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Technology use and clinical outcomes in a racial-ethnic minority cohort of children and adolescents with Type 1 diabetes

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Abstract

Objectives: Technology use has been shown to improve diabetes control, but minority youths tend to have low rates of technology use and exhibit suboptimal glycemic control. We examined the impact of continuous glucose monitors (CGM) and continuous subcutaneous insulin infusion (CSII) on glycemic control in a racial-ethnic minority cohort of children and adolescents with type 1 diabetes (T1D).

Methods: A cross-sectional study was conducted among 140 pediatric T1D patients seen at a multidisciplinary clinic. From January to November 2022, data on demographics and glycated hemoglobin (HbA_{1c}) levels were collected. Patients were categorized as technology (CGM, CSII, or both) or non-technology users (finger stick meter (FS) and multiple daily injections (MDI)).

Results: The majority identified as Hispanic (79 %) and had public health insurance (71 %). Sixty-nine percent used technology. Compared with non-technology users, technology users had significantly lower mean HbA_{1c} levels (9.60 vs. 8.40 %, respectively) (p=0.0024), though no group (CGM + CSII, CGM + MDI, FS + CSII, and FS + MDI) achieved a mean HbA_{1c} level of <7.0 %. Regarding minority status, no significant differences in mean HbA_{1c} levels existed between Hispanics and Blacks in the CGM + MDI and FS + CSII groups (p=0.2232 and p=0.9224, respectively). However, there was a significant difference in mean HbA_{1c} levels between Hispanic and Black non-technology users (9.19 vs. 11.26 %, respectively) (p=0.0385).

Conclusions: Technology users demonstrated better glycemic control than non-technology users. Further research is needed to investigate factors affecting glycemic control in minority youths with T1D.

Keywords: disparities; minorities; technology; Type 1 diabetes

Introduction

Type 1 diabetes (T1D) affects over 1.2 million youths (<20 years) around the globe [1]. In the United States, 83 % of children and adolescents with T1D fail to achieve the American Diabetes Association's (ADA's) recommended glycated hemoglobin (HbA_{1c}) level of <7.0 % [2]. If left untreated, hyperglycemia can lead to cardiovascular disease, peripheral vascular system damage, eye disease, neuropathy, and nephropathy [3]. Life-threatening complications can lead to premature death but can be delayed or prevented if T1D is effectively managed.

Glycemic control is the central focus of diabetes management. As such, advances in diabetes technologies for the management of T1D have been made in recent years to improve glycemic control and quality of life [4, 5]. The use of diabetes technologies, defined as continuous glucose monitors (CGM) and continuous subcutaneous insulin infusion (CSII), is linked to lower HbA_{1c} levels [6, 7]. Furthermore, pediatric patients who use both technologies demonstrate lower HbA_{1c} levels than those who use only one [6].

Youths of racial and ethnic minorities with T1D exhibit worse clinical outcomes than their non-Hispanic White (White) counterparts [8, 9], rendering it essential to understand the unique challenges of this population. Disparities in the treatment and outcomes of youths with T1D have been described at the national level [10]. Between 2006 and 2016, CSII use was 29 % in Black, 36 % in Hispanic, and 65 % in White youths with T1D, with minorities having the worst glycemic control [11]. A cross-sectional study among pediatric patients

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with T1D showed that 71 % of White patients used CSII and 76 % used CGM, whereas only 16.6 % of Hispanic patients used CSII and 10.8 % used CGM [12]. Socioeconomic factors, like health insurance status, are associated with clinical outcomes of T1D [13, 14]. Compared to youths with T1D and private health insurance, those with T1D and public health insurance exhibited worse glycemic control and a higher prevalence of risk factors for cardiovascular disease [15].

Time in range (TIR) has emerged as a valuable metric for assessing glycemic control and enhancing diabetes management. In a comprehensive analysis of 18 articles, a study revealed a strong inverse association between paired HbA_{1c} and TIR metrics, suggesting that TIR could be the preferable metric for evaluating clinical outcomes [16].

This study aims to compare clinical outcomes based on treatment modalities in a racial-ethnic minority cohort of youths with T1D.

Materials and methods

This cross-sectional chart review was approved by the Institutional Review Board of Nicklaus Children's Hospital and was conducted in accordance with ethical principles for medical research.

We evaluated the use of technologies and their impact on glycemic control among 140 pediatric patients (<21 years of age) with T1D who were seen at a multidisciplinary clinic from January to November 2022. Clinicians encouraged the use of diabetes technologies during all encounters and assisted patients with diabetes education.

Demographic information, health insurance status, technology usage, and glycemic control were extracted from electronic medical records for analysis. Self-reported race/ethnicity was categorized as Hispanic, Black, or White. Patients were classified as technology users if they used CGM + CSII, CGM and multiple daily injections (MDI), or finger stick meter (FS) and CSII. Patients using FS + MDI were categorized as non-technology users. Glycemic control was assessed by measuring HbA_{1c} levels. The paired metrics of HbA_{1c} and TIR were evaluated for CGM users who had accessible CGM data.

Two-sample t-tests were conducted to compare the mean ages of technology and non-technology users, to examine the mean HbA_{1c} levels of technology and non-technology users, as well as to assess potential disparities in mean HbA_{1c} levels between minority groups (Hispanic and Black). Chi-squared tests were used to examine potential associations between technology usage and multiple categorical variables, namely sex, race/ethnicity, and health insurance status. A Pearson correlation coefficient was calculated to determine whether there was a relationship between paired HbA_{1c} levels and TIR for CGM users.

Results

We analyzed data of 140 youths with T1D among the ages of 4–20 years (Table 1). Sixty-four (46 %) patients were female, and 76 (54 %) were male. One-hundred and eleven (79 %) patients identified as Hispanic, 23 (17 %) were Black, and 6 (4 %) were White. Ninety-nine (71 %) patients had public health insurance, 36 (25 %) had private health insurance, and 5 (4 %) were uninsured. Ninety-seven (69 %) patients were technology users (CGM and/or CSII). Twenty-seven (19 %) patients achieved the ADA's recommended HbA_{1c} level of <7.0 %. Thirty-five patients had HbA_{1c} levels within 7.1–8 %, 24 (17 %) had levels within 8.1–9 %, and 54 (39 %) had levels >9 %.

Table 1: Demographics and clinical outcomes of technology vs. non-technology users.

	Technology users	Non-technology users	p-Value
n	97	43	N/A
Age, years	12.97 ± 3.25	14.09 ± 3.56	0.0700
Sex			0.0868
Female	49 (51 %)	15 (35 %)	
Male	48 (49 %)	28 (65 %)	
Race/Ethnicity			0.5035
Hispanic	78 (80 %)	33 (77 %)	
Black	14 (15 %)	9 (21 %)	
White	5 (5 %)	1 (2 %)	
Health insurance			0.8213
Public	69 (71 %)	30 (70 %)	
Private	24 (25 %)	12 (28 %)	
Uninsured	4 (4 %)	1 (2 %)	
HbA1C			0.0024
<7 %	20 (21 %)	7 (16 %)	
7.1–8 %	27 (28 %)	8 (19 %)	
8.1–9 %	17 (17 %)	7 (16 %)	
>9 %	33 (34 %)	21 (49 %)	

The majority of users had public health insurance and were Hispanic (Table 2). Thirteen percent of the CGM + CSII, 25 % of the CGM + MDI, 27 % of the FS + CSII, and 16 % of the FS + MDI groups achieved the ADA's recommended HbA_{1c} level of <7.0 %.

Compared to non-technology users, there were significant differences in mean HbA_{1c} levels between both groups of CGM users but not FS + CSII users (Table 3). There were no significant differences in mean HbA_{1c} levels between Hispanics and Blacks in the CGM + MDI and FS + CSII groups, but there was a significant difference in mean HbA_{1c} levels between Hispanic and Black non-technology users (Table 4).

TIR data were accessible for 28 CGM + CSII users (adherence mean of 86 %) and 35 CGM + MDI users (adherence mean of 80 %). There were strong inverse associations between HbA_{1c} levels and TIR for both CGM + CSII users and CGM + MDI users (R=−0.81 and R=−0.52, respectively).

Table 2: Glycemic Control based on technology use, race, and health insurance status.

	Technology users			Non-technology users
	CGM + CSII	**CGM + MDI**	**FS + CSII**	**FS + MDI**
n	38	48	11	43
HbA_{1C}				
<7 %	5 (13 %)	12 (25 %)	3 (28 %)	7 (16 %)
7.1–8 %	18 (47 %)	9 (19 %)	0 (0 %)	8 (19 %)
8.1–9 %	4 (11 %)	9 (19 %)	4 (36 %)	7 (16 %)
>9 %	11 (29 %)	18 (37 %)	4 (36 %)	21 (49 %)
Average HbA_{1c}	8.06 % ± 1.25 %	8.53 % ± 1.98 %	9.13 % ± 2.59 %	9.60 % ± 2.66 %
Race				
Hispanic	36 (95 %)	35 (73 %)	7 (64 %)	33 (77 %)
Black	0 (0 %)	11 (23 %)	3 (27 %)	9 (21 %)
White	2 (5 %)	2 (4 %)	1 (9 %)	1 (2 %)
Insurance				
Public	25 (66 %)	34 (71 %)	10 (91 %)	30 (70 %)
Private	13 (34 %)	10 (21 %)	1 (9 %)	12 (28 %)
uninsured	0 (0 %)	4 (8 %)	0 (0 %)	1 (2 %)

Table 3: Glycemic control based on technology use.

			Technology users compared to non-technology users
p-Value			0.0024
	Each technology user group compared to non-technology users		
	CGM + CSII	**CGM + MDI**	**FS + CSII**
p-Value	0.0016	0.0296	0.6014

Table 4: Glycemic control based on technology use and minority (Hispanics vs. Blacks).

	Technology users		Non-technology users
	CGM + MDI	**FS + CSII**	**FS + MDI**
n	46	10	42
HbA_{1c}			
Hispanic	8.33 ± 1.65	9.13 ± 2.72	9.19 ± 2.65
Black	9.19 ± 2.93	9.33 ± 3.33	11.26 ± 2.23
p-Value	0.2232	0.9224	0.0385

Discussion

This study compared clinical outcomes based on treatment modalities in a racial-ethnic minority cohort of youths with T1D. Both technology and non-technology groups consisted primarily of Hispanic individuals with public health insurance. Our findings revealed a significant adoption of technology among the minority population, which was associated with improved glycemic control.

Previous studies have highlighted disparities in the usage of diabetes technologies among racial and ethnic groups [17–20]. One cross-sectional study demonstrated that White children are 1.5–3 times more likely than Hispanic children and 3–6 times more likely than Black children to use CGM [19]. However, within our cohort, a substantial proportion of minority individuals utilized technology, with 70 % of Hispanics and 61 % of Blacks compared to 80 % of Whites, suggesting progress in reducing disparities. Our study found a significant difference in mean HbA_{1c} levels between technology and non-technology users (8.40 vs. 9.60 %, respectively) (p=0.0024), indicating that technology use in diabetes management contributes to improved glycemic control. By emphasizing the higher utilization rates of technology use among minority individuals and its association with improved glycemic control, our study underscores the importance of addressing disparities in access to diabetes technologies.

Our study also investigated the impact of minority status (Hispanic and Black) on glycemic control outcomes within specific technology use groups. In the CGM + MDI and

FS + CSII groups, there were no significant differences in mean HbA_{1c} levels between Hispanics and Blacks (p=0.2232 and p=0.9224, respectively), showing that technology use had a similar effect on glycemic control regardless of minority status. This suggests that technology may have the potential to serve as an equalizer in diabetes care.

However, the study did identify a significant difference in mean HbA_{1c} levels between Hispanic and Black non-technology users (9.19 vs. 11.26 %, respectively) (p=0.0385). This finding indicates that there may be disparities in glycemic control outcomes based on minority status when technology is not utilized.

Among the 3 technology groups examined, CGM + CSII exhibited the lowest mean HbA_{1c} levels. This observation is consistent with the results of a prior study [6], which indicated that pediatric patients utilizing both technologies achieved lower HbA_{1c} levels compared to those using one alone. Our study provided further support for previous research [21–23] by confirming the existence of an inverse association between HbA_{1c} levels and TIR.

However, it is important to note that none of the groups, irrespective of technology use and race/ethnicity, achieved a mean HbA_{1c} level of <7.0 %. Interestingly, despite the CGM + CSII group demonstrating the most favorable mean HbA_{1c} levels, this group had the lowest proportion of individuals who achieved an HbA_{1c} level <7.0 %. A plausible explanation for the low proportion is that the majority of patients in the CGM + CSII group did not use hybrid closed loop systems.

Several limitations in our study should be considered. One limitation is the imbalanced representation of ethnic groups, with a disproportionate number of Black and White patients compared to Hispanic patients. This ethnic predominance may have influenced the findings related to elevated HbA_{1c} levels despite the high rates of technology use observed.

As socioeconomic status (SES) can affect the availability of resources necessary for effective diabetes management, another limitation of this study is the lack of a systematic method to assess the SES of each patient and subsequently pair this information with HbA_{1c} levels. The impact of SES on nutrition and diabetes management is often compounded by various psychological factors. Individuals from disadvantaged socioeconomic backgrounds may experience higher levels of stress, which can affect their eating habits and thereby their glycemic control [24].

Psychological distress, such as depression and anxiety, can have detrimental effects on diabetes management in young individuals [25, 26]. According to the Juvenile Diabetes Research Foundation, adolescents with T1D are 5 times more likely to suffer from depression than adolescents without T1D. Furthermore, eating disorders are prevalent among individuals with T1D, with a 2–3 fold increase compared to those without T1D [27]. Disordered eating behaviors that lead to insulin misuse for weight management negatively affect diabetes control [27]. As such, another limitation is the absence of data regarding the aforementioned factors.

Given that the results of this study may not fully encompass the unique experiences and outcomes of minority patients regarding glycemic control, it is essential to conduct additional evaluations that consider socioeconomic and psychological factors contributing to suboptimal glycemic control. Continued efforts to address disparities in access to diabetes technologies and to investigate the impact of socioeconomic and psychological factors on diabetes management are crucial for optimizing care and reducing the burden of T1D for patients and their families, particularly those from racial-ethnic minorities.

Research ethics: The Declaration of Helsinki was adequately addressed.

Informed consent: Not applicable.

Ethical approval: The local Institutional Review Board deemed the study exempt from review.

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