

Frequency and Cost of Diabetic Ketoacidosis in Germany – Study in 12 001 Paediatric Patients

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Abstract



Aims: Recently, medical expenditures were found to be 2-fold increased in paediatric patients with diabetic ketoacidotic events (DKA) in the U.S., in particular due to hospitalization. Aim of our study was to analyse DKAs and associated costs in Germany, where structured diabetes care including education is available for all patients.

Methods: For all 12001 diabetic patients 0–19 years of age (52.6% male, mean age (SD) 12.6 (3.9) years) documented in a German-wide database, all DKAs were assessed, as well as costs for diabetes-related treatment. Associations between costs and DKA were estimated using log-linear models.

Results: 457 (3.8%) patients had at least 1 DKA during 2007. Total annual costs for patients without, with 1, or ≥ 2 DKAs were €3330 (95%-CI 3292–3368), €6935 (CI 6627–7244), and €10728

(CI 9813–11644), respectively, with largest differences for hospitalization costs (€693, €4145, €8092). Age-sex-diabetes duration-adjusted cost ratios for patients with 1, or ≥ 2 DKAs compared to patients without DKA were 2.2 (CI 2.1–2.3) and 3.6 (CI 3.1–4.1), respectively.

Conclusions: In Germany, paediatric diabetic patients with DKA had up to 3.6-fold higher diabetes-related costs compared to those without DKA. This cost excess was higher compared to a U.S. study, however, the proportion of patients with DKA was much lower (3.8% versus 14.9%). The lower frequency of DKA in Germany may be due to a higher access to and utilization of diabetes education. Interventions should reduce DKA and resulting hospital admission in pediatric patients in order to reduce costs and improve quality of life.

Introduction



Few data is available regarding medical expenditures associated with acute complications in patients with paediatric diabetes. In the U.S., expenditures were found to be mainly increased in patients with diabetic ketoacidotic events (DKA), in particular due to hospitalisation, with up to 2-fold higher costs [1]. In Germany, all patients with paediatric diabetes have extensive diabetes education, mainly performed as inpatient care in contrast to other countries [2,3]. The risk of DKA has been reported to be lower than in the U.S. [4]. We aimed to estimate the 1-year cumulative incidence of at least 1 DKA and analyse differences in medical expenditures between paediatric patients with diabetes with and without DKA in Germany (○ **Table 1**).

Methods



We used 2007 data of the continuous diabetes data acquisition system for prospective surveillance (Diabetes Prospective Documentation, DPV), a computer-based documentation system which is used in more than 250 German centers providing paediatric diabetes care. The methods have been described in detail [5]. Briefly, DPV provides all sociodemographic data, laboratory measures, and clinical data of the routine diabetes care of patients. 2 times annually, all centers send anonymized data sets to a central data registry. After plausibility checks, data are centrally analysed. For all 12001 diabetic patients 0–19 years of age with continuous documentation in 2007 (52.6% male, mean age (SD) 12.6 (3.9) years, diabetes duration 5.5 (3.4) years, mean HbA1c (SD) 61 (8) mmol/mol (7.7 (1.4)%), 16.4% of the patients with migration background), all DKAs (defined as hospital admission due to acute hyperglycemia or pH <7.3) were

Table 1 Mean total annual diabetes-related costs¹ in patients with paediatric diabetes with and without diabetic ketoacidosis (DKA). DPV, Germany 2007.

	Mean annual costs per patient [Euro]	Cost ratio ²
no DKA	3 330 (95%-CI 3 292–3 368)	1
one DKA	6 935 (95%-CI 6 627–7 244)	2.2 (95%-CI 2.1–2.3)
more than one DKA	10 728 (95%-CI 9 813–11 644)	3.6 (95%-CI 3.1–4.1)

¹Including costs for inpatient and outpatient care, insulin, injection equipment and pumps, blood glucose self control material

²Adjusted for age, sex, and diabetes duration

assessed, as well as costs for diabetes-related treatment. To estimate costs, the following health care utilization variables were assessed in detail: diabetes-related hospitalisations, diabetes-related outpatient consultations, mean daily insulin dose, type of insulin, continuous subcutaneous insulin infusion (CSII), daily blood glucose self-measurements, treatment with antihypertensive drugs, lipid-lowering agents, and biguanides. The study took the perspective of the statutory health insurance. Monetary valuation was performed based on 2007 prices, using mean retail prices of the official German Index of Medicines, DRGs, and medical service fees of the statutory health insurance's price scale for outpatient care. If the subjects took part in a Disease Management Program (DMP), corresponding mean DMP fees were included. Associations between costs and DKA were estimated using log-linear models, adjusting for age, sex, and diabetes duration.

Results

457 (3.8%) patients had at least 1 DKA during 2007 (389 one, 68 2 or more). Patients with DKA were more likely to be in pubertal age (proportion of patients aged 10–14 years: no DKA: 41%, 1 DKA: 50%, 2 or more DKAs: 54%, $p < 0.001$), and to have a migration background (16%, 21%, and 18%; $p = 0.02$).

Mean total annual costs per patient in 2007 were €3 489 (95%-CI 3 448–3 530) (US\$ (30.06.2007) 4 701 (4 646–4 757)). Costs were significantly increased in patients with DKA. Total annual costs in patients without, with 1, or ≥ 2 DKAs were €3 330 (3 292–3 368), €6 935 (6 627–7 244), and €10 728 (9 813–11 644), respectively, with largest differences for hospitalisation costs (€693, €4 145, €8 092). Cost ratios of total costs in patients with 1 or ≥ 2 DKAs compared to patients without DKA, adjusted for age, sex, and diabetes duration, were 2.2 (95%-CI 2.1–2.3) and 3.6 (95%-CI 3.1–4.1), respectively. Additional adjustment for migration background did not alter results.

Discussion

Several limitations have to be considered. Our analysis was not population-based but represents the majority of German paediatric diabetes care facilities. As a consequence, the results of the study may not be representative for all patients with type 1 diabetes less than 20 years of age in Germany. However, the DPV documentation system is used in all kinds of medical facilities. Also, when comparing our study population with a population-based cohort, course and outcomes of diabetes care have been shown to be very similar [3]. There may be some uncertainty in

our cost estimation, e.g. we have applied the general items of the medical fee schedule for calculating outpatient care costs. However, we do not believe that this should have biased the association between DKA and costs. The strength of our study lies in using a comprehensive computer database containing data from continual, standardised documentation of routine care. Thus, our health care utilization data can be assumed to be rather valid and unbiased. Nevertheless, under- or overreporting cannot be excluded. On the other hand, many of the clinics use this documentation system for administrative purposes and regular data validity tests are being performed on the DPV data. Hence, we consider that our estimates are valid.

Thus, in Germany, paediatric patients with DKA had up to 3.6-fold higher diabetes-related costs compared to those without DKA. This cost excess was much higher compared to the U.S. study [1]. In our study, the proportion of patients with DKA was much lower compared to the U.S. analysis (3.8% vs. 14.9%). The lower frequency of DKA in Germany may be due to a better and easier access to and higher utilisation of diabetes education. Increased hospitalisation and higher costs among patients sustaining DKA may be due to poor diabetes control. This hypothesis is supported by HbA1c values observed in patients without, with 1, or ≥ 2 DKAs (61 ± 9 , 77 ± 3 , 89 ± 4 mmol/mol, corresponding to 7.7 ± 1.3 , 9.2 ± 1.9 , and $10.3 \pm 1.8\%$, respectively). Intervention strategies should be developed to reduce DKA and resulting hospital admission in paediatric patients in order to reduce costs, but also improve quality of life.

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Declaration of Competing Interests: Nothing to declare.

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