Obesity and diabetes have been increasing in the U.S. at an alarming rate over the past decade (1–3). Although national data have not yet quantified an increase in diabetes-associated morbidity and mortality, it is reasonable to assume an increasing trend. Coronary heart disease, the principal cause of death among diabetic patients, is of particular concern in this regard. To date, however, despite the growing incidence of diabetes, U.S. age-adjusted coronary heart disease mortality has continued to fall (4–6). We have been unable to identify any population-based data to quantify recent effects of diabetes on coronary heart disease mortality and morbidity.

Availability of data for New York City has provided an opportunity to determine a more detailed picture of evolving diabetes and diabetes-related mortality and morbidity in a large, diverse, and well-defined population. We now report mortality and hospitalization data for diabetic people in New York City (1990–2000).

RESEARCH DESIGN AND METHODS

Datasets

Mortality. New York City mortality records for the two 3-year periods of 1989–1991 and 1999–2001 were provided by the New York City Department of Health, which records all births and deaths in the city. Information identifying individuals was eliminated to preserve confidentiality. Underlying causes of death were coded by a physician according to the ICD. The ICD-9 (7) was used for coding 1989–1991 data and ICD-10 (8) for 1999–2001 data. The major categories in our analysis were deaths of all causes and those recorded on the death certificate as underlying cause of death, including cardiovascular disease, coronary heart disease, acute myocardial infarction, stroke, diabetes, and cancer. The ICD codes for these diagnoses, based on ICD-9 and ICD-10, respectively, are listed in Table 1.

Hospitalization. Statewide Planning and Research Cooperative System (SPARCS) data (1988–2002) of New York State were created by the New York State Department of Health (9) and contain discharge data abstracted for at least 95% of all New York State acute care hospitalizations, except psychiatric and federal hospitals. SPARCS data include patients’ disposition, age, sex, race, admission status, physician and hospital identifiers, principal diagnosis and up to 14 secondary diagnoses, and principal procedure code and up to 14 other procedure codes. Data records in the system are abstracted from medical records by trained medical records personnel in each hospital, and the New York State Department of Health is responsible for verifying the accuracy of reported information. This analysis included all records of hospitals located on the five boroughs of New York City.

Diagnostic coding was based on the ICD-9-CM. Myocardial infarction was defined by the principal diagnosis codes 410.0–410.9. Subjects were then further defined by presence/absence of diabetes (ICD-9 250) in 14 other diagnostic codes. Hospitalization with diabetes complications was defined as a principal diagnostic code of lower-extremity amputation (ICD-9 250–250.9 with procedure codes of 84.10–84.19), ketoacidosis (ICD-9: 250.1), hyperosmolar coma (ICD-9 250.2), renal disorders (ICD-9 250.4), opportunistic manifestations (ICD-9 250.5), neurological manifestations (ICD-9 250.6), and peripheral circulatory disorders (ICD-9 250.7).

Census data. Census data for New York City in 1990 and 2000 were obtained from the U.S. Census Bureau.

Data analysis. Analyses were limited to people 35 years and older. Annual age- and sex-adjusted rates for all-cause and cause-specific mortality for men and women were estimated using mortality records for 1989–1991 and 1999–2001 and U.S. census data for 1990 and 2000. Relative mortality ratios and 95% CIs of age-adjusted mortality rates for 2000 and 1990 were estimated to determine mortality change from 1990 to 2000.

In-hospital mortality rate was estimated by identifying patients who died during hospitalization. Relative mortality ratios and 95% CIs of age-adjusted hospitalization rates for 2000 and 1990 were determined. All rates were adjusted to the 2000 U.S. standard population.

To determine the impact of diabetes morbidity by applying new diagnostic criteria (blood glucose 126 instead of 140 mg/dl) in 1997 (10), hospitalizations with principal diagnosis of diabetes (ICD-9 250) and percentage of patients with diabetes comorbidity among patients hospitalized with acute myocardial infarction were examined from 1988 to 2002.

RESULTS

The total population in New York City increased from 7,289,839 in 1990 to 8,004,759 (9.8%) in 2000. Mean ages were 35.9 ± 22.0 and 35.6 ± 21.9 years, and the percentages of men were 46.8 and 47.3% in 1990 and 2000, respectively. Those aged 35 years and older in 1990 and 2000 were 47.8 and 49.4%, respectively, and among these, average ages were 54.7 and 53.9 years.

Age-adjusted mortality rates from 1990 to 2000 (Table 2) decreased by 30% for men and 21% for women. Acute myocardial infarction mortality overall decreased by one-half (52 and 50% for men and women, respectively). In contrast, diabetes mortality increased 61 and 52% for men and women, respectively.

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Age-adjusted annual hospitalization rates for selected complications of diabetes increased overall from 596 to 856 per 100,000 people (44% [95% CI 1.37–1.50]) from 1990 to 2000. Peripheral circulatory disorder was the most frequent complication, followed by ketoacidosis. All hospitalization rates for complications of diabetes increased in 2000 except for ketoacidosis and ophthalmic manifestations (Fig. 1).

Age-adjusted hospitalization rates for acute myocardial infarction overall were unchanged (from 850 to 858 per 100,000) from 1989–1991 to 1999–2001 (Fig. 2). However, this total obscured a significant increase (from 186 to 286 per 100,000) among people with diabetes, which essentially offset the decreased incidence (from 665 to 572 per 100,000) among those without diabetes. Although rates in the two periods were similar, an increasing population could explain the modest (5%) increase in the actual number of myocardial infarction admissions (from 75,165 to 79,439). Admissions for acute myocardial infarction in patients without diabetes actually decreased from 58,866 to 52,529 over this time. In contrast, admissions for patients with diabetes increased by 65% from 16,299 to 26,910.

Overall, from 1988 to 2002, average days in hospital for acute myocardial infarction decreased from 12.0 to 7.3 days. Although this decrease was similar for patients with diabetes, annual hospitalization rates for acute myocardial infarction overall were unchanged (from 850 to 858 per 100,000) from 1989–1991 to 1999–2001 (Fig. 2). However, this total obscured a significant increase (from 186 to 286 per 100,000) among people with diabetes, which essentially offset the decreased incidence (from 665 to 572 per 100,000) among those without diabetes. Although rates in the two periods were similar, an increasing population could explain the modest (5%) increase in the actual number of myocardial infarction admissions (from 75,165 to 79,439). Admissions for acute myocardial infarction in patients without diabetes actually decreased from 58,866 to 52,529 over this time. In contrast, admissions for patients with diabetes increased by 65% from 16,299 to 26,910.

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and without diabetes, because of the increased number of diabetic admissions, total days for those with diabetes increased by 51% (from 34,188 to 51,566). Among patients without diabetes, total hospital days decreased 58% (from 132,520 to 55,462) (Fig. 3).

In-hospital mortality for acute myocardial infarction has declined for patients with and without diabetes (Fig. 4). The percentage of acute myocardial infarction hospitalizations occurring in diabetic people and total hospitalization for patients with a principal diagnosis of diabetes increased steadily from 1988 to 2002 (Fig. 5). However, there was no apparent sudden impact associated with the 1997 reduction in the diagnostic blood glucose criteria for diabetes from 140 to 126 mg/dl (10).

**DISCUSSION**

During the last decade, in New York City, diabetes mortality has increased by >50%, and hospitalization for complications of diabetes has increased by 44%. In addition, although the total number of people hospitalized for acute myocardial infarction remained constant over the decade, the rate of diabetes-associated acute myocardial infarction hospitalization increased by 54%. The net result was to reverse what otherwise might have been an overall decline in incidence of acute myocardial infarction. Because coronary heart disease mortality continued to decline, increased incidence must have been accompanied by a reduced case fatality rate. That was the case for in hospital mortality for both diabetic and nondiabetic subjects.

The U.S. age-adjusted all-cause death rates declined from 1990 to 2000 by 12% from 1,202.8 to 1,053.8 per 100,000 for men and by 3% from 750.9 to 731.4 for women (11). From 1980 to 2003, age-adjusted prevalence of diagnosed diabetes nearly doubled from 2.8 to 4.9%. In 2003, the incidence of diagnosed diabetes among adults between 18 and 79 years of age was 7.0 per 1,000 people (12). Similarly, age-adjusted incidence increased 41% from 1997 to 2003, confirming that variance in prevalence was not due to aging of the population (13). Coincidently, there has been a dramatic rise in obesity in the U.S. In 1991, four states had obesity prevalence rates of 15–19%, and none had rates at or
above 20%. By 2003, 15 states had obesity rates of 15–19%, 31 had rates of 20–24%, and 4 had rates exceeding 25% (14).

Here in New York City, diabetes has also been recognized as a major health problem (15). The Health Department estimates that 520,000 adult New Yorkers have diagnosed diabetes, and another 265,000 have undiagnosed diabetes. In 2003, diabetes was the fourth leading cause of death in the city, after heart disease, cancer, and influenza/pneumonia (16). The observed increased diabetes hospitalization and mortality rates in New York City are consistent with the nationwide trends in both obesity and diabetes (17,18). The coincidence of obesity and diabetes is associated with poorer control of glucose, blood pressure, and cholesterol (19), thus creating a higher risk for both cardiovascular and microvascular morbidity and mortality. (20)

A persistent decline in age-adjusted coronary heart disease mortality has been among the proudest U.S. public health and medical care achievements of the past half-century. Risk factor reduction and improved treatment of patients with acute myocardial infarction has both decreased incidence of acute myocardial infarction and increased case survival rates (21–23). Acute myocardial infarction is the most common cause of death among diabetic people. The data here suggest that in-hospital mortality rates for diabetic patients are following the favorable trend affecting myocardial infarction in general. Absent information about the actual size of the diabetic population in New York City, we could neither determine diabetes-related incidence of myocardial infarction nor diabetes case fatality rate. Therefore, it is possible that although diabetes incidence, hospitalization, and mortality rates all went up during the last decade, the case fatality rate could still have fallen. Nevertheless, the hospital burden of acute myocardial infarction is increasingly dependent on the diabetic component of the population at a time when the incidence of acute myocardial infarction is almost certainly falling among those without diabetes. These trend lines are poised to cross, so that diabetic subjects may soon account for most acute myocardial infarction hospital bed days.

The strength of the study lies in its large size and standardized methodology, which are critical for time-trend assessment. But the study is limited to administrative data. The cause of death was the underlying cause of
death defined as “the disease, or injury, which initiated the train of events leading directly to death” (24). It was selected by trained New York City Department of Health personnel from among the conditions entered by the physician on the death certificate. When more than one cause or condition was recorded, the underlying cause was determined by the sequence of conditions on the certificate. Clearly, imprecision exists. For example, some of the deaths attributed to diabetes may actually have been due to acute myocardial infarction. Likewise, in some deaths attributed to acute myocardial infarction, diabetes may not have been listed. However, these errors were unlikely to have been systematic nor to have varied between the two time periods. In addition, the proportion of diabetes deaths actually captured through death is surely imprecise and probably an underestimation of the real prevalence. Thus, although we have no reason to suspect that this phenomenon changed over the relatively short term of this study, it is still likely that the overall fraction of diabetes-related deaths observed here is even less than in reality. Finally, it should be aware that the hospital payment system might have tendency toward upcoding of hospital records to include more severe form of disease.

There was no indication of variation of this tendency over the two periods.

In 1999, ICD-10 replaced ICD-9 to define the underlying cause of death in death certificates. This change could have altered coding cause of death and contributed to the observed difference of mortality in two periods. To test this hypothesis, the same deaths have been coded by both ICD-9 and ICD-10, and a comparability ratio was calculated by dividing the number of deaths classified by ICD-10 by the number of deaths classified by ICD-9. The comparability ratio for diabetes was 1.0082 (25). Therefore, the observed increased diabetes mortality rate in 2000 is unlikely to be explained by the change in ICD coding. Finally, the lower diagnostic threshold for diabetes, introduced in 1997, seems to have had little impact on hospitalization trends. Perhaps this primarily affected younger, more recently diagnosed subjects. These individuals were less likely to appear in morbidity and mortality statistics so soon after the change in diagnostic criteria. The data reported here probably involve older, more established diabetic subjects, likely to have been diagnosed long before the change in diagnostic criteria.

The implications of these findings are substantial. With growing incidence and prevalence of diabetes and its heightened risk for coronary heart disease, increasing numbers of acute myocardial infarction hospitalizations can hardly be a surprise, although the magnitude of and sharp rising of the trend is of great concern. To date, declining incidence among nondiabetes and reduced in-hospital mortality rates have combined to sustain a continuing decline in age-adjusted mortality from acute myocardial infarction. Likewise, an impressive decline in length of stay has more than compensated for the increase in events. It is unlikely, however, that these two beneficial trends can persist. More likely, both total coronary heart disease mortality and hospital resources committed to acute myocardial infarction will increase in real terms in the near future in New York, and probably for the nation as a whole, if the epidemic of diabetes continues.

In summary, diabetes-related morbidity, mortality, and particularly hospitalization for acute myocardial infarction have increased dramatically in New York City over the past decade. If continued, these trends may well overwhelm recently achieved dramatic reductions in coronary artery disease morbidity and mortality.

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