Preventable Hospitalization Among Elderly Medicare Beneficiaries With Type 2 Diabetes

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OBJECTIVE — To examine the impact of comorbid conditions on preventable hospitalizations among Medicare beneficiaries aged ≥65 years with type 2 diabetes.

RESEARCH DESIGN AND METHODS — Data were drawn from the 1999 Medicare Standard Analytic Files, a 5% nationally representative random sample of Medicare beneficiaries. The analysis sample included 193,556 Medicare beneficiaries aged ≥65 years with type 2 diabetes (ICD-9-CM codes 250.xx) who were enrolled in fee-for-service Medicare. Preventable hospitalization was assessed by measuring ambulatory care–sensitive conditions, an accepted measure of hospitalizations that could have been prevented with appropriate outpatient care. Multivariable analyses controlled for demographics; mortality; renal, ophthalmic, or neurological manifestations of diabetes; type of physician providing the outpatient care; and per capita community-level indicators of income and hospital beds.

RESULTS — Ninety-six percent of beneficiaries in the sample had a comorbidity, and 46% had five or more comorbidities. Among beneficiaries with type 2 diabetes, cardiovascular-related comorbidities were common and accounted for increased odds of preventable hospitalization, controlling for other factors. The likelihood of a preventable hospitalization increased in the presence of a claim for comorbid congestive heart failure, cardiomyopathy, coronary atherosclerosis, hypertension, or cardiac dysrythmias. Noncardiovascular comorbidities associated with a greater likelihood of preventable hospitalization included chronic obstructive pulmonary disease, asthma and lower respiratory disorders, Alzheimer's disease/dementia, personality/anxiety disorders, depression, and osteoporosis. Our data suggest that nearly 7% of all hospitalizations could be avoided.

CONCLUSIONS — These findings support the need for improved outpatient care strategies to reduce the impact of comorbidity on unnecessary hospitalization in patients aged ≥65 years with type 2 diabetes.

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ype 2 diabetes is a major cause of morbidity and mortality. Diabetes complicates the diagnosis and treatment of other medical disorders, particularly in an elderly population already burdened by extensive comorbidity (1). For instance, both diabetes and older age can mask the typical manifestations of cardiac ischemia (2–4). Elderly patients with diabetes have more extensive atherosclerosis (5), experience worse clinical outcomes after revascularization (6–11), and are two to four times more likely to die from cardiovascular disease (CVD) than elderly patients without diabetes (12–15). Appropriate management of subjects with type 2 diabetes and other comorbidities may differ substantially from the management of those without comorbidities (16–18). Individuals with diabetes and concomitant comorbidities are at an increased risk of using greater resources by requiring more hospitalizations, longer hospital stays, and more expensive services (12,19–21).

Despite knowledge regarding interactions between diabetes and specific comorbid conditions, little is known about the extent to which comorbidities lead to breakdowns in access or processes of care. Hospitalization for ambulatory care–sensitive conditions (ACSCs), such as diabetes with ketoacidosis, malignant hypertension with congestive heart failure (CHF), or pneumococcal pneumonia, implies a breakdown in outpatient care. Bindman et al. (22) provided empirical evidence that hospitalizations for chronic medical conditions like diabetes may be prevented if patients receive access to timely and appropriate outpatient treatment. These authors and others have used the term "preventable hospitalization" to describe hospitalizations that are sensitive to the quality of ambulatory care provided (22,23). Thus defined, preventable hospitalizations are also considered an indicator of inadequate primary care (24).

We analyzed the impact of chronic comorbidity on preventable hospitalizations among Medicare beneficiaries aged ≥65 years with type 2 diabetes. Our aim was to provide clinicians who were routinely engaged in the care of these patients with information on the specific comorbidities that place beneficiaries with type 2 diabetes at greatest risk of hospitalizations that could potentially be prevented through improved outpatient processes of care.

RESEARCH DESIGN AND METHODS

This study used a nationally representative cross-sectional sample of Medicare beneficiaries aged ≥65 years. Data were drawn from the 1999 Medicare Standard Analytic Files, a 5% nationally representative random sample of fee-for-service claims from Medicare beneficiaries ($n = 2,055,561$). Beneficiaries were excluded if they were aged <65 years, without both Medicare Part A and Part B coverage, or not residing in the U.S. Health maintenance organization enrollees, comprising 17.3% of Medicare beneficiaries nationwide in 1999 (25), were also excluded because they are unlikely to have complete claims information.

Subjects were defined as having type 2 diabetes if they had one claim in an inpatient setting or two claims in the physician/supplier file or outpatient file with a reported ICD-9-CM code of 250, 250.0, 250.00, 250.02, 250.4, 250.40, 250.42, 250.5, 250.50, 250.52, 250.6, 250.60, 250.62, 250.7, 250.70, 250.72, 250.8, 250.9, 250.90, or 250.92 ($n = 193,556$). Two outpatient claims were required to increase the specificity of diagnoses. We excluded 10,647 beneficiaries with type 1 diabetes (<1% of the population) from the analysis if there was not also a claim for type 2 diabetes during the year because *1*) the diagnosis of type 1 diabetes in this age-group may often be inaccurate, as insulin-treated type 2 diabetes may be miscoded as type 1 diabetes, and *2*) there are relatively few people in the Medicare population with type 1 diabetes (26). Chronic conditions were coded using the Clinical Classification System developed by the Agency for Healthcare Research and Quality (27). The Clinical Classification System aggregates all diagnosis codes into 259 unique, clinically homogeneous categories (e.g., essential hypertension, osteoarthritis, prostate cancer). We also merged data from the 1999 Area Resource File to obtain per capita community level indicators of income and hospital beds (28).

Definition of ACSCs

ACSCs were defined by panels of physicians as conditions that should not require hospitalization if ambulatory care treatment is provided in a timely and appropriate manner (24). The Medicare inpatient hospital claims data file was used to identify beneficiaries with all-cause hospitalization and preventable hospitalizations. The ICD-9-CM code reported as the primary diagnosis for each hospitalization was used to determine whether a hospitalization could be classified as potentially preventable (see online appendix at http://care.diabetesjournals.org). We adapted this definition of ACSC hospitalization from the study by Culler et al. (29) of Medicare beneficiaries aged ≥65 years.

Analysis

Multiple logistic regression was used to test the hypothesis that specific comorbid conditions increased the likelihood of preventable hospitalization among Medicare beneficiaries aged ≥65 with type 2 diabetes. Multivariable analysis controlled for age; sex; race; mortality; number of unique physicians seen during the year; type of physician seen (at least one outpatient visit to a primary care physician, endocrinologist, or cardiologist); renal, ophthalmic, or neurological manifestations of diabetes (ICD-9-CM codes 250.4x, 250.5x, and 250.6x, respectively); number of comorbid conditions; per capita income at the county level; and hospital beds per capita. We chose these variables because each could influence the probability of preventable hospitalization (23,29,30). The chronic conditions chosen in the analysis were either cardiovascular related or among the 25 most prevalent chronic comorbid conditions of beneficiaries with type 2 diabetes. Cardiovascular comorbidities were of specific interest because of their high prevalence among beneficiaries with type 2 diabetes and the complications that result from these conditions (5,10–12). Analyses were conducted using SAS statistical software version 8.02 (31).

RESULTS

Prevalence of comorbid conditions with diabetes

We identified a total of 193,556 Medicare beneficiaries aged ≥65 years with type 2 diabetes using the claims data (15.6% of the sample population). A disproportionate number of the Medicare population with type 2 diabetes were African American compared with those without type 2 diabetes (11 vs. 7%, $P < 0.0001$). Fifty-eight percent with type 2 diabetes were women, and 11% were aged ≥85 years. Almost all Medicare beneficiaries (96%) with type 2 diabetes had at least one other chronic condition. Almost half (46%) of Medicare beneficiaries aged ≥65 years with type 2 diabetes had five or more comorbid conditions (Fig. 1).

The ten most prevalent comorbidities accompanying type 2 diabetes are shown in Fig. 2; the top five were related to CVD. Comorbidity to type 2 diabetes increased health care utilization dramatically. A beneficiary aged ≥65 years with diabetes and no comorbid conditions saw 5.6 unique physicians a year on average, 16.4 physicians if they had five comorbidities, and 28.2 if they had ≥10 comorbidities.

A beneficiary aged ≥65 years with type 2 diabetes who was hospitalized during the year spent an average of 13.3 days in the hospital. Without comorbidity, this number decreased to 4.3 days per year. Five comorbidities almost doubled the average number of days spent in the hospital (to 8.0 days), and people with ≥10 comorbidities had an average of 23.7 hospital days.

There were 32,518 preventable hospitalizations among Medicare beneficiaries aged ≥65 years with type 2 diabetes, constituting 7% of all inpatient stays. The chronic conditions most commonly associated with preventable hospitalizations were CHF, pneumonia, chronic obstructive pulmonary disease (COPD), dehydration, and diabetes. Forty percent of all preventable hospitalizations were attributed to CHF, 21% to pneumonia, 13% to COPD, and 2% to diabetes. The comorbidities associated with preventable hospitalizations in diabetes were similar to those in the generic population ($P > 0.05$). Hospitalization for CHF disproportionately affected beneficiaries with type 2 diabetes compared with Medicare beneficiaries without type 2 diabetes ($P < 0.0001$).

Expenditures for preventable hospitalizations were high. The average per capita cost of a preventable hospitalization was $7,935 among type 2 diabetes beneficiaries. Total expenditures per capita for preventable hospitalizations were far higher among type 2 diabetes beneficiaries with CVD comorbidities than for those without CVD comorbidities ($26,733 vs. $13,150). Among those with a preventable hospitalization, nearly three-fourths were hospitalized once during the year with a preventable condition and more than one-quarter experienced multiple hospital admissions for an ACSC, further raising Medicare expenditures.
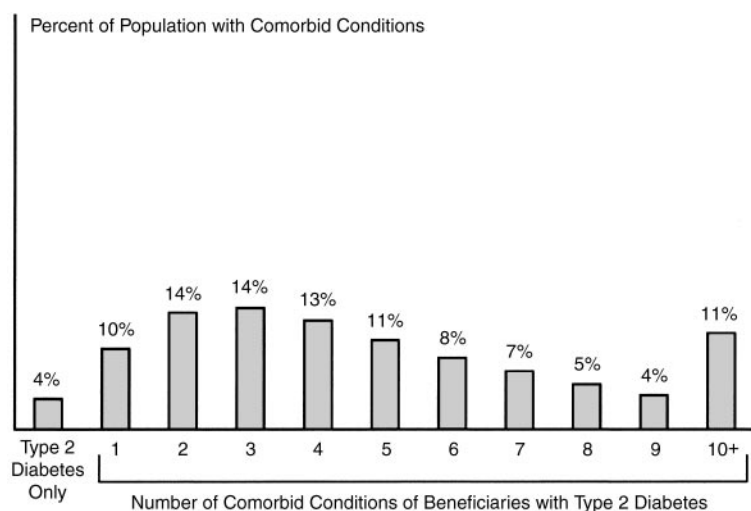
Figure 1—*The number of comorbid conditions among Medicare beneficiaries aged ≥65 years with type 2 diabetes.*

Specific comorbid conditions and preventable hospitalizations

Several specific cardiovascular comorbidities increased the likelihood of preventable hospitalization after controlling for potential confounders (Table 1). Beneficiaries with type 2 diabetes and CHF were over three times more likely to have a preventable hospitalization than those without CHF. Cardiomyopathy, coronary atherosclerosis, hypertension, and cardiac dysrythmias also raised the odds of preventable hospitalization among beneficiaries with type 2 diabetes, controlling for other factors.

Certain noncardiovascular comorbidities were also associated with a greater likelihood of preventable hospitalization. Beneficiaries with type 2 diabetes and COPD were 2.4 times more likely to experience preventable hospitalization than type 2 diabetes beneficiaries without COPD. The likelihood of preventable hospitalization also increased for benefi-

ciaries with type 2 diabetes if they had comorbid asthma or lower respiratory disorders, Alzheimer's disease/dementia, personality/anxiety disorder, depression, and osteoporosis.

A few comorbidities appeared to be associated with a lower probability of preventable hospitalization among those with type 2 diabetes. Those with lipid disorders were 34% less likely to have a preventable hospitalization. This occurs because of the low prevalence of beneficiaries with lipid disorders without a comorbid claim for conduction disorders. Once conduction disorders are controlled for in the analysis, the added effect of lipid disorders on preventable hospitalizations is negative. Claims for a diagnosis of cataract, glaucoma, hyperplasia of the prostate, cancer of the prostate, spondylosis/intervertebral disc disorders, other connective tissue disease, or other eye disorder also lowered the odds of preventable hospitalization.

Other factors that significantly increased the likelihood of preventable hospitalization ($P < 0.05$) included age ≥75 years, nonwhite race, female sex, and mortality during the year. The odds of preventable hospitalization increased by 17% for each added comorbid condition, when all other factors were held constant.

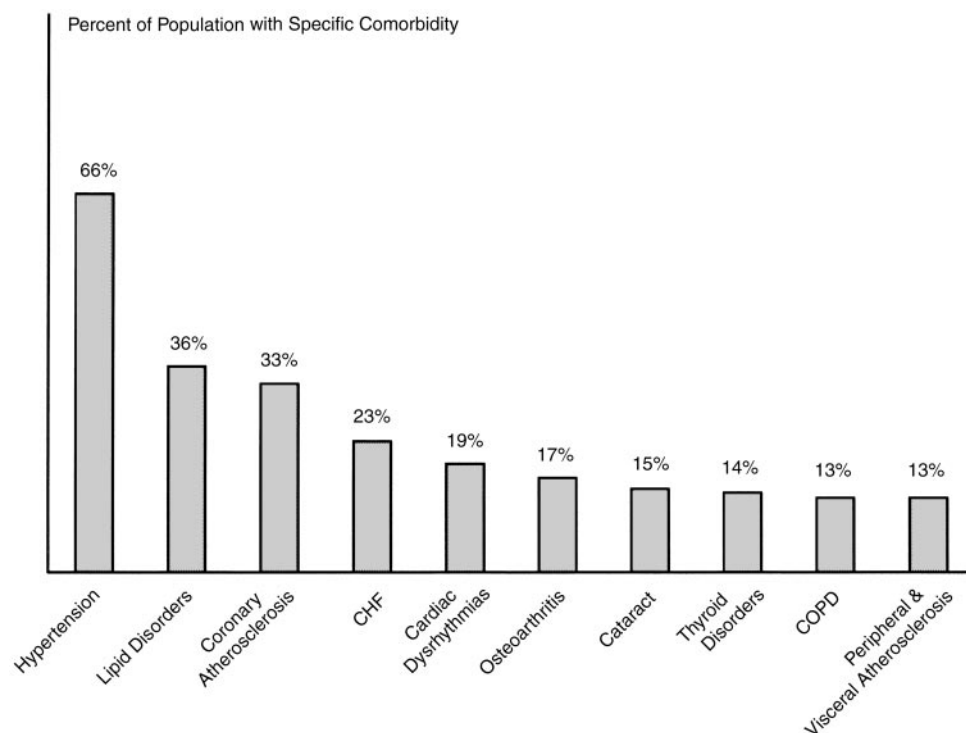With one exception, seeing any par-

Figure 2—*The 10 most prevalent comorbid conditions among medicare beneficiaries aged ≥65 years with type 2 diabetes.*

Table 1—*Factors associated with preventable hospitalization for Medicare beneficiaries aged ≥65 years with type 2 diabetes (multiple logistic regression model)*

	OR	95% CI	
Variable name			
Cardiac comorbidities			
CHF	3.41	3.27	3.55
Cardiomyopathy	1.66	1.57	1.76
Coronary atherosclerosis	1.31	1.25	1.36
Hypertension	1.25	1.19	1.30
Cardiac dysrhythmias	1.12	1.08	1.17
Peripheral vascular disease	0.94	0.89	0.98
Lipid disorders	0.67	0.64	0.69
Ill-defined heart disease	0.98	0.93	1.04
Cerebrovascular disease	0.95	0.91	1.00
Noncardiac comorbidities			
COPD	2.44	2.34	2.54
Asthma	1.56	1.46	1.66
Other lower respiratory	1.47	1.38	1.57
Other kidney disorders	1.39	1.32	1.47
Alzheimer's disease/dementia	1.36	1.30	1.43
Conduction disorders	1.27	1.20	1.34
Nutritional/endocrine/metabolic	1.23	1.16	1.31
Respiratory failure	1.23	1.15	1.32
Heart valve disorders	1.22	1.16	1.28
Anxiety/personality disorders	1.22	1.14	1.32
Depression	1.13	1.07	1.20
Other nervous system disorders	1.11	1.05	1.19
Osteoporosis	1.11	1.03	1.19
Thyroid disorders	0.94	0.89	0.98
Retinal problems	0.89	0.84	0.95
Glaucoma	0.87	0.82	0.92
Hyperplasia of prostate	0.87	0.81	0.93
Other connective tissue disease	0.84	0.78	0.91
Spondylosis/intervertebral disc disorders	0.83	0.78	0.88
Other eye disorders	0.83	0.76	0.91
Cancer of the prostate	0.82	0.74	0.90
Chronic renal failure	0.81	0.76	0.87
Cataract	0.80	0.76	0.84
Skin cancer	0.79	0.71	0.87
Osteoarthritis/rheumatoid	0.99	0.95	1.03
Chronic ulcer of the skin	1.00	0.94	1.07
Renal, ophthalmic, or neurological manifestations of diabetes	0.99	0.95	1.04
Number of comorbidities	1.17	1.16	1.19
Per capita income at the county level	1.00	1.00	1.00
Hospital beds per capita	1.00	1.00	1.00
Age (years)			
65–69	Reference group		
70–74	1.05	0.99	1.10
75–79	1.13	1.07	1.19
80–84	1.25	1.18	1.32
≥85	1.44	1.35	1.53
Race			
White	Reference group		
African American	1.14	1.08	1.20
Other	1.08	1.00	1.17
Sex			
Male	Reference group		
Female	1.11	1.07	1.15
Mortality	1.50	1.42	1.57
Number of unique doctor visits	1.00	0.99	1.00
Type of doctor			
Endocrinologist	0.98	0.82	1.16
Primary care physician	0.94	0.89	1.00
Cardiologist	0.88	0.80	0.96
Primary care * endocrinologist	1.01	0.85	1.21
Cardiologist * endocrinologist	0.93	0.80	1.08
Primary care * cardiologist	1.01	0.92	1.11

The dependent variable was ACSC hospitalization. Source: 1999 Medicare Standard Analytic Files 5% File.

ticular type of specialist at any point during the year was not a significant predictor of hospitalization ($P > 0.05$). Beneficiaries with diabetes who saw a cardiologist did have a 12% lower odds of experiencing a preventable hospitalization compared with beneficiaries who did not see a cardiologist ($P < 0.001$). None of the odds ratios corresponding to the interaction terms between the types of physicians were significant, nor were the odds ratios associated with the number of different physicians seen, the per capita income at the county level, or the number of hospital beds per capita.

We performed a sensitivity analysis of the data by eliminating people from the model who died during the year. There were no significant changes to the comorbid conditions, the demographic variables, or the community level indicators. The "type of doctor seen" variables did become significant predictors of preventable hospitalizations. Patients who were seen solely by their primary care physician, endocrinologist, or cardiologist were significantly more likely to experience preventable hospitalization during the year. Patients who were seen by primary care physicians and endocrinologists, cardiologists and endocrinologists, or primary care physicians and cardiologists were significantly less likely to experience a preventable hospitalization.

CONCLUSIONS — Comorbid conditions increase the likelihood of preventable hospitalizations among patients aged ≥65 years with type 2 diabetes. Using a nationally representative sample, our data suggest that nearly 7% of all hospitalizations in Medicare beneficiaries with type 2 diabetes could be avoided. Specific conditions associated with increased rates of preventable hospitalization included CHF, other cardiovascular-related conditions, COPD, asthma, and mental disorders.

Our work confirms and extends the findings of others by analyzing a disease-specific population, identifying multiple comorbid conditions, and including patient access measures at the community level. Culler et al. (29) reported that diabetes increased the odds of a preventable hospitalization among Medicare beneficiaries aged ≥65 years by 23% compared with beneficiaries without diabetes (29). Wolff et al. (30) reported that preventable hospitalization rates increased as the

number of chronic conditions a beneficiary had increased. Our data extend these studies by identifying specific comorbid conditions that are associated with preventable hospitalizations in a disease-specific population.

While our study is the first to address preventable hospitalizations in elderly type 2 diabetic patients with comorbidities, several reports have identified inadequacies in primary care for older adults with diabetes and comorbid illnesses. Asch et al. (32) estimated that only 36% of patients with diabetes receive an HbA_{1c} or fructosamine assessment every 6 months and only 43% receive eye exams every year. In addition, Weiner et al. (33) found that 45% of elderly Medicare beneficiaries received no cholesterol screening.

The presence of comorbidities in our analysis was related to a remarkable proliferation in the number of different physicians seeing individual Medicare beneficiaries. Thus, while the average beneficiary without comorbidity saw 5.6 physicians, this number increased fivefold, to 28.2 doctors, if the individual had 10 comorbidities. It may be speculated that communication among caregivers deteriorates as the number of unique physicians involved in the care of these elderly beneficiaries increases, which could complicate outpatient care management.

There are several mechanisms by which comorbid conditions can increase preventable hospitalizations in diabetes. Ability to adhere to prescribed treatment regimens may be more difficult because of complex, hard to understand, or possibly opposing treatment recommendations by different physicians (34,35). Other data show that individuals with diabetes especially benefit from interventions aimed at improving patient adherence to therapeutic recommendations (36). Comorbidity may also discourage adherence to multiple complex treatment regimens due to depressed mood about high burden of disease—individuals with diabetes and depression are less likely than those without depression to achieve adequate levels of glycemic control (37,38).

Our data strongly support the need for improving the current system of chronic disease management in Medicare. According to the Institute of Medicine, "the most effective approach to chronic illness includes access to the entire medical record for each patient, coordination of treatment between various health care providers, and simplicity of system use for both the practitioner and the patient" (39). A second approach advocated by the Institute of Medicine is multidisciplinary disease management. Multidisciplinary disease management has been found to lower HbA_{1c} levels, improve self-care practices, and reduce hospital utilization among individuals with diabetes in a health maintenance organization setting compared with similar patients receiving care from their primary care physician (40).

Limitations

Several limitations in our data are worth mentioning. First, because we used administrative claims data, we were unable to measure several factors that may confound the relation between comorbidity and preventable hospitalizations, such as availability of primary care physicians and specialists, individual indicators of socioeconomic status, satisfaction with care, and disease severity. Despite this limitation, however, the strength of our data lies in its large size, national representativeness, and extensive listing of multiple chronic conditions.

The second limitation is that we relied on the claims-coding process to identify comorbid conditions and preventable hospitalizations. Claims-based selection and misclassification bias would likely bias the prevalence rates of our chronic conditions downward. Despite any underestimation of the prevalence of chronic conditions, it is unlikely that the relative impact of any specific comorbidity would change dramatically. In addition, while preventable hospitalizations have been linked to poorer outpatient access, chart reviews have not been performed to validate whether patients with preventable hospitalizations are more likely than similar patients without preventable hospitalization to fail to receive timely and appropriate services. This was not possible given the framework of our study.

The third limitation is the cross-sectional nature of our data. This precluded us from establishing causal relationships between comorbidities and preventable hospitalizations. Finally, because we only studied fee-for-service Medicare beneficiaries aged ≥ 65 years with type 2 diabetes with both Part A and Part B Medicare, our findings may not be generalizable to younger individuals,

Medicare beneficiaries enrolled in managed care plans, or Medicare beneficiaries without supplemental insurance.

In conclusion, this study demonstrates that comorbidities complicate care among elderly Medicare beneficiaries with type 2 diabetes. Cardiovascular conditions, in particular, resulted in a greatly increased rate of hospitalization that may be prevented through improvements in timely and effective outpatient care. These preventable hospitalizations are not only a burden to individuals, but also a considerable cost to the Medicare program. The enormous number of unique physicians involved in caring for individuals with diabetes and comorbidities highlights the challenges of delivering coordinated care to elderly beneficiaries. Given the aging U.S. population and the burden of type 2 diabetes, improved outpatient strategies for the management of high-risk elderly patients with type 2 diabetes are worthy of attention by policy makers, health care administrators, and clinicians.

References

1. Redelmeier DA, Tan SH, Booth GL: The treatment of unrelated disorders in patients with chronic medical diseases. *N Engl J Med* 338:1516–1520, 1998
2. Gregoratos G: Clinical manifestations of acute myocardial infarction in older patients. *Am J Geriatr Cardiol* 10:345–347, 2001
3. Koistinen MJ: Prevalence of asymptomatic myocardial ischaemia in diabetic subjects. *BMJ* 301:92–95, 1990
4. Mehta RH, Ruane TJ, McCargar PA, Eagle KA, Stalhandske EJ: The treatment of elderly diabetic patients with acute myocardial infarction: insight from Michigan's Cooperative Cardiovascular Project. *Arch Intern Med* 160:1301–1306, 2000
5. Kannel WB, McGee DL: Diabetes and cardiovascular disease: the Framingham Study. *JAMA* 241:2035–2038, 1979
6. Malmberg K, Ryden L: Myocardial infarction in patients with diabetes mellitus. *Eur Heart J* 9:259–264, 1988
7. Herlitz J, Malmberg K, Karlson B, Ryden L, Hjalmarson A: Mortality and morbidity during a five-year follow-up of diabetics with myocardial infarction. *Acta Med*

Scand 224:31–38, 1988

8. Karlson B, Herlitz J, Hjalmarson A: Prognosis of acute myocardial infarction in diabetic and non-diabetic patients. *Diabet Med* 10:449–454, 1993

9. Jacoby R, Nesto R: Acute myocardial infarction in the diabetic patient: pathophysiology, clinical course and prognosis. *J Am Coll Cardiol* 20:736–744, 1992

10. The Bypass Angioplasty Revascularization Investigation (BARI) Investigators: Comparison of coronary bypass surgery with angioplasty in patients with multivessel disease. *N Engl J Med* 335:217–225, 1996

11. Detre KM, Lombardero MS, Brooks MM, Hardison RM, Holubkov R, Sopko G, Frye RL, Chaitman BR: The effect of previous coronary-artery bypass surgery on the prognosis of patients with diabetes who have acute myocardial infarction. *N Engl J Med* 342:989–997, 2000

12. Morbidity and Mortality Weekly Report (MMWR): *Major Cardiovascular Disease (CVD) During 1997–1999 and Major CVD Hospital Discharge Rates in 1997 Among People with Diabetes: United States* [article online], 2001. Available from http://www.cdc.gov/mmwr/preview/mmwrhtml/mm5043a2.htm. Accessed 10 May 2002

13. Stamler J, Vaccaro O, Neaton JD, Wentworth D: Diabetes, other risk factors, and 12-year cardiovascular mortality for men screened in the multiple risk factor intervention trial. *Diabetes Care* 16:434–444, 1993

14. Barrett-Connor EL, Cohn BA, Wingard DL, Edelstein SL: Why is diabetes mellitus a stronger risk factor for fatal ischemic heart disease in women than in men? *JAMA* 265:627–631, 1991

15. Goldbourt U, Yaari S, Medalie JH: Factors predictive of long-term coronary heart disease mortality among 10,059 male Israeli civil servants and municipal employees. *Cardiology* 82:100–121, 1993

16. Gary TL, Crum RM, Cooper-Patrick L, Ford D, Brancati FL: Depressive symptoms and metabolic control in African-Americans with type 2 diabetes. *Diabetes Care* 23:23–29, 2000

17. Van Spronsen DJ, Janssen-Heijnen MLG, Breek WPM, Coebergh JWW: Prevalence of co-morbidity and its relationship to treatment among unselected patients with Hodgkin's disease and non-Hodgkin's lymphoma, 1993–1996. *Ann Hematol* 78:315–319, 1999

18. Zanobetti A, Schwartz J: Are diabetics more susceptible to the health effects of airborne particles? *Am J Respir Crit Care Med* 164:831–833, 2001

19. Norlund A, Apelqvist J, Bitzen PO, Nyberg P, Schersten B: Cost of illness of adult diabetes mellitus underestimated if comorbidity is not considered. *J Intern Med* 250:57–65, 2001

20. Hodgson TA, Cohen AJ: Medical care expenditures for diabetes, its chronic complications, and its comorbidities. *Prev Med* 29:173–186, 1999

21. Krop JS, Powe NR, Weller WE, Shaffer TJ, Saudek CD, Anderson GF: Patterns of expenditures and use of services among older adults with diabetes. *Diabetes Care* 21:747–752, 1998

22. Bindman AB, Grumbach K, Osmond D, Komaromy M, Vranizan K, Lurie N, Billings J, Stewart A: Preventable hospitalizations and access to health care. *JAMA* 274:305–311, 1995

23. Blustein J, Hanson K, Shea S: Preventable hospitalizations and socioeconomic status. *Health Aff* 17:177–189, 1998

24. Millman M (Ed.): *Access to Health Care in America: IOM Report*. Washington, DC, National Academy Press, 1993

25. Laschober MA, Kitchman M, Neuman P, Strabic AA: Trends in Medicare supplemental insurance and prescription drug coverage. *Health Aff* 21:W127–W138, 2002

26. Harris MI, Cowie CC, Eastman R: Health insurance coverage for adults with diabetes in the U.S. population. *Diabetes Care* 17:585–591, 1994

27. Agency for Healthcare Research and Quality (AHRQ): Clinical classification software (ICD-9-CM): summary and download [article online]. Available from http://www.ahrq.gov/data/hcup/ccs.htm. Accessed 15 July 2001

28. *Area Resource File (ARF)*. Washington, DC, National Center for Health Workforce Information and Analysis, Bureau of Health Professions, Department of Health and Human Services, 2001

29. Culler SD, Parchman ML, Przybylski M: Factors related to potentially preventable hospitalizations among the elderly. *Med Care* 36:804–817, 1998

30. Wolff J, Starfield B, Anderson GF: Prevalence, expenditures, and complications of multiple chronic conditions in the elderly. *Arch Intern Med* 162:2269–2276, 2002

31. SAS Institute: *SAS Version 8.02*. Cary, NC, SAS, 2000

32. Asch S, Sloss E, Hogan C, Brook R, Kravitz R: Measuring underuse of necessary care among elderly Medicare beneficiaries using inpatient and outpatient claims. *JAMA* 284:2325–2333, 2000

33. Weiner JP, Parente ST, Garnick DW, Fowles J, Lawthers AG, Palmer RH: Variation in office-based quality: a claims-based profile of care provided to Medicare patients with diabetes. *JAMA* 273:1503–1508, 1995

34. Colt HG, Shapiro AP: Drug-induced illness as a cause for admission to a community hospital. *J Am Geriatr Soc* 37:323–326, 1989

35. Larme AC, Pugh JA: Attitudes of primary care providers toward diabetes. *Diabetes Care* 21:1391–1396, 1998

36. Roter DL, Hall JA, Merisca R, Nordstrom B, Cretin D, Svarstad B: Effectiveness of interventions to improve patient compliance: a meta analysis. *Med Care* 36:1138–1161, 1998

37. Van-der-Does FEE, Neeling JNDD, Snoek FJ, Kostense PJ, Grootenhuis PA, Bouter LM, Heine RJ: Symptoms and well-being in relation to glycemic control in type II diabetes. *Diabetes Care* 19:204–210, 1996

38. Lustman PJ, Griffith LS, Clouse RE, Cryer PE: Psychiatric illness in diabetes mellitus: relationship to symptoms and glucose control. *J Nerv Ment Dis* 174:736–742, 1986

39. Washburn ER: Fast forward: a blueprint for the future from the Institute of Medicine. *Physician Exec* 27:8–14, 2001

40. Sadur CN, Moline N, Costa M, Michalik D, Mendlowitz D, Roller S, Watson R, Swain BE, Selby JV, Javorski WC: Diabetes management in a health maintenance organization. *Diabetes Care* 22:2011–2017, 1999