

Diabetic Ketoacidosis Charges Relative to Medical Charges of Adult Patients With Type I Diabetes

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OBJECTIVE — To determine the medical charges for treating diabetic ketoacidosis (DKA) episodes relative to direct medical care charges of adult patients with type I diabetes.

RESEARCH DESIGN AND METHODS — Using data from an electronic medical record system, we identified adult patients with type I diabetes who had received inpatient or outpatient care on at least two occasions between 1 January 1993 and 30 June 1994. Resources and charges for hospitalizations, emergency room visits, outpatient visits, and pharmaceuticals were recorded during this period. One additional year of information was collected to assess the resources and charges associated with multiple DKA episodes.

RESULTS — A total of 200 patients were identified, of whom 72 (36.0%) experienced a total of 161 DKA episodes. The direct medical care charges associated with DKA episodes represented 28.1% of the direct medical care charges for the cohort of patients with type I diabetes. The average charge per DKA episode was \$6,444. The estimated annual medical care charge for each patient was \$7,855 (\$13,096 per patient experiencing a DKA episode versus \$4,907 per patient not experiencing an episode). Multiple DKA episodes were experienced by 24 (12.0%) of the study patients and accounted for 55.6% of the direct medical care charges for these patients.

CONCLUSIONS — DKA episodes represented more than \$1 of every \$4 spent on direct medical care for adult patients with type I diabetes and \$1 of every \$2 in those patients experiencing multiple episodes. Interventions that are capable of even a modest reduction in the number of DKA episodes could produce substantial cost savings in a health care system and could be particularly cost-effective in adult patients with recurrent DKA.

Diabetic ketoacidosis (DKA) is a life-threatening complication of diabetes that is often preventable. In the U.S., DKA was the underlying cause of death for 1,858 patients with diabetes in 1989 (1). The age-adjusted rate of DKA mortality was 28.4 per 100,000 patients with diabetes (1). The annual incidence rate for DKA from population-based studies ranges from 4.6 to 8 episodes per 1,000 patients with either type I or type II diabetes (2,3).

In 1990, DKA was a listed diagnosis on 104,000 hospital discharges and served as the primary diagnosis for 82,000 hospital discharges in the U.S. (1). Currently, it is estimated that DKA is included on 3–4% of all hospital discharge summaries among patients with diabetes, with female patients being more likely than male patients to be hospitalized with DKA (4). The treatment of DKA can consume significant health care resources, resulting in increased health care

charges, particularly in patients experiencing multiple DKA episodes. A prior study showed that more than one-third of hospitalizations for DKA occurred in patients with at least one prior DKA hospitalization in a 3-year period (5). Interventions, including comprehensive management programs (6), psychotherapy (7), treatment protocols (8), stepwise intervention programs (9,10), and decentralized nurse-managed and physician-backed programs (11), have been shown to reduce the number of DKA episodes and the number of health care resources used to treat DKA. Prior studies have attempted to estimate the cost of treating DKA episodes (3,12), but no study has assessed the charges for treating DKA relative to total medical charges of patients with type I diabetes. Health care planners need to understand the component of their budget spent on treating DKA episodes in proportion to the medical charges of patients with type I diabetes so that interventions may be efficiently targeted. This study provides information on the direct medical care charges associated with DKA episodes relative to the direct medical care charges of adult patients with type I diabetes. The results of this type of economic analysis could aid decision-makers in managed care organizations when making financial investments to care for patients with type I diabetes.

RESEARCH DESIGN AND METHODS

Patients were identified from the electronic Regenstrief Medical Record System (RMRS), which captures data for ~17,000 hospitalizations and 250,000 outpatient encounters per year at Wishard Memorial Hospital, a city-county teaching hospital in Indianapolis, Indiana (13,14). From the RMRS, we can collect resource utilization and billing information from outpatient clinic visits, outpatient pharmacy visits, emergency room visits, and hospitalizations to Wishard Memorial Hospital. The system currently contains over 120 million observations on more than 1.5 million patients. Overall, the population seeking care at sites included in the RMRS is 54% female, 46% African-American,

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DCCT, Diabetes Control and Complications Trial; DKA, diabetic ketoacidosis; RMRS, Regenstrief Medical Record System.

can, and predominantly indigent.

For the purposes of this study, we assessed only adult patients >18 years of age as of 1 January 1993. This was done for two reasons. First, charge and resource utilization for non-DKA-related hospitalizations, outpatient visits, and outpatient pharmacy visits could be vastly different for adults >18 years of age than for children. Second, Wishard Hospital is located adjacent to Riley Hospital for Children; there was concern that the majority of children in the RMRS who experience DKA would be hospitalized at Riley Hospital, and the RMRS does not capture hospitalization charge data for this institution.

We identified a cohort of adult patients who either had received an explicit diagnosis of type 1 diabetes (ICD-9-CM 250.01 or 250.03) or were diagnosed with diabetes before 30 years of age. To ensure that our cohort contained only patients with type 1 diabetes, we included only patients who were started on insulin before 30 years of age and who were still maintained on insulin at the time of this study. As a further precaution, we also excluded any patient who had ever received a prescription for an oral diabetic medication. Prescription information was gathered from Wishard Memorial Hospital Outpatient Pharmacy.

Although repeated prior studies and internal audits have shown that patients cared for at RMRS clinics receive >90% of their care at a facility served by the RMRS (13,14), we only included patients who had received inpatient or outpatient care on at least two occasions at a facility included in the RMRS during the period 1 January 1993 to 30 June 1994. We made this limitation to be sure that patients in this cohort received ongoing care from a facility linked to the RMRS. The study start date of 1 January 1993 was selected because the RMRS was first able to capture complete charge information generated from institution billing records on this date.

From the type 1 diabetes cohort, episodes of DKA were identified based on an admission and discharge ICD-9-CM code of 250.1 (diabetes with ketoacidosis) or 250.3 (diabetic coma with ketoacidosis). The RMRS captures only one admission diagnosis per hospitalization but multiple discharge diagnoses; therefore, episodes of DKA were also considered if they were listed as the primary discharge diagnosis (ICD-9-CM code 250.1 or 250.3).

Another objective of the study was to assess the proportion of type 1 diabetes

direct medical care charges due to patients' experiencing multiple DKA episodes. Therefore, we collected 1 additional year (until 30 June 1995) of medical resource utilization and the respective charges to the patients or to their payers. In addition, we assessed the number of DKA episodes experienced by the cohort and the resources and charges associated with these episodes.

Data extraction of the medical care resources included number of hospitalizations, length of hospital stay (days), number of emergency room visits, and number of outpatient visits. The direct medical care charges billed to patients or to their payers included outpatient visit charges (including outpatient laboratory, physician consultation, and procedure charges), outpatient pharmacy charges, emergency room charges and inpatient hospitalization charges (including laboratory, pharmacy, physician consultation, and procedure charges). Specifically regarding physician consultation charges we used the charge of the CPT-4 (Current Procedural Terminology, 4th ed.) codes most frequently billed in the RMRS between 1 January 1993 and 30 June 1995 for outpatient visits, hospital admission work-ups and subsequent days in the hospital. The emergency room visit charges already included physician charges associated with each visit; therefore, we did not need to estimate these charges from CPT-4 codes. The most commonly billed CPT-4 codes for outpatient visits, hospital admission work-ups and subsequent days in the hospital were 99213, 99222, and 99232, respectively. The database is not able to capture charges related to nursing home or home health care. All direct medical care charges reflect actual charges billed to the study patients or to their third-party payers and were subsequently adjusted to 1995 dollars.

Patient-years of observation were used to compensate for patients who entered the RMRS after 1 January 1993 or died before 30 June 1995. Medical resources and medical care charges were annualized by dividing the sum of all resources and charges incurred from 1 January 1993 to 30 June 1995 by the number of observed patient-years during this same period.

All DKA episodes were associated with hospitalizations; therefore, the direct medical care charges for treating DKA episodes were calculated by combining charges from inpatient hospitalizations, emergency room visits, and any outpatient visits that resulted from the DKA episode. All medical care

resources utilized and charges accrued were used to calculate the direct medical care charges, regardless of the association with diabetes or other illnesses.

Statistical analysis

Data analyses were performed using the SPSS statistical package (SPSS, Chicago, IL). Descriptive values are given as means \pm SD. Statistical tests of patient demographics between DKA and non-DKA groups include unpaired *t* tests of patient age and χ^2 tests of patient race, sex, and insurance group. Medical resources utilized were compared using unpaired *t* tests. To verify the parametric results, a nonparametric analysis of medical resources utilized was also performed using Wilcoxon rank-sum test. Parametric and nonparametric analyses were very similar; therefore, only parametric values are reported. Statistical significance was considered at $P < 0.05$. Because of the lack of established statistical tests comparing medical charge data, we did not report the statistical significance of medical charges between DKA and non-DKA groups.

RESULTS — We identified 200 patients with type 1 diabetes who met study criteria. Of the 200 patients, 72 (36.0%) had experienced at least one DKA episode during the 2.5-year observation period. The 72 patients experienced a total of 161 DKA episodes during the 2.5-year study.

All DKA episodes resulted in hospitalization. Of the 161 hospitalizations for DKA, 150 (93.2%) had DKA listed as both the primary admission diagnosis and the primary discharge diagnosis. Ten hospitalizations did not have an admission diagnosis identified but had DKA listed as the primary discharge diagnosis; therefore, these hospitalizations were also included for study. One hospitalization had DKA listed as the primary admission diagnosis but as the second discharge diagnosis. Upon closer evaluation of the laboratory results associated with this hospitalization, it was clearly evident that the hospitalization was due to DKA; therefore, this hospitalization was included as a DKA-related hospitalization. An additional 21 hospitalizations were identified that listed DKA as one of the discharge diagnoses but not as the primary admission diagnosis or as the primary discharge diagnosis; therefore, these hospitalizations were not classified as DKA related. We classified these 21 hospitalizations as non-DKA-related instead of

Table 1—Characteristics of study patients with type I diabetes

	All patients	Without DKA	With DKA
<i>n</i>	200	128	72
Age (years)	43.3 ± 15.3 (19.5–87.2)	42.8 ± 16.3 (20.6–87.2)	44.2 ± 13.4 (19.5–77.7)
Women	85 (42.5)	56 (43.8)	29 (40.3)
Caucasian	92 (46.0)	65 (50.8)	27 (37.5)
African-American	108 (54.0)	63 (49.2)	45 (62.5)
Insurance			
Self-pay	68 (34.0)	38 (29.6)	30 (41.7)
Indigent program	26 (13.0)	24 (18.8)	2 (2.8)*
Medicaid	40 (20.0)	24 (18.8)	16 (22.2)
Other	66 (33.0)	42 (32.8)	24 (33.3)

Data are means ± SD (range) or *n* (%). The Caucasian group includes two Asian patients and one patient of unknown ethnicity. "Other" insurance includes private pay, Medicare, and other government insurance. * $\chi^2 = 11.3$, 3 df, $P = 0.01$.

DKA-related because we could not confidently conclude that all 21 hospitalizations occurred as a result of DKA.

The mean length of time that each patient received medical care from a facility in the RMRS was 9.8 ± 5.5 years. A total of 21 patients (10.5%) had not been seen at a facility in the RMRS before 1 January 1993, and 12 patients (6.0%) died during the study period. These 33 patients accounted for 358 months of missing patient observations between 1 January 1993 and 30 June 1995. Therefore, annual estimates were based on 5,642 months (2.35 years) of patient observations. Of the 12 patients who died before 30 June 1995, 4 died during a hospitalization for DKA, while 5 died during non-DKA-related hospitalizations and 3 died outside of the hospital of unknown causes. Among the five patients who died during non-DKA-related hospitalizations, three deaths were related to sepsis, one was listed as myocardial infarction, and one was related to congestive heart failure.

The mean age for all patients was 43.3 ± 15.3 years. There were no significant differences between the DKA and non-DKA groups with respect to age, sex, or race (Table 1). Regarding insurance status, we found that 68 (34.0%) patients were self-pay, 26 (13.0%) were enrolled in the Wishard Hospital Indigent Program, 40 (20.0%) were receiving Medicaid, and 66 (33.3%) received another form of insurance, including private-pay, Medicare, and other government insurance. The Wishard Hospital Indigent Program is a state tax-supported program that provides medical assistance based on low income level to residents of Marion County, Indiana. Glycosylated hemoglobin measurements were

analyzed to assess the diabetes control of our study population. Based on the 140 (70.0%) patients who had a total of 322 glycosylated hemoglobin measurements performed during the study period, patients experiencing DKA episodes had a significantly higher glycosylated hemoglobin value than patients not experiencing a DKA episode (14.2 ± 4.7 vs. 11.6 ± 3.5%, respectively; $P < 0.001$).

The 200 patients with type I diabetes accumulated direct medical care charges of \$3,691,969 over the 2.5-year study period. The estimated annual direct medical care charges for all 200 patients with type I diabetes was \$1,571,050 and represents a mean annual cost of \$7,855 ± 12,345 per person (Table 2). Hospitalization charges represented 71.7% of the total medical care charges. Physician consultation charges estimated from the most frequently billed CPT-4 codes were \$55 per each outpatient visit, \$135 per each hospital admission work-up, and \$85 per each subsequent hospital day. Direct medical care charges for

the 72 patients (36.0%) who experienced DKA episodes represented 60% of the direct medical care charges of all 200 patients with type I diabetes. The estimated annual mean per-person direct medical care charge for a patient not experiencing a DKA episode was \$4,907 ± 10,842 vs. \$13,096 ± 13,166 per patient experiencing at least one DKA episode.

There were a total of 355 hospitalizations during the study period, giving an average 151 annual hospitalizations for DKA-related and non-DKA-related events for all 200 study patients, which accounted for 971 hospital bed days (6.4 days per hospitalization). Of the 151 hospitalizations per year, 109 (72.2%) occurred in the group of 72 patients with one or more DKA episodes. Of these 109 hospitalizations, 69 (63.3%) were for DKA. When we assessed both DKA-related and non-DKA-related resources utilized, patients who experienced at least one DKA episode required a longer hospital stay for any reason (8.7 vs. 2.7 days, $P \leq 0.0001$), more emergency room visits (1.9 vs. 0.9 visits, $P = 0.001$), and more outpatient visits (9.1 vs. 5.1 visits, $P = 0.01$) per person per year than did patients who did not experience a DKA episode. Also, patients experiencing DKA episodes were hospitalized (for any reason) 2.5 times more often than the other patients.

The mean charge per DKA episode was \$6,444 ± 6,411 (Table 3). Intensive care unit charges represented 19.2% of the DKA hospitalization charges. The sum of all DKA episode charges was \$1,037,549 over the 2.5-year study period and accounted for 28.1% of the direct medical care charges for all patients with type I diabetes.

Of the 72 patients who experienced DKA episodes, 24 (33.3% of patients with DKA episodes) experienced two or more DKA episodes and comprised 70.2% (113

Table 2—Estimated annual medical care charges for patients with type I diabetes

	All patients	Without DKA	With DKA
<i>n</i>	200	128	72
Hospitalization charges	\$1,126,634	\$423,018	\$703,616
Emergency room visits	\$91,831	\$41,099	\$50,732
Outpatient charges	\$270,217	\$130,324	\$139,893
Pharmacy charges (outpatient)	\$82,368	\$33,703	\$48,665
Totals	\$1,571,050	\$628,144	\$942,906
Per patient	\$7,855 ± 12,345	\$4,907 ± 10,842	\$13,096 ± 13,166

Charges are adjusted to 1995 dollars and rounded to the nearest \$1; per patient data are means ± SD. Hospitalization charges include inpatient pharmacy charges and emergency room visits resulting in hospitalization. Emergency room visit charges include only those not resulting in hospitalization.

Table 3—Medical care resources utilized and charges for 161 DKA episodes, 1 January 1993 to 30 June 1995

	Length of stay (days)	Hospitalization charges	Number of emergency visits	Emergency visit charges	Total episode charges
All DKA episodes	890	\$974,949	128	\$62,600	\$1,037,549
ICU charges		\$186,915			
Per episode	5.5 ± 3.4	\$6,055 ± 6,330		\$489 ± 268	\$6,444 ± 6,411

Charges are adjusted to 1995 dollars and rounded to the nearest \$1. Per episode data are means ± SD. Hospitalization charges include inpatient pharmacy charges. All patients seen in the emergency room for DKA were hospitalized. Per episode emergency room charges are based on 128 emergency room visits for DKA.

of 161) of all DKA episodes over the study period. Three or more episodes were experienced by 14 patients (19.4% of patients with DKA episodes) and represented 57.8% of all episodes. Of particular note, 12 patients (16.6% of patients with DKA episodes) experienced four or more episodes, which accounted for 54% of all DKA episodes; and 3 patients each experienced 10 or more episodes, which accounted for 21.7% of all episodes.

The DKA-related and non-DKA-related direct medical care charges for the 24 patients who experienced two or more DKA episodes represented 32.7% of the total direct medical care charges of all study patients. Specifically, DKA-related charges represented 55.6% of the medical care charges for these patients and 18.2% of the direct medical care charges of all 200 patients.

The DKA-related and non-DKA-related direct medical care charges for 14 patients who experienced three or more episodes represented 25.9% of the direct medical care charges of all 200 patients. Direct medical care charges due to DKA hospitalizations represented 59.9% of the total medical care charges for patients experiencing three or more DKA episodes (Table 4). Additionally, 12 patients who experienced four or more episodes accounted for

25.1% of the DKA-related and non-DKA-related direct medical care charges of all study patients. The estimated annual DKA-related and non-DKA-related direct medical care charge for a patient experiencing four or more DKA episodes was \$32,872 vs. \$4,907 per patient not experiencing a DKA episode (Table 4).

As expected, patients experiencing multiple DKA episodes consumed a significant amount of health care resources. Each patient who experienced multiple DKA episodes spent an average of 15.2 days each year in the hospital for both DKA-related and non-DKA-related events, and patients experiencing four or more DKA episodes were hospitalized an average of 22.7 days each year.

It was not a study objective to determine predictors of patients likely to experience DKA, but the study results suggest that having one DKA episode predicts having additional episodes. Specifically, over one-third of our study patients who experienced a single prior DKA episode during the study period went on to experience multiple DKA episodes.

CONCLUSIONS — In this study cohort, DKA represented more than one of every four health care dollars spent on direct medical care for patients with type I

diabetes. Additionally, DKA represents \$1 of every \$2 spent on medical care for patients experiencing multiple episodes. Health care provider organizations could design interventions directed at reducing the number of recurrent DKA episodes in patients with type I diabetes and produce a substantial cost savings to their health care systems. An example of a potential cost-saving measure is the use of a diabetes case manager to follow patients at risk of experiencing multiple DKA episodes. Hypothetically, a case manager could be hired half-time, at a cost of \$25,000 per year, to care for the 24 patients who had two or more DKA episodes. If the diabetes case manager could reduce the number of DKA episodes in these 24 patients by one-half, from 113 to 56 episodes, at a cost \$6,444 per episode, a net cost savings of nearly \$125,000 per year could occur. Savings are realized even if the case manager is only 4% effective in reducing the number of DKA episodes. Not only would a cost savings related to decreased DKA hospitalizations occur, but such an intervention might improve these patients' quality of life and reduce long-term diabetes-related complications. A recent study of an urban African-American population showed that two-thirds of the episodes of DKA may be preventable by improving patient educa-

Table 4—Estimated annual DKA-related and non-DKA-related medical care charges for subgroups of study patients

	No DKA episodes	1 or more episodes	2 or more episodes	3 or more episodes	4 or more episodes
n	128	72	24	14	12
Hospitalization charges	\$423,018	\$703,616	\$410,422	\$335,758	\$324,502
Emergency room visits	\$41,099	\$50,732	\$30,713	\$25,647	\$25,123
Outpatient charges	\$130,324	\$139,893	\$55,200	\$33,135	\$32,424
Pharmacy charges (outpatient)	\$33,703	\$48,665	\$17,994	\$12,495	\$12,419
Totals	\$628,144	\$942,906	\$514,329	\$407,035	\$394,468
% charges due to DKA	0	46.8	55.6	59.9	58.9
Annual charge per patient	\$4,907 ± 10,842	\$13,096 ± 13,166	\$21,430 ± 17,911	\$29,074 ± 19,825	\$32,872 ± 18,821

Charges are adjusted to 1995 dollars and rounded to the nearest \$1. Per patient data are means ± SD. Hospitalization charges include inpatient pharmacy charges and emergency room visits associated with hospitalization. Emergency visit charges include only those visits not resulting in hospitalization.

tion and access to care (15). As more state programs move toward managed care, health care providers should recognize those patients who contribute significantly to the costs of health care.

One limitation of the study findings was that the study was conducted in a predominantly indigent, inner-city population. The patients represent an inner-city population as reflected by the finding that 48.2% of the patients had no insurance or were enrolled in the Wishard Hospital Indigent Program. A prior study has reported that patients who are uninsured or insured by Medicaid have higher hospitalization rates for conditions that could have been avoided (16). The same study showed that patients without health insurance or patients insured with only Medicaid had hospitalizations for DKA two to three times higher than patients with diabetes who had private health insurance. Therefore, the hospitalization rate for DKA and the fraction of costs attributable to DKA may be higher in this study cohort than in patients with type I diabetes in a different population. In addition, the Wishard Hospital physicians and their practices reflect standard practices of a city-county hospital associated with an academic medical center.

It was interesting that patients who experienced DKA episodes required more outpatient visits and longer hospital stays and were seen in the emergency room more often for both DKA-related and non-DKA-related causes than patients who did not experience a DKA episode. This finding may suggest that adult patients with type I diabetes who experience DKA have more advanced disease, but unfortunately, the RMRS does not allow us to access information on the severity of illness of our study patients. However, despite the poor glucose control of our study patients, previous studies of interventions in patients identified from the RMRS have proven successful (17,18).

A potential limitation is that the RMRS could report only one primary admission diagnosis. Therefore, additional DKA episodes and episode charges may have not been included when patients were hospitalized for multiple problems. Twenty-one hospitalizations were identified with ICD-9-CM codes for DKA listed as one of the discharge diagnoses, but DKA was not listed as the primary admission diagnosis or as the primary discharge diagnosis. Based on our definitions, we classified these hospitalizations as non-DKA-related and did

not include them in the group defined as having experienced a DKA episode. Unfortunately, RMRS does not allow us to separate DKA-related hospitalization medical charges from medical charges incurred for other medical conditions associated with the hospitalization.

This study includes both insured and uninsured patients, unlike prior studies that only assessed resources used by insured patients with diabetes (19). There is limited cost data for patients with type I diabetes with which to compare our annual cost estimate of \$7,855 \pm 12,345 per person (20,21). Researchers from the Diabetes Control and Complications Trial (DCCT) (22) estimated that the costs associated with the clinical management of patients receiving intensive insulin therapy were approximately \$4,000 per year. Our study design and population is much different from that of the DCCT study. Moreover, our study examined both diabetes-related and non-diabetes-related medical charges. Not only did we determine direct medical care charges for adult patients with type I diabetes in an inner-city population, but we demonstrated that the charges associated with DKA episodes constitute a significant portion of the total direct medical care costs for type I diabetes.

Our assessment of the resources utilized in the treatment of DKA is similar to that of prior studies. In our study, the 72 patients who experienced a DKA episode were hospitalized an average of 5.5 \pm 3.4 days per episode, which is similar to findings in a recent study that demonstrated that the average length of stay for a DKA episode was 5.7 \pm 4.9 days (23). There is great disparity in the literature regarding incidence rates of DKA in patients with type I diabetes. Prior studies (2,3,24) have not examined inner-city populations nor have they specifically assessed patients with type I diabetes.

Another limitation is that the database includes only charges that occurred at one of the facilities included in the RMRS; therefore, our total charge estimates may be conservative because patients may have received care at a facility that is not part of the RMRS. Prior studies in this population have shown that <10% of patients occasionally receive care at a facility outside of the RMRS (13,14). Also, our medical charge estimates include only direct medical charges associated with hospitalizations, emergency room visits, outpatient visits, and outpatient pharmacy charges. We did not have medical charges for nursing homes and home health care, nor

did we include indirect medical costs. The American Diabetes Association (25) has shown that nursing home charges accounted for only 6% of the total medical charges for patients with both type I and type II diabetes in 1992. A prior study by Rubin et al. (26) in patients with all types of diabetes demonstrated that home health care represented only 4% of their total diabetes cost estimates. This cost estimate is potentially smaller in our study because we included only patients with type I diabetes, who are generally younger and less likely to need nursing home services. Additionally, we did not estimate the indirect charges associated with type I diabetes, such as short- or long-term disability or death. Regardless of the absolute medical charges, our objective was to determine the proportionate costs of medical care for DKA episodes.

We conclude that DKA episodes consume a significant proportion of health care dollars spent on adult patients with type I diabetes. Interventions capable of even a modest reduction in the number of DKA episodes could produce a significant cost savings in a health care system.

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