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Health Care Access and Glycemic Control in Youth and Young Adults with Type 1 and Type 2 Diabetes in South Carolina

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Abstract

Affordability and geographic accessibility are key health care access characteristics. We used data from 481 youth and young adults (YYA) with diabetes (389 type 1, 92 type 2) to understand the association between health care access and glycemic control as measured by HbA_{1c} values. In multivariate models, YYA with state or federal health insurance had HbA_{1c} percentage values 0.68 higher (p=0.0025) than the privately insured, and those without insurance 1.34 higher (p<0.0001). Not having a routine diabetes care provider was associated with a 0.51 higher HbA_{1c} (p=0.048) compared to having specialist care, but HbA_{1c} did not differ significantly (p=0.069) between primary vs. specialty care. Distance to utilized provider was not associated with HbA_{1c} among YYA with a provider (p=0.11). These findings underscore the central role of health insurance and indicate a need to better understand the root causes of poorer glycemic control in YYA with state/federal insurance.

Keywords

Health care access; determinants of health; insurance coverage; children’s health; diabetes

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Introduction

Affordability and geographic accessibility are key dimensions of access to health care and important determinants of health care utilization.[1] A growing number of studies have consistently found that health care access, defined in terms of economic access (e.g., health insurance coverage) and geographic access, are strongly tied to positive health outcomes.[2,3] For individuals diagnosed with youth-onset type 1 diabetes (T1D) or type 2 diabetes (T2D), regular interactions with health care providers are necessary components of lifelong disease self-management.[4] Studies have shown the need for the integration of both patient-initiated (e.g., glucose monitoring) and provider-initiated (e.g., periodic HbA_{1c} testing) behaviors for successful glycemic control.[5,6] The American Diabetes Association (ADA) recommends regular blood testing for HbA_{1c} levels for all individuals diagnosed with diabetes.[7] In addition, prescriptions for insulin or oral diabetes agents need to be obtained and refilled regularly, and glucose monitoring supplies purchased. Each of these occur at considerable cost to the patient or their family.

Optimal glycemic control is the hallmark of diabetes management and is key to reducing risk of chronic complications such as kidney disease, neuropathy, retinopathy, cardiovascular disease and preventing premature mortality.[7–11] Thus, lowering HbA_{1c} to levels below or around 7% or 53.0mmol/mol, in adult[7,8,10,11] and 7.5% or 58.5mmol/mol in children[12,13] is considered the standard for optimal glycemic control.

Unfortunately, our data suggest that55.6% of youth and young adults (YYAs) with T1D and 46% of those with T2D did not achieve optimal glycemic control in 2001–2005.[14] Minority YYAs are particularly at risk. Nationwide, 65% of non-Hispanic black and 61% of Hispanic YYAs with T1D do not have optimal glycemic control compared to 53% of non-Hispanic whites, and similar disparities exist in T2D (41% and 49% compared to 29%, respectively).[14] More recent data confirm that there is still much room for improvement of glycemic control in T1D and T2D, despite increasing availability of new technologies such as insulin pumps and continuous glucose monitoring.[15–17] This raises the question as to what individual, social, environmental and health care systems factors may present barriers to good glycemic control, particularly in the domain of health care access.[18]

Geographic access to pediatric and adult endocrinologists is highly variable across the United States (US), with these specialists concentrated in urban areas.[19] In South Carolina, a largely rural state with only a handful of distinct urban centers, only 54.6% of children have access to a pediatric endocrinologist within 20 miles, while 84.9% of adults have access to an endocrinologist within 20 miles of their home, compared to national averages of 64% and 85.4% respectively.[19] Moreover, the Southern US, as a whole, has a particularly unfavorable ratio of children with diabetes to pediatric endocrinologists at 335:1 compared to the 290:1 national average.[20] Thus, geographic access can be a barrier to seeking and receiving recommended care.

Unfortunately, having geographic access does not guarantee access to a provider, because in the US, health insurance type is another determinant of access to care. Health insurance coverage for youth with diabetes in the US is largely dependent on their parents' or guardians' health insurance access, though some federal programs such as Medicaid and the Children's Health Insurance Program (CHIP) offer coverage specifically for children with disabilities or in low-income households.[21] The 2010 Affordable Care Act (ACA) significantly increased affordable health insurance options nationwide, and additionally offered states the opportunity to expand coverage of their Medicaid programs.[22] Consequently, the uninsured US population declined to record low levels in 2016 at 8.9% of the population.[21] Some states, including South Carolina, did not take advantage of Medicaid expansion.[21] Moreover, South Carolina's eligibility levels continue to be very low compared to national averages, perpetuating long-standing trends of having higher than national rates of uninsured including in children.[23] Thus, the current situation is particularly troublesome for YYAs with diabetes in South Carolina, particularly as they age out of their parents' health insurance plans.

This paper aims to evaluate the association of health care access, defined using four measures pertinent to insurance, usual provider, provider type, and geographic distance, with glycemic control in a South Carolina YYAs with diabetes participating in the SEARCH for Diabetes in Youth Study in 2012–2015.[4]

Research Design and Methods

SEARCH is a multi-center study conducted at five centers in the continental US that initiated ascertainment of youth <20 years of age with physician-diagnosed diabetes in 2001 and is described in detail elsewhere.[4] Initially, SEARCH was a surveillance effort that identified prevalent (existing) and incident (newly-diagnosed) cases of diabetes. In SEARCH Phase 3 (funding period 2010–2015), the surveillance effort focused on individuals <20 years of age with incident T1D or T2D or other type (e.g. maturity onset diabetes in youth, hybrid type, etc.) diagnosed between 2010 and 2014. Additionally, SEARCH participants from SEARCH 1 and 2 aged 10 years or older who had at least 5 years of diabetes duration were invited for a study visit consisting of questionnaires, physical examinations, and laboratory measures. This group is referred to as the SEARCH cohort. The cross-sectional study presented here represents all YYAs participating in the SEARCH for Diabetes in Youth cohort in South Carolina and encompasses the entire data collection period (January 2012 – June 2015). Only data collected at this cohort visit were utilized. Participants' ages ranged from six to 30 years (median 16 years). Participants provided informed consent (if ≥18 years old) or assent (if <18 years old) along with parental consent before data collection. This study was approved by the University of South Carolina's Institutional Review Board.

Exposure Measures

Questionnaires on demographic, socioeconomic, and clinical characteristics were completed by parents/guardians of participants <18 years of age and by participants ≥18 years of age. Health care access was measured by four variables: health insurance type, whether the participant had a usual provider, the specialty of that provider if one was indicated (provider type), and distance from residence to the usual provider.

Health insurance type was queried by asking about the kind of health insurance or health care plan, offering eight answer choices which were subsequently grouped into private insurance (i.e. insurance through employer or purchased independently or from military) and state or federal insurance (e.g. Medicaid, Medicare, state- or federally funded, tribe or Indian Health Service).(21) If multiple types of insurance were selected, participants were allocated to the more comprehensive type of insurance. Individuals in the no insurance group gave no indication of having any type of health insurance.[24]

Participants were given the opportunity to have their laboratory results sent to the health care provider of their choice. Provider name, address and type were collected as part of the consent process, not in the surveys, and was entered in the participant tracking database. For participants who named a usual provider, this information was used to characterize whether a participant had a regular health care provider (yes/no). Study staff reviewed the provider type information provided by the participants and corrected when needed based on detailed knowledge of South Carolina's care providers. The provider type information was then grouped into three categories: (1) primary care (pediatrician, family practice doctor, general practice doctor, internist, nurse practitioner/physician's assistant), (2) specialist (pediatric or adult endocrinologist/diabetologist (diabetes specialist)), and (3) unknown/none.

Lastly, distance to the utilized provider was estimated. The participant's home address and provider address were geocoded, and the road-network distance between them was calculated using ArcGIS version 10.3. The distance values were winsorized at the 95th percentile. For the participants who did not provide the name of a regular health care provider (n=92, 18.8%), no attempt was made to assess distance. These individuals were omitted from the analyses focusing on distance, which implies that the results apply only to persons with a health care provider. The home address was furthermore used to determine if individuals lived in urban or non-urban census tracts, using the Rural-Urban Commuting Areas (RUCAs) definition and contrasting the 'urban core' category with all others.[25]

Outcome Measures

Whole blood samples collected during the cohort study visit were analyzed for HbA_{1c} by the Northwest Lipid Metabolism and Diabetes Research Laboratories in Seattle, WA, using an automated nonporous ion-exchange high-performance liquid chromatography system (model G-7; Tosoh Bioscience, Montgomeryville, Pennsylvania).[14] Thus, analyses presented here are based on a single HbA_{1c} measure. HbA_{1c} is the standard way to measure glycemic control over the past three months. We also used the ADA and International Society for Pediatric and Adolescent Diabetes (ISPAD) 2014 Guidelines for HbA_{1c} to categorize participants' glycemic control. For ages <18 years, 1) <7.5% or <58.0 mmol/mol is optimal, 2) 7.5–9.0% or 58.0 −75.0 mmol/mol is suboptimal, and 3) >9.0% or >75 mmol/mol is high-risk.(12,13) For ages ≥18 years, 1) <7.0% or <53.0mmol/mol is optimal, 2) 7.0–9.0% or 53.0–75.0 mmol/mol is suboptimal, and 3) >9.0% or >75.0 mmol/mol is high-risk.[7]

Covariate Measures

Demographic questions on sex, race, and ethnicity were modeled after the US Census Bureau format.[26] Information about the age at diagnosis and the age at each visit was used to compute the duration of each individual's diabetic condition. Diabetes type was based on information obtained from health care providers during the participant recruitment process. We limited our analyses to include individuals with T1D and T2D diabetes only. Information on type of medication regimen was assessed by questionnaire. Information on utilization of an insulin pump was available and integrated with the medication regimen.

Parent/guardians reported their highest educational degree or level of schooling completed, as well as that of their partner/spouse, selecting from 16 different choices. To assess household income, participants were presented with nine income ranges from "less than $5,000" to "$100,000 and greater." The young adult SEARCH participants were asked these same questions about their parents, following the rationale that in early adulthood, the socioeconomic characteristics of the parental household influence the socioeconomic status of the young adult. Because household income was not reported by about 25% of the sample, we created a composite, dichotomous socioeconomic status (SES) variable using household income and parent education data. Lower SES was defined when household income was under $50,000/year (rounded up as an approximation of median household income regardless of parent education category) which is a reasonable threshold for South Carolina[27], or, if income data was missing, when parent education was less than a bachelor's degree. We defined higher SES as household income ≥$50,000/year and any parent education category, or ≥bachelor's degree if income data was missing.[28] Using this composite SES variable resulted in only eight participants with missing SES data. This composite SES variable significantly predicted HbA_{1c} and glycemic control whereas the individual income and education variables were not predictive.

Statistical Analyses

The original sample included 564 participants. We sequentially excluded six T1D YYA who reported not taking insulin, and those missing type of health care provider (n=17), insurance information (n=9), medication regimen (n=36), type of insulin administration (n=3), SES (n=8) or HbA_{1c} (n=4), leaving a sample of 481 with complete information for three of the four health care access characteristics. For analyses focusing on distance, another n=89 without a regular care provider had to be excluded, leaving us with n=392 who indicated having a health care provider and for whom distance to provider could be calculated.

To evaluate the possibility of selection bias caused by missing data, we compared demographic characteristics of the included versus excluded participants and found no significant differences in terms of sex, race/ethnicity and SES, though included participants were significantly younger (17.7 vs. 20 years old) and had a shorter duration of diabetes (96 vs. 101 months). The same conclusion was reached for a comparison of the included in the distance analyses to those excluded.

Descriptive statistics are presented for the entire sample as well as by diabetes type. For continuous variables (age, duration of diabetes, BMI Z-score, HbA_{1c}, and distance to healthcare provider), mean and standard deviations were calculated. Percentages for each of the categorical variables (e.g. sex, race/ethnicity, SES, medication type, glycemic control category, health insurance, existence of a healthcare provider, and type of healthcare provider) were calculated.

To evaluate the association of the four health care access variables with HbA_{1c}, we first estimated four unadjusted linear regression models, one for each access predictor (health insurance type, regular health care provider, type of health care provider seen for diabetes care, and distance to health care provider). The next set of multivariable models included the covariates urban vs. non-urban designation, participant's age at visit, sex, race/ethnicity, diabetes type, duration of diabetes, and medication type (adjustment 1). A second level of adjustment added SES.

Subsequently, these analyses were repeated using logistic regression with the clinically highly relevant glycemic control category as a variable, i.e., high-risk (HbA_{1c} >9.0% or >74.9mmol/mol; coded as 1) versus combined optimal and suboptimal categories (HbA_{1c} ≤9.0% or ≤74.9mmol/mol; coded as 0). We additionally evaluated whether the association might differ by diabetes type, race/ethnicity, and urban designation by including interaction terms between each of these effect-modifiers and the respective health care access characteristic in the models. No evidence of interaction was found. Data analyses were conducted using SAS 9.4.

Results

The demographic, clinical and health care access characteristics of the sample are presented in Table 1. The analytical sample of 481 comprised 389 YYA with T1D and 92 with T2D. The average age of the participants was 17.7 years, 16.8 years among T1D and 21.7 years among T2D. The sample was 58% female, 63% white (with 73% of T1D vs. 22% of T2D being white), and 52% characterized as low SES (with 47% of T1D vs. 76% of T2D). The average participant had diabetes for 95 months. The majority of T1D and T2D patients did not have optimal glycemic control; however, there were differences among the types. Whereas 35% of participants with T1D had suboptimal and 57% had high-risk glycemic control, among those with T2D, 12% had suboptimal and 57% had high-risk glycemic control.

About 60% of the participants had private health insurance, but this proportion differed by diabetes type, with 66% of YYA with T1D versus 37% of YYA with T2D having private health insurance. The percent YYA without health insurance was 6% in T1D and 34% in T2D. Lack of health insurance was associated with age (data not shown in Table), specifically across the three age groups < 18, 18–26, and 27 years and older, the percent uninsured was zero percent, 16% and 14% among T1D, respectively, and zero percent, 38% and 57% in T2D.

The degree of specialization of the regular health care provider of the YYA also differed by diabetes type, with the majority (71%) of T1D YYA seeing a specialist such as a pediatric endocrinologist or endocrinologist versus only 32% of T2D YYA. Additionally, the proportion of YYA who did not indicate a regular health care provider was also noteworthy, with 42% of YYA with T2D not indicating a provider versus 13% of T1D. There were also some differences in the percent indicating a regular provider by insurance status (data not shown in tables): The proportion with a regular provider was 86%, 91%, and 61% among the T1D with state/federal insurance, private insurance, and no insurance, respectively. Among the T2D, these proportions were 81%, 65%, and 29%, respectively. Health insurance status and diabetes type were also associated with receiving care from a specialist provider, the proportions being 70%, 76%, and 26% among T1D and 48%, 38%, and 10% among T2D for those with state/federal insurance, private insurance, and no insurance, respectively. On average, participants traveled about 27.9 miles to their healthcare provider, and this value was similar among T1D and T2D.

Table 2 presents the unadjusted and multivariate-adjusted associations between health care access characteristics and HbA_{1c}. Because we did not find evidence for potential effect-modification of the health care access – HbA_{1c} association by diabetes type (all p-values for interactions ranged from 0.18–0.80), results are shown for the entire sample, including both T1D and T2D. For each of the four health care access variables, three models are shown (unadjusted, adjusted for covariates, adjusted for covariates and SES).

Health insurance type was significantly associated with HbA_{1c} in adjusted multivariable models: YYA who had state or federal health insurance had higher HbA_{1c} levels (unstandardized regression coefficient b=0.68; p=0.0025) compared to those with private insurance. YYA without insurance also had higher HbA_{1c} levels (b=1.34; p<0.0001) than YYA with private insurance. Additionally, YYA who did not report having a regular healthcare provider (i.e. did not provide an address for their results to be sent to) had higher HbA_{1c} levels than participants who reported having a regular healthcare provider (b= 0.51; p=0.048). With respect to the type of health care provider, those receiving care from a primary healthcare provider had non-significantly higher HbA_{1c} levels (b=0.44; p=0.069) than those receiving care from a specialist, while those who either did not have a healthcare provider had significantly higher HbA_{1c} levels (b=0.66; p=0.015) than participants who received care by a specialist. Distance to healthcare provider was not associated with HbA_{1c} among those YYA who indicated having a provider (p=0.105). We further explored the role of urban vs. non-urban designation and found it not to be associated with HbA_{1c} either; consequently, its inclusion or exclusion did not impact the role of distance or any of the other access variables. Urban vs. non-urban designation was likewise unassociated with having a provider. Race/ethnicity did not modify the results.

With respect to high-risk glycemic control (Table 3), YYA who had state or federal insurance had 2.4 higher odds (95% CI [1.4, 4.2]; p=.0011) and YYA without health insurance had 6.3 higher odds (95% CI [2.3–17.4]; p=0.0003) of high-risk glycemic control compared to those who had private insurance in the fully adjusted models. The other health care access characteristics were not significantly associated with high-risk glycemic control. There was no evidence of significant effect modification by diabetes type, race/ethnicity or urban designation.

Discussion

There is an urgent need to identify ways to improve glycemic control and metabolic health in YYA with diabetes given the low rates of glycemic control overall, and the rising number of YYA with diabetes.[14,29] Of the health care access characteristics evaluated in this cross-sectional study, health insurance coverage, type of health insurance coverage, and having a health care provider were all significantly associated with HbA_{1c}, but type of health care provider and distance to a health care provider were not among those with a health care provider.

Previous research among adolescents has shown that lack of health insurance compared to having private insurance is associated with decreased odds of having had a preventive health care visit in the last year, as well as having had any health care visit or with identifying a usual source of care.[30] While in the past, the presence of diabetes could affect eligibility for health insurance coverage due to pre-existing condition clauses, this issue has been alleviated by the ACA, which was in effect during the time our data were collected.[22,31] A recent study evaluating changes in health care utilization after Medicaid expansion or expanded private insurance under the ACA has shown "[…] increased access to primary care, fewer skipped medications, reduced out-of-pocket spending, increased glucose testing among patients with diabetes, and increased regular care for chronic conditions…" While South Carolina residents did not benefit from Medicaid expansion, the ACA's insurance exchanges and regulation against exclusion of pre-existing conditions could have afforded more YYA with diabetes access to health insurance coverage.[32] Yet 6% of T1D and almost 34% of T2D youth in this South Carolina sample indicated not having health insurance. The consequences thereof are borne out in our results of a 1.34 higher HbA_{1c} value among the uninsured and a more than 6-fold higher odds of high risk glycemic control than among those with private insurance.[33]

In addition, we found that YYA with diabetes who had with state or federal insurance had 0.68 higher HbA_{1c} levels compared to those with private insurance. Our findings echo a prior longitudinal study of YYA with T1D, which found that Medicaid insurance holders were twice as likely to have sustained poor HbA_{1C} levels as those with private insurance.[34] One potential explanation may be that Medicaid-insured persons may have poorer access to specialty care, though that was not directly supported in our data as the proportion seeing specialists was relatively similar between state/federal-funded insurance holders and those with private insurance (66% vs. 71%) Another reason is that state or federal health insurance plans offer incomplete protection against medical expenditures associated with diabetes.[35] It is well established that costs associated with glucose testing supplies are often not fully reimbursed, causing some families to forgo health care visits and to reduce medication regimens and glucose testing supplies.[31] In adults with diabetes, cost-related medication underuse is well documented and is also associated with food insecurity, which is why it has been referred to as the "treat or eat" dilemma.[36]

When interpreting our findings one also needs to consider the close interrelation between insurance type, race/ethnicity and socioeconomic status. In the US, significant racial/ethnic-related inequities exist in educational and economic opportunities.[37] These in turn affect the availability, types, and eligibility for employment opportunities. Employment is highly linked to availability of health insurance and type of health insurance. Disentangling these complexities cannot be addressed appropriately within the structure of the regression models chosen here. Within the confines of these models, it should be noted that minority race/ethnicity was a significant predictor of higher HbA_{1c} and poorer glycemic control. Our statistical adjustment for socioeconomic status and race/ethnicity is thus a simplification, as it treats these concepts as statistically independent from the health care access characteristics which they clearly are not in reality.

We did not find evidence for a significant difference in glycemic control between those receiving care by a primary care provider compared to a specialist. Given the complexity of treating T1D and T2D, particularly in youth, patients often seek care from a specialist.[38] In our sample, the type of care was strongly dependent on diabetes type, with 71% of YYA with T1D treated by a specialist versus 16% by a primary care provider, compared to YYA with T2D of whom 32% were seen by a specialist and 26% a primary care provider. Given that pediatric and adult endocrinologists are predominantly located in urban areas in the US, whereas primary care is more widely distributed, it has been suggested that complex care delivery for persons with diabetes may be improved by having primary care providers in rural areas partner with specialists using telehealth.[19,39] This could include use of telemedicine consultations to allow remote specialists to assess rural patients. In addition, one could consider broader implementation of teleconsultation to enhance skills of primary care providers, for instance using a model like Project ECHO.[40] Most important is that YYA with diabetes have a regular health care provider as we also found that having a regular health care provider was associated with lower HbA_{1c} levels.

Geographic access was hypothesized to be inversely associated with glycemic control, but our study failed to find a significant association. Our findings were similar to a previous study among children and adolescents with T1D[41] but differed from several studies in T2D adults which reported effects of distance to provider.[42–44] However, as noted below, our distance analysis was restricted to YYA with a reported provider, that is, a group likely to have an ongoing relationship with a provider. However, more recent studies suggest a more nuanced and complex relationship between distance and health care utilization than a simple linear function of distance of clinic from home.[45,46]

Diabetes type is an important consideration examining health care access and glycemic control, as is race/ethnicity. While T1D has historically been associated with higher SES, T2D in YYA is associated with lower SES.[47–51] In our sample, 73% of T1D YYA were of white race/ethnicity and 54% had higher SES, compared to 22% white race/ethnicity among T2D YYA of whom only 24% had higher SES. Despite these differences, mean HbA_{1c} levels at 9.6% or 81.4mmol/mol were quite similar across diabetes types and indicative of very poor glycemic control. Of note, insulin pump use in the South Carolina sample was lower than percentages reported across all SEARCH centers and national estimates.[52–54]In addition, while the majority of insulin pumps were routinely covered in South Carolina for most Medicaid types (albeit with significant paperwork requirements), most types of continuous glucose monitors are still not covered. This is important because continuous glucose monitoring has been shown to improve glycemic control, including in those using insulin injections.[55,56] Moreover, these newer technologies are frequently unaffordable for those lacking health insurance altogether. SEARCH has recently shown the impact of these poor glycemic control levels on the prevalence of complications (including kidney disease, retinopathy, peripheral neuropathy, cardiovascular autonomic neuropathy, arterial stiffness and hypertension): The percent of YYA with complications ranged from 5.6% to 14.4% among T1D and from 9.1 to 47.4 among T2D.[15]

A number of limitations of this study need to be acknowledged. The provider access characteristics (having a provider and location) were collected as part of the study's consent process, not the main study protocol. However, given that the consent form was sent to participants ahead of the clinic visit, the staff trained on consent procedures, including looking up provider names and addresses when needed, we are confident that these data are sufficiently standardized. While we cannot exclude the possibility that some participants may have either elected to not name their provider or simply forgotten their provider's name, we believe the vast majority of participants who indicated not having a health care provider did so accurately. Our study used only a single geographic measure in the analysis – driving distance – and not other potentially more informative distance-related metrics such as driving time or consideration of activity spaces.[45,46] Moreover, average distances in South Carolina will not be representative of other regions of the US. YYA who did not provide the name of their provider had to be excluded from distance analyses. Given that this is a high-risk group, this could result in a bias toward the null for the distance analyses among those with a provider. We also did not have data on the frequency of utilization linked to the same provider for which distance was calculated.[46] Moreover, while we adjusted a number of key confounding variables, we did not control for factors such as parental involvement in medical care, or the availability or affordability of medication and supplies.[57] Last but not least, some misclassification of socioeconomic status will be occur because the parental level of education and income was used as a proxy for the young adult participants status, as SEARCH did not collect self-reported education and income for these participants.

Among the strengths of our study is that we considered multiple different health care access characteristics that function at different levels according to Andersen's Behavioral Model of Health Services Use.[18] We also used road-network based driving distances rather than the Euclidian (straight-line) distance, and actual utilized (vs. closest potential) provider location for computation of distance from residence to practice. We had indirect information on the use of health services (e.g., whether a person indicated a regular diabetes provider), as well as both contextual and individual enabling or barrier characteristics, including the distance to provider and insurance status and type which characterize the means to access services available to an individual. We did not, however, have information on the process of medical care, such as the behavior of providers in the delivery of medical care (e.g., patient counseling, test ordering, and reminders of visits), which can also affect the use of health services and personal health behaviors.

In summary, our study has a number of potential implications for health care policy and research. First, the poorer glycemic control among those YYA without health insurance shines a light on the insufficiencies of the current health care system, the consequences of which will be amplified as this population of YYA with diabetes continues to age. Second, if replicated in other studies, the poorer glycemic control in YYA with state or federal versus private insurance needs to be better characterized, because solutions will differ widely depending on the root causes of this disparity. Lastly, even though lack of health insurance is the foremost reason for YYA with diabetes to not have a health care provider, future research should aim to understand the barriers to seeking care among those who have health insurance.

Conclusion

Our most recent work on the trends in diabetes incidence in youth suggests that substantial increases in the number of T1D and T2D youth in the US can be expected in the next forty years.[29,58] Despite vast improvements in treatments for diabetes, a large proportion of youth with diabetes fall short of achieving the current recommendations for glycemic control, a critical component in preventing serious, life-changing complications of disease.[14–17] Our study of health care access characteristics suggests a significant and clinically meaningful relationship between lack of health insurance, type of health insurance, having a regular provider and poor glycemic control, a measure that serves the dual purpose of indicating poor recent control of diabetes, as well as predicting risk of future complications. This work further underscores the importance of social determinants of health on diabetes management outcomes in youth and young adults.

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Abbreviations:

YYA	Youth and young adults
HbA_{1c}	Hemoglobin A_{1c}
T1D	Type 1 Diabetes Mellitus
T2D	Type 2 Diabetes Mellitus
ADA	The American Diabetes Association
DCCT	The Diabetes Control and Complications Trial
CVD	Cardiovascular diseases

US	United States
ACA	The 2010 Affordable Care Act
RUCAs	Rural-Urban Commuting Areas
ISPAD	International Society for Pediatric and Adolescent Diabetes
SES	Socioeconomic status
NCATS	National Center for Advancing Translational Sciences
NIH	National Institutes of Health

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Table 1.

Characteristics of 481 participants with Type 1 and Type 2 Diabetes of the SEARCH 3 Visit, South Carolina Site, 2012 −2015

Characteristics	Type 1 Diabetes n=389	Type 2 Diabetes n=92	All n=481
Demographic and Socioeconomic Characteristics			
Age, mean(SD)	16.8 (4.3)	21.7 (3.5)	17.7 (4.6)
Sex,%			
Male	44.5	32.6	42.2
Female	55.5	67.4	57.8
Race/ethnicity, %			
White	72.5	21.7	62.8
Non-White	27.5	78.3	37.2
Socioeconomic status[1], %			
Low	46.5	76.1	52.2
High	53.5	23.9	47.8
Urban Residence			
Non-urban	33.7	40.2	34.9
Urban	66.3	59.8	65.1
Clinical Characteristics			
Duration of DM, mean (SD)	95.3 (21.4)	95.0(21.8)	95.2 (21.4)
Medication type, %			
Pump	54.5	4.4	44.9
Insulin (not by pump) only	41.1	18.5	36.8
Insulin (not by pump) and pills	4.4	26.1	8.5
Pills only	---	30.4	5.8
None	---	20.6	4.0
BMI Z score, mean (SD)	0.6 (1.0)	1.9 (0.9)	0.8 (1.1)
HbA1c, %, mean (SD)	9.6 (1.9)	9.5 (3.0)	9.6 (2.2)
Glycemic control[2], %			
Optimal	8.2	31.5	12.7
Suboptimal	34.5	12.0	30.1
High risk	57.3	56.5	57.2
Access Characteristics			
Health insurance, %			
State/Federal	28.5	29.3	28.7
Private	65.6	37.0	60.1
Other/None	5.9	33.7	11.2
Regular health care provider indicated by participant, %			
Has Provider	87.4	57.6	81.7
Does not indicate provider	12.6	42.4	18.3
Type of regular health care provider, %			

Characteristics	**Type 1 Diabetes n=389**	**Type 2 Diabetes n=92**	**All n=481**
Specialist	71.2	31.5	63.6
Primary	16.2	26.1	18.1
None	12.6	42.4	18.3
Distance to healthcare provider[3], miles, mean (SD)	28.3 (26.2)	25.6 (25.9)	27.9 (26.1)

[1] Socioeconomic status (SES); Low SES = household income <$50,000/year and any parent education category, or parent education < bachelor's degree if income data were missing; High SES = household income >=$50,000/year and any parent education category, or parent education >= bachelor's degree if income data were missing

[2] Glycemic control levels: Optimal ; suboptimal ; high risk

[3] Distance is winzorized at 95th percentile (values at or above the 95th percentile are set to the value of the 95th percentile)

Table 2.

Association of health care access characteristics and HbA_{1C} from linear regression analyses South Carolina site, SEARCH 3 visit, 2012 – 2015

	Unadjusted			**Adjustment 1**			**Adjustment 2**		
Health care access characteristics	**b**	**SE**	***p***	**b**	**SE**	***p***	**b**	**SE**	***p***
Insurance Type (n=481)									
State/Federal vs. Private	1.211	0.216	<0.0001	0.804	0.216	0.0002	0.680	0.224	0.0025
None vs. Private	1.480	0.309	<0.0001	1.479	0.327	<0.0001	1.338	0.334	<0.0001
Regular healthcare provider indicated by participant (n=481)									
No vs. Yes	0.624	0.256	0.0149	0.563	0.260	0.0306	0.510	0.258	0.0484
Type of healthcare provider (n=481)									
Primary vs. Specialist	0.376	0.262	0.1526	0.460	0.246	0.0625	0.444	0.244	0.0696
None vs. Specialist	0.707	0.262	0.0071	0.716	0.272	0.0087	0.659	0.270	0.0150
Distance to healthcare provider, miles (n=392)	−0.005	0.004	0.2646	−0.006	0.004	0.1126	−0.006	0.004	0.1051

b: unstandardized regression coefficient

SE: Standard Error

Adjustment 1 = Health care access characteristic, urban vs. non-urban designation, age, sex, race/ethnicity, diabetes type, duration of diabetes, medication type

Adjustment 2 = Adjustment 1 + SES

Table 3.

Association of health care access characteristics and high risk glycemic control, South Carolina site, SEARCH 3 visit, 2012 – 2015

	High risk (>9.0% HbA_{1C}) vs. suboptimal and optimal (≤9.0% HbA_{1C}) glycemic control								
	Unadjusted			**Adjustment 1**			**Adjustment 2**		
Health care access characteristics	**OR**	**95%CI**	***p***	**OR**	**95% CI**	***p***	**OR**	**95% CI**	***p***
Insurance Type (n=481)									
State/Federal vs. Private	3.65	2.33–5.71	<0.0001	2.84	1.70–4.74	<.0001	2.43	1.43–4.15	0.0011
None vs. Private	4.85	2.40–9.78	<0.0001	7.62	2.79–20.81	<0.0001	6.34	2.31–17.41	0.0003
Regular healthcare provider indicated by participant (n=481)									
No vs. Yes	1.57	0.97–2.54	0.0683	1.41	0.78–2.61	0.2807	1.33	0.71–2.49	0.3685
Type of healthcare provider (n=481)									
Primary vs. Specialist	1.27	0.78–2.06	0.3336	1.36	0.78–2.36	0.2828	1.36	0.77–2.38	0.2899
None vs. Specialist	1.65	1.01–2.71	0.0467	1.55	0.82–2.96	0.1815	1.47	0.77–2.81	0.2469
Distance to healthcare provider, miles (n=392)	1.00	0.99–1.003	0.2498	0.99	0.98–1.002	0.1186	0.99	0.98–1.002	0.1093

OR: Odds Ratio

Adjustment 1 = Health care access characteristic, urban vs. non-urban designation, age, sex, race/ethnicity, diabetes type, duration of diabetes, medication type

Adjustment 2 = Adjustment 1 +