HHS Public Access

Author manuscript

Diabetes Res Clin Pract. Author manuscript; available in PMC 2020 November 01.

Published in final edited form as:

Diabetes Res Clin Pract. 2019 November ; 157: 107869. doi:10.1016/j.diabres.2019.107869.

Hospital Admissions for Hyperglycemic Emergencies in Young Adults at an Inner-City Hospital

Rachel A Wolf, MPH[a], **J. Sonya Haw, MD**[b], **Sudeshna Paul, PhD**[a], **Melissa Spezia Faulkner, PhD**[a,c], **EunSeok Cha, PhD**[a,d], **MK Findley, PhD**[a], **Farah Khan, MD**[b,e], **Sara Markley Webster, MD**[b], **Anastasia-Stefania Alexopoulos, MD**[f], **Komal Mehta, MD**[b], **David A Alfa, MD**[b], **Mohammed K Ali, MD**[a,g]

[a]Nell Hodgson Woodruff School of Nursing, Emory University, Atlanta, GA

[b]School of Medicine, Emory University, Atlanta, GA

[c]School of Nursing, Georgia State University, Atlanta, GA

[d]Chungnam National University, College of Nursing, Daejeon, South Korea

[e]Division of Metabolism, Endocrinology and Nutrition, University of Washington, Seattle, WA

[f]Division of Endocrinology, Duke University Medical Center, Durham, NC

[g]Rollins School of Public Health, Emory University, Atlanta GA

Abstract

Aims: There is limited information characterizing young adults (18-35 years) (YA) with diabetes, especially those admitted for hyperglycemic emergencies. The study aims were to examine associations of patient-level characteristics with hyperglycemic emergency hospitalization and to identify variations based on diabetes type and glycemic control.

Methods: We conducted retrospective analysis of 273 YA admitted to an inner-city hospital with diabetic ketoacidosis (DKA) or hyperosmolar hyperglycemic nonketotic syndrome (HHS). T-tests, Chi-Square tests, and ANOVA identified differences in demographics, diabetes history, clinical indicators, complications/comorbidities, and hospital admission stratified separately by diabetes type (1 vs 2) and admission HbA1c <9% (75mmol/mol), ≥9% to 12% (108mmol/mol), ≥12%).

Corresponding Author: Rachel Wolf, MPH, School of Nursing, Emory University, 69 Jesse Hill Jr. Drive NE, Rm 208, Atlanta, GA 30303, (o) 404-778-1688, (f) 404-524-3052, rwolf@emory.edu.

Author contributions:

RW and MKF prepared and edited the manuscript. MKF, FK, SMW, ASA, DA assisted with data extraction and reviewed and edited the manuscript. SP guided the data analyses. MA, EC, MF, JSH participated in the development of the initial study design, methods, interpretation and reviewed and edited the manuscript. JSH is the guarantor of this work and, as such, had full access to all the data in the study and takes responsibility for the integrity of the data and the accuracy of the analyses performed.

Conflict of interest: The authors report no potential conflicts of interest related to this article

Prior abstract publication: Parts of this study were presented in abstract form at the 76th American Diabetes Association Scientific Sessions, New Orleans, LA, June 10-14, 2016. Haw, J. S., Faulkner, M. S., Findley, M. K., Cha, E. S., Khan, F., Markley, S., Alexopoulos, A.S., Paul, S., & Ali, M. K. (2016, June). *Hyperglycemic Emergencies in Young* Adults *with Diabetes in an Inner-City County Hospital*. Abstract No. 1268, published in *Diabetes*, Supplement, Health Care Delivery-Economics.

Results: Mean admission HbA1c was 12.4% (112mmol/ml). HbA1c was ≥9.0% for 90.5%. The main DKA/HHS trigger was medication nonadherence (57.9%), with 35.6% presenting with new-onset type 2 diabetes. Only 3.7% utilized outpatient diabetes clinics, 38.8% were re-hospitalized within the year, and 69% lacked insurance. Diabetes complications (44.7%) and psychiatric co-morbidities (35.5%) were common. Significantly more YA with type 1 diabetes had insurance, whereas YA with type 2 diabetes had higher admission HbA1c. YA with HbA1c ≥12% were more likely to be Black and lack insurance.

Conclusions: YA hospitalized for DKA/HHS in an inner-city hospital tended to have severely uncontrolled diabetes. Many already had comorbidities and diabetes complications, high use of acute care services and low use of diabetes specialty services. YA characteristics varied by diabetes type and HbA1c. Overall, a substantial percentage lacked insurance, potentially impacting healthcare utilization patterns and medication adherence, and leading to DKA/HHS admissions.

Keywords

Young adults; hyperglycemic emergency; vulnerable populations; inpatient hospitalization; glycemic control

1. Introduction

Diabetes is a complex, chronic disease that is increasing in prevalence worldwide [1], [2]. The annual rate of increase in incidence of type 1 diabetes is approximately 3-4% per year [1]. The prevalence of type 2 diabetes is also increasing among youth; between 2001 and 2009 the prevalence for type 2 diabetes increased by 30.5% (0.34 per 1000 in 2001 to 0.48 per 1000 in 2009) among children and adolescents [3]. Thus an increasing number of young adults will be living with diabetes. This greater prevalence of diabetes in young adults (age 18-35 years) will lead to higher rate of diabetes complications, higher healthcare utilization and more years lived with disability [4]. Yet, diabetes in young adults continues to be understudied.

National data suggest that glycemic control is often poor among young adults, and that young adults have some of the highest rates of hyperglycemic emergencies such as diabetic ketoacidosis (DKA) and hyperglycemic hyperosmolar syndrome (HHS) as compared to other age groups [5]–[7]. Uncontrolled diabetes (HbA1c ≥ 9.0%, 75mmol/mol) [8] and multiple hyperglycemic emergencies during young adulthood have the potential to greatly affect morbidity and mortality throughout adult life [9]. Additionally, treatment of diabetic emergencies has a substantial economic burden. The average cost of one hospital admission for a hyperglycemic emergency in the United States is $17,500 per patient, and it is estimated that the total annual hospital cost of hyperglycemic emergency management nationally is $2.4 billion [10].

Despite the vulnerability of the young adult population with diabetes and their risk of hyperglycemic emergency, most studies either focus on youth under the age of 18 years or fail to consider young adults separately from the general adult population over the age of 18. Additionally, less is known about minority and disadvantaged young adults with diabetes, although we know ethnic, cultural, and socioeconomic differences affect diabetes prevalence

and outcomes and compound the risk of hospitalizations and diabetes related complications [11], [12]. Despite major advances in medical knowledge and diabetes treatment options, socioeconomic, ethnic, and racial inequalities in access to care result in a higher risk of complications and poorer glycemic control for the disadvantaged [12].

The purpose of this retrospective study was to examine the association of poor glycemic control and patient-level characteristics (e.g. demographics, healthcare utilization, diabetes history, and diabetes complications/comorbidities) with hospitalization for hyperglycemic emergencies at an inner-city county hospital among a highly vulnerable population of disadvantaged, primarily minority, young adults with diabetes. We also investigated whether and how these patterns of patient characteristics related to hospitalization for hyperglycemic emergency varied based on type of diabetes and severity of glycemic control at admission. This characterization can be further used to identify potentially modifiable targets for interventions to prevent hospital admissions for hyperglycemic emergencies specific to young adults aged 18 to 35.

2. Subjects, Materials, and Methods

2.1 Study Sample

We used electronic health records (EHR) from Grady Health System in Atlanta, Georgia for this retrospective study. Grady Memorial Hospital (Grady) is a 953-bed academic county hospital that serves low resource inner-city patients. We used the International Classification of Diseases (ICD)-9 codes indicating DKA or HHS to identify patients admitted to Grady between January 2010 and November 2015. We included all patients 18 to 35 years old at the time of first admission for DKA/HHS in the study and excluded patients only seen in the emergency department or clinic and not admitted to the hospital, those without evidence of DKA or HHS, or those that did not have a diagnosis of type 1 diabetes or type 2 diabetes (i.e. gestational diabetes and secondary diabetes were excluded). IRB approval was obtained from Emory University, and the study was authorized by the Grady Hospital Research Oversight Committee. All analyses and study procedures complied with HIPAA regulations and federal regulations for the protection of human research subjects and inclusion of women and minorities.

2.2 Data Collection

Based on the data extraction protocol established, retrospective chart reviews using EHR was completed between December 2015 and December 2016 (by MKF, FK, SMW, ASA, DAA). The first hyperglycemic emergency that occurred between January 2010 and November 2015 was identified as the primary DKA/HHS admission. Data were extracted relating to the primary admission; however, all EHR documentation was also examined to gather patient history and information about previous and subsequent encounters and hospital admissions (see Supplementary Table S1 for further description of data extraction). An extraction sheet was created indicating each variable and coding schema including a denotation for missing information. Ten cases were reviewed by all extractors to ensure minimal reviewer variability and consensus in coding for each variable. Chart reviews focused on extracting demographic and socioeconomic factors, diabetes disease history

including complications, comorbidities, and inpatient variables from the DKA/HHS hospital admission.

Demographic factors: Age, sex, ethnicity, race, insurance status, and SES have been identified as risk factors for hyperglycemic emergencies in other age groups [13]–[22]. For this study, race was coded as a dichotomous variable (Black/Non-Black). Ethnicity was recorded as Hispanic or non-Hispanic. SES was derived from the zip code at the time of the primary admission and coded as the median household income for that zip code according to the 2011-2015 U.S. Census Bureau's American Community Survey 5-Year Estimates [23]. Insurance was coded as a dichotomous variable (insured/uninsured) and subcategorized by type of insurance (private/public).

Healthcare utilization: Information regarding healthcare utilization (emergency room visits, hospitalizations, clinic visits) in the year following the DKA/HHS admission, and diabetes clinic attendance in the year prior to the event was also collected. Grady Hospital provides diabetes care services through its Diabetes Center, a specialized multidisciplinary team of diabetes nurses, certified diabetes educators, podiatrists, dieticians, and endocrinologists offering a full range of services for diabetes patients. The EHR encounter log was analyzed to determine if the patient utilized the Grady Diabetes Center for any diabetes services within the year prior to their primary DKA/HHS admission. Hospital utilization was defined as frequency of emergency room visits and other hospitalizations for any reason in the year following the primary DKA/HHS admission.

Diabetes history, chronic complications and comorbidities: We abstracted potential risk factors for hyperglycemic emergency related to diabetes history, including type of diabetes, age at diagnosis, and duration of diabetes [18], [20], [24]–[26]. Chronic complications and comorbidities were also abstracted from medical records to examine their prevalence among this young adult population [13], [14], [27]–[29]. Chronic diabetes complications were classified both as a dichotomous variable (present/not present) and by type of complication: microvascular (retinopathy, nephropathy, and neuropathy), macrovascular (cardiovascular disease), and other complications. To categorize obesity, body mass index (BMI) was stratified by the Centers for Disease Control (CDC) classification for underweight, normal/healthy weight, overweight, and obese [30]. History of mental health comorbidities was categorized as a dichotomous variable (present/not present). History of depression and substance use were also examined separately.

Hyperglycemic emergency characteristics: Hyperglycemic emergency characteristics included precipitating factors of DKA/HHS, length of hospital stay for the primary admission, admission to the intensive care unit (ICU), ICU length of stay, and HbA1c. Precipitating factors for the primary DKA/HHS admission were categorized as medication non-adherence (including not being able to get medications, discontinuing medication, and changing medications without consulting a healthcare provider), infections, new onset diabetes diagnoses, and other. Prior HbA1c was recorded as the most recent plasma HbA1c prior to the primary admission. Admission HbA1c was recorded as the first plasma HbA1c obtained during the primary admission.

2.3 Data Analysis

Data were reviewed for implausible values. Missing data was assumed to be at random and complete case analysis was used for all analyses (see Supplementary Tables S2–S3 for summary of missing data stratified by diabetes type and glycemic control). Descriptive statistics were used to examine overall characteristics of young adults admitted for hyperglycemic emergency. Independent t-tests or Chi-square tests were conducted to assess differences in characteristics of the young adults stratified by type of diabetes.

A separate analysis was conducted to examine differences based on admission HbA1c. To examine difference based on admission HbA1c values, admission HbA1c was stratified as <9% (75 mmol/mol), ≥9% (75 mmol/mol) to <12% (108 mmol/mol), and ≥12% (108 mmol/mol). Poor glycemic control as indicated by a HbA1c ≥9% was chosen as the first cut-point based on the Health Resources and Service Administration (HRSA) and the Healthcare Effectiveness and Data Information Set (HEDIS) [8]. The second cut-point of 12% (108 mmol/mol) indicated severely poor glycemic control. Analysis of variance (ANOVA) and Chi- square tests were conducted, using the Bonferroni method to adjust for multiple comparisons. The significance level was set at 0.05 for all analyses. All analyses were performed in SPSS (SPSS Version 22, Armonk, NY).

3. Results

3.1 All Young Adult Admissions

During the study period, there were 2,427 total admissions with an ICD-9 classification indicating DKA or HHS. Of these, 703 (29%) were young adult admissions (18-35 years) with 326 unique medical record numbers. Inclusion/exclusion criteria removed 53 patients leaving 273 in the study sample. These 273 young adults accounted for a total of 636 DKA/HHS admissions during the five-year study period.

The average age at admission was 26.0± 4.5 years, and the study sample predominantly identified as Black (83.5%). Only 31% of patients admitted for DKA/HHS had health insurance (Table 1). Uncontrolled diabetes with an HbA1c ≥9% (75 mmol/mol) at admission was present in 90.5% of the study sample, with an average HbA1c at admission of 12.4% (112 mmol/mol) ± 2.61%. In terms of healthcare utilization patterns, only 3.7% of those admitted had utilized the Grady Diabetes Center in the preceding year, while 43% utilized the emergency department and 38% were hospitalized in the following year. The precipitating factor for 58% of young adults' index admission was medication non-adherence (Table 2). Chronic complications related to diabetes were present in 45% of the young adults admitted, and a history of psychiatric conditions was present in 36%.

3.2 Diabetes Type

Characteristics of patients by diabetes type are presented in Table 1 and Table 2. Most young adults admitted with DKA or HHS had a diagnosis of type 1 diabetes (73.3%). Patients with type 2 diabetes were less likely to have health insurance (19.2% vs. 35.0%, $p<0.05$), and less likely to be hospitalized the year following the index admission (24.7% vs 42.5%, $p<0.05$). Regarding diabetes history, patients with type 1 diabetes were significantly younger at

diagnosis (14.9 ± 6.5 years vs 25.6 ± 6.1 years, $p<0.001$) and had significantly longer duration of disease (10.3 ± 6.9 years vs 2.7 ±4.5 years, $p<0.001$). In terms of complications and comorbidities, patients with type 1 diabetes had significantly lower BMI (24.8 8kg/m^2 vs 35.8 8kg/m^2, p<0.001) but greater frequency of depression (16.5% vs 11.0%, p <0.05).

Hospital admission characteristics also differed by diabetes type. Patients with type 2 diabetes had a significantly higher admission HbA1c compared to those with type 1 diabetes (13.1% (120 mmol/mol) vs 12.1% (109 mmol/mol), $p=0.02$). Although nonadherence was the leading cause of admission for both type 1 and type 2 diabetes, non-adherence as the cause of admission was significantly more common in young adults with type 1 diabetes (type 1 diabetes: 61.5% vs type 2 diabetes: 47.9%, $p<0.05$). Likewise, infections were a more common precipitating factor for admission for patients with type 1 diabetes when compared to patients with type 2 diabetes (type 1 diabetes: 21.5% vs type 2 diabetes: 9.6%, $p<0.05$). In addition, 36% of the index admissions in type 2 diabetes patients were attributed to newly diagnosed diabetes (vs 3.5% in type 1 diabetes $p<0.001$). Among all patients newly diagnosed with diabetes at the time of index admission, 66.7% were male, 15.2% were of Hispanic ethnicity and 75.8% were Black. Overall HbA1c for these patients was 12.9% (117mmol/mol), (13.4% (123mmol/mol) for type 1 and 12.8% (116mmol/mol) for type 2). Additionally, these patients with newly diagnosed diabetes, compared to patients who had been previously diagnosed with diabetes prior to index admission, had higher proportions of being uninsured (71.4% for type 1, 96.1% for type 2), and fewer hospitalizations post DKA admission (28.6% for type 1,11.5% for type 2).

3.3 Glycemic Control at Admission

Characteristics of patients stratified by HbA1c at admission are presented in Table 3 and Table 4. Several significant differences were found for those patients with admission HbA1c ≥12% relative to those patients admitted with lower HbA1c. A significant portion of patients with admission HbA1c ≥12% were Black when compared to the two lower HbA1c strata; 92.2% of patients in the HbA1c ≥12% (108 mmol/mol) strata were Black as compared to 75.3% of patients with an HbA1c of ≥9% to <12% and 65.0% of patients with an HbA1c <9% (75 mmol/mol) $p<0.05$). Significantly fewer patients with an admission HbA1c ≥12% (108 mmol/mol) had insurance, compared to those with an HbA1c of <9% (75 mmol/mol) (21.6% vs 60.0%, $p<0.001$). Patients with admission HbA1c ≥12% (108mmol/mol) were also less likely to have public health insurance compared to those with an HbA1c of <9% (75mmol/mol) (10.3% vs 40.0%, p<0.05), but there was no difference between these groups in terms of private health insurance coverage. Additionally, higher admission HbA1c was associated with significantly shorter duration of diabetes (6.32 years if ≥12% (108mmol/mol) vs 8.08 years if HbA1c ≥9% to 12% (75mmol/mol to 108mmol/mol) vs 13.56 years if HbA1c <9% (75 mmol/mol), p<0.05). The highest admission HbA1c strata also had significantly higher mean HbA1c prior to hospital admission as compared to other admission HbA1c strata (mean of 12.29% [111 mmol/mol] if admission HbA1c ≥12%, 10.12% [87mmol/mol] if ≥9% to 12%, 9.30% [78mmol/mol] if <9%; p<0.05).

4. Discussion

Young adults, especially Black young adults are underrepresented in studies related to DKA/HHS hospitalizations, despite evidence that this population has disproportionally high rates of diabetic emergencies and hospital utilization [13]–[15]. Our study investigated patient-level characteristics of this population and is one of the first studies to differentiate characteristics of young adults admitted for DKA or HHS to a large, inner-city hospital based on diabetes type and glycemic control. The primary findings of this study were: 1) young adults with type 1 and type 2 diabetes admitted for DKA/HHS have severely uncontrolled diabetes prior to the hospitalization; 2) nonadherence to medications was the most common cause for DKA/HHS, but significant differences by diabetes type were also evident; and 3) inadequate access to healthcare, particularly in the form of lack of health insurance may play a significant role in DKA/HHS admissions and healthcare utilization patterns.

Most patients admitted for DKA/HHS had very high HbA1c, at a mean of 12.4% (112mmol/mol) at admission and a prior HbA1c of 11.0% (97mmol/mol). Both of these values are well above American Diabetes Association (ADA) recommended target HbA1c of less than 7% (53 mmol/mol) [31] for adults over 18 years and also greater than the less stringent HbA1c goals (<8%, 64 mmol/mol) recommended for young adults who are transitioning from pediatric to adult care [9]. Having a high HbA1c at the last visit prior to hospital admission indicates potentially missed opportunities prior to admission to identify high risk patients and provide interventions to prevent these later admissions for hyperglycemic emergency. The strikingly high levels of mean HbA1c seen among the majority of patients in our study also indicate the chronicity of poor glycemic control in this population and signifies the need to identify targeted approaches specific to young adults with diabetes.

While non-adherence was the most common cause of admission for both patients with type 1 and type 2 diabetes, it was significantly more common among patients with type 1 diabetes. Though presentation as new-onset diabetes was the precipitating factor for admission in about 1/3 of admissions in patients with type 2 diabetes, it was rarely a precipitating factor among patients with type 1 diabetes. With the high proportion of Black patients in our cohort, this may reflect a significantly higher proportion of patients with ketosis-prone diabetes presenting in young adulthood than previously recognized. However, because patients with type 1 diabetes are generally diagnosed earlier than patients with type 2 diabetes, this trend also reflects the higher number of new type 2 diagnoses at this later age compared to those with type 1 diabetes. Regardless, this may suggest that a large proportion of this population of young, disadvantaged adults with type 2 diabetes are being diagnosed through emergency services rather than primary care and deserves further investigation. Appropriate screening tools for high risk young adult populations may need to be implemented to identify and treat young adults at risk for type 2 diabetes prior to diagnosis through acute care services [32]. Due to the unique characteristics and health service needs of young adults with newly diagnosed diabetes, further studies are warranted to explore specific methods for early diagnosis and treatment.

Our study found that patients with type 2 diabetes had comparable rates of chronic diabetes complications relative to those with type 1 diabetes, despite the overall shorter duration of disease. This supports growing evidence that early onset type 2 diabetes is an aggressive disease that needs to be identified early (not in the emergency care setting) and treated aggressively by providers [33]. For instance, the SEARCH study, a national multi-center study that examined diabetes prevalence, incidence, and complications among youth less than 20 years of age with prospective follow-up of youth with diabetes, found that youth and young adults with type 2 diabetes had a greater incidence of microvascular complications compared to the general population of youth and young adults and those with type 1 diabetes [34].

Data such as these regarding precipitating factors for admission and prevalence of complications suggest disturbing trends in healthcare access and usage among this young adult population. Interruptions in health insurance coverage are more common among young adults [35], and 34% of young adults report a coverage gap between pediatric and adult diabetes care spanning longer than six months [36]. The mean age of all young adults admitted with DKA/HHS in this study was 26 years, corresponding to the age at which parental insurance coverage is discontinued. Lack of insurance in this study was related to severely uncontrolled diabetes upon admission and has previously been found to be associated with higher HbA1c as well as higher rates of inpatient and ED use [22], [35].

In this sample less than 4% of the young adult population were seen at the outpatient diabetes center the year before their primary DKA/HHS admission, suggesting that there are challenges to accessing and utilizing outpatient diabetes care services, which is critical to early treatment and prevention of both diabetes related complications and emergency hospitalizations [37]. With over one third of patients being hospitalized and over 40% of patients making ER visits in the year post index admission, these data suggest that these young adults may represent a population with high (and high cost) healthcare utilization through acute care settings.

Young adults in general have the highest rate of mental health issues, with over 25% of 18-25-year olds reporting any mental health issue [38]. The percentage of young adults with mental health comorbidities in this study was over 35%, which merits concern given the impact that mental health on diabetes health outcomes such as glycemic control. Mental health services for individuals with diabetes and mental health comorbidities are often inadequate, and mental health issues such as depression contribute to both medication non-adherence and underusage of healthcare services for chronic illnesses, both of which appear to be concerns among this population based on the findings of this study [39]–[41]. Providers need to be alerted to the high need for mental health services among these vulnerable young adults admitted for hyperglycemic emergency and additional measures should be taken to facilitate use of mental health services among this population through enhanced screening and better linkage to mental health services.

Data collected in this study were limited to information within the Grady Health System EHR and did not capture information from the patient's utilization of other hospital systems, which would provide a more complete understanding of these patients' healthcare access

patterns. There was bias in data completeness favoring patients who have high utilization rates of the Grady Health System as there were more encounters in the chart from which to extract data. Additionally, some patient data were not reported in the Grady EMR, particularly for prior HbA1c, chronic complications, and mental health (see Supplementary Tables S2–3). In the emergency department, patients with type 1 diabetes were often not diagnosed based on autoantibody screening, which is the ADA standard for diagnosis [31]; however, characterized differences in age and BMI between those patients classified as having type 1 vs type 2 diabetes correspond to the expected differential profile for these classifications.

Despite these limitations, this study contributes to a better understanding of an understudied population of young adults admitted to an inner-city hospital for hyperglycemic emergencies and highlights current gaps in care and research that need to be further explored. With an increasing number of young adults living with diabetes and likely to experience complications of the disease, it is essential to identify those young adults who are at high risk for hyperglycemic emergencies. Our study underscores the importance of characterizing disadvantaged young adult populations with diabetes in order to develop better understanding of risks for hyperglycemic emergency and poor health outcomes and highlights some important differences based on diabetes type that could be valuable in assessing risk and improving health outcomes. This study suggests that intervention for this young adult population as a whole will need to address issues such as medication non-adherence, mental health, and healthcare access to decrease hospitalizations for DKA or HHS among this vulnerable population.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

Acknowledgements

Funding: MKF was partially supported by the Training in Interventions to Improve Outcomes in Chronic Conditions grant funded by the National Institute of Nursing Research Training Program (2T32NR012715-06A1). MKA and MF were partially supported by the Georgia Center for Diabetes Translation Research funded by the National Institute of Diabetes and Digestive and Kidney Diseases (P30DK111024). ASA is supported by the National Institutes of Health under Award Number T32DK007012.

References

[1]. Patterson CC et al., “Trends in childhood type 1 diabetes incidence in Europe during 1989–2008: evidence of non-uniformity overtime in rates of increase,” Diabetologia, vol. 55, no. 8, pp. 2142–2147, 8 2012. [PubMed: 22638547]

[2]. Vehik K and Dabelea D, “The changing epidemiology of type 1 diabetes: why is it going through the roof?,” Diabetes Metab. Res. Rev, vol. 27, no. 1, pp. 3–13, 1 2011. [PubMed: 21218503]

[3]. Dabelea D et al., “Prevalence of Type 1 and Type 2 diabetes among children and adolescents from 2001 to 2009,” JAMA, vol. 311, no. 17, pp. 1778–1786, 5 2014. [PubMed: 24794371]

[4]. Bardenheier BH et al., “Disability-free life-years lost among adults aged ≥50 years, with and without Diabetes Mellitus,” Diabetes Care, vol. 39, no. 7, pp. 1222–1229, 7 2016. [PubMed: 26721810]

[5]. Pinto CA et al., "Changes in diabetes medication regimens and glycemic control in adolescents and young adults with youth-onset type 2 diabetes: The SEARCH for diabetes in youth study," Pediatr. Diabetes, vol. 19, no. 6, pp. 1065–1072, 2018.

[6]. Centers for Disease Control and Prevention, "Diabetes atlas," 2018.

[7]. Beck RW, Tamborlane WV, Bergenstal RM, Miller KM, DuBose SN, and Hall CA, "The T1D Exchange Clinic Registry," J. Clin. Endocrinol. Metab, vol. 97, no. 12, pp. 4383–4389, 12 2012. [PubMed: 22996145]

[8]. National Committee for Quality Assurance, "Comprehensive diabetes care: This HEDIS measure." 2017.

[9]. American Diabetes Association, "Glycemic targets. Sec 6. In Standards of Medical Care in Diabetes-2017," Diabetes Care, vol. 40, no. Supplement 1, pp. S48–S56, 1 2017. [PubMed: 27979893]

[10]. Kitabchi AE, Umpierrez GE, Miles JM, and Fisher JN, "Hyperglycemic crises in adult patients with diabetes," Diabetes Care, vol. 32, no. 7, pp. 1335–1343, 7 2009. [PubMed: 19564476]

[11]. Campbell JA, Walker RJ, Smalls BL, and Egede LE, "Glucose control in diabetes: the impact of racial differences on monitoring and outcomes," Endocrine, vol. 42, no. 3, pp. 471–482, 12 2012. [PubMed: 22815042]

[12]. Ricci-Cabello I, Ruiz-Pérez I, Labry-Lima AOD, and Márquez-Calderón S, "Do social inequalities exist in terms of the prevention, diagnosis, treatment, control and monitoring of diabetes? A systematic review," Health Soc. Care Community, vol. 18, no. 6, pp. 572–587, 11 2010. [PubMed: 21040063]

[13]. Bradford AL, Crider CC, Xu X, and Naqvi SH, "Predictors of recurrent hospital admission for patients presenting with diabetic ketoacidosis and hyperglycemic hyperosmolar state," J. Clin. Med. Res, vol. 9, no. 1, pp. 35–39, 1 2017. [PubMed: 27924173]

[14]. Randall L et al., "Recurrent diabetic ketoacidosis in inner-city minority patients: Behavioral, socioeconomic, and psychosocial factors," Diabetes Care, vol. 34, no. 9, pp. 1891–1896, 9 2011. [PubMed: 21775761]

[15]. Rewers A et al., "Predictors of acute complications in children with type 1 diabetes," JAMA, vol. 287, no. 19, pp. 2511–2518, 5 2002. [PubMed: 12020331]

[16]. Kitabchi AE and Nyenwe EA, "Hyperglycemic crises in diabetes mellitus: diabetic ketoacidosis and hyperglycemic hyperosmolar state," Endocrinol. Metab. Clin. North Am, vol. 35, no. 4, pp. 725–751, viii, 12 2006. [PubMed: 17127143]

[17]. Kitabchi AE, Umpierrez GE, Fisher JN, Murphy MB, and Stentz FB, "Thirty years of personal experience in hyperglycemic crises: Diabetic ketoacidosis and hyperglycemic hyperosmolar state," J. Clin. Endocrinol. Metab, vol. 93, no. 5, pp. 1541–1552, 5 2008. [PubMed: 18270259]

[18]. Liu C-C, Chen K-R, Chen H-F, Huang H-L, Ko M-C, and Li C-Y, "Trends in hospitalization for diabetic ketoacidosis in diabetic patients in Taiwan: analysis of national claims data, 1997-2005," J. Formos. Med. Assoc. Taiwan Yi Zhi, vol. 109, no. 10, pp. 725–734, 10 2010. [PubMed: 20970069]

[19]. Musey VC, Lee JK, Crawford R, Klatka MA, McAdams D, and Phillips LS, "Diabetes in urban african-americans. I. Cessation of insulin therapy is the major precipitating cause of diabetic ketoacidosis," Diabetes Care, vol. 18, no. 4, pp. 483–489, 4 1995. [PubMed: 7497857]

[20]. Nyenwe E et al., "Admissions for diabetic ketoacidosis in ethnic minority groups in a city hospital," Metabolism, vol. 56, no. 2, pp. 172–178, 2 2007. [PubMed: 17224329]

[21]. Steenkamp DW, Alexanian SM, and McDonnell ME, "Adult hyperglycemic crisis: A review and perspective," Curr. Diab. Rep, vol. 13, no. 1, pp. 130–137, 2 2013. [PubMed: 23115048]

[22]. Hall AG, Harman JS, and Zhang J, "Lapses in medicaid coverage: Impact on cost and utilization among individuals with diabetes enrolled in medicaid," Med. Care, vol. 46, no. 12, pp. 1219–1225, 2008. [PubMed: 19300311]

[23]. 2011-2015 American Community Survey 5-Year Estimates, "Median household income" U.S. Census Bureau, 2017.

[24]. Cooper H, Tekiteki A, Khanolkar M, and Braatvedt G, "Risk factors for recurrent admissions with diabetic ketoacidosis: a case-control observational study," Diabet. Med, vol. 33, no. 4, pp. 523–528, 4 2016. [PubMed: 26489986]

[25]. Newton CA and Raskin P, "Diabetic ketoacidosis in type 1 and type 2 Diabetes Mellitus: Clinical and biochemical differences," Arch. Intern. Med, vol. 164, no. 17, pp. 1925–1931, 9 2004. [PubMed: 15451769]

[26]. Goguen J and Gilbert J, "Hyperglycemic emergencies in adults," Can. J. Diabetes, vol. 37, pp. S72–S76, 4 2013. [PubMed: 24070967]

[27]. Barski L et al., "Comparison of diabetic ketoacidosis in patients with type-1 and type-2 Diabetes Mellitus," Am. J. Med. Sci, vol. 345, no. 4, pp. 326–330, 4 2013. [PubMed: 23377164]

[28]. Balla U, Malnick S, and Schattner A, "Early readmissions to the department of medicine as a screening tool for monitoring quality of care problems:," Medicine (Baltimore), vol. 87, no. 5, pp. 294–300, 9 2008. [PubMed: 18794712]

[29]. Govan L et al., "Achieved levels of HbA1c and likelihood of hospital admission in people with type 1 diabetes in the Scottish population: A study from the Scottish Diabetes Research Network Epidemiology Group," Diabetes Care, vol. 34, no. 9, pp. 1992–1997, 9 2011. [PubMed: 21788623]

[30]. Centers for Disease Control and Prevention, "About adult BMI healthy weight." 29-8-2017.

[31]. American Diabetes Association, "Classification and diagnosis of diabetes," Diabetes Care, vol. 40, no. Supplement 1, pp. S11–S24, 1 2017. [PubMed: 27979889]

[32]. Yan F, Cha E, Lee ET, Mayberry RM, Wang W, and Umpierrez G, "A self-assessment tool for screening young adults at risk of type 2 diabetes using Strong Heart Family Study data," Diabetes Educ., vol. 42, no. 5, pp. 607–617, 10 2016. [PubMed: 27480523]

[33]. Nadeau KJ et al., "Youth-Onset Type 2 Diabetes Consensus Report: Current Status, Challenges, and Priorities," Diabetes Care, vol. 39, no. 9, pp. 1635–1642, 9 2016. [PubMed: 27486237]

[34]. Hamman RF et al., "The SEARCH for Diabetes in Youth Study: Rationale, findings, and future directions," Diabetes Care, vol. 37, no. 12, pp. 3336–3344, 12 2014. [PubMed: 25414389]

[35]. Rogers MAM, Lee JM, Tipirneni R, Banerjee T, and Kim C, "Interruptions in private health insurance and outcomes in adults with Type 1 diabetes: A longitudinal study," Health Aff. (Millwood), vol. 37, no. 7, pp. 1024–1032, 7 2018. [PubMed: 29985705]

[36]. Garvey KC et al., "Health care transition in patients with type 1 diabetes: Young adult experiences and relationship to glycemic control," Diabetes Care, vol. 35, no. 8, pp. 1716–1722, 8 2012. [PubMed: 22699289]

[37]. Holmes-Walker DJ, Llewellyn AC, and Farrell K, "A transition care programme which improves diabetes control and reduces hospital admission rates in young adults with Type 1 diabetes aged 15–25 years," Diabet. Med, vol. 24, no. 7, pp. 764–769, 7 2007. [PubMed: 17535294]

[38]. Substance Abuse and Mental Health Services Administration, "Results from the 2017 national survey on drug use and health: Detailed tables," 2017.

[39]. Lin EHB et al., "Relationship of depression and diabetes self-care, medication adherence, and preventive care," Diabetes Care, vol. 27, no. 9, pp. 2154–2160, 9 2004. [PubMed: 15333477]

[40]. Gonzalez JS et al., "Depression and Diabetes Treatment Nonadherence: A Meta-Analysis," Diabetes Care, vol. 31, no. 12, pp. 2398–2403, 12 2008. [PubMed: 19033420]

[41]. Sartorius N, "Depression and diabetes," Dialogues Clin. Neurosci, vol. 20, no. 1, pp. 47–52, 3 2018. [PubMed: 29946211]

Table 1.

Young Adults Admitted with DKA/HHS: Demographics and Healthcare Utilization by Diabetes Type

Characteristic	All admissions (n=273)	Type 1 Diabetes (n=200)	Type 2 Diabetes (n=73)
Age at primary admission, years (mean, sd)	26.02 (4.52)	25.12 (4.25)	28.48 (4.36) *
Sex (%)			
Male	52.7	52.0	54.8
Female	47.3	48.0	45.2
Ethnicity (%)			
Non-Hispanic	94.9	96.0	91.8
Hispanic	5.1	4.0	8.2
Race (%)			
Black	83.5	84.0	82.2
Non-Black	16.5	16.0	17.8
Median Household Income, $10k (mean, sd)	41.89 (15.29)	42.12 (15.89)	41.25 (13.61)
Insurance (%)			
Any insurance	30.8	35.0	19.2 **
Private Insurance	11.4	13.0	6.8
Public Insurance	19.4	22.0	12.3
No Insurance	69.2	65.0	80.8 *
Healthcare Utilization (%) +			
Emergency Visits	43.2	44.5	39.7
Hospitalization	37.7	42.5	24.7 **
Diabetes Center Attendance	3.7	4.5	1.4

* significant at alpha p<.001

** significant at alpha p<0.05

+ Emergency visits and hospitalizations in year *after* index admission, Diabetes Center attendance in year *prior* to admission

Table 2.

Young Adults Admitted with DKA/HHS: Diabetes History, Hospital Admission Characteristics, and Chronic Complications/Comorbidities by Diabetes Type

Characteristic	All admissions (n=273)	Type 1 Diabetes (n=200)	Type 2 Diabetes (n=73)
Diabetes History			
Diabetes Type (%)			
Type 1	73.3	---	---
Type 2	26.7	---	---
Age at Diagnosis, years (mean, sd)	18.40 (8.15)	14.86 (6.53)	25.63 (6.1) *
Duration of Disease, years (mean, sd)	7.80 (7.19)	10.30 (6.92)	2.68 (4.54) *
Hospital Admission			
Precipitating factors for admission (%)			
Medication Non-adherence	57.9	61.5	47.9 +
Infection	18.3	21.5	9.6 +
New Onset	12.1	3.5	35.6 +
Other	11.2	13.5	6.8
Length of Stay, days (mean, sd)	3.75 (3.6)	3.60 (3.28)	4.15 (4.32)
Admission to ICU			
ICU Admission (%)	13.2	15.0	5.5
ICU Length of Stay, days (mean, sd)	0.39 (1.37)	0.46 (1.49)	0.21 (0.94)
Glycemic Control (mean, sd)			
Admission HbA1c, %	12.38 (2.61) [112 mmol/mol]	12.11 (2.69) [109 mmol/mol]	13.07 (2.29) + [120 mmol/mol]
Prior HbA1c, %	11.00 (2.71) [97 mmol/mol]	10.94 (2.70) [96 mmol/mol]	11.38 (2.83) [101 mmol/mol]
Chronic Complications/Comorbidities			
Chronic Diabetes Complications (%)			
Any Diabetes Complication	44.7	46.0	41.1
Macrovascular complications	0.7	0.5	1.4
Microvascular complications	18.7	19.0	17.8
Other diabetes complications	35.2	37.0	30.1
Obesity			
BMI (mean, sd)	27.76 (8.85)	24.83 (5.76)	35.83 (10.72) *
Underweight (%)	3.7	4.5	1.4
Normal weight (%)	37.0	46.5	11.0 +
Overweight (%)	20.9	22.5	17.8
Obese (%)	26.4	14.5	57.5 +
Mental Health			
Any mental health co-morbidity (%)	35.5	35.5	35.6
Substance use	21.2	20.0	24.7

Characteristic	All admissions (n=273)	Type 1 Diabetes (n=200)	Type 2 Diabetes (n=73)
Depression	15.0	16.5	11.0[+]

Abbreviations: ICU=intensive care unit; HbA1c=hemoglobin A1c; BMI=body mass index

[*] significant at alpha p<0.001

[+] significant at alpha p<0.05

Table 3.

Young Adults Admitted with DKA/HHS: Demographics and Healthcare Utilization by Admission HbA1c

Characteristic	HbA1c<9.0% [<75mmol/mol] (n=20)	9.0% ≤ HbA1c <12.0% (n=75)	HbA1c ≥12.0% [≥108mmol/mol] (n=116)
Age at primary admission, years (mean, sd)	27.50 (4.60)	26.82 (4.35)	25.44 (4.54)
Sex (%)			
Male	45.0	54.7	54.3
Female	55.0	45.4	45.7
Ethnicity (%)			
Non-Hispanic	100.0	92.0	96.6
Hispanic	0.0	8.0	3.4
Race (%)			
Black	65.0	75.3	92.2 *
Non-Black	35.0	24.7	7.8
Median Household Income, $10k	46.09 (20.38)	44.17 (16.91)	40.16 (12.60)
Insurance (%)			
Any insurance	60.0	37.4	21.6 +
Private Insurance	20.0	9.3	11.2
Public Insurance	40.0	28.0	10.3 ±
No Insurance	40.0	62.6	78.4
Healthcare Utilization (%) §			
Emergency Visits	40.0	45.4	40.5
Hospitalization	45.0	44.0	31.0
Diabetes Center Attendance	0.0	4.0	0.9

Abbreviations: ICU=intensive care unit; HbA1c=hemoglobin A1c; BMI=body mass index

* significant difference between HbA1c≥12% and 9.0% ≤ HbA1c<12.0%, HbA1c≥12% and HbAc1 <9% at alpha p<0.001

+ significant difference between HbA1c≥12.0% and HbA1c <9.0% at alpha p<0.001

± significant difference between HbA1c≥12% and 9.0% ≤ HbA1c <12.0%, HbA1c≥12% and HbAc1 <9% at alpha p<0.05

§ Emergency visits and hospitalizations in year *after* index admission, Diabetes Center attendance in year *prior* to admission

Table 4.

Young Adults admitted with DKA/HHS: Diabetes History, Hospital Admission Characteristics, and Chronic Complications/Comorbidities by Admission HbA1c

Characteristic	HbA1c<9.0% [<75mmol/mol] (n=20)	9.0% ≤ HbA1c <12.0% (n=75)	HbA1c ≥12.0% [≥108mmol/mol] (n=116)
Diabetes History			
Diabetes Type (%)			
Type 1	90.0	74.7	67.2
Type 2	10.0	25.3	32.8
Age at Diagnosis, years (mean, sd)	14.42 (5.33)	18.78 (8.76)	19.39 (8.25)
Duration of Disease, years (mean, sd)	13.56 (5.32)	8.06 (7.69)	6.32 (6.25) *,+
Hospital Admission			
Precipitating factors for admission (%)			
Non-adherence	55.0	57.3	62.1
Infection	30.0	18.7	16.4
New Onset	0.0	16.0	14.7
Other	15.0	8.0	6.9
Length of Stay, days (mean, sd)	4.75 (4.83)	4.00 (3.81)	3.8 (3.74)
Admission to ICU			
ICU Admission (%)	25.0	18.7	7.8
ICU Length of Stay, days (mean, sd)	1.75 (3.76)	0.51 (1.21)	0.14 (0.56) +,±
Glycemic Control (mean, sd)			
Admission HbA1c, %	7.78 (0.78) [62 mmol/mol]	10.51 (0.86) [91 mmol/mol]	14.37 (1.39) § [134 mmol/mol]
Prior HbA1c, %	9.30 (2.41) [78 mmol/mol]	10.12 (2.60) [87 mmol/mol]	12.29 (2.57) *,‖ [111 mmol/mol]
Chronic Complications/Comorbidities			
Chronic Diabetes Complications (%)			
Any Diabetes Complication	60.0	44.0	43.1
Macrovascular complications	0.0	0.0	0.9
Microvascular complications	25.0	16.0	14.7
Other diabetes complications	55.0	37.3	31.9
Obesity			
BMI (mean, sd)	25.64 (5.99)	29.81 (11.27)	27.33 (8.04)
Underweight (%)	0.0	5.3	4.3
Normal weight (%)	50.0	33.3	36.2
Overweight (%)	25.0	20.0	23.3
Obese (%)	20.0	30.7	26.7
Mental Health (%)			
Any mental health co-morbidity	30.0	34.7	36.1
Substance use	25.0	17.3	12.1
Depression	5.0	17.3	21.6

* significant difference between HbA1c <9.0% and HbA1c ≥12.0% at alpha p<0.05

[+] significant difference between HbA1c <9% and 9.0% ≤HbA1c <12.0% at alpha p<0.05

[±] significant difference between HBA1c <9.0% and HbA1c ≥12% at alpha p<0.001

[§] significant difference between all groups at alpha p<0.001

[‖] significant difference between 9.0% ≤HbA1c <12.0% and HbA1c ≥ 12.0% at alpha p<0.05