



Health Care Utilization Trends Across the Transition Period in a National Cohort of Adolescents and Young Adults With Type 1 Diabetes

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OBJECTIVE

Lack of effective transition from pediatric to adult care may contribute to adverse outcomes in young adults with type 1 diabetes. The understanding of outpatient and acute care utilization patterns across the adolescent to young adult transition age in type 1 diabetes populations is suboptimal in the U.S.

RESEARCH DESIGN AND METHODS

We studied claims data from 14,616 individuals diagnosed with type 1 diabetes, aged 16–24 years, and enrolled in a large national health plan for ≥1 year from 2005 to 2012. Annual outpatient and emergency department visits and hospitalization rates were calculated at each age. Generalized estimating equations were used to assess the association of age-group (adolescents [age 16–18 years] vs. young adults [age 19–24 years]), outpatient visits, and sociodemographic variables with emergency department visit and hospitalization rates.

RESULTS

Endocrinologist visits declined from 2.3 per year at age 16 years to 1.5 per year by age 22. Emergency department rates increased per year from 45 per 100 at age 16 to 63 per 100 at age 20, then decreased to 60 per 100 by age 24. Hospitalizations per year climbed from 14 per 100 at age 16 to 21 per 100 at age 19, then decreased to 17 per 100 by age 24. In statistical models, young adults experienced higher rates of emergency department visits (incidence rate ratio [IRR] 1.24 [95% CI 1.18, 1.31]) and hospitalizations (IRR 1.25 [95% CI 1.15, 1.36]) than adolescents. Additional significant predictors of emergency department visits and hospitalizations included female sex and Black race. Individuals with two or more endocrinologist visits per year were less likely to have emergency department visits and hospitalizations; higher income was also protective.

CONCLUSIONS

Results highlight concerning increases in acute care utilization for young adults with type 1 diabetes who are less engaged with outpatient diabetes care and highlight socioeconomic risk factors that warrant further study.

Type 1 diabetes is a chronic medical condition with intensive management demands related to insulin administration, glucose monitoring, and adjustment for nutrition

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and exercise. As adolescents with type 1 diabetes progress to young adulthood, they assume responsibility for daily diabetes self-management as well as the logistics of diabetes care and supplies, all in the setting of competing life demands and decreasing parental support (1). Young adults with type 1 diabetes are at increased risk for suboptimal adherence and adverse health outcomes, including poor glycemic control (2,3), acute diabetes complications such as diabetic ketoacidosis (4), chronic microvascular complications (5), and early mortality (6,7).

In addition to increased self-management responsibility, young adults must also ultimately transition from pediatric to adult diabetes care providers. Previous studies from patient and provider perspectives have highlighted challenges in the type 1 diabetes transition process, including suboptimal pediatric transition preparation and care coordination, gaps between pediatric and adult care, and patient dissatisfaction with the transition experience (8–14).

Lack of effective transition from pediatric to adult diabetes care may lead to problematic gaps in health care delivery, with an associated increased risk for adverse outcomes in young adults with type 1 diabetes (1,15). A recent general transition systematic review highlighted pretransition use of health services as an important determinant in care gaps in addition to demographic and patient behavior characteristics (16).

However, transition practices vary considerably in different countries and care delivery settings. Some countries have a mandated transition age of 18 years, including Canada, where administrative data set analysis revealed an increase in post-transition diabetes hospitalizations (17). In contrast, transition timing is heterogeneous in the U.S., although multiple studies have cited a mean transition age of 19–20 years (9,18,19). State Medicaid data analyses have demonstrated associations between gaps in specialty care and increased hospitalizations in pediatric patients with diabetes, as well as generally high emergency department and inpatient use in young adults with type 1 diabetes (20,21). Recent claims (22) and National Inpatient Sample (23) analyses showed high rates of diabetic ketoacidosis in young adults relative to older adults (22) and younger adolescents (23). However, further research is

needed to better understand shifts in both outpatient and acute care patterns across the transition age range as well as predictors of acute care utilization in adolescents and young adults with type 1 diabetes.

Health insurance claims data provide a standardized source of information and a holistic view of patients' interactions with the health care system across care locations. Leveraging claims data to clarify trends in outpatient and acute care utilization as younger patients age may help to inform transition interventions and enable tracking of the transition process and outcome measures over time. The objectives of this study were to 1) assess trends in outpatient care, emergency department visits, and inpatient hospitalizations across the older adolescent and young adult years in a large national sample of patients with type 1 diabetes and 2) evaluate whether age, sociodemographic variables, and outpatient care utilization are associated with emergency department utilization and hospitalizations.

RESEARCH DESIGN AND METHODS

Cohort Definition

Our study population included commercially insured adolescents and young adults (16–24 years old) in Optum's deidentified Clinformatics Data Mart database who were enrolled between 1 January 2005 and 31 December 2012. The Optum data include enrollment information and all medical, pharmacy, and hospitalization claims from ~40 million commercially insured members of a large national health plan.

We defined members living with type 1 diabetes by using a combination of type 1 diabetes ICD-9 codes plus one or more insulin prescription codes. Members aged 16–24 years meeting the ICD-9 plus insulin prescription criteria and with ≥ 12 months of health plan enrollment were included. The first year in which the member met the type 1 diabetes criteria was considered the ascertainment year for baseline analysis. Sociodemographic and comorbidity variables (as described below) were collected during this ascertainment year. The analytic data set included all medical, pharmacy, and hospitalization claims for all available person-times for patients in the cohort during the 16–24-year age range. During our cohort construction, we identified 14,616 individuals meeting the

above criteria, contributing 34,533 patient-years to the study. The unit of analysis was age-years or the year during which a given individual was a specific age between 16 and 24 years.

Outpatient Visits

To construct outpatient visit utilization measures, provider types were classified in the Optum data set as adult or pediatric, along with primary care or subspecialty designation. Family practice and obstetrics/gynecology providers were excluded. We first identified outpatient visits based on CPT evaluation and management codes, then classified all outpatient visits as to adult or pediatric providers, and finally classified these visits as primary care or endocrinology. In statistical models, we defined receiving regular primary care as having one or more primary care visits per age-year and regular endocrinology as having two or more endocrinology visits per age-year.

Outcome Measures

Health care utilization measures in this study included total emergency department visits, high-severity emergency department visits, total hospitalizations, and diabetes hospitalizations categorized by the Agency for Healthcare Research and Quality (AHRQ) as preventable. We applied algorithms for detecting emergency department visits using a combination of place of service, revenue, and CPT codes. We used a validated modification of the Billings emergency department visit classification algorithm to categorize more acute emergency department visits as high severity (24–26). The Billings algorithm provides a probability that a given visit is nonemergency, is emergent but primary care treatable, or requires emergency department care. Per the validated approach, we defined visits as high severity when the probability that the primary diagnosis required emergency department care was $\geq 75\%$.

We identified total hospitalizations using a standard approach and excluded birth hospitalizations on the basis of ICD-9-CM diagnosis codes. We also calculated diabetes hospitalizations specifically designated as preventable using a combination of the four AHRQ-validated diabetes preventable hospitalization categories: diabetes short-term complication (e.g., diabetic ketoacidosis), diabetes long-term

complication, uncontrolled diabetes, and lower-extremity amputation among patients with diabetes.

Covariates

We used the Johns Hopkins Adjusted Clinical Groups (ACG) system comorbidity score (version 10) algorithm, a validated measure that categorizes diagnoses based on ICD codes and predicts mortality (27,28), to assess members' baseline ascertainment year morbidity. Consistent with previous studies, low morbidity was defined as a score of <2.0 and high morbidity as ≥ 3.0 (26).

To derive proxy demographic measures, the data vendor linked the insurance policy holder's most recent residential street address to their 2000 U.S. Census block group. We created validated income- and education-level categories with low income defined as residence in neighborhoods with below poverty levels of >20%; midincome of 11–20%, and high income of <10%. Census-based measures of socioeconomic status have been validated (29,30) and used in multiple studies to examine the impact of policy changes on disadvantaged populations (31–33).

We classified members as from predominantly White, Black, or Hispanic neighborhoods if they lived in a U.S. Census block group (geocoding) with at least 75% of residents of the respective race/ethnicity. We then applied a superseding ethnicity assignment if members had an ethnically unique surname (34) and classified remaining members as from mixed race/ethnicity neighborhoods. This validated approach of combining surname analysis and census data has positive and negative predictive values of ~80 and 90%, respectively (35). Other covariates included calendar year, age category (16–18 vs. 19–24 years), sex, and U.S. region (West, Midwest, South, and Northeast).

Statistical Analysis

Annual outpatient, emergency department visit, and nonbirth hospitalization rates were prorated over a year if the member did not have 12 months of enrollment. We aligned members at their age and assessed annual measures at each age from 16 to 24 years. We generated marginal adjusted rates by age for outpatient visits (primary care, endocrinology, and total outpatient visits), emergency department visits, and nonbirth

hospitalizations using generalized estimating equations (GEEs) (36–38) and plotted them with CIs. These marginal adjusted rates included adjustment for sex, U.S. region, ACG morbidity score, race/ethnicity, and neighborhood income/education. We also calculated the percentage of individuals at each age year with zero adult plus pediatric endocrinology visits.

We then used GEEs to assess the impact of age-group (16–18 vs. 19–24 years), outpatient visits, and sociodemographic variables on emergency department visit and hospitalization rates, accounting for within-patient clustering over time. We specified a negative binomial distribution for count outcomes (e.g., emergency department visits, nonbirth hospitalization) using the log link function. Models were adjusted for age category (16–18 vs. 19–24 years), receipt of regular primary care, number of endocrinology visits (zero, one, two or more), number of outpatient visits per year, sex, U.S. region, ACG morbidity score, race/ethnicity, and neighborhood income/education. Statistical analyses were conducted using Stata 15 (StataCorp LLC, College Station, TX). $P < 0.05$ conveyed statistical significance. The Harvard Pilgrim Health Care Institutional Review Board approved this study.

RESULTS

We identified 14,616 members with type 1 diabetes in the 16–24-year age range, contributing 34,533 patient-years to the analytic data set over the selected age-years. During the ascertainment year, 47% were female, 75% resided in high-income neighborhoods, 84% lived in high education neighborhoods, and 76% were White (Table 1). The mean ACG morbidity score was 2.5 (SD 3.2). The majority of members were from the South (42%) and Midwest (34%).

Trends in Outpatient Visits: Specialty Versus Primary Care and Pediatric Versus Adult Care

Over the 16–24-year age range, pediatric endocrinology visits decreased from 1.7 visits per year at age 16 years to 0.5 visits per year by age 20 and 0.08 per year by age 24. Pediatric primary care visits decreased on a similar scale from 1.5 per year at age 16 years to 0.3 per year by age 20 and 0.05 per year by age 24. Adult endocrinology visits increased from

Table 1—Characteristics at cohort ascertainment

Characteristic	Value
Age, years, %	
16	10.9
17	11.4
18	11.8
19	11.8
20	11.3
21	11.0
22	10.5
23	10.5
24	10.8
Male sex, %	52.9
Race/ethnicity, %	
White	75.4
Mixed	13.7
Hispanic	7.4
Black	1.9
Asian	1.4
Missing ($n = 33$)	0.2
Neighborhood below poverty level, %	
<10%	75.0
11–20%	17.6
>20%	7.5
Missing ($n = 21$)	0.1
Neighborhood below high school education level, %	
<10%	84.4
11–20%	11.8
>20%	3.7
Missing ($n = 21$)	0.1
U.S. region, %	
South	42.5
Midwest	33.7
West	14.7
Northeast	9.1
Missing ($n = 9$)	0.06
ACG score at the first enrolled year within age 16–24 years, mean \pm SD	2.5 \pm 3.3
Data are from 14,616 individuals contributing 34,533 patient-years to the study.	

0.6 per year at age 16 years to a maximum of 1.4 per year by age 24. Adult primary care visits were lower than specialty visits for this population, increasing from 0.2 visits per year at age 16 years to 0.75 per year by age 24 (Fig. 1A). Overall, combined pediatric and adult endocrinology visits decreased from 2.3 per year at age 16 years to 1.7 per year by age 20 and 1.5 by age 24. Combined pediatric and adult primary care visits decreased from 1.7 per year at age 16 years to 0.8 per year by age 20 and 0.8 per year by age 24 (Fig. 1B). Zero endocrinologist (adult plus pediatric) visits increased from 22% of individuals at age 16 years to 41% by age 24 years. The incidence rate ratio (IRR) of

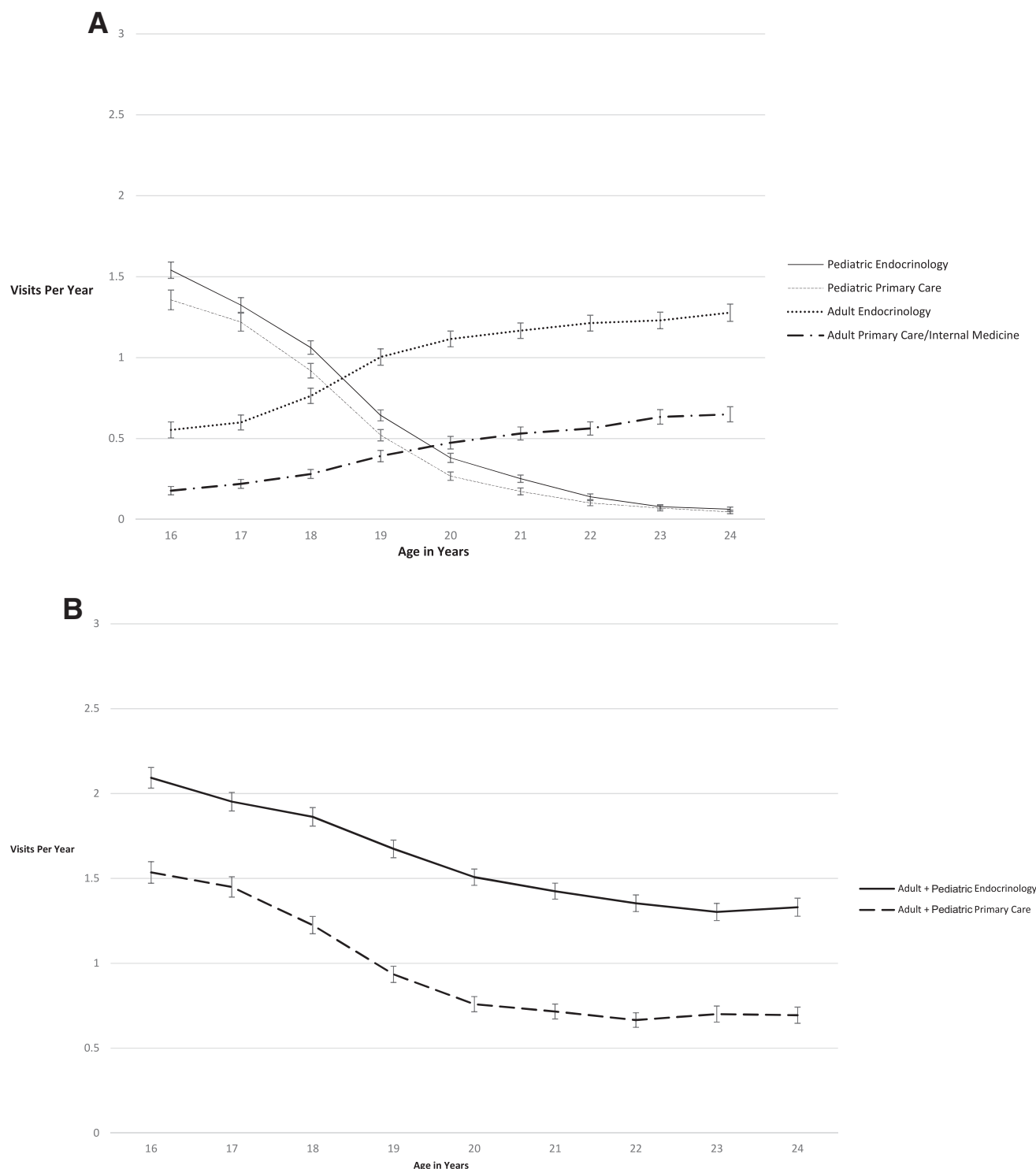


Figure 1—Outpatient visit trends by age. *A*: Trends broken down by pediatric endocrinology, pediatric primary care, adult endocrinology, and adult primary care and internal medicine visits. *B*: Trends broken down by adult plus pediatric endocrinology and adult plus pediatric primary care visits. Depicted are marginal rates (visits per year) by age for outpatient visits, with adjustment for sex, U.S. region, ACG morbidity score, race/ethnicity, and neighborhood income/education.

having one or more endocrinology visits per year in 19–24-year-olds, compared with 16–18-year-olds, was 0.80 (95% CI 0.78, 0.81). The IRR of having one or more primary care visits per year in 19–24-year-olds, compared with 16–18-year-olds, was 0.57 (95% CI 0.78, 0.81).

Trends in Proxy Health Outcomes by Age

Overall emergency department visits increased from 45 per 100 per year at age 16 years to 63 per 100 per year by age 20, then stabilized to 60 per 100 per year by age 24. High-severity emergency

department visits increased from 10 per 100 per year at age 16 years to 13 per 100 per year by age 20, decreasing to 8 per 100 per year by age 24.

Total hospitalizations increased from 13 per 100 per year at age 16 years to 21 per 100 per year by age 20, stabilizing

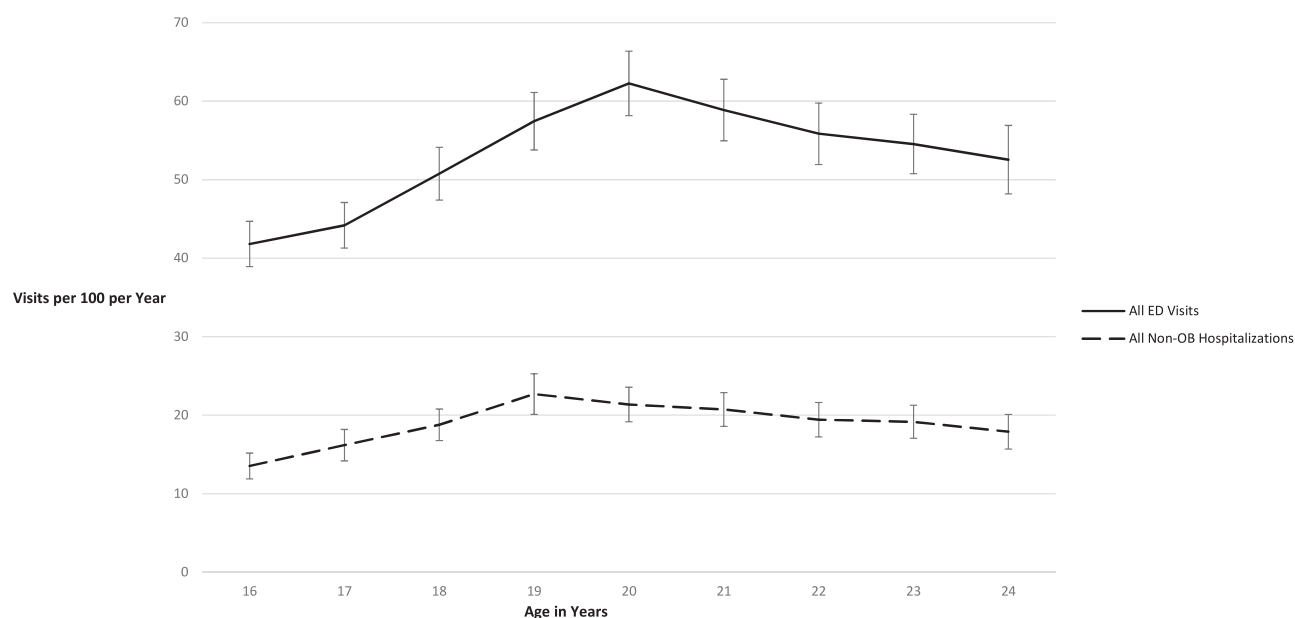


Figure 2—Overall emergency department (ED) visits and nonobstetric (non-OB) hospitalizations by age. Depicted are marginal adjusted rates (visits per 100 per year) by age for ED visits and non-OB hospitalizations, with adjustment for sex, U.S. region, ACG morbidity score, race/ethnicity, and neighborhood income/education.

at 17 per 100 per year by age 24 (Fig. 2). AHRQ preventable diabetes hospitalizations increased from 8 per 100 per year at age 16 years to 14 per 100 per year by age 19, decreasing to 9 per 100 per year by age 24.

Variables Affecting Acute Care Utilization

Overall Emergency Department Visits

In the GEE analysis assessing predictors of overall emergency department visits, young adults (aged 20–24 years) were significantly more likely to have emergency department visits relative to adolescents (IRR 1.24 [95% CI 1.18, 1.31]), as were those with race classified as Black versus White (IRR 1.35 [95% CI 1.11, 1.63]) or mixed neighborhood race/ethnicity versus White (IRR 1.18 [95% CI 1.08, 1.29]) and females versus males (IRR 1.19 [95% CI 1.12, 1.25]) (Table 2). Those with higher medical complexity as per ACG score also had increased emergency department visits (IRR 1.11 [95% CI 1.10, 1.63] per unit ACG score increase). Regional differences were also noted, with higher rates of emergency department visits in the Midwest and South relative to the Northeast and West. Lower income (IRR 1.22 [95% CI 1.12, 1.32] for neighborhood poverty level $\geq 10\%$) and lower education (IRR 1.21 [95% CI 1.09, 1.33] for neighborhood education below high

school $\geq 10\%$) were also associated with higher risk for emergency department visits. Individuals with two or more endocrinology visits per year were significantly less likely to have an emergency department visit in that year (IRR 0.78 [95% CI 0.73, 0.82]), with a similar but smaller protective effect for one endo-

crinology visit (IRR 0.88 [95% CI 0.82, 0.94]); a significant effect was not seen for one or more primary care visits.

Hospitalizations

In the models assessing predictors of hospitalizations, similar patterns were seen

Table 2—Predictors of overall emergency department visits

Variable	IRR (95% CI)	P
Female (ref. male)	1.19 (1.12, 1.25)	<0.0001
Young adult aged 19–24 years (ref. 16–18 years)	1.24 (1.18, 1.31)	<0.0001
Race (ref. White)		
Black	1.35 (1.11, 1.63)	0.002
Mixed	1.18 (1.08, 1.29)	<0.0001
Hispanic	1.09 (0.97, 1.21)	0.14
Asian	0.83 (0.57, 1.20)	0.33
ACG score	1.11 (1.10, 1.12)	<0.0001
U.S. region (ref. West)		
Midwest	1.35 (1.22, 1.49)	<0.0001
South	1.16 (1.06, 1.28)	0.002
Northeast	1.16 (1.02, 1.32)	0.023
Lower income (neighborhood poverty level $\geq 10\%$) (ref. $<10\%$)	1.22 (1.12, 1.32)	<0.0001
Lower education (neighborhood below high school $\geq 10\%$) (ref. $<10\%$)	1.21 (1.09, 1.33)	<0.0001
≥ 1 Primary care visits per year (ref. <1)	1.05 (0.99, 1.11)	0.06
Endocrinology visits per year (ref. 0)		
≥ 2	0.78 (0.73, 0.82)	<0.0001
1	0.88 (0.82, 0.94)	<0.0001

Boldface indicates significance at $P < 0.05$. ref., reference.

Table 3—Predictors of inpatient (nonobstetric) hospitalizations

Variable	IRR (95% CI)	P
Female (ref. male)	1.32 (1.19, 1.45)	<0.0001
Young adult aged 19–24 years (ref. 16–18 years)	1.25 (1.15, 1.36)	<0.0001
Black (ref. White)	1.43 (1.06, 1.93)	0.018
Mixed	1.22 (1.06, 1.40)	0.007
Hispanic	1.09 (0.90, 1.32)	0.37
Asian	1.00 (0.56, 1.77)	0.99
ACG score	1.14 (1.13, 1.15)	<0.0001
U.S. region (ref. West)		
Midwest	1.16 (0.99, 1.35)	0.07
South	1.13 (0.98, 1.31)	0.10
Northeast	0.83 (0.67, 1.02)	0.07
Lower income (neighborhood poverty level $\geq 10\%$) (ref. $<10\%$)	1.22 (1.07, 1.40)	0.003
Lower education (neighborhood below high school $\geq 10\%$) (ref. $<10\%$)	1.28 (1.09, 1.50)	0.002
≥ 1 Primary care visit per year (ref. <1)	1.06 (0.97, 1.15)	0.22
Endocrinology visits per year (ref. 0)		
≥ 2	0.76 (0.69, 0.84)	<0.0001
1	0.96 (0.87, 1.08)	0.58

Boldface indicates significance at $P < 0.05$. ref., reference.

compared with the overall emergency department visit analyses (Table 3). Young adults (aged 20–24 years) were significantly more likely to be hospitalized relative to adolescents (IRR 1.25 [95% CI 1.15, 1.36]), as were those with race classified as mixed versus White (IRR 1.21 [95% CI 1.06, 1.40]) and females versus males (IRR 1.32 [95% CI 1.19, 1.45]). Individuals with race classified as Black versus White experienced more hospitalizations (IRR 1.43 [95% CI 1.06, 1.93]). Individuals with higher medical complexity as per ACG score also experienced more hospitalizations (IRR 1.14 [95% CI 1.13, 1.15] per unit ACG score increase). Significant regional differences were not noted for hospitalizations. Lower income (IRR 1.22 [95% CI 1.07, 1.40] for neighborhood poverty level $\geq 10\%$) and lower education (IRR 1.28 [95% CI 1.09, 1.50] for neighborhood education below high school $\geq 10\%$) also conferred higher risk. As with overall emergency department visits, individuals with two or more endocrinology visits per year were significantly less likely to be hospitalized in that year (IRR 0.76 [95% CI 0.69, 0.83]). Statistically significant protective effects were not noted for one endocrinology visit or one or more primary care visits.

CONCLUSIONS

Results from our sample, representing >14,000 commercially insured adolescents and young adults with type 1 diabetes from diverse locations across the U.S., demonstrate concerning declines in outpatient care utilization and concomitant increases in costly adverse proxy health outcomes across the late adolescent and early young adult years. These data depict the experiences of adolescents and young adults from the first decade and a half of the 21st century and provide an important point of comparison for researchers and policymakers aiming to reduce acute care utilization and improve outcomes in this vulnerable population.

Overall, annual endocrinology visits (pediatric and adult) in this population declined by >50%, from 2.3 per year at age 16 years to 1.7 per year by age 20 and 1.5 by age 24. Furthermore, the percentage of individuals with zero endocrinologist visits increased from 22 to 41% between age 16 and 24 years. The American Diabetes Association recommends medical assessment every 3 months for this population (39). Adult primary care visits were lower than adult endocrinology visits at all age points. The substantial drop-off in pediatric visits and increase

in adult visits around age 19 years suggests a trend of transition to adult care in that age range, which is consistent with limited U.S. data in the diabetes literature (18,19). The endocrinologist visit data are particularly relevant because previous research has shown that endocrinologists (rather than primary care providers) provide the main diabetes care for the majority of young adults with type 1 diabetes (40). Among young adults aged ≥ 18 years in the SEARCH for Diabetes in Youth study (a population-based cohort), 45% designated their main diabetes care provider as an adult endocrinologist and 24% as a pediatric endocrinologist compared with only 17% as a primary care provider or general practitioner (40).

In our results, visits to pediatric providers declined, but the difference was not fully recouped by visits to adult providers. Possible contributing factors include competing young adult life demands, clinical recommendations to be seen less frequently in adult clinics, or the reported relative decrease in availability of adult endocrinology providers in the U.S. (41). However, fragmentation of care around transition is also an important factor that contributes to decreased visit rates in young adults. Gaps >6 months between pediatric and adult care have been reported by 21–34% of posttransition young adults with type 1 diabetes, with gaps occurring less frequently in individuals who had regular pediatric visits in the year before transition (9,11). Young adults with gaps between pediatric and adult care may be at risk for further loss to follow-up and disconnection from adult care. Given the vulnerability and increased risk of adverse outcomes in young adults, careful attention to transition planning, coordinated adult care referrals, and young adult support is warranted across the transition period.

We found that inpatient hospitalization rates increased from 14 per 100 per year in members aged 16 year to 21 per 100 per year by age 19, and emergency department visits increased from 45 per 100 per year in those aged 16 to 63 per 100 per year by age 20. For comparison, in a published analysis of largely older adults from the Optum database ($N = 23,493$, 88% aged >40 years, any diabetes type), total hospitalizations were ~ 13 per 100 per year, and emergency department

visits were 25 per 100 patient-per year (26). Our population had higher rates, especially for young adults and for emergency department utilization. In our multivariate models, young adults were ~25% more likely to have emergency department visits or hospitalizations relative to adolescents.

Our acute care utilization data correspond with hospitalization trends reported from other populations. For instance, in a California Medicaid analysis, 19–21-year-olds with type 1 diabetes had significantly higher rates of hospitalizations and emergency department visits compared with younger age-groups (21). A more recent California statewide inpatient database analysis showed a significant rise in diabetes-related hospitalizations between age 17 and 19 years (42). A Nationwide Inpatient Sample analysis also showed age-specific increases in annual hospitalizations for diabetes at ages 20–24 years (43). A population-based administrative data set analysis of young adults with type 1 diabetes aged 18–20 years in Ontario showed a significant increase in diabetes-related hospitalizations in the 2 years after transition to adult care (17). A recent systematic literature review of diabetic ketoacidosis prevalence in adults highlighted that young adults aged 18–25 years were at highest risk (4).

The high emergency department utilization in young adults (far above hospitalization rates) is striking and raises the concern that young adults may be seeking routine care (e.g., insulin prescription refills) in the emergency department setting. Of note, total emergency department visits were at least four times higher than high-severity emergency department visits in our analyses. While less is known about emergency care utilization in young adults with type 1 diabetes, high rates of emergency care utilization related to lack of routine care have been reported in the general young adult population (44,45) and in young adults with asthma (46).

Lack of a diabetes medical home may be one cause of increased emergency department utilization. Importantly, we found that individuals with two or more endocrinology visits per year were >20% less likely to have an emergency department visit or hospitalization, and even one endocrinology visit per year was associated with a >10% decreased risk of emergency department use. However, we found no protective association between

primary care visits and either type of acute care utilization for this population. These results suggest an integral role for subspecialty diabetes care, which may function as a safety net in preventing loss to follow-up and related acute care utilization for older adolescents and young adults, as well as the need for improved integration between diabetes specialty care and primary care.

Previous work using Medicaid claims has shown that children and adolescents admitted for diabetic ketoacidosis were significantly less likely to have visited an endocrinologist in the preceding 120 days (20). In a single-center longitudinal onset cohort of 61 children and adolescents with type 1 diabetes, those with irregular endocrinology follow-up were more likely to be admitted for diabetic ketoacidosis (47). In addition, the above Ontario analysis showed that continuity of the patient-physician relationship was protective against hospitalization in posttransfer young adults with type 1 diabetes (17). More broadly, poor access to medical care has been linked to higher rates of hospitalizations across multiple chronic diseases in adults (48).

Other salient findings for significant predictors of acute care utilization included race/ethnicity and geocoded socioeconomic variables. We observed an increased incidence of emergency department use in Black and mixed race individuals; the trend for hospitalizations was markedly similar, although the *P* value for Black race did not meet the specified level of significance, possibly because of small sample size. We also noted a significantly elevated risk for both emergency department use and hospitalizations in the setting of lower education or income levels. These observations suggest a need to provide active and innovative outreach to populations with risk factors for greater emergency department use and for hospitalization. Such efforts may help to reduce the recognized health disparities that are evident in racial and ethnic minority groups, a finding affirmed in our analyses.

Recent studies have highlighted racial/ethnic and socioeconomic disparities in glycemic outcomes and advanced diabetes technology treatment modalities in children (49,50) and young adults (51). Future studies with larger minority samples are needed to uncover and address

interventions for modifiable drivers of disparities in type 1 diabetes.

Strengths of this study include the large sample size and ability to assess both pediatric and adult visits and acute care utilization at a high level with a national scope across various health care settings and regions. However, there are a number of limitations. The study covers the years 2005–2012 and does not include data from more recent years, although the results provide an important point for comparison in the challenging landscape of type 1 diabetes transition. Information on glycemic control (hemoglobin A_{1c} values) is not available in the claims data environment. Our data do not include information on diabetes device (insulin pump, continuous glucose monitor) use or telehealth utilization, though these were less prevalent during the study period; future studies should examine diabetes technology claims to assess the impact of these devices on transition care trends. Our study used a dynamic cohort design with variable participation times, and we were not able to pinpoint the precise time of transition to adult diabetes care; future studies should perform analyses on continuously enrolled populations to clarify transition patterns. Socioeconomic and racial/ethnic data were limited by geocoding and neighborhood-level variables (though obtained through well-validated approaches) and have the potential for misclassification; our sample had minimal racial and ethnic diversity and more of a focus on Midwestern and Southern populations. Finally, our results may not be representative of newly insured people and do not include information about publicly insured populations.

In conclusion, young adults with type 1 diabetes experience decreased subspecialty endocrinology care and increased emergency department utilization and hospitalizations compared with adolescents, which is further compounded by social determinants of health. Young adults may experience disruptions in outpatient diabetes care during the high-risk transition period, and more frequent subspecialty diabetes care is strongly associated with decreased acute care utilization. There is an urgent need to test interventions to improve transition preparation and care navigation targeted to high-risk groups and to strengthen the diabetes medical home and specialty care/

primary care integration across diverse populations of young adults with type 1 diabetes.

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Duality of Interest. No potential conflicts of interest relevant to this article were reported.

Author Contributions. K.C.G. researched data and wrote the manuscript. J.A.F. and L.L. contributed to the discussion and reviewed and edited the manuscript. F.Z. and R.L. analyzed data and reviewed and edited the manuscript. J.F.W. researched data, analyzed data, and reviewed and edited the manuscript. K.C.G. 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 data analysis.

Prior Presentation. Parts of this study were presented in abstract form at the 77th Scientific Sessions of the American Diabetes Association, San Diego, CA, 9–13 June 2017.

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