

## BRIEF REPORT



WILEY

# Evaluation of HbA1c and glucose management indicator discordance in a population of children and adolescents with type 1 diabetes

Claudia Piona<sup>1</sup> | Marco Marigliano<sup>1</sup> | Enza Mozzillo<sup>2</sup> | Francesca Di Candia<sup>2</sup> | Angela Zanfardino<sup>3</sup> | Dario Iafusco<sup>3</sup> | Giulio Maltoni<sup>4</sup> | Stefano Zucchini<sup>4</sup> | Elvira Piccinno<sup>5</sup> | Claudio Maffei<sup>1</sup>

<sup>1</sup>Department of Surgery, Dentistry, Gynecology and Pediatrics, Section of Pediatric Diabetes and Metabolism, University and Azienda Ospedaliera Universitaria Integrata of Verona, Verona, Italy

<sup>2</sup>Regional Center of Pediatric Diabetes, Department of Translational and Medical Sciences, Section of Pediatrics, Federico II University, Naples, Italy

<sup>3</sup>Regional Center of Pediatric Diabetology "G. Stoppoloni" - University of Campania "Luigi Vanvitelli", Naples, Italy

<sup>4</sup>Pediatric Unit, IRCCS Azienda Ospedaliero-Universitaria di Bologna, Bologna, Italy

<sup>5</sup>Metabolic Disorder and Diabetes Unit, "Giovanni XXIII" Children Hospital, Bari, Italy

## Correspondence

Marco Marigliano, Department of Surgery, Dentistry, Gynecology and Pediatrics, Section of Pediatric Diabetes and Metabolism, University and Azienda Ospedaliera Universitaria Integrata of Verona, Verona, Italy.  
Email: marco.marigliano@univr.it

## Abstract

**Background:** Glucose management indicator (GMI) is a useful metric for the clinical management of diabetic patients using continuous glucose monitoring (CGM). In adults, a marked discordance between HbA1c and GMI has been reported. To date, no studies have evaluated this discordance in children/adolescents with type 1 diabetes (T1D).

**Methods:** HbA1c and real-life CGM data of the 12 weeks preceding HbA1c measurement were collected from 805 children/adolescents. The absolute difference between HbA1c and GMI was calculated for both the 12-week and 4-week periods preceding HbA1c measurement and the proportion of discordant patients was defined according to specific thresholds in the entire study population and in subjects stratified by type of CGM, insulin therapy, gender, age and puberty. Regression analyses were performed with HbA1c-GMI discordance as dependent variable and patients' characteristics as independent ones. A new GMI equation for children and adolescent was derived from the linear regression analysis between mean glucose and HbA1c.

**Results:** HbA1c-GMI discordance calculated on the 12-week period was  $<0.1$ ,  $\geq 0.5$  and  $\geq 1.0$  in 24.8, 33.9 and 9.2% of the subjects, respectively. No significant differences in the proportion of discordant patients were found comparing patients stratified by type of CGM, insulin therapy, gender, age and puberty. GMI-HbA1c discordance was not significantly explained by age, gender, BMI, type of CGM, insulin therapy, hemoglobin, anemia and autoimmune diseases ( $R^2 = 0.012$ ,  $p = 0.409$ ). HbA1c-GMI discordance calculated on the 4-week period was comparable. GMI (%) equation derived for this cohort was:  $3.74 + 0.022x$  (mean glucose in mg/dl).

**Conclusions:** GMI could be meaningfully discordant respect to HbA1c in more than a third of children/adolescents with T1D. This discrepancy should be taken into careful consideration when the two indices are directly compared in daily clinical practice.

## KEYWORDS

children and adolescents, continuous glucose monitoring, glucose management indicator, HbA1c, type 1 diabetes

## 1 | INTRODUCTION

In recent years, glucose management indicator (GMI) has emerged as a useful metric for the clinical management of patients with diabetes using continuous glucose monitoring (CGM).<sup>1</sup> This metric is calculated from the mean glucose value using an equation derived from HbA1c and CGM data of four clinical trials.<sup>2</sup> These trials included subjects using Dexcom G4 and G5 sensors with a wide range of age and affected by both type 1 and type 2 diabetes. Data about the discordance between laboratory measured HbA1c and GMI have been firstly reported by the authors of GMI equation, and more recently by Perlman et al who conducted a real-world analysis demonstrating that a substantial discordance can be found in 50% of adult patients.<sup>3</sup>

To the best of our knowledge, nowadays no studies have evaluated this discordance in pediatric subjects with type 1 diabetes (T1D) analyzing real-world data. The aims of this study were to test, in a large cohort of children and adolescents, the hypothesis that HbA1c and GMI are discordant, to identify potential factors affecting the discrepancy and to derive a (specific) GMI equation for pediatric patients.

## 2 | RESEARCH DESIGN AND METHODS

Eight hundred and five children and adolescents with T1D were consecutively enrolled in five Regional Centers for Pediatric Diabetes in Italy. Inclusion criteria were: age between 2 and 18 years (both inclusive); diagnosis of T1D for at least 1 year; at least 6 months of current use of intermittently scanned CGM device (isCGM, Abbott FreeStyle Libre<sup>®</sup> Glucose Monitoring System) or real-time CGM device (rtCGM, Dexcom G5<sup>®</sup> CGM System or Dexcom G6<sup>®</sup> CGM System). Exclusion criteria were switching from multi-daily injections (MDI) to continuous subcutaneous insulin infusion (CSII) or vice versa within the last 6 months; insulin therapy with CSII with automated insulin delivery systems; diagnosis of glucose-6-phosphate dehydrogenase deficiency (G6PDD) and/or hemoglobinopathies (i.e., thalassemia, Sickle cell disease).

The study protocol was approved by the Institutional Ethics Committee of the participating Centers and all participants and their parents provided written informed consent.

During the enrolment visit, the following clinical and demographic parameters were recorded: age of onset and duration of T1D; gender; anthropometric measurements (height and weight); pubertal status (Tanner stages I-V),<sup>4</sup> type of CGM device, type of insulin therapy and daily insulin dosages; HbA1c measured using DCA Vantage<sup>®</sup> Analyzer; diagnosis of celiac disease, Hashimoto's thyroiditis, other autoimmune diseases and/or other significant concomitant systemic chronic diseases. In addition, the value of Hemoglobin concentrations (g/L) measured on the same day of HbA1c was collected and used to establish the diagnosis of anemia according to age-specific cut-off as defined WHO guidelines.<sup>5</sup> Mean glucose concentration was calculated from CGM data collected from the 12 weeks and the 4 weeks preceding the HbA1c measurement. In order to ensure an adequate amount of

data, participants were included in the analysis if at least 80% of expected CGM readings were available. GMI was calculated according to the equation derived from adult subjects with T1D:  $GMI (\%) = 3.31 + 0.02392 * \text{mean glucose concentration (mg/dl)}$ .<sup>2</sup>

Kolmogorov–Smirnov test was used to assess normal distribution of variables. Skewed variables were transformed (natural log transformed or square root transformed, if and as needed) to correct for non-Gaussian distribution. Descriptive statistics are reported as mean (SD) for continuous variables normally distributed and as median and interquartile range for data with non-normal distribution. Categorical data are presented as absolute frequencies (n) and percent values (%), unless otherwise specified.

The absolute difference between HbA1c and GMI was calculated for each patient for both the 12- and 4-week periods and this difference was reported as HbA1c-GMI discordance. The absolute values of HbA1c-GMI discordance were categorized according to several thresholds (i.e., <0.1, ≥0.1, ≥0.2, ≥0.3, ≥0.4, ≥0.5, ≥0.6, ≥0.7, ≥0.8, ≥0.9, ≥1.0) in order to define the proportion of patients who were discordant in entire study population and also in subgroups of patients stratified according to the type of CGM device (isCGM and rtCGM), insulin therapy administration (MDI and CSII), gender, age (age groups: 2–8, 8.1–12, 12.1–18 years) and pubertal status (prepubertal, pubertal, postpubertal). The comparison of the proportion of patients who were discordant between subgroups was performed categorizing patients in 11 subgroups according to the value of HbA1c-GMI discordance (i.e., <0.1, 0.1–0.2, 0.21–0.3, 0.31–0.4, 0.41–0.5, 0.51–0.6, 0.61–0.7, 0.71–0.8, 0.81–0.9, 0.91–1.0, >1.0) and using multiple Chi-square test.

Moreover, the discordance between HbA1c and GMI calculated on the 12-week sampling period was evaluated using Bland–Altman Plots (HbA1c-GMI discordance plotted on the y-axis and the average of HbA1c and GMI value plotted on the x-axis).

Multiple regression and logistic regression analyses were performed with the value HbA1c-GMI discordance (continuous) and HbA1c-GMI discordance ≥0.1, ≥0.5 and ≥1.0 as the dependent variables, respectively. The factors that could contribute to explain this difference [i.e., age, gender, BMI (continuous), CGM device (isCGM vs. rtCGM), insulin therapy administration (MDI vs. CSII), hemoglobin (continuous), anemia (present vs. absent), autoimmune diseases (present vs. absent)] were considered as independent variables.

Moreover, in a subsample of 271 patients, in order to perform a second evaluation of HbA1c-GMI discordance, an analog analysis was run between the HbA1c measured during the visit immediately following the enrolment and the CGM data collected in the 12 weeks preceding the HbA1c measurement. HbA1c-GMI discordance and the proportion of patients who were discordant for this second visit were compared to those calculated for the enrolment visit using paired-samples *t*-test and McNemar test (marginal homogeneity tests), respectively.

GMI equation was derived from the linear regression analysis between HbA1c value and mean glucose concentration calculated from CGM data collected from the 12 weeks preceding the HbA1c measurement.

**TABLE 1** Characteristics of the entire study population and of subgroups of patients according to the type of CGM device used and insulin therapy administration

	Overall (n = 805)	Type of CGM			Insulin therapy		
		isCGM (n = 534)	rtCGM (n = 271)	p	MDI (n = 533)	CSII (n = 272)	p
Age (years)	13.08 (4.33)	13.59 (4.18)	12.08 (4.46)	<0.001	13.49 (4.32)	12.27 (4.25)	0.001
Diabetes duration (years)	6.26 (4.07)	6.29 (4.24)	6.19 (3.70)	0.72	6.24 (4.22)	6.28 (3.76)	0.89
M/F (n, %)	409 (50.8)/ 396 (49.2)	273 (51.1)/ 261 (48.9)	136 (50.2)/ 135 (49.8)	0.80	269 (50.5)/ 264 (49.5)	140 (51.5)/ 132 (48.5)	0.78 0.82
Pubertal status (n, %)							
prepubertal	241 (29.9)	134 (25.1)	107 (39.5)	<0.001	142 (26.6)	99 (36.4)	
pubertal	191 (23.7)	130 (24.3)	61 (22.5)		128 (24.0)	63 (23.2)	0.012
postpubertal	373 (46.3)	270 (50.6)	103 (38.0)		263 (49.3)	110 (40.4)	
BMI kg/m <sup>2</sup>	19.98 (3.60)	20.35 (3.70)	19.25 (3.30)	<0.001	20.23 (3.70)	19.48 (3.350)	0.005
BMI Z score	0.007 (0.036)	0.006 (0.027)	0.008 (0.050)	0.43	0.007 (0.039)	0.007 (0.031)	0.79
MDI/CSII (n, %)	533 (66.2)/ 272 (33.8)	483 (90.4)/ 51 (9.6)	50 (18.5)/ 221 (81.5)	<0.001	NA	NA	-
Hb (g/L)	13.75 (1.09)	13.80 (1.15)	13.66 (0.97)	0.10	13.75 (1.16)	13.76 (0.96)	0.91
Anemia (n, %)	38 (4.9)	28 (5.4)	10 (3.7)	0.29	31 (6.0)	7 (2.6)	0.034
celiac disease	99 (12.3)	61 (11.4)	38 (14)	0.28	62 (11.6)	37 (13.6)	0.42
Hashimoto's thyroiditis	79 (9.8)	57 (10.7)	22 (8.1)	0.25	62 (11.6)	17 (6.3)	0.015
others	10 (1.2)	9 (1.7)	1 (0.4)	0.11	9 (1.7)	1 (0.4)	0.11
HbA1c (% mmol/mol)	7.66 (0.89), 60.2 (9.82)	7.76 (0.91), 61.37 (10.05)	7.45 (0.82), 58.0 (8.99)	<0.001	7.73 (0.93), 60.95 (10.22)	7.53 (0.80), 58.82 (8.85)	0.003
Mean glucose (mg/dl, mmol/L) <sup>a</sup>	180.88 (31.99), 10.03 (1.77)	186.24 (33.87), 10.33 (1.87)	170.04 (24.38), 9.43 (1.35)	<0.001	185.56 (33.32), 10.29 (1.84)	171.43 (26.64), 9.51 (1.47)	<0.001
GMI (% mmol/mol) <sup>a</sup>	7.63 (0.76), 59.92 (8.33)	7.76 (0.81), 61.35 (8.84)	7.37 (0.58), 57.12 (6.36)	<0.001	7.74 (0.79), 61.17 (8.70)	7.41 (0.63), 57.48 (6.96)	<0.001
HbA1c-GMI discordance (n, %)							
<0.1	200 (24.8)	134 (25.1)	66 (24.4)		138 (25.9)	62 (22.8)	
≥0.1	605 (75.2)	400 (74.9)	205 (75.6)		395 (74.1)	210 (77.2)	
≥0.2	501 (62.2)	330 (61.8)	171 (63.1)		327 (61.4)	174 (64.0)	
≥0.3	411 (51.1)	265 (49.6)	146 (53.9)		267 (50.1)	144 (52.9)	
≥0.4	319 (39.6)	200 (37.5)	119 (43.9)		205 (38.5) 173	114 (41.9)	
≥0.5	273 (33.9)	170 (31.8)	103 (38.0)	0.78 <sup>b</sup>	173 (32.5)	100 (36.8)	0.79*
≥0.6	215 (26.7)	135 (25.3)	80 (29.5)		137 (25.7)	78 (28.7)	
≥0.7	162 (20.1)	103 (19.3)	59 (21.8)		107 (20.1)	55 (20.2)	
≥0.8	121 (15.0)	74 (13.9)	47 (17.3)		78 (14.6)	43 (15.8)	
≥0.9	95 (11.8)	59 (11.0)	36 (13.3)		64 (12.0)	31 (11.4)	
≥1.0	74 (9.2)	47 (8.8)	27 (10.0)		51 (9.6)	23 (8.5)	

Abbreviation: CGM, continuous glucose monitoring.

<sup>a</sup>Mean glucose concentration and GMI calculated from CGM data collected from the 12 weeks preceding the HbA1c measurement.

<sup>b</sup>The p values refer to the results of multiple chi-square test performed categorizing subjects in 11 subgroups according to the absolute value of HbA1c-MI discordance (i.e., <0.1, 0.1-0.2, 0.21-0.3, 0.31-0.4, 0.41-0.5, 0.51-0.6, 0.61-0.7, 0.71-0.8, 0.81-0.9, 0.91-1.0, >1.0).

Finally, correlations between HbA1c and each CGM metric were also assessed by Spearman correlation coefficient.

Significance level for all tests was set at  $p < 0.05$ . Data were analyzed using SPSS version 20.0 software (SPSS, Chicago, IL, USA).

### 3 | RESULTS

Characteristics of the entire study population and of subgroups of patients stratified according to the type of CGM device, insulin

**TABLE 2** Multiple regression analysis

Variables	B	Lower 95% CI	Upper 95% CI	p Value
Age	−0.006	−0.007	0.007	0.908
Gender	−0.06	−0.086	0.013	0.147
BMI	−0.035	−0.011	0.005	0.47
Pubertal status	0.018	−0.033	0.045	0.752
CGM device (isCGM vs. rtCGM)	0.032	−0.046	0.087	0.55
Insulin therapy administration (MDI vs. CSII)	0.01	−0.06	0.073	0.85
Hemoglobin (g/L)	0.004	−0.026	0.028	0.934
Anemia (present vs. absent)	−0.006	−0.025	0.108	0.888
Autoimmune diseases (present vs. absent)	−0.068	−0.103	0.004	0.068
$R^2 = 0.012, p = 0.409$				

Note: Dependent variables: presence of HbA1c-GMI discordance (GMI calculated from mean glucose value of CGM data collected from the 12 weeks preceding the HbA1c measurement). Independent variables: age, gender, BMI (continuous), pubertal status (prepubertal, pubertal, postpubertal), type of CGM device (isCGM vs. rtCGM), type of insulin therapy administration (MDI vs. CSII), hemoglobin (continuous), anemia (present vs. absent), autoimmune diseases (present vs. absent).

Abbreviation: CGM, continuous glucose monitoring.

therapy administration, gender, age and pubertal status are shown in Table 1 and in Table S1.

In the entire study population, in about a quarter (24.8%) of the patients the discordance, calculated on the 12-week sampling period was <0.1, while 33.9 and 9.2% had a difference  $\geq 0.5$  and  $\geq 1.0$ , respectively. The analysis of the percentage of discordant patients according to the type of CGM device (FGM vs. rtCGM and Dexcom G5 vs. Dexcom G6), to insulin therapy administration, gender, age and pubertal status revealed no significant differences in the proportion of patients categorized according to the specific HbA1c-GMI discordance thresholds and, in particular, in patients with a discordance  $\geq 0.5$  (all  $p > 0.05$ ). The analysis of HbA1c-GMI discordance calculated on the 4-week sampling period demonstrates comparable results with 25.8, 32.9 and 8.6% of the patients showing a difference <0.1,  $\geq 0.5$  and  $\geq 1.0$ , respectively (Tables S2 and S3).

Figure S1 illustrates Bland-Altman Plot with HbA1c-GMI discordance, calculated on the 12-week sampling period, plotted on the y-axis and the average of GMI and HbA1c value plotted on the x-axis. A negative correlation between the HbA1c-GMI discordance and the average of GMI and HbA1c value was observed ( $R = -0.263, p < 0.001$ ).

Table 2 presents the results of multiple regression analysis showing that the inter-individual variability of GMI-HbA1c discordance was not significantly explained by any of the dependent variables analyzed ( $R^2 = 0.012; p = 0.409$ ). These results were confirmed by binary logistic regression analyses run with HbA1c-GMI discordance  $\geq 0.1, \geq 0.5$  and  $\geq 1.0$  as dependent variables (Table S4), also analyzing HbA1c-GMI discordance calculated on the 4-week sampling period (Tables S5 and S6). Multiple and binary logistic regression analysis performed considering also the direction of difference between GMI and HbA1c showed analog results (data not shown).

The absolute value of HbA1c-GMI discordance and the proportion of patients who were discordant at the second visit was

calculated in a subsample composed by 271 patients are shown in Table S7. The average time between the enrolment visit and the second visit was 13.4 weeks (1.2 SD). The comparison of HbA1c-GMI discordance of the second visit with the discordance of the enrolment visit did not show significant differences between both the absolute value of the discrepancy ( $p = 0.576$ ) and the proportion of discordant patients ( $p = 0.375$ ).

The following regression equation was derived from CGM data of the entire study population:  $GMI (\%) = 3.74 (95\%CI 3.52-3.97) + 0.022 (95\% CI 0.20-0.23) \times (\text{mean glucose in mg/dl})$  or  $GMI (\text{mmol/mol}) = 17.40 (95\% CI 14.92-19.88) + 4.262 (95\% CI 4.019-4.505) \times (\text{mean glucose in mmol/L}; R^2 = 0.596, p < 0.001)$ . GMI values calculated for various CGM-derived mean glucose concentrations are presented in Table S8.

The correlation analysis between HbA1c and CGM metrics showed a positive correlation with TAR >180 mg/dl ( $r = 0.762$ ) %TAR >250 mg/dl ( $r = 0.720$ ; both  $p < 0.0001$ ). A strong negative correlation was found with TIR ( $r = -0.752$ ), whereas a weak negative correlation was found with TBR ( $r = -0.221, p < 0.001$ ), % time <54 mg/dl ( $r = -0.157$ ; all  $p < 0.001$ ).

## 4 | DISCUSSION

In this cross-sectional study, we report for the first time on the discrepancy between HbA1c and GMI in a large cohort of children and adolescents with T1D evidencing that this discrepancy was  $\geq 0.5$  and  $\geq 1.0$  in more than third and about one tenth of the subjects. These levels are higher compared to 28 and 3% reported by Bergenstal et al,<sup>2</sup> whereas the real-world analysis performed by Perlman et al showed higher percentages of discordant patients compared to ours (50% of adults subjects with  $\geq 0.5$  and 22% with  $\geq 1.0$ ).<sup>3</sup> The sample recruited in our study is composed by children and

adolescents, thus it had different demographic and clinical characteristics compared to the cohorts of subjects analyzed in the two previous studies, not allowing a direct comparison between them.

Several physical and biological factors could affect hemoglobin glycosylation and red blood cell survival and, thus, the relationship between HbA1c and mean glucose possible explaining HbA1c-GMI discordance.<sup>6</sup> Among these factors, we investigated the possible role of hemoglobin concentration, presence of anemia and/or autoimmune diseases, age and pubertal status, showing that they did not significantly explain HbA1c-GMI discordance.

The types of CGM and insulin therapy administration were also considered as possible factors influencing HbA1c-GMI discordance. The GMI equation was, in fact, developed using data of patients using only rtCGM sensors (Dexcom®). In addition, a recent study conducted in adults with T1D showed the regression equation to calculate GMI varied by CGM system suggesting that the development of device-specific regression equations for GMI may be warranted.<sup>7</sup>

In our study population, the percentage of patients with a discordance  $\geq 0.5$  was higher in rtCGM users compared to subjects using isCGM, however this difference was not statically significant and regression analysis confirmed that the type of CGM did not significantly affect the discordance. Comparable results were obtained for insulin therapy administration.

GMI values calculated according to the regression equation derived from CGM data of our study population widely range with wide variability of GMI value for each value of mean glucose concentrations. According to our findings, we speculate that neither the use of this new GMI equation or the creation of new GMI equations in specific subpopulations of patients stratified by the CGM device or type of insulin therapy could improve the accuracy of the estimation of GMI from mean glucose. Therefore, a clinically significant discrepancy between HbA1c and GMI could be still detected. This is in accordance with the observation that as a quite wide range of possible HbA1c values for a specific value of mean glucose and vice versa can be observed in daily clinical practice.<sup>8</sup> Moreover, the analysis of the relationships between HbA1c and CGM metrics described in this large cohort of pediatric subjects with T1D further support the increasing importance of the evaluation of these metrics, beyond HbA1c value.

The main limitation of this study is that only Caucasian subject were analyzed leaving unexplored the evaluation of the possible influence of ethnicity, in particular African American, on the HbA1c-GMI discordance. Moreover, the use of an equation for GMI calculations derived from adult subjects with T1D could have influenced the evaluation of HbA1c-GMI discordance.

The strengths include the analysis of real-life CGM data in a large well-characterized cohort of children and adolescents with T1D with evaluation of HbA1c-GMI discordance calculated on two sampling periods (12 weeks corresponding to the “gold-standard” visit-to-visit period during which the quarterly measurement of HbA1c is recommended; 4 weeks corresponding to the sampling period more frequently analyzed in daily clinical practice). In addition, for a subsample of patients, a multicomparison of this discordance was performed for each patient. Finally, The large sample of subjects allows analyzing data also in

subpopulations of subjects categorized according to several relevant features possibly influencing both HbA1c and mean glucose values.

In conclusion, this study showed that more than one third of children and adolescents with T1D have a substantial and clinically significant discordance between HbA1c and GMI. This discordance was not explained by the several potential biological factors investigated. In the present pandemic COVID19 era, GMI is increasingly used in clinical practice for the evaluation of glycometabolic control, in particular during the alternating telemedicine and in-person visits. For this reason, Pediatric diabetologists should have knowledge that GMI could be markedly lower or higher than laboratory-measured HbA1c and, thus, this discrepancy should be taken into careful consideration when they are directly compared.

## ACKNOWLEDGMENTS

The authors kindly thank the patients and their families who participated in the study.

## CONFLICT OF INTEREST

The authors declare no conflict of interest.

## AUTHOR CONTRIBUTIONS

Claudio Maffei, Claudia Piona and Marco Marigliano designed the study. Claudia Piona and Marco Marigliano researched and analyzed data and wrote the manuscript. Enza Mozzillo, Francesca Di Candia, Angela Zanfardino, Dario Iafusco, Giulio Maltoni, Stefano Zucchini and Elvira Piccinno researched data. Enza Mozzillo, Giulio Maltoni and Stefano Zucchini discussed and edited the manuscript. Claudio Maffei co-wrote and edited the manuscript. Claudio Maffei 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 and the accuracy of the data analysis.

## PEER REVIEW

The peer review history for this article is available at <https://publons.com/publon/10.1111/pedi.13299>.

## DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available from the corresponding author upon reasonable request.

## ORCID

Claudia Piona  <https://orcid.org/0000-0001-5168-8317>

Marco Marigliano  <https://orcid.org/0000-0002-3232-8807>

Enza Mozzillo  <https://orcid.org/0000-0002-8437-8494>

Angela Zanfardino  <https://orcid.org/0000-0003-0641-1321>

Dario Iafusco  <https://orcid.org/0000-0002-9398-3856>

Stefano Zucchini  <https://orcid.org/0000-0003-1184-7170>

Claudio Maffei  <https://orcid.org/0000-0002-3563-4404>

## REFERENCES

1. Carlson AL, Criego AB, Martens TW, Bergenstal RM. HbA1c: the glucose management indicator, time in range, and standardization of continuous glucose monitoring reports in clinical practice. *Endocrinol Metab Clin North Am*. 2020;49(1):95-107.

2. Bergenstal RM, Beck RW, Close KL, et al. Glucose management indicator (GMI): a new term for estimating A1C from continuous glucose monitoring. *Diabetes Care*. 2018;41(11):2275-2280.
3. Perlman JE, Gooley TA, McNulty B, Meyers J, Hirsch IB. HbA1c and glucose management indicator discordance: a real-world analysis. *Diabetes Technol Ther*. 2020;23(4):253-258.
4. Tanner JM, Whitehouse RH. Clinical longitudinal standards from birth to maturity for height, weight, velocity and stages of puberty. *Arch Dis Child*. 1976;51:170-179.
5. WHO. *Haemoglobin Concentrations for the Diagnosis of Anaemia and Assessment of Severity*. Vitamin and Mineral Nutrition Information System. World Health Organization; 2011.
6. Makris K, Spanou L. Is there a relationship between mean blood glucose and glycated hemoglobin? *J Diabetes Sci Technol*. 2011;5(6):1572-1583.
7. Angellotti E, Muppavarapu S, Siegel RD, Pittas AG. The calculation of the glucose management indicator is influenced by the continuous glucose monitoring system and patient race. *Diabetes Technol Ther*. 2020;22(9):651-657.
8. Piona C, Marigliano M, Mozzillo E, et al. Relationships between HbA1c and continuous glucose monitoring metrics of glycaemic control and glucose variability in a large cohort of children and adolescents with type 1 diabetes. *Diabetes Res Clin Pract*. 2021;177:108933.

#### SUPPORTING INFORMATION

Additional supporting information may be found in the online version of the article at the publisher's website.

**How to cite this article:** Piona C, Marigliano M, Mozzillo E, et al. Evaluation of HbA1c and glucose management indicator discordance in a population of children and adolescents with type 1 diabetes. *Pediatr Diabetes*. 2021;1-6.  
doi:10.1111/pedi.13299