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Original Article

Contribution of income to self-management and health outcomes in pediatric type 1 diabetes

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Low income has been established as a risk factor for poorer outcomes in youth with type 1 diabetes; however, the effect of moderate income has not been studied. The purpose of this secondary analysis of baseline data from a multi-site study was to compare glycemic control, self-management, and psychosocial outcomes [depression, stress, and quality of life (QOL)] at different income levels in adolescents with type 1 diabetes. Youth ($n = 320$, mean age = 12.3 ± 1.1 , 55% female, 64% white, mean A1C = 8.3 ± 1.4) completed established self-management and psychosocial measures. A1C levels were collected from medical records. Caregivers reported annual family income, categorized as high ($> \$80K$), moderate ($\$40 - 80K$), or low ($< \$40K$). Youth from high-income families had significantly lower A1C (mean = 7.9 ± 1.2) than those from the moderate-income group (8.6 ± 1.7 , $p < 0.001$) or the low-income group (mean A1C = 8.6 ± 1.5 , $p = 0.003$). Youth from the high-income group reported significantly better diabetes problem solving and more self-management goals than those from the moderate- or low-income groups (both $p < 0.01$). Youth from the high-income group also reported significantly fewer symptoms of depression, lower levels of perceived stress, and better QOL than those in the moderate or low-income groups (all $p < 0.05$). Multivariate linear regression models were used to test psychological and behavioral predictors of A1C and QOL. Parents' education status ($p < 0.05$) and self-management activities ($p < 0.01$) were significant predictors of hemoglobin A1c, while income ($p < 0.01$) and self-management activities ($p < 0.05$) were significant predictors of QOL.

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Type 1 diabetes mellitus is a chronic metabolic disorder and is one of the most common chronic diseases in childhood (overall prevalence of 0.18% in children and adolescents) (1). Maintaining glycemic control reduces risk of acute and long-term complications (2, 3), but the literature demonstrates that many youth, and especially those from low-income families, have difficulty maintaining glycemic control (4). Low-income youth have poorer diabetes outcomes, including significantly worse glycemic control than their high-income peers (5). Several possible mechanisms that may explain poorer diabetes outcomes in low-income youth have been identified: lower education level of parents,

greater parental depressive symptoms, lower levels of acceptance from parents, greater family conflict, and less maternal knowledge about T1D have been associated with both lower income and poorer glycemic control (6–8). Low-income youth are also at greater risk for poorer quality of life (QOL) and poorer adherence to treatment regimens than high-income youth (9, 10).

Several other demographic factors have been implicated in diabetes outcomes, many of which are confounded with income. For example, studies show that household structure also has a significant impact on glycemic control (11) such that youth living in single-parent households are significantly more likely

to have poor glycemic control than those in two-parent households (12). In addition, youth living with their biological parents typically have significantly better glycemic control than those living in any types of alternative family arrangements (13). Youth living in single-parent households are more likely to be of lower income than youth in two-parent households (14), and household structure may, therefore, eclipse the effect of income on glycemic control (15). Race and ethnicity also play an important role in T1D disease management and may explain some of the disparities in health outcomes. For example, African American adolescents are often in poorer glycemic control and demonstrate lower adherence to treatment recommendations than their Caucasian counterparts (16–19). While Hispanic adolescents also appear to have an increased risk of poor glycemic control compared with Caucasian adolescents, they are typically in better glycemic control than African American adolescents (16, 20). Ethnic minorities have also been shown to have significantly lower income than non-minority families (20). The contribution of socioeconomic status and cultural differences underlying the increased risk of glycemic control in ethnic minorities still requires further analysis.

While several studies have demonstrated the link between income and glycemic control, and QOL, the mechanisms of these effects are still unclear. Increased stress may be an important factor to consider, because the ways in which adolescents cope with diabetes-related stress have been associated with poorer glycemic control (21, 22). Differences in self-management or adherence to treatment may also explain these differences, because self-management has been linked to glycemic control (23). In addition, little is known about moderate-income youth, who are susceptible to many of the factors which are suspected to impact the glycemic control of low-income youth. As a result, one aim of this study was to compare glycemic control (A1C), behavioral (self-management), psychosocial (stress, family conflict), and QOL outcomes of youth with T1D in low-, moderate-, and high-income families. A second aim of this study was to determine the degree to which demographic, behavioral, and psychosocial factors influenced glycemic control and QOL in youth with T1D in a multivariate model.

Methods

This study is a secondary analysis of baseline data from a randomized clinical trial; the aim of the larger study was to evaluate the effect of an internet-based coping skills training intervention on glycemic control (A1C), psychosocial adaptation (QOL), and family adaptation (conflict) compared with that of an internet-based

education intervention for adolescents with type 1 diabetes (24).

Participants and procedure

Adolescents aged 11–14 yr with type 1 diabetes were eligible for participation in the study if they had been diagnosed for at least 6 months, had no other serious medical conditions, were able to speak and write English, were school grade appropriate to age within 1 yr, and had access to high-speed internet at home, at school, or in the community (required for study intervention). Participants were identified from four university-affiliated outpatient clinical sites in the United States. From these sites, 541 adolescents were identified as eligible. Of these, 320 adolescents were consented in line with university Institutional Review Board requirements. The only significant differences in recruitment rates were income and race/ethnicity; Black, Hispanic, and biracial low-income youth passively refused participation at higher rates than white and higher income youth (25). Behavioral, psychosocial, and QOL data were collected online on a password-protected, study-specific Web site. A1C levels were collected from medical records.

Measures

Demographic. Parents completed a questionnaire on family demographics, including income, race/ethnicity, parent education, marital status, and gender. In our sample, low-income was defined as annual family income of \$40 000 USD or less, moderate-income was defined as \$40 000–\$79 999 USD, and high-income was defined as \$80 000 USD or greater. Race/ethnicity was categorized as white (non-Hispanic) or non-white. Participants who identified as Hispanic/Latino (18%), Black or African American (11%), more than one race (5%), or other (2%) were included in the non-white category. Parental education was categorized as less than high school, high school diploma, more than high school (e.g., some college or associate's degree), or college diploma. Marital status was categorized as married/partnered or single/divorced.

Glycemic control. Glycosylated hemoglobin (A1C) served as an objective measure of glycemic control over the most recent 8–12 wk and is routinely measured quarterly in patients with T1D. The American Diabetes Association suggests a target A1C level of 8% or below. In our sample, 80% of the analyses were performed using the Bayer Diagnostics DCA2000 Bayer, Tarrytown, NY, which has a normal range of 4.2–6.3% and provides results in 6 min using a fingerstick blood sample. Additional methods included Roche Tina-quant, immunoturbidimetry, and high

performance liquid chromatography. There were no significant differences between participants who were measured with the DCA 2000 Bayer, Tarrytown, NY and those who used different methods.

Psychosocial

Children's Depression Inventory. The Children's Depression inventory is a 26-item self-report questionnaire that measures depressive symptoms in youth. It is scored from 0 to 52, with higher scores reflecting more symptoms of depression (26, 27). The Cronbach's alpha was 0.90 in our sample.

Revised Diabetes Family Conflict Scale. The Revised Diabetes Family Conflict Scale is a 19-item questionnaire that measures the degree of diabetes treatment conflict between family members related to diabetes management activities (28). It is scored from 19 to 57, with higher scores indicating more conflict within the family. Diabetes conflict is rated on a 3-point scale: 1 = never argue, 2 = sometimes argue, and 3 = always argue; higher scores indicate greater conflict. The Cronbach's alpha was 0.87 in our sample.

Perceived Stress Scale. The Perceived Stress Scale is a 14-item measure, which characterizes the degree to which an individual appraises situations in his or her own life as stressful. The measure targets feelings of stress and hassles during the past month (29). For example, it assesses the extent to which participants found their lives to be unpredictable, uncontrollable, and overloaded (29). A five-point Likert scale ranging from 0 (never) to 4 (very often) is used to rate each item, with a range of 0–56; higher scores indicate greater perceived stress. The Cronbach's alpha was 0.80 in our sample.

Pediatric Quality of Life Instrument. The Pediatric Quality of Life instrument is a measure developed to evaluate QOL in children with chronic health conditions (30). We used the 28-item diabetes-specific QOL version, which includes five discrete subscales, including general diabetes QOL, general type 1 diabetes treatment QOL, specific type 1 diabetes treatment QOL, worry, and communication. The measure is scored on a scale of 0–100, where higher scores reflect better QOL. Health-related, diabetes specific QOL was analyzed in this study; the Cronbach's alpha was 0.90 in our sample.

Behavioral

Self-Management in Adolescents with Diabetes Questionnaire. The Self-Management in Adolescents with Diabetes questionnaire (SMOD-A) was used to assess self-management tasks and goals of adolescents with T1D (31). The self-report questionnaire consists

of 52-items, which comprise five subscales: collaboration with parents, diabetes care activities (e.g., how consistently the adolescent performs key management activities), diabetes problem solving (e.g., how well the adolescent adjusts regimen based on appropriate factors), diabetes communication (e.g., how effectively the adolescent communicates with parents, providers, and friends), and goals (e.g., how well the adolescent's ideas about diabetes converge with seven potential goals) (31). In this study, we used the following subscales: activities (Cronbach's alpha was 0.77 in our sample), collaboration (Cronbach's alpha was 0.85 in our sample), and goals (Cronbach's alpha was 0.75 in our sample) as indicators of self-management.

Data analysis

We conducted analyses of variance to test for group differences between low-, moderate-, and high-income families on several outcomes, including A1C levels, perceived stress, depressive symptoms, self-management and problem solving, goal setting, and QOL. Post hoc analyses were conducted to examine mean differences between income categories. To control for multiple comparisons and limit type 1 error, we used Bonferroni corrections. Linear regression analyses were used to determine the effect of income and other psychological/behavioral factors on A1C and QOL after adjusting for potential confounds (race, parent education, and marital status).

Results

Our sample included 36% non-white participants, 55% female, 22% low-income, 28% moderate-income, 50% high-income. Mean A1C was 8.3 ($\pm 1.4\%$). Additional sample characteristics are included in Table 1.

As hypothesized, we found a significant effect of income on glycemic control, perceived stress, depressive symptoms, self-management, problem solving, and QOL in the univariate analyses (see Table 2). Youth in low- and moderate-income families had significantly higher A1C ($p < 0.01$), greater perceived stress ($p < 0.01$), and greater depressive symptoms ($p < 0.05$) than youth from high-income families. In addition, youth in low- and moderate-income families reported significantly lower self-management goals ($p < 0.01$), lower problem solving ($p < 0.01$), and decreased diabetes QOL ($p < 0.05$). As depicted in Fig. 1, there were no significant differences between low- and moderate-income youth on any of the outcomes. We also found significant effects for parental education; youth whose parents had a high school degree or less had significantly higher A1C ($p < 0.01$) and lower use of problem solving ($p < 0.001$) than youth whose parents had more education. See Table 3.

Table 1. Characteristics of study participants (n = 320)

Characteristic	N (%) or mean (SD)
Gender	
Male	143 (45%)
Female	177 (55%)
Race/ethnicity*	
White non-Latino	204 (64%)
Non-white	114 (36%)
Age	12.3 ± 1.1
Parent marital status*	
Single parent	24 (8%)
Married/partnered	251 (79%)
Divorced/separated	34 (11%)
Parent 1 education*	
<12 yr	15 (5%)
12 yr	85 (27%)
> 12 yr	214 (67%)
Parent 2 education*	
<12 yr	3 (1%)
12 yr	76 (24%)
> 12 yr	163 (51%)
Therapy type	
Conventional injections*	49 (15%)
Basal injections	78 (24%)
Pump therapy	182 (57%)
Income	
<\$40 000	70 (22%)
\$40 000–\$79 999	90 (28%)
\$80 000+	160 (50%)

*Missing values.

The multivariate linear regression model predicting A1C was significant ($F(300,9) = 4.68$, $p < 0.01$), explaining 13% of the variance in A1C ($R^2 = 0.13$). In the final model, parents' education status ($p < 0.05$) and self-management activities ($p < 0.01$) were the only significant predictors of hemoglobin A1c. See Table 4.

Similarly, the multivariate linear regression model predicting diabetes QOL was significant ($F(302,9) = 17.68$, $p < 0.05$), explaining 35% of the variance in diabetes-related QOL ($R^2 = 0.35$). In the final model, income ($p < 0.01$) and self-management activities ($p < 0.05$) were significant predictors of diabetes QOL (see Table 4).

Table 2. Univariate analyses with income – mean (SD)

	Low-income	Moderate-income	High-income
A1C	8.60 (1.55)*	8.67 (1.75)*	7.95 (1.16)
Depressive symptoms	8.30 (7.04)*	7.42 (7.78)*	5.25 (7.12)
Family conflict	27.33 (7.19)	26.51 (4.91)	25.59 (5.28)
Perceived stress	23.79 (8.74)*	22.87 (7.76)*	19.45 (7.31)
Quality of life	78.81 (12.76)*	78.78 (11.82)*	82.52 (9.72)
Responses to stress	1.98 (0.83)	2.02 (0.70)	1.91 (0.74)
Self-management: activities	32.10 (5.70)*	30.84 (5.81)*	33.11 (5.56)
Self-management: goals	14.91 (2.59)*	15.34 (2.86)*	16.07 (2.68)
Self-management: problem solving	12.57 (4.23)*	13.81 (4.11)*	15.74 (3.10)

*Significant differences between high-income and other groups.

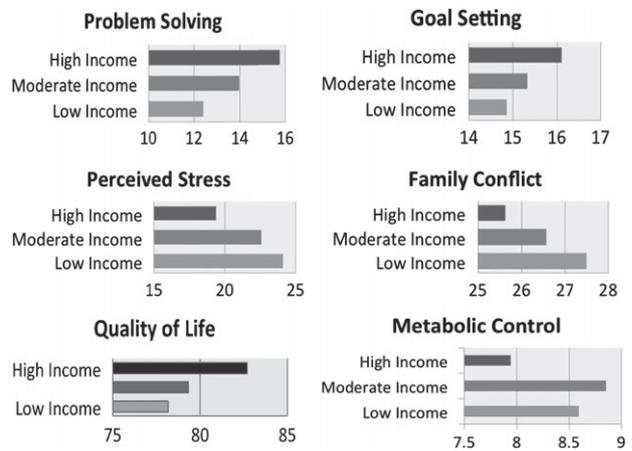


Fig. 1. Univariate analyses.

Discussion

In this study, we examined the differences in health outcomes in low-, moderate-, and high-income families in a representative sample of adolescents with T1D. We found that youth from low- and moderate-income families were at risk for poorer health outcomes compared with those from high-income families. Notably, youth from moderate-income families appear to be challenged with T1D care as much as those from low-income families.

In our sample, moderate-income youth were more similar to low-income youth with regard to glycemic control, perceived stress, depressive symptoms, self-management activities, problem solving, and QOL compared with high-income youth. T1D requires a complex treatment regimen; considerable financial resources appear to be important for optimal psychosocial, behavioral, and clinical outcomes. Our results suggest that the increased financial resources available to moderate-income youth maybe still be insufficient to significantly improve upon diabetes outcomes experienced by low-income youth. A possible explanation for these findings may be that moderate-income families are more likely than high-income families to have a single parent or two working

Table 3. Univariate analyses of parental education – mean (SD)

	Less than high school	High school degree	More than high school
A1C	9.17 (1.80)*	8.63 (1.68)*	8.10 (1.35)
Depressive symptoms	7.00 (5.46)	7.25 (7.80)	5.78 (6.92)
Family conflict	26.33 (5.89)	26.77 (5.96)	26.00 (5.74)
Perceived stress	23.87 (7.53)	22.46 (7.58)	20.60 (7.96)
Quality of life	76.52 (13.94)	80.16 (11.79)	81.62 (10.36)
Self-management: activities	33.47 (5.83)	32.04 (5.78)	32.38 (5.65)
Self-management: goals	14.27 (3.06)	15.35 (2.86)	15.88 (2.64)
Self-management: problem solving	11.13 (4.52)*	13.76 (3.77)*	14.96 (3.81)

*Significant differences between highest education and other groups.

Table 4. Multivariate analyses (p-value)

	A1C Beta (p-value)	QOL Beta (p-value)
Demographic		
Income (\$80 000+ vs. <\$80 000)	−0.09 (0.24)	−0.01 (0.86)
Race (White vs. non-white)	−0.04 (0.56)	−0.04 (0.42)
Parent education	−0.14 (0.04)	0.05 (0.38)
Marital status (partnered vs. single parent)	0.20 (0.77)	0.06 (0.28)
Gender (male vs. female)	0.03 (0.64)	0.05 (0.36)
Therapy type (pump vs. injection)	−0.09 (0.11)	−0.04 (0.41)
Psychological		
Perceived Stress Scale (PSS)	0.06 (0.32)	−0.51 (0.00)
Family Conflict (DFC)	−0.03 (0.59)	−0.05 (0.33)
Behavioral		
SMOD activity	−0.2 (0.01)	0.13 (0.02)

QOL, quality of life; SMOD, Self-Management in Adolescents with Diabetes questionnaire.

parents (32), which could result in less parental supervision and support for diabetes management. In our sample, marital status was significantly different across low-, moderate-, and high-income groups. Because the recommended diabetes treatment regimen is complex, family support for adolescents' diabetes self-management is critical to maintaining glycemic control (33).

Parents' education status and self-management activities were significantly associated with A1C levels in our sample. Interestingly, income was not a significant predictor of A1C, after adjusting for other demographic and psychosocial variables. A likely connection between parent education and self-management is that parents are still primarily responsible for T1D self-management in the early childhood period; thus, parental educational level may impact how well parents are able to complete complicated aspects of T1D self-management tasks, such as adjustments to insulin dose. Parent and child collaboration with T1D self-management and a gradual transfer of responsibility from parent to

child have been identified as essential to independent adolescent self-management (34, 35). Therefore, parental education may affect self-management more than family income because parents who are able to manage successfully diabetes treatment foster an environment for better disease maintenance and improved A1C.

Surprisingly, family conflict and perceived stress were not significant correlates of A1C levels as they have been shown to be associated with glycemic control in adolescents (33, 36). It is possible that if parents are able to maintain a role in diabetes management with a gradual transfer of responsibility to the child during the developmental phase of early adolescence, family conflict and stress may be minimized; a slow transition to independent diabetes management to the child likely decreases the stress placed on the child. It is also important to recognize that only 13% of the variance for A1C levels was explained by this model. Other factors, such as family support, peer relations, daily insulin dose, and adolescent body mass index have been shown to be associated with A1C in adolescents with T1D and were not evaluated in this study (37, 38).

Our multivariate model of QOL explained a significant amount of variance (35%) and indicated that income and self-management activities were significantly associated with QOL. A possible explanation of this finding may be that youth from higher income families have additional support and resources available to them for their diabetes care, and therefore disease maintenance does not negatively affect their QOL in the same way as it does for families with fewer resources. Similar to glycemic control, adolescents' report of greater self-management activities were significantly associated with QOL, suggesting that adolescents who are comfortable managing their diabetes do not perceive it as interfering with their lives. On the other hand, greater perceived stress was associated with poorer QOL, indicating that youth may benefit from support in identifying and using adaptive coping strategies. Contrary to previous research (39, 40), we did not find significant differences related to marital status in

either of our multivariate analyses, after controlling for race/ethnicity and income.

Strengths of our study include the large, relatively diverse sample, which included 320 participants, 36% of whom were non-white, representative of T1D prevalence rates nationally. The primary limitation was that adolescents in our sample were in relatively good glycemic control (mean A1C = 8.3 ± 1.4) and of a similar age range (11–14). Adolescents in poorer glycemic control and older adolescents are at a higher risk for poor health outcomes; therefore, it is important to understand if income uniquely affects health outcomes in this population. In addition, it is important to note that these data were conducted from 2008 to 2011, a time of economic downturn in the United States.

Another important limitation of our study was the dichotomous categorical comparison of race, white and non-white. While our study garnered a diverse population, our sample size was not large enough to provide us with enough power to further categorize race. We recognize that there are important cultural differences between the individuals in our population that were a part of the non-white category, a nuance that was lost in our analysis. As a result, future research that further parses apart the role of race/ethnicity in income categories is indicated.

A further limitation is the income categorization that we used in our analyses. To our knowledge, there is no standard consensus on what constitutes ‘middle income’. Based on the 2012 US Department of Health and Human Services Poverty Guidelines, a family of five with an income of \$27 010 would be considered ‘low income’ (41). Additionally, the median income in the United States in 2012 was \$51 371; and state estimates ranged from \$71 122 in Maryland to \$37 095 in Mississippi (42). Therefore, estimates of ‘middle class’ income ranges vary. We determined our categories based on the data were collected and extrapolating from available information about income categorization.

In conclusion, adolescents in moderate-income families may require additional attention aimed at optimizing behavioral, psychosocial, and clinical elements in order to improve health outcomes. Our results suggest that moderate-income youth are equally vulnerable to poor T1D outcomes related to stress, depression, self-management, problem solving, and QOL as low-income youth. Our results indicate that the most important contributors to poor A1C in our population were parents’ education status and self-management activities; similarly, the most important contributors to poor QOL in our population were income and self-management activities. These results suggest that behavioral interventions targeting improved self-management activities and psychosocial

interventions that target moderate-income families to the same extent as low-income families are targeted may significantly impact the A1C and QOL in moderate-income youth with T1D.

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