Patient Characteristics Associated with Differences in Admission Frequency for Diabetic Ketoacidosis in U.S. Children's Hospitals

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Abstract

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Objectives: To determine across and within hospital differences in the predictors of 365-day admission frequency for diabetic ketoacidosis (DKA) in children at U.S. children's hospitals.

Methods: Multi-center retrospective cohort analysis of 12,449 children 2-18 years of age with a diagnosis of DKA in 42 U.S. children's hospitals between 2004 and 2012. The main outcome of interest was the maximum number of DKA admissions experienced by each child within any 365-day interval during a 5-year follow-up period. The association between patient characteristics and the maximum number of DKA admissions within a 365-day interval was examined across and within hospitals.

Results: In the sample, 28.3% of patients admitted for DKA experienced at least one additional DKA admission within the following 365 days. Across hospitals, patient characteristics associated with increasing DKA admission frequency were public insurance (OR 1.97, 95% CI, 1.71-2.26), non-Hispanic black race (OR 2.40, 95% CI, 2.02-2.85), age ≥12 (OR 1.98, 95% CI, 1.7-2.32), female gender (OR 1.41, 95% CI, 1.29-1.55), and mental health comorbidity (OR

1.36, 95% CI, 1.13-1.62). Within hospitals, non-Hispanic black race was associated with higher odds of 365-day admission in 59% of hospitals and public insurance was associated with higher odds in 56% of hospitals. Older age, female gender, and mental health comorbidity were associated with higher odds of 365-day admission in 42%, 29%, and 15% of hospitals, respectively.

Conclusions: Across children's hospitals, certain patient characteristics are associated with more frequent DKA admissions. However, these factors are not associated with increased DKA admission frequency for all hospitals.

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INTRODUCTION

Diabetic ketoacidosis (DKA) is a life-threatening but preventable complication in children and adolescents with type 1 diabetes (T1D).[1] Despite improvements in insulin delivery methods and means of glucose monitoring, hospital admission for DKA in children is extremely common worldwide as the risk of DKA in established type 1 diabetes is 1–10% per patient per year.[2]

With rapidly rising healthcare costs and increasing interest in accountable care organizations across the United States (U.S.), there is an emphasis for hospitals to deliver high value care.[3,4] Better management of patients with chronic disease offers one potential strategy to control costs and eliminate unwarranted variation in pediatric healthcare. In pediatric hospitals, 23% of charges are accounted for by 2.9% of the patients with frequent recurrent readmissions, most of whom have a chronic disease such as diabetes mellitus.[5]

Tieder, et al. recently reported that readmission for DKA within a year of hospitalization is common in the U.S. and that widespread variation exists in DKA readmission rates, length of stay, and total standardized costs across 38 children's hospitals.[6,7] Interventions to prevent readmission for DKA could improve short- and long-term outcomes for children with diabetes (e.g. cerebral edema and neurological injury), improve the quality of life for children and their families (e.g. missed time from school and work), and potentially provide cost savings.

A better understanding of risk factors for frequent DKA admission can potentially guide healthcare improvement efforts across the continuum of diabetes care and ultimately lead to better patient outcomes and lower costs, especially for the most vulnerable patients. Equally important, however, is understanding whether patients with high-risk profiles have better outcomes in some hospitals compared to similar patients cared for in other hospitals. If this is the

case, elucidating the differences in how care is provided in higher performing hospitals would be warranted. Thus, this study aimed to determine across and within hospital differences in the predictors of 365-day admission frequency for DKA at 42 U.S. children's hospitals.

PATIENTS AND METHODS

This was a retrospective cohort analysis using data from Pediatric Health Information System (PHIS), which contains administrative data from 42 academic children's hospitals affiliated with the Children's Hospital Association. All hospitals were located in an urban setting and the median number of pediatric beds for the hospitals included in the analysis was 289 (interquartile range, 206 to 350). PHIS data allows for tracking of patients over time and includes detailed information about hospital encounters such as patient demographics, admission and discharge date, payers, physicians, diagnoses, procedures, service location, and charges. Children's Hospital Association and participating hospitals jointly assure data quality.[8]

The study included children 2-18 years old who were discharged between January 1, 2004 and December 31, 2012 with an *International Classification of Diseases, 9th Revision, Clinical Modification* (ICD-9) principal discharge diagnosis of DKA (250.11 and 250.13) or secondary discharge diagnosis of DKA and any principal diagnosis of a diabetes related diagnosis or complication such as cerebral edema as previously outlined.[6] To minimize over-classification of DKA, patients that did not have a billing code for intravenous insulin were excluded. Children were followed across multiple admissions to the same PHIS hospital using unique numerical patient identifiers.

This study was considered exempt from regulatory review. The Children's Hospital of Philadelphia Committee for the Protection of Human Subjects does not consider the receipt or use of the PHIS data as human subjects research according to 45 CFR 46.101(b4) because the

participants are not readily identifiable. A data use agreement between the Children's Hospital Association and the Children's Hospital of Philadelphia addresses HIPAA and participant privacy requirements.

Patient Covariates

Demographic characteristics analyzed were age, gender, race/ethnicity (non-Hispanic white, non-Hispanic black, Hispanic, Asian, or other), and insurance type (public, other) as these characteristics have been previously shown to be associated with increased risk of hospitalization for DKA.[9-11] Clinical characteristics included the presence or absence of a mental health comorbidity (e.g. eating disorders, psychiatric conditions, and substance abuse), diagnoses indicating complex chronic conditions (CCC) and the need for technology assistance (e.g. gastrostomy, tracheostomy) as these may contribute to readmission risk.[5] The diagnoses indicating a CCC referred to an additional diagnosis of a co-occurring chronic condition and were identified based on publicly available tables of CCC using ICD-9 codes and procedure codes that are readily available in the PHIS database.[12]

Main Outcome Measure: Maximum 365-Day Admission Frequency

The maximum 365-day admission frequency for each child was evaluated, which was defined as the maximum number of hospitalizations for DKA within a 365-day interval over a 5-year follow-up period. For a patient to be eligible for the study, the child had to experience a DKA admission in 2004, 2005, 2006, or 2007. Children were then followed for a 5-year period (1,825 days) after their index DKA admission that made them eligible for the study cohort. To construct the main outcome variable for analyses, i.e., maximum 365-day admission frequency for DKA during the 5-year follow-up period, 1,825 365-day intervals were assessed for each child in the cohort. For each of the 365-day intervals assessed, the number of DKA admissions

was summarized as 0, 1, 2, or ≥ 3 admissions. The 365-day interval with the highest number of DKA admissions was used as the outcome for both the within and across hospital analyses.

We chose not to use methods commonly employed to measure readmissions for several reasons. First, we were unable to reliably determine index admissions for an episode of care with the PHIS data, specifically we were unable to identify admissions for new onset diabetes when the risk for DKA can be temporarily lowered in the first year or more after diagnosis because of a transient partial clinical remission of T1D. A teenager diagnosed at 4 years of age after presenting in DKA in 1996, for example, would not be identified in the dataset until a later re-hospitalization for DKA that occurred during the study period (2004-2012). Second, we did not aim to solely evaluate hospital admissions believed to be related to prior hospital care; rather we sought to evaluate the healthcare delivery system's ability to prevent frequent hospital admissions for DKA. Finally, we elected to look at rolling 365-day intervals rather than single calendar-year intervals over the 5-year follow-up period since single calendar-year intervals can artificially truncate the follow-up period (e.g., a child hospitalized for first DKA admission late in the year).

Statistical Analysis

We compared categorical variables across 365-day admission frequency groups (0, 1, 2, ≥ 3 admissions) using chi-square tests. To establish patient characteristics associated with increasing 365-day admission frequency, we modeled the data using a multinomial model with a cumulative logit link function. In order to account for the clustering of patients within hospitals, we used a generalized estimating equation approach. We derived odds ratios (OR) from these models to assess the association between each patient characteristic and an incrementally increasing number of 365-day admissions.

We also developed hospital specific models to determine if different patient characteristics were differentially associated with 365-day admission frequency across hospitals. First, for each individual hospital, we examined the association between patient characteristics and the odds of increasing 365-day admission frequency. We then grouped hospitals into three categories for each patient characteristic examined: those hospitals where the characteristic was associated with an OR < 1 for increased 365-day admission frequency, those where the characteristic was associated with an OR = 1 for increased 365-day admission frequency, and those where the characteristic was associated with an OR > 1 for increased 365-day admission frequency. Finally, we compared the median hospital-level frequency for each patient characteristic in each of these three categories with a Kruskal-Wallis test to assess whether PHIS hospital patient mix varied for these characteristics across categories.

Thirty-four of the 42 hospitals had adequate patient sample size to permit model convergence for the within-hospital analysis. The other 8 hospitals had <150 discharges and <2% of their patients had greater than one readmission and thus, when modeling with categorical variables such as age, the sample size became too sparse for analysis at the individual hospital level. All analyses were performed using SAS v. 9.3 (SAS Institute, Cary, NC), and p-values <0.05 were considered statistically significant.

RESULTS

365-Day Admission Frequency

Among a total of 12,449 children that met study inclusion criteria, 3,527 (28.3%) experienced 1 or more DKA admissions within a 365-day interval during their 5-years of follow-

up (Table I). In addition, 709 patients (5.7%) experienced 3 or more DKA admissions within 365 days and these patients accounted for 24.5% of all DKA admissions.

Across-Hospital Analysis

As 365-day admission frequency increased from 0 to ≥3, there was an increase in the percentage of patients that were female (50.3% to 61.8%, $p<0.001$), non-Hispanic black (16.1% to 46.5%, $p<0.001$), and older children, particularly those ≥12 (47.4% to 58.3%, $p<0.001$). In addition, there was an increase in the percentage of patients who had public insurance (from 27.8% to 56.0%, $p<0.001$) and who had a mental health comorbidity (from 5.1% to 8.6%, $p<0.001$) as admission frequency increased. The presence of a complex chronic condition or technology dependence was not associated with increasing 365-day admission frequency. In the adjusted multivariable analysis, older age, female gender, non-Hispanic black race, public insurance, and mental health comorbidity remained significantly associated with higher 365-day admission frequency (Table II).

Within-Hospital Analysis

The differences in hospital-level patient characteristics associated with 365-day admission frequency are presented in Table III. Being non-Hispanic black was associated with higher odds of admission in 20/34 (59%) of hospitals and having public insurance was associated with higher odds of 365-day admission in 56% (19/34) of hospitals. Older age, female gender, and mental health comorbidity were associated with higher odds of 365-day admission in 14/34 (42%), 10/34 (29%), 5/34 (15%) of hospitals, respectively.

We found no association between the median percentage of patients admitted with older age, public insurance, or of female gender when comparing hospitals that had an OR > 1 to those that had an OR = 1 (Table IV). There was, however, an association between the median

percentages of patients who were non-Hispanic black or who had a mental health comorbidity and hospitals that had an OR > 1 for increasing 365-day DKA admission frequency compared to hospitals in the other two categories.

DISCUSSION

In a national sample of freestanding children's hospitals, we found that the publicly insured, non-Hispanic black children, adolescents, females, and children with mental health comorbidities have higher odds of experiencing increased hospital admissions for DKA within 365 days. However, these clinical and demographic characteristics were not predictive of frequent DKA admissions across all hospitals, suggesting that some children with diabetes are receiving care in delivery systems that provide higher quality of care. Further, while the makeup of the patient population an individual hospital serves may play a role in the frequency of DKA admission, our analysis demonstrates that even when accounting for patient mix, differences exist between high-performing and low-performing hospitals.

This study examines predictors of 365-day admission frequency for DKA in children with diabetes mellitus within U.S. children's hospitals. While previous studies have demonstrated that patient-specific characteristics impact a child's risk of frequent admission for DKA, [10-11,13-14] our within-hospital analysis demonstrates differences among institutions and suggests that the risk for recurrent DKA admission may, in part, be related to healthcare system factors. This is supported by the finding that the variation in frequent DKA admissions could not solely be explained by individual hospital patient case-mix.

Similar to prior studies, we found that older children and females are at higher risk for frequent admission for DKA, further demonstrating that patients with these characteristics

struggle with self-management as parental monitoring, supervision, and involvement in diabetes care declines[15,16] and when unhealthy weight control practices may increase.[17,18] However, our results also provide evidence that these at-risk patients had higher odds of frequent DKA admission at some hospitals compared to others despite there being no difference in the distribution of female patients and older youth across the hospitals included in the within-hospital analysis. Thus, some health systems may be successfully implementing novel age- and gender-specific interventions to improve adherence to diabetes management and health outcomes. An intensive, family-centered, community-based program targeting adolescents with chronically poor metabolic control, for example, demonstrated reduced hospital admissions for DKA over 24 months.[19]

Children with public insurance had nearly twice the 365-day admission frequency for DKA compared to children with other types of health insurance but had higher odds of frequent DKA admission in only about half of the hospitals. Further, we found no significant difference between high-performing and low-performing hospitals in the proportion of T1D youth served with public insurance. Publicly insured children have been shown to have reduced access and longer waiting times for outpatient subspecialty care,[20] as well as more unmet medical and prescription drug needs than privately insured children.[21] Given the differences among institutions in DKA admission frequency, future studies should examine factors such as health care access and affordability that might explain the hospital-level differences.

While innovative interventions designed to overcome the risks associated with high-risk patient characteristics are successfully being incorporated into the pediatric diabetes care model[22] and may help address frequent DKA admission, system-oriented quality improvement strategies are likely also warranted. Our across-hospital analysis further supports the notion that health

disparities exist among youth with T1D[23] and that despite being underreported, youth with frequent DKA admissions are more likely to have underlying psychosocial problems or psychiatric disorders.[24] The finding that hospitals with a higher odds of frequent DKA admissions also serve a disproportionately larger population of non-Hispanic black patients and patients with mental health comorbidities suggests that these patient characteristics may be serving as a proxy for unmeasured factors that may be driving the frequent DKA admissions in these patients.

The incidence of DKA in patients with established diabetes is a National Quality Forum endorsed diabetes-specific outcome measure for healthcare quality.[25] Although the recurrence of DKA is nearly always preventable, the present study demonstrates that over a 5-year follow-up period more than 1 in 4 children hospitalized for DKA experience at least one additional DKA admission within the following 365 days. Each episode of DKA can have serious consequences and the economic burden is considerable with an average cost of $7,142 per DKA hospitalization.[6,26]

The fact that there are differences among institutions is of interest and deserves more detailed exploration to determine the significance of various factors that might contribute to these differences. Comparative research examining processes of care in high-performing versus low-performing hospitals might inform interventions for diabetes care and guide policy change. Availability of internationally accepted prevention measures for DKA for patients such as access to a 24-hour telephone helpline for emergency advice and treatment, use of home blood ketone monitoring, and appropriate psychosocial evaluation at time of DKA admission,[2] for example, may help explain hospital differences. Further, higher-performing hospitals may not be distinguished by specific practices and protocols but instead by organizational environments that

could foster higher-quality care.[27,28] Broad statewide differences in healthcare access and affordability may also play a large role in determining the quality of care received by children within a given healthcare system.[29]

Addressing preventable DKA admissions will require novel approaches tailored to the unique features of an individual health care system and the population that it serves. Since a reliable and comprehensive pediatric national data source does not exist at this time, a quality improvement collaborative among children's hospitals could disseminate interventions proven to be successful in other healthcare systems and that appear to have a real impact on a high-cost patient population.[30] The rise in Accountable Care Organizations designed to increase care coordination across the inpatient and outpatient setting, reduce cost, and align incentives within healthcare systems offers another avenue to improve the quality of care and eliminate preventable DKA admissions.[31]

This study has several limitations. First, residual confounding may exist for unobserved differences. For example, some DKA admissions may not have been captured if a patient was hospitalized at another hospital. Further, some of the variation in hospitals may be driven by differences in geographic referral patterns among hospitals. Second, we did not have access to other patient-related factors that can contribute to the DKA such as glycemic control, number of clinic visits, level of education, and adherence to insulin regimen. In addition, system-level factors were not available as the PHIS database solely provides information regarding clinical and resource utilization data for inpatient, ambulatory surgery, emergency department and observation unit patient encounters for the 42 children's hospitals examined in this study. Third, we were unable to examine whether the availability and use of psychology or social work resources during inpatient admissions was associated with improved DKA outcomes. The

billing practices for social work consults and mental health services are currently not reliable enough in the PHIS database to provide a meaningful representation of the availability and use of psychological counseling. Fourth, while we attempted to mitigate misclassification by requiring IV insulin treatment in addition to DKA-specific codes for disease, errors and variation in coding practices may have resulted in misclassification. Fifth, data from freestanding children's hospitals may not be generalizable to other settings such as community hospitals.

Finally, it is important to note that while the point of measurement to identify suboptimal chronic disease management within healthcare systems for the current study was at the hospital level, frequent DKA admissions are mostly due to factors outside of hospital care. There may be additional unmeasured outpatient clinical or socioeconomic factors that contribute to these results.

CONCLUSION

Reducing avoidable hospital admissions represents a unique opportunity to lower health care costs while increasing the quality of patient care.[30] Efforts to address admissions for DKA should focus on patients at risk for frequent admissions.[32] Findings in this study have important implications for the care of children with diabetes and can contribute to decision modeling or cost-effectiveness studies to determine how best to overcome these risks. Intensive interventions for high-risk patients that yield even small reductions in frequent admissions may be sustainable, given the high costs associated with inpatient care and adverse neurological outcomes. Comparative work between hospitals should be carried out to evaluate care processes and outcomes at each center with an aim to generalize successful interventions for reducing frequent DKA admissions.

REFERENCES

1. International Society for Pediatric and Adolescent Diabetes. Global IDF/ISPAD Guideline for Diabetes in Childhood and Adolescence [Internet]. ISPAD.org. 2011 [cited 2015 Apr 10]. pp. 1–132. Available from: http://www.ispad.org/NewsFiles/IDF-ISPAD_Diabetes_in_Childhood_and%20Adolescence_Guidelines_2011.pdf
2. Wolfsdorf JI, Allgrove J, Craig ME, Edge J, Glaser N, Jain V, et al. Diabetic ketoacidosis and hyperglycemic hyperosmolar state. Pediatr Diabetes. 2014;15 Suppl 20:154–179.
3. Fisher ES, Shortell SM. Accountable care organizations: accountable for what, to whom, and how. JAMA. 2010 Oct 20;304:1715–6.
4. Porter ME. What is value in health care? N Engl J Med. 2010;363:2477–81.
5. Berry JG, Hall DE, Kuo DZ, Cohen E, Agrawal R, Feudtner C, et al. Hospital utilization and characteristics of patients experiencing recurrent readmissions within children's hospitals. JAMA. 2011 Feb 16;305:682–90.
6. Tieder JS, McLeod L, Keren R, Luan X, Localio R, Mahant S, et al. Variation in Resource Use and Readmission for Diabetic Ketoacidosis in Children's Hospitals. Pediatrics. 2013 Jul 22;132:237–44.
7. Keren R, Luan X, Localio R, Hall M, McLeod L, Dai D, et al. Prioritization of comparative effectiveness research topics in hospital pediatrics. Arch Pediatr Adolesc Med. 2012 Dec;166:1155–64.
8. Mongelluzzo J, Mohamad Z, Have Ten TR, Shah SS. Corticosteroids and mortality in children with bacterial meningitis. JAMA. 2008;299:2048–55.
9. Levine BS, Anderson BJ, Butler DA, Antisdel JE, Brackett J, Laffel LM. Predictors of glycemic control and short-term adverse outcomes in youth with type 1 diabetes. J Pediatr. 2001 Aug;139:197–203.
10. Rewers A, Chase HP, Mackenzie T, Walravens P, Roback M, Rewers M, et al. Predictors of acute complications in children with type 1 diabetes. JAMA. 2002 May 15;287:2511–8.
11. Smaldone A, Honig J, Stone PW, Arons R, Weinger K. Characteristics of California children with single versus multiple diabetic ketoacidosis hospitalizations (1998-2000). Diabetes Care. 2005 Aug;28:2082–4.
12. Feudtner C, Christakis DA, Connell FA. Pediatric deaths attributable to complex chronic conditions: a population-based study of Washington State, 1980-1997. Pediatrics. 2000;106:205-209.
13. Fritsch M, Rosenbauer J, Schober E, Neu A, Placzek K, Holl RW, et al. Predictors of diabetic ketoacidosis in children and adolescents with type 1 diabetes. Experience from a large multicentre database. Pediatr Diabetes. 2011 Apr 6;12:307–12.
14. Randall L, Begovic J, Hudson M, et al. Recurrent Diabetic Ketoacidosis in Inner-City Minority Patients: Behavioral, socioeconomic, and psychosocial factors. Diabetes Care. 2011;34:1891-1896.
15. Helgeson VS, Siminerio L, Escobar O, Becker D. Predictors of metabolic control among adolescents with diabetes: a 4-year longitudinal study. J Pediatr Psychol. 2009;34:254-270.

16. Paris CA, Imperatore G, Klingensmith G, Petitti D, Rodriguez B, Anderson AM, et al. Predictors of insulin regimens and impact on outcomes in youth with type 1 diabetes: the SEARCH for Diabetes in Youth study. J Pediatr. 2009 Aug;155:183–9.e1.
17. Ackard DM, Vik N, Neumark Sztainer D, Schmitz KH, Hannan P, Jacobs DR Jr. Disordered eating and body dissatisfaction in adolescents with type 1 diabetes and a population-based comparison sample: comparative prevalence and clinical implications. Pediatr Diabetes. 2008;9:312-319.
18. Meltzer LJ, Johnson SB, Prine JM, Banks RA, Desrosiers PM, Silverstein JH. Disordered eating, body mass, and glycemic control in adolescents with type 1 diabetes. Diabetes Care. 2001;24:678-682.
19. Ellis D, Naar-King S, Templin T, Frey M, Cunningham P, Sheidow A, et al. Multisystemic therapy for adolescents with poorly controlled type 1 diabetes: Reduced diabetic ketoacidosis admissions and related costs over 24 months. Diabetes Care. 2008;31:1746-1747.
20. Bisgaier J, Rhodes KV. Auditing Access to Specialty Care for Children with Public Insurance. N Engl J Med 2011; 364:2324-2333.
21. Cassedy A, Fairbrother G, Newacheck PW. The impact of insurance instability on children's access, utilization, and satisfaction with health care. Ambul Pediatr. 2008;8:321–8.
22. Harris MA, Wagner DV, Heywood M, Hoehn D, Bahia H, Spiro K. Youth repeatedly hospitalized for DKA: proof of concept for novel interventions in children's healthcare (NICH). Diabetes Care. 2014;37:e125-e126.
23. Borschuk AP, Everhart RS. Health Disparities Among Youth With Type 1 Diabetes: A Systematic Review of the Current Literature. Fam Syst Health. 2015.
24. Delamater AM, de Wit M, McDarby V, Malik J, Acerini CL. Psychological care of children and adolescents with type 1 diabetes. Pediatric Diabetes 2014: 15 (Suppl. 20): 232–244.
25. National Quality Forum. Diabetes Short-Term Complications Admission Rate (PQI 01) [Internet]. 2014 Sep [cited 2015 Jul 10]. Available from: http://www.qualityforum.org/QPS/0272
26. Jiang H, Russo C, Barrett M. Nationwide frequency and costs of potentially preventable hospitalizations. Statistical brief. 2010 Apr;72.
27. Bradley EH, Curry LA, Spatz ES, Herrin J, Cherlin EJ, Curtis JP, et al. Hospital strategies for reducing risk-standardized mortality rates in acute myocardial infarction. Ann Intern Med. 2012 May 1;156:618–26.
28. Curry LA, Spatz E, Cherlin E, Thompson JW, Berg D, Ting HH, et al. What distinguishes top-performing hospitals in acute myocardial infarction mortality rates? A qualitative study. Ann Intern Med. 2011 Mar 15;154:384–90.
29. Radley DC, McCarthy D, Lippa JA, Hayes SL, Schoen C. Aiming Higher: Results from a Scorecard on State Health System Performance, 2014 [Internet]. 2014 [cited 2015 Jul 10]. Available from: http://www.commonwealthfund.org/~/media/files/publications/fund-report/2014/apr/1743_radley_aiming_higher_2014_state_scorecard_corrected_62314.pdf
30. Minott J. Reducing Hospital Admissions [Internet]. academyhealth.org. 2008 [cited 2015 Apr 10] pp. 1-11. Available from: http://www.academyhealth.org/files/publications/ReducingHospitalReadmissions.pdf.

31. Tu T, Muhlestein D, Kocot SL, White R. The Impact of Accountable Care: Origins and Future of Accountable Care Organizations [Internet]. 2015 May [cited 2015 Jul 10]. Available from: http://leavittpartners.com/wp-content/uploads/2015/05/Impact-of-Accountable-Care_Origins-05.2015.pdf
32. Srivastava R, Keren R. Pediatric readmissions as a hospital quality measure. JAMA. 2013 Jan 23;309:396–8.

TABLE I. 365-Day DKA Admission Frequency for Children Admitted to 42 Children's Hospitals Over a 5-Year Follow-Up Period

Patient Characteristic	Number of Patients	365-Day DKA Admission Frequency *Maximum Number of Admissions Within a 365-Day Interval During the Follow-up Period*				
	OVERALL	**0**	**1**	**2**	**3+**	
	12449	**8923 (71.7%)**	**2022 (16.2%)**	**795 (6.4%)**	**709 (5.7%)**	**P-value**
Gender						
Female	6576 (52.8%)	4489 (50.3%)	1179 (58.3%)	470 (59.1%)	438 (61.8%)	<.001
Male	5912 (47.2%)	4434 (49.7%)	843 (41.7%)	325 (40.9%)	271 (38.2%)	
Age						
< 7	2199 (17.7%)	1806 (20.2%)	298 (14.7%)	69 (8.7%)	26 (3.7%)	
7-9	2104 (16.9%)	1533 (17.2%)	333 (16.5%)	131 (16.5%)	107 (15.1%)	<.001
10-11	2042 (16.4%)	1351 (15.1%)	381 (18.8%)	147 (18.5%)	163 (23%)	
≥12	6104 (49.0%)	4233 (47.4%)	1010 (50%)	448 (56.4%)	413 (58.3%)	
Race						
Non-Hispanic White	7235 (58.1%)	5560 (62.3%)	1051 (52.0%%)	358 (45.0%)	266 (37.5%)	
Non-Hispanic Black	2602 (20.9%)	1437 (16.1%)	540 (26.7%)	295 (37.1%)	330 (46.5%)	
Hispanic	1313 (10.5%)	943 (10.6%)	232 (11.5%)	70 (8.8%)	68 (9.6%)	<.001
Asian	82 (0.7%)	60 (0.7%)	15 (0.7%)	4 (0.5%)	3 (0.4%)	
Other	1217 (9.8%)	923 (10.3%)	184 (9.1%)	68 (8.6%)	42 (5.9%)	
Insurance						
Public	4077 (32.7%)	2482 (27.8%)	833 (41.2%)	365 (45.9%)	397 (56.0%)	<.001
Other	8372 (67.3%)	6441 (72.2%)	1189 (58.8%)	430 (54.1%)	312 (44.0%)	
Mental Health						
Yes	828 (6.7%)	526 (5.9%)	166 (8.2%)	66 (8.3%)	70 (9.9%)	<.001
No	11621 (93.3%)	8397 (94.1%)	1856 (91.8%)	729 (91.7%)	639 (90.1%)	
Complex Chronic Condition						
Yes	726 (5.8%)	544 (6.1%)	108 (5.3%)	47 (5.9%)	27 (3.8%)	0.062
No	11723 (94.2%)	8379 (93.9%)	1914 (94.7%)	748 (94.1%)	682 (96.2%)	
Technology assistance						
Yes	306 (2.5%)	225 (2.5%)	56 (2.8%)	14 (1.8%)	11 (1.6%)	0.171
No	12143 (97.5%)	8698 (97.5%)	1966 (97.2%)	781 (98.2%)	698 (98.4%)	

TABLE II. Multivariable Analysis of Patient Characteristics Associated With Increasing 365-Day DKA Admission Frequency

Patient Characteristic	Odds Ratio (95% Confidence Interval)
Female vs. male gender	1.41 (1.29, 1.55)
Age	
< 7	Reference
7-9	1.85 (1.57, 2.17)
10-11	2.39 (2.05, 2.79)
≥12	1.98 (1.7, 2.32)
Race	
Non-Hispanic White	Reference
Non-Hispanic Black	2.4 (2.02, 2.85)
Hispanic	1.09 (0.85, 1.39)
Asian	1.11 (0.67, 1.84)
Other	0.97 (0.81, 1.16)
Public v. other insurance	1.97 (1.71, 2.26)
Mental health v. no mental health	1.36 (1.13, 1.62)

TABLE III. Patient Characteristics by PHIS Hospital and Odds of 365-Day DKA Admission at Individual Hospital Level.

PHIS Hospital*	Total Number Of DKA Admissions (2004-2012)	PATIENT CHARACTERISTIC									
		Gender		Age		Race		Payer		Mental Health	
		% of Female Patients	Odds of 365-Day DKA Admission (Female v. Male)	% of 12+ Patients	Odds of 365-Day DKA Admission (12+ v. <7)	% Non-Hispanic Black Patients	Odds of 365-Day DKA Admission (Non-Hispanic Black v. Non-Hispanic White)	% of Public Insurance Patients	Odds of 365-Day DKA Admission (Public v. Other)	% of Mental Health Patients	Odds of 365-Day DKA Admission (Yes v. No)
1	244	60.7		43.9		17.2		44.7		8.6	
2	305	53.1		47.5		4.9		30.2		4.3	
3	305	52.8		45.9		6.2		15.7		4.9	
4	500	50.4		49.6		12.2		30.2		8.6	
5	335	54.3		54.0		51.0		27.2		4.2	
6	311	49.8		46.3		20.9		16.4		9.3	
7	620	55.3		44.4		23.9		10.0		4.4	
8	670	52.8		53.1		38.8		29.4		7.0	
9	437	51.7		51.3		16.9		42.1		4.8	
10	419	49.9		49.9		57.0		45.6		1.9	
11	377	53.8		49.3		17.5		44.0		5.8	
12	647	50.9		46.8		21.3		25.3		7.6	
13	235	51.1		46.4		22.1		24.3		4.3	
14	242	55.8		45.9		5.4		17.4		5.8	
15	440	54.3		45.9		48.0		43.0		4.8	
16	412	56.1		50.2		16.3		37.4		6.6	
17	339	51.9		47.8		6.8		32.2		8.0	
18	478	53.8		41.6		31.2		16.5		4.0	
19	113	54.9		50.4		1.8		16.8		8.8	
20	280	53.2		54.6		12.5		36.1		3.2	
21	297	51.2		51.5		6.7		59.3		2.7	
22	241	58.1		53.9		44.8		37.8		5.4	
23	229	50.2		55.0		13.5		36.7		5.2	
24	306	46.4		50.7		18.6		47.7		2.3	
25	121	53.7		52.9		43.0		52.1		8.3	
26	307	55.4		49.8		25.1		39.7		6.5	
27	330	48.5		51.5		8.8		21.2		6.4	
28	131	53.4		55.0		6.9		18.3		9.9	
29	80	53.8		55.0		17.5		50.0		15.0	
30	71	53.5		56.3		3.8		28.2		9.9	
31	249	48.6		51.0		10.0		35.7		5.6	
32	203	55.2		52.7		14.3		60.6		6.4	
33	140	59.3		55.0		15.7		58.6		5.0	
34	61	57.4		49.2		6.6		29.5		9.8	

*** Hospitals sorted by overall odds of 365-day DKA admission frequency going from highest to lowest overall odds**

Legend Odds ratio significantly >1; Odds ratio no different than 1; Odds ratio significantly <1

TABLE IV. Association Between Hospital Patient Mix and the Odds of Increasing 365-Day DKA Admission Frequency

PATIENT MIX CHARACTERISTIC	MEDIAN [IQR] PERCENTAGES OF PATIENT MIX CHARACTERISTICS FOR HOSPITALS IN EACH ODDS RATIO (OR) CATEGORY			p-value
	Hospitals with OR < 1.0	Hospitals with OR = 1.0	Hospitals with OR > 1.0	
% Female		53.5% [50.8, 54.9]	53.2% [51.7, 55.3]	0.876
% 12+ years of age		50.8% [48.4, 53.4]	49.5% [46.3, 53.1]	0.345
% Non-Hispanic black		12.5% [6.8, 15.7]	21.1% [14.6, 35.0]	0.034
% Public insurance		29.5% [16.8, 39.7]	37.4% [28.1, 44.7]	0.145
% With mental health	3.2% [3.2, 3.2]	5.5% [4.3, 7.3]	9.3% [8.8, 9.9]	0.013