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Diabetes Mellitus and Infection: An Evaluation of Hospital Utilization and Management Costs in the United States

Lindsey Korbel¹ and John David Spencer²

¹The Ohio State University College of Medicine

²Center for Clinical and Translational Research, The Research Institute at Nationwide Children's

Abstract

Aims—The objective of this study is to evaluate the number of diabetics that seek medical treatment in emergency departments or require hospitalization for infection management in the United States. This study also assesses the socioeconomic impact of inpatient infection management among diabetics.

Methods—We accessed the Healthcare Cost and Utilization Project's Nationwide Emergency Department Sample database and the Nationwide Inpatient Sample database to perform a retrospective analysis on diabetics presenting to the emergency department or hospitalized for infection management from 2006-2011.

Emergency Department: Since 2006, nearly 10 million diabetics were annually evaluated in the emergency department. Infection was the primary reason for presentation in 10% of these visits.

Among those visits, urinary tract infection was the most common infection, accounting for over 30% of emergency department encounters **for infections**. Other common infections included sepsis, skin and soft tissue infections, and pneumonia. Diabetics were more than twice as likely to be hospitalized for infection management than patients without diabetes.

Hospitalization: Since 2006, nearly 6 million diabetics were annually hospitalized. 8-12% of these patients were hospitalized for infection management. In 2011, the inpatient care provided to patients with DM and infection was responsible for over \$48 billion dollars in aggregate hospital charges.

Conclusions—Diabetics commonly present to the emergency department and require hospitalization for infection management. The care provided to diabetics for infection management has a large economic impact on the United States healthcare system. More efforts are needed to develop cost-effective strategies for the prevention of infection in patients with diabetes.

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Corresponding Author: John David Spencer, The Research Institute at Nationwide Children's, 700 Children's Drive, Columbus OH, 43205, (614) 355-2884 john.spencer@nationwidechildrens.org.

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Keywords

Diabetes Mellitus; Infection; Economics; Hospitalization; Emergency Department

1. Introduction

Diabetes mellitus (DM) is one of the most common systemic diseases worldwide. Currently, DM affects an estimated 366 million people. By 2030, it is estimated that over 550 million people will have DM – affecting more than 1 in 3 Americans.^{1,2} In the United States, DM is the 7th leading cause of death and has been shown to be an independent risk factor for early death. DM is associated with multiple co-morbid conditions – including infection. Patients with Type 1 and Type 2 DM are at increased risk for infection secondary to poor glycemic control, diabetic neuropathy, and impaired innate and adaptive immune responses.³⁻⁵ Diabetics are at increased risk for community-acquired infections as well as rare infections like malignant otitis externa, rhinocerebral mucormycosis, and emphysematous pyelonephritis.⁶⁻⁸ Sepsis also occurs more frequently and has a higher mortality rate in patients with DM than in other individuals.⁷ In general, patients with diabetes are often more likely to develop recurrent infections or complications from infections that require inpatient hospital management.⁹

The care provided to diabetics imposes a substantial burden on the United States healthcare system in the form of increased medical costs, chronic disability, and premature mortality. Medical costs for diabetics are ~2.3-fold higher than non-diabetic patients. Nearly half of the direct medical costs of diabetic care are believed to be associated with management of diabetic complications.^{10,11} In 2012, the American Diabetes Association (ADA) estimated that DM increased healthcare costs \$245 billion – a 41% increase from 2007.¹⁰

To date, the economic burden and resource allocation for common diabetic complications like infection is not well defined. Given the increasing prevalence of DM in the United States, there is a need quantify the frequency in which diabetics seek care for infection and evaluate the associated costs and healthcare resource allocation. Thus, using the largest publically available all-payer emergency department (ED) and inpatient databases in the United States, we evaluate the number of diabetics requiring ED treatment or hospitalization for infection and estimate the financial impact associated for inpatient infection management in the presence of DM.

2. Materials and Methods

2.1 Data Source

A retrospective analysis was performed using the Healthcare Cost and Utilization Project's (HCUP) Nationwide Emergency Department Sample database (NEDS) and the Nationwide Inpatient Sample database (NIS). The Healthcare Cost and Utilization Project databases (HCUP), sponsored by the Agency for Healthcare Research and Quality (AHRQ), were designed to identify and track trends in hospital utilization, access, cost, and outcome across the United States.^{12,13}

The HCUP-NEDS is the largest all-payer emergency department database available in the United States. In 2011, it included data from 950 emergency departments in 30 states and encompasses 30 million patient encounters. National estimates are weighted to reflect all 50 states.¹² The HCUP-NIS is the largest inpatient database available in the US. It is a sample of US community hospitals, defined as all non-Federal, short-term, general, and other specialty hospitals, excluding hospital units of institutions. In 2011, the NIS included 1,049 hospitals in 46 states resulting in data from over 8 million hospitalizations. It is estimated that the sampling includes over 90 percent of discharges from US community hospitals.¹³ National estimates were weighted to reflect all 50 states.

2.2 Patient Identification

HCUP-NEDS—Patients presenting to the ED with primary diagnosis of DM were identified using the AHRQ's Clinical Classification Software (CCS), a system that groups over 12,000 ICD-9-CM diagnosis codes into 260 clinically meaningful categories.¹⁴ Diabetics were identified using CCS diagnosis codes for DM without complications (CCS 49) and DM with complications (CCS 50). The CCS software was used in place of ICD-9-CM codes so that we could capture a larger patient population and a population already assigned to defined cohorts. Related diagnoses were also identified using the CCS. Data collected included number of ED visits, number of hospital admissions, and associated secondary diagnoses.

HCUP-NIS—The HCUP-NIS uses the same CCS as the HCUP-NEDS. Patients hospitalized with the principal diagnosis of DM and the associated diagnoses were identified using the CCS (CCS 49 and 50). Data collected included number of hospitalizations, secondary diagnoses, and length of hospital stay. Hospital economics were evaluated by examining hospital charges. These charges represent what the hospital billed the patient for services rendered during the hospitalization and do not reflect reimbursement.

2.3 Data Analysis

To report national estimates, the HCUP-NIS and HCUP-NEDS developed discharge weights using the American Hospital Association Universe. With each national estimate, the HCUP-NIS and HCUP-NEDS report standard errors that were calculated using SUDAAN software (RTI International, Research Triangle Park, NC, USA). Statistical significance was determined using a two-tailed *p*-value. A *p*-value <0.05 was considered statistically significant.

3. Results

3.1 Diabetics commonly seek medical attention in the ED for infection management

According to 2006 HCUP-NEDS data, 8.8 million diabetic patients were evaluated in the ED. By 2011, this number rose to roughly 12.5 million. In 2006, 850,000 diabetic patients were treated in the ED for infection and over 500,000 were hospitalized for additional inpatient management. By 2011, 1.2 diabetics were evaluated in the ED for infection and 817,000 were hospitalized for infection management (Table 1). Skin and soft tissue infections, sepsis, pneumonia, and urinary tract infections (UTI) were the most frequent

infections encountered. Since 2006, UTI accounted for the highest proportion of annual infections, followed closely by skin infections and pneumonia.

To verify the association of DM and UTI, we utilized the HCUP-NEDS to evaluate the number of patients that present to the ED with the primary diagnosis of UTI. From 2006-2011, nearly 3 million patients present annually to the ED for UTI evaluation. Ten percent of these patients have DM. Patients with UTI in the presence of DM are more than two-times more likely to be hospitalized for UTI management than patients without DM.

3.2 Diabetics are routinely hospitalized for infection management

According to 2007 HCUP-NIS data, over 5 million diabetic patients were hospitalized. In 2011, this number increased to 8.2 million. During this period, the number of diabetics annually hospitalized for inpatient infection management increased from 453,000 to over 1 million (Table 2) – representing a 146% increase in hospitalizations. Similar to the HCUP-NEDS data, skin and soft tissue infections, sepsis, pneumonia, and UTI were the most common types of infections with sepsis and pneumonia accounting for the largest number of hospitalizations.

3.3 Hospital charges for diabetic management are increasing

From 2006-2011, HCUP-NIS data indicate that hospital charges (i.e. the hospital bill) for diabetic admissions increased. During this period, the mean length of hospitalization remained the same. In 2006, mean hospital charges for inpatient DM management increased from \$31,000 to \$94,000 per hospital stay – representing a 203% increase (Figure 1). Hospital charges increased if diabetics were hospitalized for sepsis or UTI management. By 2011, aggregate hospital charges exceeded \$48 billion for infection management in the diabetic population.

4. Conclusions

To our knowledge, this is the first large cohort study to provide detailed estimates of hospital resource utilization and costs for infections among diabetics in the United States. In the present study, we accessed the HCUP-NEDS and HCUP-NIS, the largest all-payer databases in the United States, to provide a comprehensive overview of healthcare utilization by diabetic patients presenting for infection management. From 2006-2011 HCUP-NEDS data suggest over 64 million patients with DM were evaluated in the ED and over 9 million of these diabetics required treatment for infection. Similarly, from 2007-2011, HCUP-NIS data suggest that over 36 million diabetics were hospitalized and over 5 million diabetics were admitted for inpatient infection management.

According to 2012 ADA data, about 25% of all inpatient hospital stays are incurred by patients with DM and about half of all physician office visits and ED visits are attributed to patients with diabetes. The majority of these encounters are for general medical conditions.¹⁰ Our results support these findings. Since 2006, our data demonstrate that nearly 20% of the diabetics evaluated in the ED seek evaluation for infections. Moreover, our data suggest that the annual number of diabetics seeking infection management in the ED or requiring hospitalization has steadily increased. Similarly, our results support the

findings by McDonald *et al* who demonstrate that the incidence and hospitalizations in the United Kingdom of community-acquired infections among diabetics are increasing.¹⁵

The increases in ED encounters and hospitalizations likely occur due to multiple factors. Significant infections, especially in the context of medication non-compliance, can alter blood sugar management.^{16,17} Diabetic patients may be more susceptible to more severe infections, rare infections, recurrent infections, or develop infection-related complications that necessitate inpatient treatment.^{6,7,9,18} Additionally, as more patients depend on acute hospital-based care facilities for medical treatment (in lieu of seeking treatment by their primary physician), acute care physicians may be more likely to hospitalize a patient due to concern for lack of appropriate follow-up. This practice may result in a patient being hospitalized with an infection that could be sufficiently treated on an outpatient basis with close primary care physician follow-up. As our healthcare system evolves, finding a more effective way to manage chronic care patients (and ensuring close follow-up) would significantly minimize overtreatment and reduce the socioeconomic burden of common illnesses.

Although diabetics are at risk for uncommon infections, our results demonstrate that diabetics are routinely evaluated and hospitalized for community-acquired infections – with skin and soft tissue infections, pneumonia, and UTI having the highest incidence. These results compliment that of Shah *et al*, who demonstrated that nearly half of all Canadians with DM require medical treatment for infection each year. In their cohort, osteomyelitis, pyelonephritis, soft tissue infections, and lower respiratory tract infections were the most common sources of infection.⁷ Of note, our HCUP-NEDS data indicate that urinary tract is the most common site of infection. Similarly, Muller *et al* demonstrate that the urinary tract is the most common site of infection among diabetics in the Netherlands.⁶

The care provided to diabetics has a significant financial impact on the United States healthcare system. In 2012, the ADA estimated that diabetes cost the United States \$245 billion, which included over \$120 billion in health services used to manage common complications of DM.¹⁰ Here, we demonstrate that aggregate hospital charges exceeded \$48 billion for infection management in the diabetic population. These estimates provide a picture of the direct medical **charges** attributable to infections associated with diabetes and its management, but they do not capture, for example, lost work-place productivity or care provided by an unpaid caregiver. As a result, they provide an under-estimate of the true economic implications.¹¹

In attempt to offset rising hospital charges for infection-related diabetes admissions, physicians need to promptly recognize, evaluate, and appropriately treat diabetics for even minor infections. Moreover, an improved understanding of the pathophysiology that may predispose diabetics to infection is warranted. Knowledge gaps include the role of potential immune defects, glucose control, and microbial susceptibility.^{4,8} Finally, improved awareness of infection and its related complications is needed. Gregg *et al* recently suggest that some of the major complications of DM including stroke, myocardial infarction, and end stage renal disease have declined.¹⁹ These findings reflect advances in patient care, improved public health efforts, and health awareness efforts directed at patients with

DM.^{19,20} Improved public health efforts, patient education, and translational research may help reduce the infection burden in diabetics.

Our paper has several inherent strengths. First, we evaluated a unique cohort of unselected populations with Type 1 and Type 2 DM. Second, we utilized the largest all-payer databases in the United States to sample large cohorts. Finally, we were able to study the associations of DM with common infections involving different organ systems.⁶ However, our study has several inherent limitations. The HCUP-NEDS database does not provide data on ED charges limiting our economic analysis to inpatient charges.¹² Our study population was identified using the AHRQ's CCS. As a result, we may have captured patients who were admitted to the hospital with additional and/or different presenting conditions (i.e. hyperglycemia, diabetic ketoacidosis, acute kidney injury, etc.). Also, to protect patient privacy, the database does not provide particular patient demographics – including age, ethnicity, or type of DM. Finally, an inevitable limitation is that the hospital charges analysis reflects prior years and does not account for hospital-specific differences in charge practices. Thus, it is difficult to develop current comprehensive estimates because up-to-the minute charge data is not available and charge practices may be lost in the heterogeneity of hospital type identified in our cohort.

In conclusion, the socioeconomic burden of DM is large and increasing at a rapid rate. Community-acquired infections among diabetic patients are common and have a significant financial impact on the healthcare system in the United States. As the proportion of the population with DM continues to rise, it can be expected that this impact will become more pronounced. Therefore, it is important to prioritize healthcare efforts in an attempt to prevent infections in diabetic patients, allocate healthcare resources appropriately, and decrease the economic burden on our health system.

5. Acknowledgements

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Figure 1.
Trends in hospital charges from 2007-2011.

Table 1

	2006	2007	2008	2009	2010	2011
Total ED Visits	101,490,523	103,307,733	105,539,163	109,292,495	109,236,834	111,724,125
Total DM ED Visits	8,805,278	9,679,460	10,493,736	11,144,124	11,842,563	12,455,306
DM+Infection	852,027	1,266,244	1,610,047	1,717,267	1,813,767	1,926,305
DM+UTI	258,941	286,919	310,521	330,609	358,707	377,390
DM+Skin Infection	263,716	287,526	305,085	324,891	355,772	379,691
DM+ Pneumonia	273,703	283,848	296,297	311,078	300,635	314,883
DM+Sepsis	55,667	63,600	204,699	227,181	255,318	297,824
Total DM Infection Admissions	505,129	541,517	700,337	752,501	785,984	817,632

Table 2

	2007	2008	2009	2010	2011
Total Hospitalizations	38,155,908	38,210,889	37,734,584	37,352,013	36,962,415
Total DM Hospitalizations	5,200,252	7,333,796	7,738,847	7,817,432	8,266,805
DM+Infection	453,814	855,182	958,436	994,454	1,117,098
DM+UTI	108,188	160,019	173,414	183,721	191,516
DM+Skin Infection	111,702	178,958	190,479	198,467	209,521
DM+ Pneumonia	218,862	291,051	314,232	300,059	323,249
DM+Sepsis	115,062	225,154	280,311	312,207	39,2812