groups, subjects with CVD were less likely to be women (39.7% of the control group and 42.3% of the diabetic group).

Average annual per-person medical care costs, adjusted for age and sex, for subjects with and without diabetes and with and without CVD are displayed in Fig. 2. Those members with neither CVD nor diabetes experienced the lowest average costs, $2,562 per person per year. About one-half of these costs (48.1%) were incurred from ambulatory care, whereas inpatient care accounted for 31.9%. Subjects with diabetes but without CVD were the next most costly group at $4,402 per year. The cost of their medical care exceeded nondiabetic costs in all categories, but again, only ~31% of their costs occurred during hospital stays. However, a larger proportion of their costs were consumed by drugs and supplies (28.6% with diabetes only vs. 20.0% with no diabetes or CVD).

Subjects with both CVD and diabetes were the most costly group ($10,172 per person per year). Over one-half their costs were incurred in the inpatient setting. Subjects with CVD but without diabetes experienced a similarly inpatient-intensive distribution of costs (51.0% inpatient) but were only about two-thirds as costly overall ($6,396).

Among subjects with diabetes, costs grew steadily until age 85 if CVD did not appear. When CVD was present, costs peaked between 55 and 64 years of age and then declined (Fig. 3). In relation to the date of diagnosis of diabetes, costs were always highest during the year immediately after diagnosis. Thereafter, costs for subjects with diabetes but without CVD followed a U-shaped trajectory, almost achieving their initial postdiagnostic level after 10 years. However, when CVD was present with diabetes, initial postdiagnostic costs were very high, $14,595 per person per year, then dropped during the second year after diagnosis, and then rose again after this drop.

CONCLUSIONS

— Medical care costs emerge from a complex interplay of biophysical, demographic, institutional, and other social processes. For example, we have previously shown that a majority of the costs that are causally associated with the diagnosis of diabetes cannot be directly attributed to diabetes treatment, known complications of diabetes (including CVD), or efforts to prevent these complications (10,11). Several studies have taken the important step of showing that costs attributable to CVD in diabetes are by far the largest biophysical component of type 2 diabetes costs (10,13–16). We extend this work by describing how CVD costs differ in subjects with and without diabetes and by comparing cost patterns with and without CVD in diabetes. Our study updates previous estimates of diabetic CVD cost in an era of increasing attention to CVD prevention and treatment in type 2 diabetes.

Our 1999 data reconfirm that CVD is

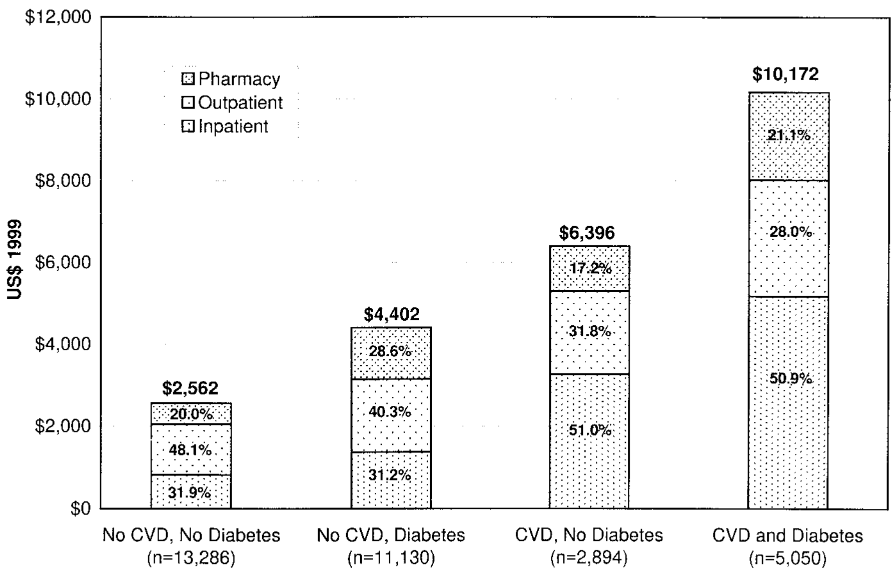

Figure 2—*Average annual medical care costs by component of cost, adjusted for age and sex.*

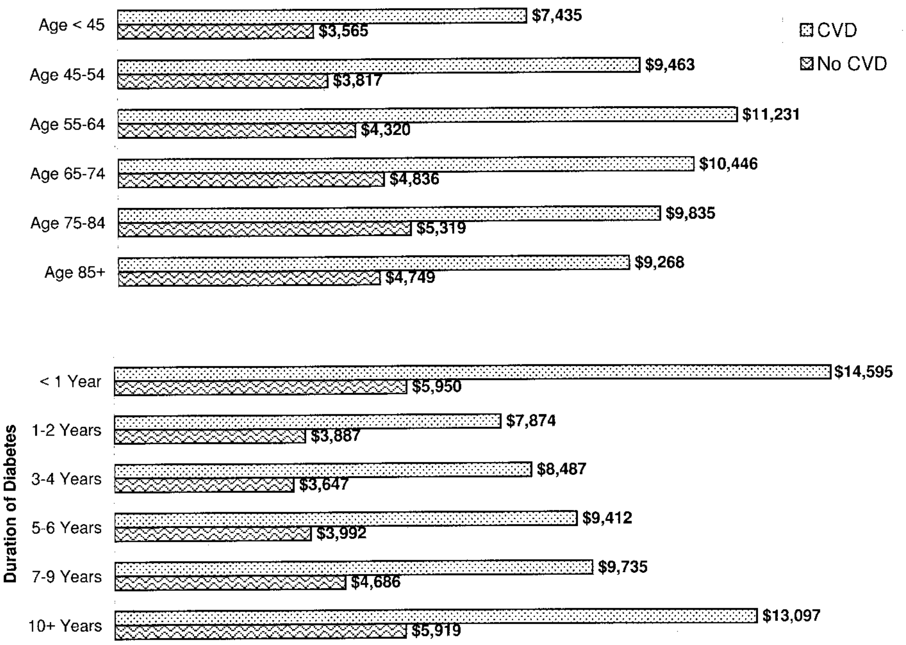

Figure 3—*Total 1999 medical care costs for subjects with diabetes by presence of CVD, age, and duration of diabetes.*

the most expensive single class of complications experienced by subjects with type 2 diabetes and that diabetes substantially increases the risk of CVD. However, the present study also shows that CVD is more severe and more expensive when it co-occurs with diabetes because of the types of CVD conditions that occur in this group. Diabetic subjects with CVD are more likely than nondiabetic subjects with CVD to experience myocardial infarction and congestive heart failure, compared with arrhythmias and other nonischemic CVD conditions. Although any-cause CVD was 1.74 times more likely in diabetes, acute myocardial infarction and congestive heart failure were 2.78 and 2.71 times more likely. Subjects with diabetes were also more likely (2.12 times) to suffer from multiple CVD diagnoses. An important consideration in the above analysis is that we were not able to screen the control population for undiagnosed diabetes. However, if diabetes was undetected, especially among those with CVD, then our estimated rates of CVD are understated in the diabetes group and overstated in the control group. The true risk ratios may therefore be even larger than those presented herein.

Much of the added cost of CVD results from hospitalizations for heart attacks, heart failure, and other major CVD events (14–16,22). In our data, this expense was true whether or not diabetes was present. Inpatient costs represented ~31% of total costs in subjects without CVD but accounted for 51% when CVD was present, regardless of the presence of diabetes. Prevention of CVD events would have a large impact on the total cost of diabetes care.

In addition to *how* costs are incurred, CVD also affects *when* and *to whom* costs occur in diabetes. Among subjects with diabetes and CVD, subjects aged 55–64 years incurred the most costs, whereas among subjects with diabetes and no CVD, older age groups incurred increasingly more costs. CVD also increased costs and accelerated cost growth after the diagnosis of diabetes. To fully understand these patterns, higher mortality in subjects with and without CVD and in older subjects must be factored in, along with the increased incidence of diabetes in older age groups and the eventual migration of most subjects with diabetes to CVD status (23–25). Although we matched subjects with and without diabetes by age and sex, it is important to note that we did not match subjects with and without CVD for comparisons within the diabetic population. Thus, in our cross-sectional data, subjects with diabetes but without CVD tend to be more recently diagnosed lower-cost cases. This pattern holds even in the older age groups because diabetes incidence rapidly increases with age. Moreover, the non-CVD group will, by definition, be subjects who did not have CVD before diabetes diagnosis, which may further distinguish them genetically and physiologically in ways we do not understand. However, none of these factors explain why the annual costs of CVD decrease after 65 years of age for subjects with diabetes. More detailed analyses of the mix of cardiovascular diagnoses, types of hospitalizations, and rates of high-cost procedures such as coronary arterial bypass grafts also failed to explain this phenomenon.

The complex relationships in diabetes among medical care costs, patient characteristics, and comorbidity are not fully understood. The present study begins to disentangle these relationships, and it provides new information about the large and unique impact of CVD on medical care costs in diabetes. Further research should explore how CVD differs between subjects diagnosed with diabetes at relatively young versus relatively old ages.

APPENDIX

ICD-9-CM Codes for CVD Diagnoses

Acute Myocardial Infarction: 410.xx
Other Ischemic Heart Disease: 414.xx
Angina: 413.xx, 411.1, 411.8
Dysrhythmia: 427.xx
Congestive Heart Failure: 428.xx, 401.91, 402.01, 402.11, 402.91, 404.01, 404.03, 404.11, 404.13, 404.91, 404.93
Other Cardiovascular Disease: 412.xx, 420.9, 421.xx, 422.xx, 423.xx, 424.xx, 425.xx, 426.xx, 429.x, 429.3

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