Secular Trends in Diabetes-Related Preventable Hospitalizations in the United States, 1998–2006

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OBJECTIVE — To examine secular trends in diabetes-related preventable hospitalizations among adults with diabetes in the U.S. from 1998 to 2006.

RESEARCH DESIGN AND METHODS — We used nationally representative data from the National Inpatient Sample to identify diabetes-related preventable hospitalizations. Based on the Agency for Healthcare Research and Quality's Prevention Quality Indicators, we considered that hospitalizations associated with the following four conditions were preventable: uncontrolled diabetes, short-term complications, long-term complications, and lower-extremity amputations. Estimates of the number of adults with diabetes were obtained from the National Health Interview Survey. Rates of hospitalizations among adults with diabetes were derived and tested for trends.

RESULTS — Age-adjusted rates for overall diabetes-related preventable hospitalizations per 100 adults with diabetes declined 27%, from 5.2 to 3.8 during 1998–2006 ($P_{trend} < 0.01$). This rate decreased significantly for all but not for short-term complication (58% for uncontrolled diabetes, 37% for lower-extremity amputations, 23% for long-term complications [all $P < 0.01$], and 15% for the short-term complication [$P = 0.18$]). Stratified by age-group and condition, the decline was significant for all age-condition groups (all $P < 0.05$) except short-term complications ($P = 0.33$) and long-term complications ($P = 0.08$) for the age-group 18–44 years. The decrease was significant for all sex-condition combination subgroups (all $P < 0.01$).

CONCLUSIONS — We found a decrease in diabetes-related preventable hospitalizations in the U.S. from 1998 to 2006. This trend could reflect improvements in quality of primary care for individuals with diabetes.

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Hospitalizations related to diabetes are costly and account for a major portion of the total expenditure on diabetes. In 2007, hospitalizations in the U.S. attributable to diabetes cost $58 billion or 50% of the total direct medical expenditure for diabetes (1). Nevertheless, a large portion of hospitalizations for diabetes may be preventable if primary care is effectively delivered (2–4). Timely and effective diagnosis, treatment, and education can result in better management of diabetes, prevent the development or worsening of complications, and lead to lower hospitalization rates. Thus, diabetes is often referred to as an ambulatory care–sensitive condition, and its associated hospitalizations are often referred to as preventable hospitalizations. Examining the trends of preventable hospitalization would facilitate our understanding of how access to and quality of primary care for diabetes has or has not improved. However, few analyses of trends in preventable hospitalizations for individuals with diabetes have been published.

The Agency for Healthcare Research and Quality (AHRQ) developed sets of disease and procedure codes using the ICD-9-CM to identify14 sets of preventable hospitalization conditions. Of the 14 conditions, four were for diabetes: uncontrolled diabetes, diabetes short-term complications, diabetes long-term complications, and lower-extremity amputations (5). The AHRQ also reported trends in rates of diabetes-related preventable hospitalizations from 1994 to 2000 (6). However, the rates reported by AHRQ used the total population (i.e., individuals with and without diabetes) as the denominator. Rates so calculated are sensitive to changes in diabetes prevalence and thus are not ideal for examining changes in access to and quality of ambulatory care for individuals with diabetes. Here, we used only adults with diabetes as the denominator to analyze national trends in the rates of diabetes-related preventable hospitalizations.

RESEARCH DESIGN AND METHODS

— We used the Healthcare Cost and Utilization Project National Inpatient Sample (NIS) to obtain diabetes-related preventable hospitalizations for adults aged ≥18 years. The NIS is the largest all-payer inpatient care database in the U.S. (7). It is an ~20% stratified sample of U.S. community hospitals and contains ~5–8 million inpatient records per year. The NIS provides information on primary and secondary diagnoses and procedures, admission and discharge status, and charges and payment source. Sampling weights are available for producing nationally representative estimates.

We adopted the four diabetes-related preventable hospitalization conditions defined in the AHRQ report (ICD-9-CM codes): 250.02 or 250.03 for uncontrolled diabetes (e.g., high glucose concentrations); 250.1–250.3 for diabetes short-term complications (e.g., diabetic ketoacidosis and hyperosmolarity); 250.4–250.9 for diabetes long-term complications (e.g., renal, ophthalmic, or neurological manifestations and peripheral circulatory disorders); and procedure code 84.1 for lower-extremity amputations (a detailed listing of codes is found

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in Table 1A of an online appendix, available at http://care.diabetesjournals.org/cgi/content/full/dc08-2211/DC1 or at http://www.qualityindicators.ahrq.gov/pqi_download.htm). These ICD-9-CM codes were selected by the AHRQ's Evidence-Based Practice Center at the University of California at San Francisco and Stanford University, using comprehensive literature reviews and empirical evaluations.

Estimates of the number of adults with diagnosed diabetes were obtained from National Health Interview Survey (NHIS) data (8). The NHIS is an annual nationally representative household survey of the noninstitutionalized civilian population of the U.S. The status of diagnosed diabetes was determined from the question, "Have you ever been told by a doctor or health professional that you have diabetes or sugar diabetes?"

Changes in the NHIS questionnaire that occurred in 1997 (9) could have affected the number of individuals identified as having diabetes. Moreover, the diabetes diagnosis criteria changed in 1997 (from fasting plasma glucose ≥140 mg/dl to ≥126 mg/dl) (10), which could result in more individuals being considered to have diabetes. Therefore, we restricted our analysis to the 1998–2006 time frame.

We calculated hospitalization rates by dividing the number of diabetes-related preventable hospitalizations by the number of adults with diagnosed diabetes. We produced hospitalization rates for each of the four conditions as well as overall rates for all four conditions. Hospitalization rates were age adjusted to the 2000 U.S. standard population. We also stratified rates by age (18–44, 45–64, 65–74, and ≥75 years) and sex (men and women). We did not report rates by race because information on race was missing for about 20–30% of the overall observations and entirely for some states in the NIS.

All data preparations were performed using SAS 9.1.3 (SAS Institute, Cary, NC). Hospitalization rates and SEMs were obtained using SUDAAN 9.0 (Research Triangle Institute, Research Triangle Park, NC) to account for complex survey design. We used linear regression, weighted by the reciprocal of the variance of each year's rate, to test for trends. We conducted *t* tests to compare hospitalization rates between groups using 2006 data. $P < 0.05$ was considered statistically significant.

Table 1—*Age-adjusted rates for overall diabetes-related preventable hospitalizations, U.S., 1998–2006*

	Diabetes-related hospital discharges	Individuals with diabetes (in thousands)	Age-adjusted hospitalization rate (%)
1998	433,529	10,386	5.2 ± 0.3
1999	434,963	10,755	4.9 ± 0.3
2000	461,048	11,863	4.7 ± 0.2
2001	464,145	13,006	4.4 ± 0.2
2002	473,149	13,391	4.6 ± 0.2
2003	485,038	14,012	4.6 ± 0.3
2004	486,989	15,126	4.5 ± 0.2
2005	483,284	16,186	3.9 ± 0.2
2006	511,047	17,110	3.8 ± 0.2

Data are *n* or rates ± SEM.

RESULTS — The total number of diabetes-related preventable hospitalizations nationwide was 433,529 in 1998 and 511,047 in 2006, an increase of 18% (Table 1). Long-term complications accounted for the largest proportion of diabetes-related hospitalizations (58% in 2006), followed by short-term complications (26%) and uncontrolled diabetes (10%). Lower-extremity amputations accounted for 16% of diabetes-related hospitalizations.

In contrast to the absolute increases in number of hospitalizations, the age-adjusted rates per 100 adults with diabetes declined 27% from 5.2 in 1998 to 3.8 in 2006 ($P_{trend} < 0.01$) (Table 1). The hospitalization rates for age-groups of 18–44, 45–64, 65–74, and ≥75 years decreased by 26, 25, 32, and 38%, respectively (all $P < 0.05$) (Fig. 1). For age-adjusted rates by sex, compared with the 1998 rate, the 2006 rate was 22% lower for men and 32% lower for women (all $P < 0.01$) (Fig. 2).

For the trends by condition, the age-adjusted rates for long-term complications, uncontrolled diabetes, and lower-extremity amputations declined by 23, 58, and 37%, respectively (all $P < 0.01$). However, the age-adjusted rates for short-term complications did not change significantly (15% decrease, $P = 0.18$) (Fig. 3). Further analyses on trends for each condition by age-group or sex showed that hospitalization rates declined for all subgroups except the age-group of 18–44 years for short-term and long-term complications (Table 2).

When we compared the rates between age-groups in 2006, individuals aged 18–44 years and those aged ≥75 years had higher overall rates than those of the other two age-groups (all $P < 0.01$). For individuals aged 18–44 years, the higher overall rate was due to higher rates

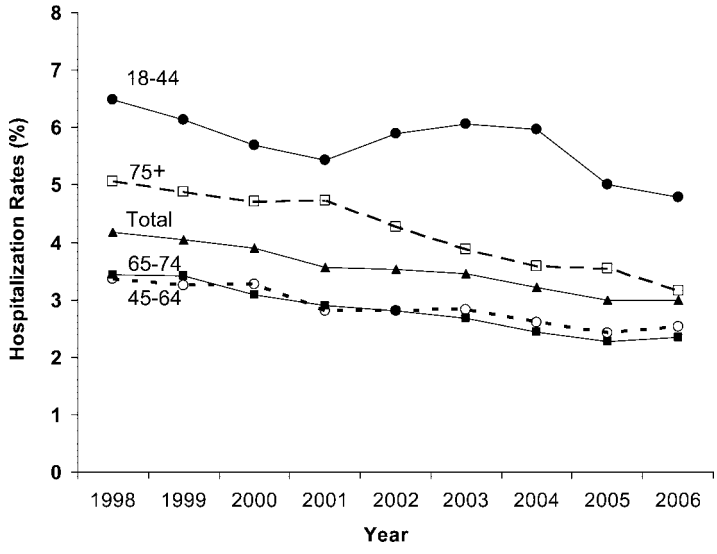

Figure 1—*Rates of diabetes-related preventable hospitalizations by age-group, U.S., 1998–2006.*

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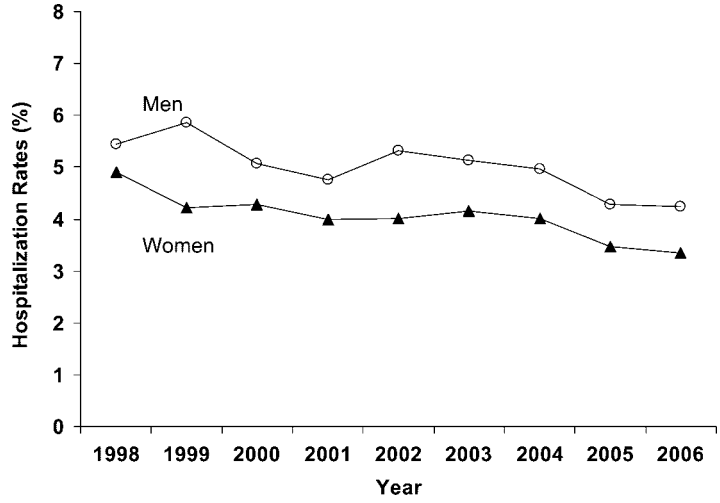

Figure 2—*Age-adjusted rates of diabetes-related preventable hospitalizations by sex, U.S., 1998–2006.*

in short-term complications and uncontrolled diabetes (all $P < 0.01$); for individuals aged ≥75 years, this was due to higher rates in long-term complications and lower-extremity amputations (all $P < 0.05$). Age-adjusted rates were higher among men for long-term complications (1.8 vs. 1.5, $P < 0.01$), uncontrolled diabetes (0.4 vs. 0.3, $P < 0.01$), lower-extremity amputations (0.5 vs. 0.3, $P < 0.01$), and overall (4.2 vs. 3.3, $P < 0.05$). Rates for short-term complications did not significantly differ by sex (1.8 vs. 1.5, $P = 0.11$).

CONCLUSIONS — From 1998 to 2006, rates of diabetes-related preventable hospitalizations declined for all conditions except for short-term complications. The nonsignificant decrease in age-adjusted rates for short-term complications was mainly attributable to the insignificant decrease among those aged 18–44 years. Rates decreased in all older age-groups. It is not clear why there was no significant decline in this youngest age-group.

AHRQ reported that during the period of 1994–2000, hospitalization rates dropped for uncontrolled diabetes, increased for short-term complications, and showed no changes for long-term complications and lower-extremity amputations (6). Our results differ from AHRQ's findings. The differences reflect the different denominators used to estimate the hospitalization rates. Furthermore, using diabetic denominators, Kuo et al. (11) showed decreased rates for ketoacidosis and lower-extremity amputations from 1992 to 2001 for Medicare beneficiaries with diabetes.

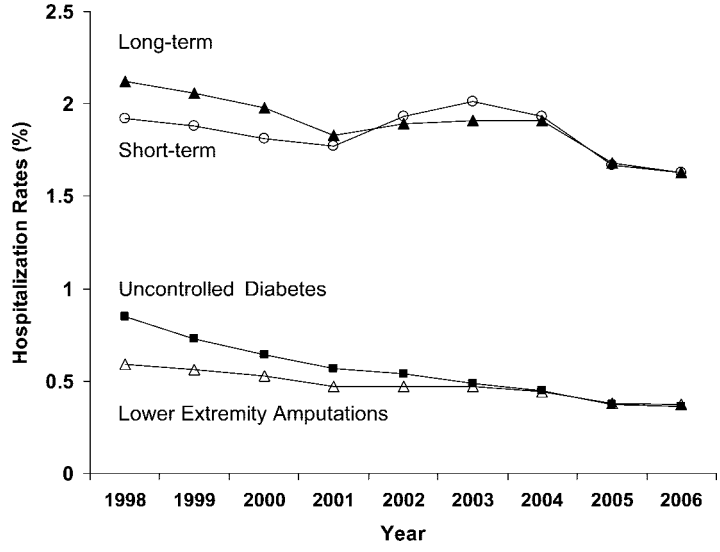

Figure 3—*Age-adjusted rates of diabetes-related preventable hospitalizations by conditions, U.S., 1998–2006.*

Reasons for the decline in diabetes-related preventable hospitalizations are not well understood. First, reduced rates for preventable hospitalizations could reflect improvements in primary care for individuals with diabetes. Diabetes treatment may have become more aggressive after publication of the findings from a series of clinical trials (12–14). The availability of new drugs and a new form of insulin increased drug selection options and may have enhanced patient adherence to therapy (15). With combined efforts of clinicians and various health organizations, glycemic control was improved over time (16,17). From 1999–2000 to 2003–2004, the percentage of individuals having A1C <7% increased from 37 to 57% and the mean A1C fell from 7.6 to 7.1% (17). Better glucose control would lead to reduced hospitalizations for uncontrolled diabetes.

Numerous factors can affect the rate for long-term hospitalizations and lower-extremity amputations, and information on changes in those factors during our study period was lacking. However, the percentage of diabetic patients who received an annual foot examination increased 37% between 1994 and 2005 (18), and rates for gangrene, a common precursor to amputation, declined between 1992 and 2001 (19). These factors may have contributed to prevention of lower-extremity amputations. In addition, the incidence of end-stage renal disease declined 21% from 1997 to 2002 (20). Both declines in the end-stage renal disease and gangrene could have contributed to the reduced rates of long-term complications.

Second, earlier detection of diabetes could have resulted in more milder cases among the diabetic population. However, a prior study showed that individuals with newly diagnosed diabetes did not become healthier or younger during the period from 1997 to 2003 (21).

Finally, a previous study showed that an increase in HMO penetration was associated with a lower rate of preventable hospitalizations (22). We examined whether the declining preventable hospitalization rates found in our study coincided with a period of rising HMO enrollments. We found the HMO enrollments decreased from 28.6% in 1998 to

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Table 2—*Age- or sex-specified rates for diabetes-related preventable hospitalizations, by conditions, U.S., 1998 vs. 2006*

	1998 rate (%)	2006 rate (%)	*P*
Short-term complication			
18–44 years	3.18 ± 0.27	2.73 ± 0.21	0.33
45–64 years	0.57 ± 0.03	0.51 ± 0.03	<0.05
65–74 years	0.31 ± 0.02	0.21 ± 0.01	<0.01
≥75 years	0.49 ± 0.04	0.2 ± 0.02	<0.01
Men	0.98 ± 0.05	0.82 ± 0.04	<0.01
Women	0.86 ± 0.04	0.73 ± 0.04	<0.01
Long-term complication			
18–44 years	2.08 ± 0.18	1.54 ± 0.12	0.08
45–64 years	1.94 ± 0.11	1.56 ± 0.09	<0.01
65–74 years	2.14 ± 0.14	1.68 ± 0.11	<0.01
≥75 years	3.01 ± 0.22	2.36 ± 0.17	<0.01
Men	2.37 ± 0.12	1.88 ± 0.10	<0.01
Women	2.03 ± 0.10	1.58 ± 0.08	<0.01
Uncontrolled diabetes			
18–44 years	1.10 ± 0.10	0.45 ± 0.04	<0.01
45–64 years	0.54 ± 0.04	0.27 ± 0.02	<0.01
65–74 years	0.50 ± 0.04	0.21 ± 0.02	<0.01
≥75 years	0.77 ± 0.06	0.27 ± 0.02	<0.01
Men	0.65 ± 0.04	0.30 ± 0.02	<0.01
Women	0.67 ± 0.05	0.28 ± 0.02	<0.01
Lower-extremity amputations			
18–44 years	0.34 ± 0.03	0.24 ± 0.02	<0.05
45–64 years	0.71 ± 0.04	0.48 ± 0.03	<0.01
65–74 years	0.94 ± 0.06	0.54 ± 0.04	<0.01
≥75 years	1.36 ± 0.10	0.66 ± 0.05	<0.01
Men	1.03 ± 0.05	0.65 ± 0.03	<0.01
Women	0.62 ± 0.03	0.33 ± 0.02	<0.01

Data are rates ± SEM.

24.5% in 2006 (23). Thus, our results are not likely to be attributable to changes in HMO penetration.

Our study is subject to several limitations. First, some hospitalizations that we considered preventable were probably not preventable. Case-by-case assessment would be required to determine the exact degree of preventability of any specific hospital admission. Second, we relied on ICD-9-CM codes to identify cases and misclassifications might exist. Third, NIS data did not contain personal identifiers, and, thus, it was impossible to identify repeated hospitalizations. Fourth, the number of states participating in the NIS changed from 22 to 37 during the study period. We do not know what bias this might have introduced. Last, a few hospital discharges for lower-extremity amputations were overlapped with a diagnosis code for one of the other three conditions. However, only <1% of cases of short-term complications and uncontrolled diabetes overlapped with lower-extremity amputations, and thus the trends for these conditions should not have been affected by lower-extremity amputation trends. Of cases of long-term complications, 16% also listed lower-extremity amputations in 2006. We reanalyzed the trends for long-term complication by excluding overlapped cases, and the conclusions remained the same.

Our study suggests that the rates for diabetes-related preventable hospitalizations have declined. It is plausible that the declining trends reflect improvement in quality of primary care for diabetes. However, further study is needed to determine the exact reasons for these declines. Hospitalization rates declined over a time when the overall burden of diabetes substantially increased. The number of individuals with diabetes is expected to increase dramatically in the future (24). Although improvements in diabetes care that result in better outcomes are welcomed, the continuing influx of new cases of diabetes and the increasing number of existing cases remain major concerns that need to be addressed.

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