



An Update on the Incidence and Burden of Diabetic Ketoacidosis in the U.S.

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A recent study by Desai et al. (1) showed that the incidence and economic burden of hospitalizations due to diabetic ketoacidosis (DKA) in the U.S. increased between 2003 and 2014 (1). We sought to understand the most recent impact of the disease in the U.S. using the 2017 National Inpatient Sample (NIS) (www.hcup-us.ahrq.gov/nisoverview.jsp).

A total of 220,340 patients were identified with a primary diagnosis of DKA (61.6 cases of DKA per 10,000 admissions) (Table 1). The incidence of DKA per 10,000 admissions was higher in males (71.2) than females (54.1), and the majority of DKA patients were covered by Medicaid (79,175 patients [36.0%], $P < 0.01$). Of all DKA patients, 53.3% were of ages 18–44 years. However, a higher incidence per 10,000 admissions was noted in patients of ages 1–17 years. The mean age of patients with DKA was 38.4 years. The total charges among DKA patients in 2017 were \$6,757,748,178, with a mean of \$30,836.19. The mean length of stay was 3.22 days. A total of 835 deaths were found among DKA patients, with a mortality rate of 0.38%. The overall mortality rate was higher among males admitted with DKA (40.5 deaths per 10,000 cases of DKA) than females (35.3 deaths per 10,000 cases of DKA). While most cases and deaths were recorded among Whites (120,330 cases [56.5%], 435 deaths [53.7%]), the

number of DKA cases per 10,000 admissions and deaths per 10,000 cases was higher among Blacks (107.2 cases and 39.1 deaths). Mortality rates in DKA patients rose with increasing age-groups. A total of 492.8 deaths were estimated per 10,000 DKA cases among patients of ages ≥ 85 years. Our study also found a higher mortality rate among DKA patients covered by Medicare (84.9 deaths per 10,000 cases).

Our results provide an update on the impact and burden of DKA in the U.S. The incidence per 10,000 admissions rose from 32.04 in 2003 and 53.4 in 2014 to reach 61.6 in 2017 (1). A higher incidence was also noted among males in 2003 and 2014. The incidence per 10,000 admissions worsened for both males and females in 2017. Similar statistically significant differences were seen among the different age-groups in the study conducted by Desai et al. (1). While the changes in incidence are not completely understood, recent studies have raised concerns about misdiagnosis of type 1 diabetes in adults. Muñoz et al. (2) reported a rise in misdiagnosis with increasing adult age-groups and an 18% increased risk of DKA. Further studies are encouraged to better understand the impact of such misdiagnosis and clinical improvements in diagnosis protocols that can help.

The incidence per 10,000 admissions was higher among patients of ages 1–17

years. A rise in incidence was also noted in all groups except for patients of ages < 1 year. The burden on Medicare and Medicaid was worse in 2017. After adjustment for inflation, our study also found that the mean hospital charges increased from \$19,659 in 2003 and \$27,506 in 2014 to \$30,836 in 2017. The total hospital charges also rose from \$5.28 billion in 2014 (adjusted) to \$6.76 billion in 2017 (1). The mean length of stay was shorter in 2017, as it decreased from 3.64 days in 2003 and 3.24 days in 2014 to 3.22 days in 2017, but the average hospital charge per day rose from \$5,400 in 2003 and \$8,489 in 2014 to \$9,576 in 2017 (1). Timely and improved protocols pertaining to the care of DKA patients as well as admitting less severe DKA cases due to a lower threshold in admission criteria could be one of the causes of shorter stays observed in 2017 (3).

Unfortunately, a slightly higher mortality rate was calculated in 2017, as it rose from 0.33% in 2014 to 0.38% in 2017. The higher incidence and mortality rate among males and among Blacks can be linked with lifestyle and sex hormones as well as racial and genetic differences in responses to treatment and management of diabetes, respectively (4,5). Since the number of comorbid conditions tends to increase with aging, the higher risks for complications in older age groups

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Table 1—Incidence and mortality of DKA in the U.S. in 2017

	DKA patients in 2017	DKA cases per 10,000 admissions			P	Deaths among DKA patients	Deaths per 10,000 DKA patients admitted	P
		2003	2014	2017				
All cases	220,340	32.04	53.6	61.6		835	37.9	
Sex					<0.01			<0.01
Male	111,150 (50.4)	38.1	62.6	71.2		450 (53.9)	40.5	
Female	109,180 (49.6)	27.7	46.6	54.1		385 (46.1)	35.3	
Race					<0.01			<0.01
White	120,330 (56.5)	—	—	54.1		435 (53.7)	36.2	
Black	56,280 (26.4)	—	—	107.2		220 (27.2)	39.1	
Hispanic	26,205 (12.3)	—	—	61.2		95 (11.7)	36.3	
Age-group (years)					<0.01			<0.01
<1	55 (0.0)	0.2	0.14	0.13		—	—	
1–17	22,170 (10.1)	106.5	153.6	176.1		15 (1.8)	69.8	
18–44	117,540 (53.3)	67.65	117.9	137.2		175 (21.0)	14.9	
45–64	59,695 (27.1)	32.65	58.9	68.4		325 (38.9)	54.5	
65–84	19,150 (8.7)	6.54	13.67	18.7		235 (28.1)	122.7	
≥85	1,725 (0.8)	2.16	3.9	5.9		85 (10.2)	492.8	
Primary payer form					<0.01			<0.01
Medicare	45,970 (20.9)	12.5	27.1	31.7		390 (46.7)	84.9	
Medicaid	79,175 (36.0)	47.6	81.1	95.7		165 (19.8)	20.9	
Private insurance	61,025 (27.8)	32.3	49.9	58.4		150 (18.0)	24.6	

Data are *n* or *n* (%) unless otherwise indicated. Data for 2003 and 2014 from Desai et al. (1).

can predispose the elderly with DKA to a higher mortality rate. While our study showed that there was an associated higher mortality rate among DKA patients covered by Medicare, it is unclear whether it is due to any differences in compliance with treatment among patients with different insurance forms.

We can, therefore, confirm that DKA is a growing concern with an equally heavy financial burden on the health care system.

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www.hcup-us.ahrq.gov/db/nis/nisdbdocumentation.jsp) and their multiple partners (<https://www.hcup-us.ahrq.gov/db/hcupdatapartners.jsp>) for allowing the authors access to their database (more details about the database are available from www.hcup-us.ahrq.gov/nisoverview.jsp).

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