Nationwide Survey of Comorbidity, Use, and Costs of All Medications in Finnish Diabetic Individuals

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OBJECTIVE — To investigate comorbidity and overall use and costs of medication for all Finnish individuals with diabetes treated with drugs compared with sex- and age-matched control subjects.

RESEARCH DESIGN AND METHODS — According to a cross-sectional population study using national registries, 116,224 individuals purchased antidiabetic medications in Finland in 1995. The same number of nondiabetic individuals matched for sex, age, and area of residence were chosen as control subjects. Age at onset of diabetes was used as a criterion for distinguishing between type 1 and type 2 diabetes. The criterion could be applied in 74% of cases. A total of 16,955 individuals were defined as having type 1 diabetes, and 68,517 were defined as having type 2 diabetes. Comorbidity was determined by linkage with a national register including all individuals entitled to special reimbursement for drug treatment for a range of chronic diseases. Data on use and costs of all medications prescribed were obtained from drug purchase records.

RESULTS — Cardiovascular diseases and uremia were, as expected, the chronic diseases most closely associated with diabetes. Use of almost all kinds of medication was significantly greater in individuals with type 1 and type 2 diabetes than in control subjects. The greatest differences were observed in relation to cardiovascular drugs and antibiotics. Unexpectedly low use of antiasthmatics was observed in individuals with both types of diabetes, low use of neuroleptics was observed in type 1 diabetic individuals, and low use of hormone replacement therapy was observed in women with type 2 diabetes. Total costs of medications for individuals with diabetes were 3.5 times greater than those for nondiabetic control subjects. The higher costs were mostly attributable to insulin therapy for individuals with type 1 diabetes. The higher costs for individuals with type 2 diabetes were related to the cost of medications other than antidiabetic medication. The possible selection bias in omitting diabetic individuals treated with diet only and individuals in whom diabetes type could not be determined must be considered in interpreting the results.

CONCLUSIONS — Greater use by and costs of medications for individuals with diabetes than for nondiabetic individuals is related not only to antidiabetic treatment but also to all other kinds of medications. Although drug treatment and the prevalence of several chronic conditions were overall greater in individuals with diabetes versus other individuals, some exceptions merit further study.

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Abbreviations: ATC, Anatomical Therapeutic Chemical; OR, odds ratio.

A table elsewhere in this issue shows conventional and Système International (SI) units and conversion factors for many substances.

Growing costs of public health care have recently been a major concern in many countries. Reducing expenses has often been successful in several areas of health care, but drug treatment has remained an area where a continuous increase in costs seems to be inevitable.

Drugs are essential to health care for most diabetic individuals. Drug treatment is a costly part of overall health care for diabetes because antidiabetic medications are relatively expensive, and diabetic individuals often need expensive additional medications. The need for careful evaluation of drug treatment for diabetic individuals is particularly relevant in Finland, where the incidence of type 1 diabetes has remained the highest in the world (1) and where the prevalence of type 2 diabetes is relatively high (2).

Use of antidiabetic drugs has been evaluated in several studies (3,4), but few data are available on overall drug consumption and costs of drug treatment for diabetic individuals. Furthermore, the numbers of individuals with diabetes in these studies have been fairly low, or selection has been involved. The first report dealing with drug use by diabetic individuals studied 2,836 diabetic subjects and an equal number of control subjects in a large health maintenance organization (5). In most subsequent studies, the numbers of diabetic individuals have been lower, or the subjects have been selected by geographical area, health care organization, or age-group (6–10). In the most recently published study (11), the number of diabetic individuals was substantially greater, but the study included markedly fewer control subjects than diabetic individuals. None of the published reports made a distinction between type 1 and type 2 diabetic individuals.

We have previously shown that the economic burden relating to health care of Finnish diabetic individuals is considerable, largely because of the high use of hospital care (12). However, costs of drug treatment in that study related only to antidiabetic drugs because no information on use of other drugs was available. A recently established national registry for prescribed drugs

Table 1—*Prevalence of chronic diseases in individuals with type 1 and type 2 diabetes and control subjects in 1995 in Finland according to special drug reimbursement records of the Social Insurance Institution*

Disease	Individuals with diabetes	Control subjects	OR (95% CI)
Type 1 diabetes (*n* = 16,955)			
Hypertension	15.2	2.4	7.5 (6.7–8.3)
Hypothyroidism	3.4	0.5	7.3 (5.8–9.3)
Coronary heart disease	2.0	0.3	6.0 (4.5–7.9)
Asthma	1.8	2.1	0.9 (0.7–1.0)
Disorders of vitamin D metabolism	1.8	0.0	50.4 (22.4–113.0)
Glaucoma	1.6	0.1	16.5 (10.1–26.9)
Epilepsy	1.6	0.8	2.2 (1.8–2.7)
Transplant complications	1.5	0.0	50.3 (20.8–122.0)
Uremia requiring dialysis	1.2	0.0	71.2 (22.8–222.6)
Rheumatoid arthritis	1.1	0.7	1.7 (1.3–2.1)
Psychoses	0.8	1.0	0.8 (0.7–1.0)
Heart failure	0.6	0.1	5.0 (3.1–7.9)
Pernicious anemia	0.2	0.0	4.4 (2.0–9.4)
Adrenal cortical hypofunction	0.2	0.0	8.8 (3.1–24.7)
Type 2 diabetes (*n* = 68,517)			
Hypertension	51.0	23.0	3.5 (3.4–3.6)
Heart failure	26.4	8.3	4.0 (3.9–4.1)
Coronary heart disease	20.2	10.8	2.1 (2.0–2.2)
Asthma	5.8	4.8	1.2 (1.1–1.3)
Glaucoma	5.1	3.4	1.5 (1.4–1.6)
Psychoses	4.8	2.5	2.0 (1.9–2.1)
Cardiac arrhythmias	4.4	2.7	1.7 (1.6–1.8)
Hypothyroidism	4.1	2.4	1.7 (1.6–1.8)
Rheumatoid arthritis	3.2	3.1	1.1 (1.0–1.1)
Gout	2.8	1.0	3.0 (2.8–3.3)
Parkinson's disease	1.2	0.8	1.4 (1.3–1.6)
Pernicious anemia	1.1	1.0	1.1 (1.0–1.3)
Epilepsy	1.0	0.9	1.1 (1.0–1.3)
Disorders of vitamin D metabolism	0.2	0.0	3.4 (2.3–5.0)
Transplant complications	0.1	0.0	2.4 (1.5–4.0)
Uremia requiring dialysis	0.1	0.0	3.6 (1.9–7.1)
Adrenal cortical hypofunction	0.1	0.0	2.2 (1.3–3.7)

Data are % or ORs (95% CIs). Differences between prevalences in individuals with diabetes and control subjects have been tested by logistical regression analysis.

has allowed the analysis of use and costs of all drugs for diabetic individuals and has allowed comparison of the use and costs of all drugs with age- and sex-matched nondiabetic control subjects. Distinguishing between type 1 and type 2 diabetic individuals was possible through linkage with another national registry that contains information on patients entitled to special reimbursement for medications related to various diseases. The latter registry also allowed us to analyze comorbidity in diabetic individuals.

RESEARCH DESIGN AND METHODS

The study population consisted of all 116,224 individuals who purchased antidiabetic drugs in 1995 from Finnish pharmacies according to the registry on medication reimbursement. The registry, which is maintained by the Social Insurance Institution of Finland, contains information on all details and costs of medications prescribed, purchased, and reimbursed that are categorized by Anatomical Therapeutic Chemical (ATC) classification (13). Purchases are linked to the unique social security numbers of individuals. The records depend on computerized information provided to the Social Insurance Institution by Finnish pharmacies. The linkage covers >90% of all pharmacies in Finland. Antidiabetic drugs were defined in this study as those with ATC code A10. Users of guar gum preparations alone were omitted because use of this drug could be related to conditions other than diabetes.

In Finland, individuals with specified chronic diseases (~50 diseases total) are entitled to special reimbursement for drug treatment costs. Special reimbursement covers 75 or 100% of the costs of drug treatment, whereas the basic reimbursement coverage is 50%. Diabetes is one of the diseases in the 100% category. To become eligible for special reimbursement for any of the specified chronic diseases, a patient must apply and send with the application a certificate from a physician giving the details of diagnosis and treatment for the disease. All individuals entitled to special reimbursement are recorded centrally by the Social Insurance Institution. Individuals can be identified in the records by their unique identification numbers, as in the case of records relating to reimbursed drugs. Identification numbers also allow information from the 2 registries to be linked.

Neither registry contains information on the type of diabetes. To define type of diabetes, we used the age at which special reimbursement began. All individuals who became entitled to special reimbursement for drug treatment of diabetes at <30 years of age were defined as having type 1 diabetes, and those who became entitled at >41 years of age were defined as having type 2 diabetes. On the basis of these criteria, our study population included 16,955 individuals with type 1 diabetes and 68,517 individuals with type 2 diabetes. In the other study, subjects' age on becoming entitled to reimbursement was either between 30 and 40 years (*n* = 6,662), or the individual had not applied for special reimbursement (*n* = 24,090). More than 97% of those who had not applied for reimbursement were >30 years of age. The average age of individuals in 1995 with type 1 diabetes was 30.4 years, and that of individuals with type 2 diabetes was 68.5 years.

For each diabetic individual in our study population, 1 matched control subject was chosen from the population registry. Control individuals were chosen from the section of the population not entitled to special reimbursement for diabetes and who did not purchase antidiabetic medications in 1995. Matching criteria were sex, age, and health center district in which the individual with diabetes lived.

Costs of medications involved all expenditures for medications prescribed in

1995 at retail prices. The prices included all dispensing costs and exceeded the wholesale prices in Finland in 1995 by a factor of 1.5. Costs are reported in U.S. dollars. The exchange rate used was the average rate in 1995—namely, $1/4.3658 Finnish marks.

Use of a medication was defined as at least 1 purchase of the medication concerned in 1995. Occurrence of other chronic diseases and use of other medication groups in individuals with diabetes compared with control subjects were calculated by logistical regression analysis and were expressed in terms of odds ratios (ORs) and 95% CIs. Comorbidity and use of other medications are presented only in individuals in whom the type of diabetes could be determined. Costs of medications will be presented in addition to the type of diabetes in all individuals purchasing antidiabetic medications. All costs of purchased medications in 1995 by individuals were totaled. Costs of antidiabetic and other medications are reported as both absolute costs and costs per individual.

RESULTS

Use of antidiabetic medications by individuals with type 1 and type 2 diabetes

Of individuals with type 1 diabetes defined according to age at onset of the disease, 98% used insulin as their only antidiabetic medication. Of individuals with type 2 diabetes, 65% were treated with oral antidiabetic agents only, 15% were treated with insulin only, and 20% were treated with a combination of oral antidiabetic agents and insulin.

Comorbidity and drug use of individuals with type 1 diabetes

In individuals with type 1 diabetes, hypertension was the most common chronic disease that involved an entitlement to special reimbursement for medication (OR 7.5) (Table 1). Coronary heart disease was also significantly higher (OR 6.0) in individuals with type 1 diabetes than in control subjects. Individuals with type 1 diabetes used all types of cardiovascular medication significantly more often than control subjects. Cardiovascular medications were used by 21% of individuals with type 1 diabetes and by 4% of control subjects (Table 2). The greatest difference in relation to cardiovascular medications concerned use of ACE inhibitors, which were used by 15% of individuals with type 1 diabetes and by 1% of the control subjects (OR 14.2). Use of β-blocking agents, calcium-channel blockers, and diuretics was significantly greater in individuals with type 1 diabetes than in control subjects. More than 6% of individuals with type 1 diabetes used such medications in each case. In control subjects, use of β-blocking agents was more common than use of calcium-channel blockers or diuretics. Lipid-reducing agents were used by 2% of individuals with type 1 diabetes but were used by only 0.4% of control subjects (OR 5.2).

Uremia requiring dialysis, disorders of vitamin D metabolism, and transplant complications were, as expected, much more common in individuals with type 1 diabetes than in control subjects (Table 1). Hypothyroidism, pernicious anemia, adrenal cortical hypofunction, and rheumatoid arthritis were also significantly more common in individuals with type 1 diabetes than in control subjects. Other chronic disorders that were significantly more common in individuals with type 1 diabetes than in control subjects were glaucoma and epilepsy.

Asthma and severe psychotic disorders were less common (but were not statistically significant) in individuals with type 1 diabetes than in control subjects (Table 1). This finding fits well with use of medication: antiasthmatics, antiallergic agents, and neuroleptics were used as often by individuals with type 1 diabetes as by control subjects (Table 2).

Use of other medications reimbursed only partly or not at all was also in most cases more common in individuals with type 1 diabetes than in control subjects (Table 2). Of individuals with type 1 diabetes, 44% had used antibacterials compared with 29% of control subjects (OR 1.9). Use of nonsteroidal anti-inflammatory agents was slightly more common (OR 1.3) in individuals with type 1 diabetes than in control subjects. Use of antidepressants (OR 1.6), hypnotics (OR 1.5), and antianxiety drugs (OR 1.3) was more common in individuals with type 1 diabetes than in control subjects.

Comorbidity and drug use in individuals with type 2 diabetes

Cardiovascular diseases were more common in individuals with type 2 diabetes than in control subjects (Table 1). Hypertension was evident in 51% of individuals with type 2

Table 2—*Percentage of users of major categories of prescription medications in individuals with type 1 diabetes and nondiabetic control subjects in Finland in 1995*

Medication (ATC code)	Individuals with diabetes	Control subjects	OR (95% CI)
Cardiovascular drugs (C02–C09)	20.5	4.4	5.6 (5.2–6.1)
ACE inhibitors (C09)	15.1	1.2	14.2 (12.3–16.3)
β-Blocking agents (C07)	6.6	2.8	2.5 (2.2–2.8)
Calcium-channel blockers (C08)	6.3	1.0	6.6 (5.6–7.8)
Diuretics (C03)	6.2	1.0	6.8 (5.8–8.0)
Nitrates (C01D)	2.2	0.3	6.7 (5.1–8.8)
Lipid-lowering agents (B04A)	2.0	0.4	5.2 (4.0–6.8)
Systemic antibacterials (J01)	43.6	29.1	1.9 (1.8–2.0)
Systemic antimycotics (J02A)	4.5	1.9	2.4 (2.1–2.7)
Nonsteroidal anti-inflammatory agents (M01A)	15.9	13.1	1.3 (1.2–1.3)
Antidepressants (N06A)	4.1	2.6	1.6 (1.4–1.8)
Antianxiety drugs (N05B)	4.0	3.2	1.3 (1.3–1.4)
Hypnotics and sedatives (N05C)	3.1	2.1	1.5 (1.3–1.7)
Neuroleptics (N05A)	1.6	1.5	1.1 (0.9–1.3)
Thyroid hormones (H03A)	4.0	0.5	7.7 (6.2–9.6)
Estrogens with or without progestogens (G03C/G03F)*	30.9	27.4	1.2 (1.0–1.3)
Adrenergic inhalations (R03A)	2.4	2.5	1.0 (0.8–1.1)
Other antiasthmatic inhalations (R03B)	2.1	2.1	1.0 (0.9–1.2)
Antipeptic ulcerants (A02B)	3.6	2.3	1.6 (1.4–1.8)

Data are % or ORs (95% CIs). Differences between percentages in individuals with diabetes and control subjects have been tested by logistical regression analysis. *In women ≥46 years of age only.

Table 3—*Percentage of users of major categories of prescription medications in individuals with type 2 diabetes and nondiabetic control subjects in Finland in 1995*

Medication (ATC code)	Individuals with diabetes	Control subjects	OR (95% CI)
Cardiovascular drugs (C02–C09)	71.1	38.0	4.0 (3.9–4.1)
ACE inhibitors (C09)	28.2	8.6	4.2 (4.1–4.3)
β-Blocking agents (C07)	32.2	19.3	2.0 (1.9–2.0)
Calcium-channel blockers (C08)	25.4	12.1	2.5 (2.4–2.5)
Diuretics (C03)	39.9	18.6	2.9 (2.8–3.0)
Nitrates (C01D)	32.9	16.5	2.5 (2.4–2.5)
Cardiac glycosides (C01A)	25.8	8.6	3.7 (3.6–3.8)
Lipid-lowering agents (B04A)	5.1	2.3	2.3 (2.2–2.4)
Antithrombotics (B01A)	17.1	8.4	2.3 (2.2–2.3)
Systemic antibacterials (J01)	47.6	28.1	1.9 (1.8–2.0)
Systemic antimycotics (J02A)	3.0	1.4	2.1 (2.0–2.3)
Antigout preparations (M04A)	3.9	1.6	2.5 (2.3–2.6)
Nonsteroidal anti-inflammatory agents (M01A)	32.8	24.0	1.4 (1.3–1.6)
Antidepressants (N06A)	9.9	5.3	2.0 (1.9–2.0)
Antianxiety drugs (N05B)	12.6	9.2	1.4 (1.3–1.5)
Hypnotics and sedatives (N05C)	20.2	12.4	1.8 (1.9–2.1)
Neuroleptics (N05A)	9.1	4.7	2.0 (1.9–2.1)
Thyroid hormones (H03A)	5.0	3.7	1.7 (1.6–1.8)
Estrogens with or without progestogens (G03C/G03F)*	11.2	14.6	0.7 (0.6–0.8)
Adrenergic inhalations (R03A)	5.1	4.9	1.0 (0.9–1.1)
Other antiasthmatic inhalations (R03B)	4.7	4.9	1.0 (0.9–1.1)
Antipeptic ulcerants (A02B)	9.8	7.8	1.3 (1.2–1.3)
Glaucoma preparations (S01E)	5.4	3.3	1.7 (1.6–1.8)

Data are % or ORs (95% CIs). Differences between percentages in individuals with diabetes and control subjects have been tested by logistical regression analysis. *In women ≥46 years of age only.

diabetes (OR 3.5), heart failure was evident in 26% (OR 4.0), coronary heart disease was evident in 20% (OR 2.1), and chronic cardiac arrhythmia was evident in 4.4% (OR 1.7). A total of 71% of individuals with type 2 diabetes (OR 4.0) used a cardiovascular drug of some kind (Table 3). Diuretics were the most commonly used cardiovascular drugs. A total of 40% of individuals with type 2 diabetes took such a drug (OR 2.9). Cardiac glycosides were used by 26% of individuals with type 2 diabetes (OR 3.7), nitrates were used by 33% (OR 2.5), β-receptor blocking agents were used by 32% (OR 2.0), calcium-channel blockers were used by 25% (OR 2.5), and ACE inhibitors were used by 28% (OR 4.2). Use of lipid-lowering drugs (5%, OR 2.3) was also significantly more common in individuals with type 2 diabetes than in control subjects.

Of the other chronic diseases included in the list of diseases for which special reimbursement for costs of medication is allowed, gout (OR 3.0), glaucoma (OR 1.5), psychotic disorders (OR 2.0), hypothyroidism (OR 1.7), and Parkinson's disease (OR 1.4) were significantly more common in individuals with type 2 diabetes than in control subjects (Table 1). Asthma, rheumatoid arthritis, and epilepsy were slightly more common in individuals with type 2 diabetes than in control subjects.

Individuals with type 2 diabetes used almost all kinds of medications more often than control subjects (Table 3). Antibacterials were used by 48% (OR 1.9), nonsteroidal anti-inflammatory agents were used by 33% (OR 1.5), antidepressants were used by 10% (OR 2.0), and hypnotics were used by 20% (OR 1.8). Use of adrenergic inhalations and other antiasthmatic preparations was similar in individuals with type 2 diabetes and control subjects. Hormone replacement therapy was the only exception to the rule. Use of estrogens (OR 0.8) and progestogens (OR 0.5) was significantly less common in women with type 2 diabetes than in control subjects.

Cost of medication

The total annual cost of all medications taken by all individuals using antidiabetic medications in Finland included in our study was $127 million in 1995 ($1,093/individual). The corresponding figure for nondiabetic control subjects was $36 million ($309/control subject). Antidiabetic drugs accounted for 41% of all costs of medications for individuals with diabetes. A total of 61% of these costs was accounted for by insulin preparations, and 39% was accounted for by oral antidiabetic agents. Costs of medications taken by all individuals with diabetes were 3.5 times greater than costs of medications taken by control subjects. After excluding antidiabetic drugs, costs of medications taken by all individuals with diabetes were still >2 times the costs of medications for control subjects.

Costs and distribution of costs differed markedly between individuals with type 1 and type 2 diabetes (Table 4). In individuals with type 1 diabetes, the total cost of medications annually was an average $1,272/patient, whereas the costs of their age-matched control subjects were substantially lower ($101/individual). Thus, the costs of all medications for individuals with type 1 diabetes were 12 times greater than those for control subjects. In individuals with type 1 diabetes, insulin treatment accounted for 62% of the total costs of medications, but the costs of medications other than antidiabetic agents were almost 5 times higher in individuals with type 1 diabetes than in control subjects.

In individuals with type 2 diabetes, annual medication costs were somewhat lower than those for individuals with type 1 diabetes (Table 4) ($1,151/patient). Distribution of costs differed markedly from that of individuals with type 1 diabetes. Costs of oral antidiabetic agents accounted for 21%, and costs of insulins accounted for 18% of the total costs of medications for individuals with type 2 diabetes. Costs for individuals with type 2 diabetes were $786/individual higher than that for control subjects. Total costs of medication for individuals with type 2 diabetes were 3 times greater than those for control subjects, and costs of medications other than antidiabetic medications were 2 times greater.

Although the difference between individual costs of medication for individuals with type 2 diabetes and those for control subjects was lower than the corresponding difference in relation to individuals with type 1 diabetes, the absolute incremental medication costs for individuals with type 2 diabetes were >2 times higher than incremental medication costs for individuals

with type 1 diabetes (Table 4). The greater absolute medication costs for individuals with type 2 diabetes versus individuals with type 1 diabetes is because individuals with type 2 diabetes are much more numerous.

CONCLUSIONS — Our results show that consumption of all drugs for diabetic individuals and related costs were markedly higher than those for nondiabetic individuals. This was only partly attributable to the use of antidiabetic drugs. Use of almost all other types of medications was also higher for diabetic individuals. However, the extent of greater use was not uniform. Use of some types of medications by diabetic individuals was similar to or even lower than the use of those drugs by nondiabetic individuals.

Our study, which involved 116,224 diabetic individuals and the same number of control subjects, is by far the largest study reported in which use of medications by diabetic individuals, including practically all individuals in Finland who purchased their antidiabetic drugs through a pharmacy, has been investigated. Access to data relating to reimbursement of drugs for other chronic diseases allowed us to study comorbidity in diabetic individuals in more detail. Because recorded data did not include information on type of diabetes, we used information on the age at which reimbursement first began as a criterion for type of diabetes. Studies have previously shown that most diabetic individuals diagnosed as such at <30 years of age in Finland have type 1 diabetes and that most of the diabetic individuals diagnosed at >40 years of age have type 2 diabetes (14). Although we acknowledge that age at onset cannot differentiate every diabetic individual by type of diabetes, it is a reasonably accurate criterion, and it allowed us to study comorbidity for both types in fairly large populations.

The well-known association between diabetes and various atherosclerotic conditions and specific ophthalmological, renal, and neural complications accounted for much of the comorbidity and greater use of other drugs by diabetic individuals compared with control subjects. Frequently scheduled visits to a physician because of diabetes also results in diagnosis and treatment of conditions that may otherwise remain unrecognized and untreated. This "coattail" effect of diabetes has already been noted in many previous reports relating to drug consumption by and comorbidity in diabetic individuals (5,8,15).

Table 4—*All annual costs and costs per individual of antidiabetic and other drug treatment for individuals with type 1 or type 2 diabetes and control subjects*

	All costs of medication ($ million)			Medication costs per individual ($)		
Group	Antidiabetic	Other	All	Antidiabetic	Other	All
Type 1 diabetes	13.4	8.2	21.6	790	482	1,272
Type 1 diabetes control		1.7	1.7		101	101
Type 2 diabetes	30.6	48.3	78.9	446	705	1,151
Type 2 diabetes control		25.0	25.0		366	366

Cardiovascular diseases and use of all types of cardiovascular drugs were distinctly and markedly more common in both type 1 and type 2 diabetic individuals than in control subjects in our study. This result was because of greater incidences of hypertension, coronary heart disease, heart failure, and other cardiovascular diseases in individuals with either type of diabetes than in control subjects. Findings have been similar in many previous studies (16,17). Use of diuretics or β-blocking agents by diabetic individuals has been criticized because these drugs may adversely affect glucose tolerance and insulin resistance and may decrease awareness of hypoglycemic symptoms (18). As in previous investigations (6,7,9,11), we found no lesser use of such drugs by diabetic individuals than by control subjects. The relatively common use of ACE inhibitors and lipid-lowering drugs agrees with current therapy guidelines (19,20). The use of these drug groups has recently increased considerably because the steepest increase in use of these drugs occurred in the late 1990s.

The fact that reimbursement for medications for uremia, transplant complications, and disorders of vitamin D metabolism was common in diabetic individuals was not unexpected because these conditions can be consequences of diabetic nephropathy. The greater use of drugs for hypothyroidism, adrenocortical hypofunction, pernicious anemia, and rheumatoid arthritis by diabetic individuals (particularly individuals with type 1 diabetes) than by control subjects undoubtedly reflects the frequent occurrence of type 1 diabetes with autoimmune disorders (21,22).

The greater use of antigout preparations and drugs for glaucoma by diabetic individuals versus control subjects agrees with comorbidity rates demonstrated in several previous studies (23–25). Although infections and inflammatory processes are probably more common and have more serious consequences in diabetic individuals than in nondiabetic individuals, most of the greater use of antibiotics and nonsteroidal anti-inflammatory agents by diabetic individuals is probably because diabetic individuals visit their physicians more often than nondiabetic individuals.

Associations between mental disorders and diabetes have been described in many reports (26). Particular emphasis has been placed on the association between depression and diabetes (27). Type 2 diabetes has been shown to be more common in elderly schizophrenic patients than in control subjects (28). These reports agree with our observations that use of antidepressants and neuroleptics in diabetic individuals is more common than in control subjects. On the other hand, schizophrenia is less common in type 1 diabetic individuals than in control subjects (29). The similar use of neuroleptic drugs and the lesser extent of special reimbursement for drugs used in psychotic disorders in individuals with type 1 diabetes than in control subjects in our study supports this suggestion.

Previous reports, some as far back as the 1930s, have suggested that asthma is rare in patients with diabetes (30,31). Theoretical explanations for this have been proposed (32,33). We also found that asthma was less common in type 1 diabetic individuals than in control subjects. No significant differences were demonstrated regarding the use of bronchodilators by diabetic individuals and control subjects.

Hormone replacement therapy for postmenopausal women has gained popularity in recent years. Women with diabetes in particular are thought to benefit from such treatment (34). Use of estrogens was one of the few drug treatments found to be significantly less common in women with type 2 diabetes than in control subjects in our study. Findings were similar in a recent study of treatment of unrelated disorders in patients with chronic diseases (35). Whether unexpected inverse association was because

menopausal symptoms were less common in women with diabetes than in control subjects or because of a reluctance to prescribe hormone replacement therapy relating to supposed side effects or higher endogenous synthesis of estrogens due to the abundant fat deposits in women with type 2 diabetes remains to be discovered.

Differences in comorbidity and use of medications other than antidiabetic medications between individuals with type 1 and type 2 diabetes were not great. With both types of diabetes, cardiovascular diseases were the main accompanying disorders. Diabetic nephropathy was another expected complication of both types of diabetes. ORs relating to cardiovascular diseases and complications of uremia were, however, greater in subjects with type 1 diabetes than in subjects with type 2 diabetes. This does not indicate a more common occurrence of complications in type 1 diabetes but rather is a consequence of the rarity of associated disorders in younger nondiabetic control subjects. The stronger association between other autoimmune diseases and type 1 diabetes versus type 2 diabetes was expected because only type 1 diabetes is autoimmune in nature. The unexpected inverse associations between some chronic conditions and type 1 or type 2 diabetes observed in our study could not be noticed in earlier studies in which no distinction had been made between types of diabetes.

The costs of all medications for diabetic individuals in our study were >3 times those of nondiabetic individuals. Similar findings have been reported previously (6,11,36). The causes of the difference were dissimilar in individuals with type 1 and type 2 diabetes in our study. In type 1 diabetes, greater costs related mainly to relatively expensive insulin treatment. In individuals with type 2 diabetes, greater costs related mainly to the common comorbidity and drug treatment of the other diseases. When costs of antidiabetic treatment were excluded, drug treatment costs were more than twice as high for individuals with diabetes than for control subjects. When calculating total costs related to diabetes, including all costs of drug treatment is important (not only those relating to antidiabetic medications) because of the substantial need for other drugs as a result of frequent comorbidity.

The greater use and higher costs of all medications for individuals with diabetes versus control subjects are among the reasons for the substantial costs related to medical care of diabetes (12,36). However, reasonable well-balanced drug treatment for diabetes itself (37,38) has been shown to result in significantly fewer diabetic complications. Intensive treatment of accompanying cardiovascular risk factors (e.g., hypertension [39] and hyperlipidemia [40]) effectively diminishes the incidence of cardiovascular complications in individuals with diabetes. The greater use of medications by individuals with diabetes can therefore be regarded in most cases as effective and appropriate prevention of complications that would be much more costly.

The most obvious limitation to our study is the lack of precise information about the type of diabetes of the individuals purchasing the antidiabetic drugs. However, we believe our choice of age at which special reimbursement first began to separate types of diabetes was satisfactory for studying the use of drugs. Using the criteria applied in our study, we could not define the type of diabetes in 26% of all individuals purchasing antidiabetic drugs. We wanted, however, to present consumption data by criteria that were as accurate as possible to guarantee validity of type of diabetes. The vast majority of the individuals in whom type of diabetes could not be defined were >30 years of age and most probably had type 2 diabetes. We analyzed the drug consumption pattern of those in whom the type of diabetes could not be determined (data not shown), and the results were fairly similar for individuals with type 2 diabetes. Thus, omitting the group without type definition does not cause meaningful selection bias in the results but only limits the numbers of individuals with type 2 diabetes. We had no opportunity to include diabetic individuals treated by diet alone in our study. This lack of diet-treated patients may have resulted in overestimation of drug use by patients with type 2 diabetes, but the error will obviously be marginal. We were able to assess only the use of prescribed medications in outpatient care. Over-the-counter medications and medications used in hospitals were not studied. The deficiency resulting from omission of these drug groups introduces bias in relation to overall consumption and more particularly to costs of drugs by individuals with diabetes, but one can assume that the general pattern of the greater use of drugs by diabetic individuals than by control subjects would not change if the deficiency were corrected.

In this study, we found and recorded in detail substantially higher use of medications for diabetic individuals versus nondiabetic individuals and associated higher costs. The greater use was not only because of antidiabetic drugs but also involved almost all drug groups. Although our study mainly adds to findings related to health care for diabetic individuals, the detailed results related to individual drug groups and associated diseases may help in forming hypotheses for testing in other studies.

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