Patient Preference and Adherence

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ORIGINAL RESEARCH

# Factors Associated with Adherence to Self-Monitoring of Blood Glucose Among Young People with Type 1 Diabetes in China: A Cross-Sectional Study

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**Background:** Self-monitoring of blood glucose (SMBG) plays a crucial role in the maintenance of glycemic control in young people with type 1 diabetes mellitus (T1DM), but most of them do not perform SMBG as recommended. Few studies comprehensively explored factors that correlate with adherence to SMBG among this population on the basis of a framework. Hence, the aims of this study were to describe adherence to SMBG among young people with T1DM in China and explore its associating factors according to the Self and Family Management (SFM) framework.

**Methods:** A cross-sectional study was conducted on young people with T1DM in Hunan Province of China from July to August 2020. Based on the SFM framework, self-reported questionnaires were organized for the collection of data on adherence to SMBG, socio-demographic and clinical factors, resources, health care system, and personal factors. Factors associated with adherence to SMBG were determined through multivariate logistic regression analysis.

**Results:** A total of 165 young people were invited, of which 122 (73.9%) completed the questionnaires. The mean age was 12.41 years (SD = 3.18), and the proportion of young people who adhered to SMBG was 53.3%. Multivariate logistic regression analysis revealed that children aged 8–12 years (OR = 0.188, P = 0.002), from two-parent families (OR = 0.232, P = 0.019), and with better personal factors (eg, with more information of SMBG, OR = 1.072, P = 0.020; lower diabetes-related worry, OR = 0.917, P = 0.031; higher level of pain during SMBG, OR = 1.852, P = 0.001), had better adherence to SMBG.

**Conclusion:** Nearly half of the young people with T1DM were not adherent to SMBG in China. Clinicians need to pay more attention to adolescents from single-parent families with regard to their adherence to SMBG. Providing management strategies of SMBG, including delivering SMBG-related information, decreasing diabetes-related worry, and relieving pain related to SMBG, may improve adherence.

**Keywords:** self-monitoring of blood glucose, young people, type 1 diabetes mellitus, influencing factors

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## Introduction

Type 1 diabetes mellitus (T1DM) is a chronic autoimmune disease characterized by insulin deficiency and resultant hyperglycemia, and people diagnosed with T1DM require lifelong insulin therapy.[1] The incidence of T1DM in young people (<18 years) is increasing globally, with an overall annual increase of 2%–3%.[2,3] Poor

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glycemic control may result in the early onset of microvascular and macrovascular complications in young people with T1DM.[4] Unfortunately, more than 50% of young people in China have failed to achieve glycemic control (hemoglobin A1c of less than 7.5%).[5] Frequent glucose monitoring can help individuals select good dietary options, physical activities, and insulin doses[6] and may thus help young people lower their HbA1c levels,[7,8] reduce the frequency of hypoglycemia, and make their lifestyles more flexible.[9] Glucose monitoring is particularly essential during adolescence, a period of elevated risk of diabetes self-management and glycemic outcome deterioration compounded by developmental, physiological, and hormonal changes related to blood glucose fluctuation.[9,10]

Various strategies for glucose monitoring have been established, including self-monitoring of blood glucose (SMBG) and continuous glucose monitoring (CGM) systems. The SMBG is the most widely used strategy in collecting detailed information about blood glucose levels at multiple time points during the day with conventional personal blood glucose meters that measure finger prick blood samples.[11,12] The international guidelines recommend the conduct of SMBG at least four times per day,[13,14] whereas guidelines in China recommend at least three times per day.[15] The CGM system provides blood glucose readings every 1–5 minutes.[16] The goal of glucose monitoring can be achieved by young people with T1DM if the CGM system can be universally used. In fact, owing to its high cost, only 24% of young people from families with high socioeconomic status in the US use the CGM system.[17,18] In general, the majority of people with T1DM use SMBG systems to monitor their glucose levels.

Therapeutic adherence is defined by the World Health Organization as "the extent to which a person's behavior corresponds to the agreed recommendations of a healthcare provider"[19] and is considered a primary factor for good chronic disease management. The goal of adherence to SMBG has not been reached by young people with T1DM.[8,20] We systematically searched existing studies with the following main search terms: "type 1 diabetes," "young people," "youth," "adolescents," "self-monitoring," "blood glucose," and "SMBG" in PubMed, Embase, Web of Science, CNKI, and Wanfang. Five studies reported the frequency of SMBG among young people with T1DM in Korea, the US, and China. In Korea, more than half of adolescents with T1DM performed the SMBG more than four times per day.[21] In the US, less than 20% of the adolescents with T1DM performed the SMBG more than four times per day.[22,23] In China, we found two studies that reported that less than 3% performed the SMBG more than once per day.[20,24] Thus, how to increase adherence to SMBG is a global concern.

Identifying the influencing factors of adherence of young people with T1DM to SMBG is a preliminary step toward the design of programs for improving adherence to SMBG. Many socio-demographic and clinical factors have been indicated, including age, gender, education level of parents, family income, and marital status of parents.[25–27] Young people and females with T1DM have better adherence to SMBG in Portugal.[26] Young people with educated mothers or high family incomes show better adherence to SMBG in Denmark and the U.S.[28,29] However, findings on family structure as an associating factor of adherence to SMBG are conflicting. Young people with T1DM in the US who are from two-parent families have better adherence to SMBG,[30] but a study in Kampala reported that young people from single-parent families are more adherent to SMBG.[31] Regarding resources, young people equipped with glycemic meters are more likely to perform the SMBG and have better adherence to SMBG.[32] Young people with a lower degree of diabetes-related worry show better adherence to SMBG in the U.S.[27] Young people with T1DM who experience low level of pain during the SMBG were found to have better adherence to SMBG in Riyadh.[25]

To the best of our knowledge, SMBG-related factors (information of SMBG, personal attitude toward SMBG, and social support associated with adherence to SMBG) are associated with adherence to SMBG among adults with T1DM.[33,34] The glycemic values of young people can be extremely variable relative to those of adults with T1DM.[35] Thus, these SMBG-related features seem to be important to young people with T1DM. However, scientific data on the above possible relationships among young people with T1DM are lacking. Overall, SMBG, as a required self-management behavior for people with diabetes, is influenced by multilevel factors that should be comprehensively explored with appropriate theoretical frameworks. The Self and Family Management (SFM) framework is intended to reflect the complexity of self-management and family management by elucidating facilitators and barriers, including socio-demographic and clinical factors, resources, health care system, and personal factors.[36] It has been used in guiding research on chronic diseases and addresses complexities by considering multilevel factors and their relationships.

The study aimed to describe the status of adherence of young people with T1DM in China to SMBG and explore the associated factors of adherence to SMBG on the basis of the SFM framework.

# Method

## Study Design and Participants

A cross-sectional survey was conducted from June to September 2020. Participants were recruited from the Diabetes Center of Central South University in the capital city of Hunan province in China, which is the largest endocrinology clinic in Hunan province and provides multidisciplinary care for young people with T1DM. The inclusion criteria were as follows: 1) T1DM diagnosed according to the standard World Health Organization definition of diabetes for over 6 months;[37] 2) age of 8–18 years; and 3) ability to read and speak Mandarin Chinese. The exclusion criteria were as follows: 1) chronic diseases other than T1DM and 2) severe mental illnesses, such as dysgnosia.

## Sample Size

The sample size was calculated using a logistic regression model with 10–15 subjects per predictor.[38] Given that 10 predictors were used, the minimum sample size was 100–150 participants. A 10% dropout rate was considered, and 165 young people with T1DM were included in the estimation. A post-hoc power analysis was conducted because the included sample size (n = 122) was less than the conservative sample size of 165. Then, whether or not the power to detect the statistical differences of the logistic regression was sufficient was determined. Assuming an α of 0.05, a base prevalence of 0.20, and R-squared value of 0.50, the two-tailed test of the null hypothesis with an OR of 1.0 for a predictor against an alternative odds ratio of 2.1 had a power of 0.87 in a logistic regression with n of 122 (G*Power 3.1).[39] In other words, the statistical power was higher than 0.8, which indicated that the sample size was sufficient.[40]

## Data Collection

The participants were recruited by two research assistants during multidisciplinary clinic visits. Eligible participants were invited to participate in this study. After signing informed consent forms, the participants were given a link to access the electronic questionnaires with tablets (wjx, https://www.wjx.cn/). The participants were asked to complete the questionnaires on site in a quiet room, and research assistants were available to answer questions. Gifts were given to the participants after data collection for their time.

## Measurements

Adherence to SMBG was assessed with a self-designed question ("How often did you perform SMBG per day in the past month?"). In accordance with the guidelines in China,[15] adherence to the SMBG was defined as performing SMBG three times or above per day.

Socio-demographic and clinical characteristics, resources, and health care system were assessed with the self-designed questionnaire. Socio-demographic and clinical characteristics, including age, gender, family history of diabetes, diabetes duration, and principal guardian's education level, occupation, and marital status, were collected. Resources reflected individual's and family's financial status and medical insurance and equipment, and thus information, particularly annual household income (in US dollars), medical insurance, insulin pump therapy, and whether or not a glucose meter is owned, was collected. The health care system was the point of access for receiving appropriate care and advice from health care providers, and it was assessed on the basis of the answers to the question "Whether health professionals give sufficient SMBG information?"

Personal factors, including SMBG-related personal factors (information of SMBG, personal attitude toward SMBG, and social support for SMBG), perceived stress, ability to cope with perceived stress, diabetes-related worry, and the level of pain during SMBG, were assessed. Information, personal attitude, social support, and behavioral skills for SMBG were measured with the Chinese version of the information-motivation-behavioral SMBG skills (IMB-SMBG) questionnaire. The original scale was developed in English[33] and then translated into Chinese.[34] The 76 items in the Chinese version include three subscales: information (30 items), motivation (25 items), and behavioral skills (21 items). The motivation subscale consists of two components, namely, personal attitudes toward SMBG and social support. A five-point scale (1 = strongly agree, 5 = strongly disagree) was used in each item. As this scale was initially developed and validated among adults, an expert panel comprising one endocrinologist, two diabetes clinicians, and two diabetes nurses was formed to evaluate the content validity of the scale for young Chinese people with T1DM. The content validity was 0.80, and all the items in the IMB-SMBG

questionnaire were suitable for use among Chinese young people with T1DM. The Cronbach's α values of the three subscales were 0.827 (information), 0.873 (motivation), and 0.915 (behavioral skills) among young people with T1DM in our study.

Perceived stress was assessed with the Perceived Stress Scale, which is a 14-item measure with a total score ranging from 0 to 56.[41] The scale was revised and translated into Chinese.[42] High scores on this scale reflect large perceived stress. A criterion score of 26 indicates a negative impact of perceived stress on physical and mental health. The Cronbach's α of this scale in a previous study on young people was 0.74.[43] In the present study, the Cronbach's α for this scale was 0.788.

Coping style was measured with the Simplified Coping Style Questionnaire (SCSQ), which was developed by Xie.[44] It is a 20-item questionnaire and comprises two subscales: active coping (12 items) and passive coping (8 items). All items are rated with a four-point scale (0 = Never, 4 = Very often). A high score represents active or passive coping behavior. The Cronbach's α values were 0.89 and 0.78 in the original study.[44] The Cronbach's α values in the present study were 0.874 and 0.851.

Diabetes-related worry was measured using a subscale of diabetes-related worry in the Chinese version Diabetes Quality of Life for Youth scale, which was developed by Ruey-Hsia Wang.[45] The subscale consists of eight items and is scored with 1–5 points, which correspond to increasing diabetes-related worry. The total score ranges from 8 to 40. The Cronbach's α in the present study was 0.922.

Pain during SMBG in the past one month was assessed using the Numeric Rating Scale, which is a single 11-point numeric scale. A score of 0 represents one pain extreme, and 10 represents the other pain extreme (0 = no pain, 1–3 = mild pain, 4–6 = moderate pain, 7–10 = severe).[46] Each respondent was asked to select a whole number that best reflects their pain intensity.

## Ethical Considerations

Young people with T1DM were informed about the proposed study's aims and details, and they joined voluntarily with the right to withdraw. Written informed consent was obtained from each participant or legal guardian. All study procedures were performed in accordance with the Declaration of Helsinki and were approved by the ethics committee of Xiangya School of Nursing, Central South University (No. 2018012).

## Data Analysis

All data were double-entered in a database, checked for accuracy, and analyzed using the Statistical Package for the Social Sciences (SPSS) for Windows version 23.0. To verify the reliability of measurements, Cronbach's α of each statistic was computed. Descriptive statistics were computed to describe the sample. One-way ANOVA was used in comparing the demographic and clinical characteristics of the participants who completed the survey with those of the participants who did not. Potential associations between the dependent variable (adherence to SMBG) and independent variables (socio-demographic and clinical characteristics, resources, health system, and personal factors) were determined with one-way ANOVA and chi-square tests. Given the possible correlations among annual household income, principal guardian's marital status, education level, occupation, and medical insurance,[47,48] the Cochran-Mantel-Haenszel (CMH) test was conducted to test the strength of the correlations of these variables to SMBG adherence reported from chi-square tests conducted in previous studies.[49] To assess the factors associated with adherence to SMBG, multivariate logistic regression was conducted (ENTER). The multivariate logistic regression model included variables with P values of <0.05 in the bivariate analysis (one-way ANOVA or chi-squared tests). A two-sided P value of <0.05 was used in establishing statistical significance, and the results were expressed as odds ratios (ORs) with 95% confidence intervals (CIs).

# Results

Of the 165 young people that were eligible to participate in this study, 159 (96.3%) agreed to participate, but 23 (13.9%) of them did not complete the survey because of conflict in schedule, and 14 (8.5%) were excluded because they did not complete the questionnaire. Thus, 122 (73.9%) young people were included. No significant differences in socio-demographic and clinical characteristics (eg, age, gender, and diabetes duration) were found between the included and excluded participants (P > 0.05).

## Socio-Demographic and Clinical Characteristics

The mean age of the participants was 12.41 years (SD = 3.18); 50% (n = 61) were in the school-aged phase (8–12 years), and 50% (n = 61) were in the adolescent phase (13–18 years). Approximately 54.9% (n = 67) of the participants were females. Only 11.5% of the participants

had a family history of diabetes. The mean duration was 3.18 years (SD = 2.76). Approximately 80.3% (n = 98) had a diabetes duration of less than five years, and 27.1% (n = 33) of the participants' principal guardians were well educated and had college education or above. Finally, 91.8% (n = 112) of the participants' principal guardians were employed, and 77% (n = 94) were married (Table 1).

## Resources and Health System

With regard to resources, nearly one-third (29.5%, n = 36) of the participants were treated with insulin pumps, and 54.9% (n = 67) of the participants had annual household incomes of less than $6282, which is considered living at the poverty level in Hunan (Hunan NBS Website). Approximately 98.4% (n = 120) of the participants were equipped with glucose meters, and 73.8% (n = 90) had medical insurance. As for the health system, nearly 90% (88.5%, n = 108) of the participants reported they received SMBG information from health professionals (Table 1).

## Personal Factors

As for personal factors, the participants' mean scores for information of SMBG, personal attitude toward SMBG, social support for SMBG, and behavioral skills for SMBG were 115.09 (SD = 11.95), 78.61 (SD = 11.74), 12.91 (SD = 1.98), and 76.32 (SD = 12.43), respectively. The score of perceived stress was 24.35 (SD = 7.55), and 41% (n = 50) reported high stress levels, with a score of more than 26. The score for active coping was 31.55 (SD = 7.32) and passive coping was 17.08 (SD = 4.09). The mean score of diabetes-related worry was 18.17 (SD = 7.45). The mean score of pain was 2.99 (SD = 1.32), with a range of 0–10 (Table 1).

## Adherence to SMBG

The mean frequency of SMBG per day was 3.33 (SD = 2.21), with a range of 1–10. Of the 122 participants, the rate of adherence to SMBG was 53.3% (n = 65). In addition, 46.7% (n = 57) performed SMBG less than three times per day (Figure 1).

## Bivariate Analysis for Adherence to SMBG

On socio-demographic and clinical factors, young people who were school-aged children (P = 0.001), have principal guardians with high levels of education (P = 0.009), and come from two-parent families (P = 0.011) were more likely to perform SMBG. After controlling for other

**Table 1** Participants' Characteristics (N = 122)

| Variables | Frequencies (n)/Mean | Percentage/ SD |
|---|---|---|
| **Socio-demographic and clinical factors** | | |
| Age | | |
| School-aged children | 61 | 50.0% |
| Adolescents | 61 | 50.0% |
| Gender | | |
| Male | 55 | 45.1% |
| Female | 67 | 54.9% |
| Family history of diabetes | | |
| Yes | 14 | 11.5% |
| No | 108 | 88.5% |
| Diabetes duration | | |
| ≤ 5 years | 98 | 80.3% |
| >5 years | 24 | 19.7% |
| Principal guardian's education level | | |
| High school and below | 89 | 72.9% |
| College and above | 33 | 27.1% |
| Principal guardian's occupation | | |
| Employed | 112 | 91.8% |
| Unemployed | 10 | 8.2% |
| Principal guardian's marital status | | |
| Married | 94 | 77.0% |
| Divorced/ widowed | 28 | 23.0% |
| **Resources** | | |
| Insulin pump therapy | | |
| Yes | 36 | 29.5% |
| No | 86 | 70.5% |
| Annual household income (USD) | | |
| ≤ $6282 | 67 | 54.9% |
| > $6282 | 55 | 45.1% |
| Equipped with Glucose meter | | |
| Yes | 120 | 98.4% |
| No | 2 | 1.6% |
| Medical insurance | | |
| Yes | 90 | 73.8% |
| No | 32 | 26.2% |
| **Health system** | | |
| SMBG information given by health professionals | | |
| Yes | 108 | 88.5% |
| No | 14 | 11.5% |
| **Personal factors** | | |
| SMBG-related personal factors | | |
| Information of SMBG, mean (SD) | 115.09 | 11.95 |
| Personal attitude towards SMBG, mean (SD) | 78.61 | 11.74 |

(*Continued*)

**Table 1** (Continued).

| Variables | Frequencies (n)/Mean | Percentage/ SD |
|---|---|---|
| Social support for SMBG, mean (SD) | 12.91 | 1.98 |
| Behavioral skills of SMBG, mean (SD) | 76.32 | 12.43 |
| Diabetes-related worry, mean (SD) | 18.17 | 7.45 |
| Perceived stress, mean (SD) | 24.35 | 7.55 |
| SCSQ | | |
| Active coping, mean (SD) | 31.55 | 7.32 |
| Passive coping, mean (SD) | 17.08 | 4.09 |
| Pain, mean (SD) | 2.99 | 1.32 |

**Abbreviations**: SMBG, self-monitoring of blood glucose; S.D., standard deviation; USD, United States Dollar.

confounders (eg, annual household income), the differences persisted (CMH test; $P < 0.05$). No statistically significant differences in adherence to SMBG, gender, family history of diabetes, diabetes duration, and principal guardian's occupation were found ($P > 0.05$; Table 2).

Regarding resources, no statistically significant associations were found among adherence to SMBG, insulin pump therapy, annual household income, whether or not a glucose meter is owned, and medical insurance ($P > 0.05$; Table 2). Regarding the health system, young people who received SMBG information from health professionals had better adherence to SMBG ($P = 0.011$; Table 2).

On personal factors, increased information on SMBG ($P < 0.001$), better personal attitude toward SMBG ($P = 0.019$), lower perceived stress ($P = 0.003$), lower diabetes-related worry ($P = 0.025$), active coping ($P = 0.027$), and higher level of pain ($P = 0.024$) were related to better adherence to SMBG. No statistically significant associations of adherence to SMBG with social support for SMBG, behavioral skills of SMBG, and passive coping were found ($P > 0.05$; Table 2).

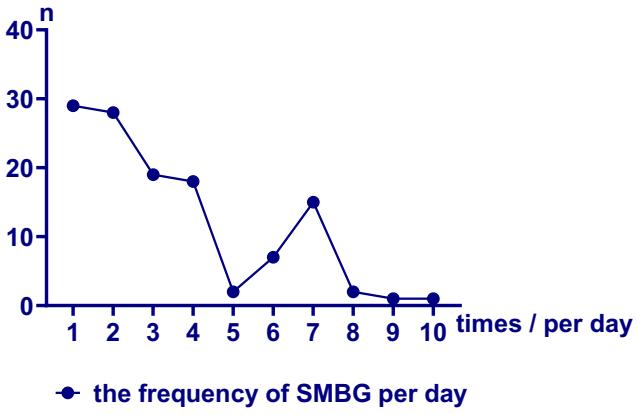


**Figure 1** The distribution of the frequency of SMBG per day.

## Multivariate Logistic Regression for SMBG Adherence

The results of multivariate logistic regression showed that school-aged children had better adherence to SMBG than adolescents with T1DM (OR = 0.188; 95% CI 0.065–0.548). Young people with more information on SMBG (OR = 1.072; 95% CI 1.011–1.137), less diabetes-related worry (OR = 0.917; 95% CI 0.849–0.992), and higher level of pain during SMBG (OR = 1.852; 95% CI 1.301–2.636) showed better adherence to SMBG. Young people from single-parent families showed poor adherence to SMBG (OR = −1.462; 95% CI 0.069–0.783; Table 3).

# Discussion

Almost half of the young people with T1DM in China were not adherent to SMBG. Guided by the SFM framework, this cross-sectional study contributes to the literature concerning the comprehensive determinants of adherence to SMBG. We confirmed that family structure is related to adherence to SMBG when the results were conflicting in the literature, and found a positive association between information on SMBG and adherence to SMBG among young people with T1DM. According to literature, personal attitude towards SMBG and social support were associated with adherence to SMBG among adults, and we did not find the same relationships among young people in this study. All the findings from this study may collectively contribute to the design of programs for improving adherence to SMBG.

The proportion of adherence to SMBG was higher than that reported in the US (53.3% vs 14.6%)[22] possibly because China and the US have different clinical requirements with regard to SMBG frequency per day for young people with T1DM. The America Diabetes Association targets SMBG frequency at least four times per day, whereas the Chinese guideline recommends performing SMBG three times and above per day.[15,50] Adherence to SMBG of young people with T1DM in China improved relative to that reported in previous studies, which showed that less than 3% of young people with T1DM

**Table 2** Differences Among Participants' Characteristics According to Adherence to SMBG

| Variables | SMBG Adherence | | $x^2/F$ | *P*-values |
|---|---|---|---|---|
| | Yes (n = 65) | No (n = 57) | | |
| **Socio-demographic and clinical factors** | | | | |
| Age, n (%) | | | 11.887 | 0.001 |
| School-aged children | 42 (68.9%) | 19 (31.1%) | | |
| Adolescents | 23 (37.7%) | 38 (62.3%) | | |
| Gender, n (%) | | | 2.463 | 0.117 |
| Male | 25 (45.5%) | 30 (54.5%) | | |
| Female | 40 (59.7%) | 27 (40.3%) | | |
| Family history of diabetes, n (%) | | | 0.068 | 0.794 |
| Yes | 7 (50.0%) | 7 (50.0%) | | |
| No | 58 (53.7%) | 50 (46.3%) | | |
| Diabetes duration, n (%) | | | 0.665 | 0.415 |
| ≤ 5 years | 54 (55.1%) | 44 (44.9%) | | |
| >5 years | 11 (45.8%) | 13 (54.2%) | | |
| Principal guardian's education level, n (%) | | | 6.874 | 0.009 |
| High school and below | 41 (46.1%) | 48 (53.9%) | | |
| College and above | 24 (72.7%) | 9 (27.3%) | | |
| Principal guardian's occupation, n (%) | | | 1.224 | 0.269 |
| Employed | 58 (51.8%) | 54 (48.2%) | | |
| Unemployed | 7 (70.0%) | 3 (30.0%) | | |
| Principal guardian's marital status, n (%) | | | 6.522 | 0.011 |
| Married | 56 (59.6%) | 38 (40.4%) | | |
| Divorced/ widowed | 9 (32.1%) | 19 (67.9%) | | |
| **Resources** | | | | |
| Annual household income (USD), n (%) | | | 2.934 | 0.087 |
| ≤ $6282 | 31 (46.3%) | 36 (53.7%) | | |
| >$6282 | 34 (61.8%) | 21 (38.2%) | | |
| Equipped with Glucose meter, n (%) | | | 2.319 | 0.128 |
| Yes | 65 (54.2%) | 55 (45.8%) | | |
| No | 0 (0.0%) | 2 (100.0%) | | |
| Insulin pump therapy, n (%) | | | 0.106 | 0.744 |
| Yes | 20 (55.5%) | 16 (44.5%) | | |
| No | 45 (52.3%) | 41 (47.7%) | | |
| Medical insurance, n (%) | | | 0.648 | 0.421 |
| Yes | 46 (51.1%) | 44 (48.9%) | | |
| No | 19 (59.4%) | 13 (40.6%) | | |
| **Health system** | | | | |
| SMBG information given by health professionals, n (%) | | | 6.445 | 0.011 |
| Yes | 62 (57.4%) | 46 (42.6%) | | |
| No | 3 (21.4%) | 11 (78.6%) | | |
| **Personal factors** | | | | |
| SMBG-related personal factors | | | | |
| Information of SMBG, mean (SD) | 119.13 (10.43) | 110.47 (11.98) | −4.269 | 0.000 |
| Personal attitude towards SMBG, mean (SD) | 80.93 (11.31) | 75.96 (11.75) | −2.379 | 0.019 |
| Social support for SMBG, mean (SD) | 13.33 (1.71) | 12.42 (2.20) | −1.548 | 0.129 |
| Behavioral skills of SMBG, mean (SD) | 78.28 (13.06) | 74.08 (11.38) | −1.879 | 0.063 |
| Diabetes-related worry, mean (SD) | 16.30 (7.31) | 20.29 (7.08) | 3.057 | 0.003 |
| Perceived stress, mean (SD) | 36.92 (8.11) | 39.97 (6.56) | 2.264 | 0.025 |
| SCSQ | | | | |
| Active coping, mean (SD) | 32.92 (7.58) | 30.00 (6.73) | −2.237 | 0.027 |
| Passive coping, mean (SD) | 17.03 (4.29) | 17.14 (3.89) | 0.147 | 0.883 |
| Pain, mean (SD) | 3.36 (2.16) | 2.57 (1.54) | −2.293 | 0.024 |

**Abbreviations**: SMBG, self-monitoring of blood glucose; S.D., standard deviation; x2, Chi-squared; F, variance ratio; USD, United States Dollar.

**Table 3** Logistic Regression of Adherence to SMBG

| Variables | B | OR | 95% CI | *P*-values |
|---|---|---|---|---|
| Age (vs school-aged children) | −1.669 | 0.188 | 0.065–0.548 | 0.002 |
| Principal guardian's marital status (vs married) | −1.462 | 0.232 | 0.069–0.783 | 0.019 |
| Principal guardian's education level (vs high school and below) | 0.995 | 2.705 | 0.828–8.841 | 0.100 |
| SMBG information given by health professionals (vs yes) | −0.924 | 0.397 | 0.076–2.084 | 0.275 |
| Information of SMBG | 0.070 | 1.072 | 1.011–1.137 | 0.020 |
| Personal attitude towards SMBG | −0.003 | 0.997 | 0.943–1.053 | 0.903 |
| Diabetes-related worry | −0.086 | 0.917 | 0.849–0.992 | 0.031 |
| Perceived stress | −0.047 | 0.954 | 0.878–1.037 | 0.267 |
| Active coping | −0.007 | 0.993 | 0.906–1.090 | 0.887 |
| Pain | 0.616 | 1.852 | 1.301–2.636 | 0.001 |

**Abbreviations**: SMBG, self-monitoring of blood glucose; B, regression coefficient; OR, odds ratios; CI, confidence intervals.

performed SMBG daily in 2010–2014.[20,24] The possible reasons were the general increase in family income, improved quality, and decreased cost of SMBG in China[29,51] and decrease in financial burden (eg, cost of daily testing supplies and glucometers). In addition, young people with T1DM were recruited from a diabetes center, where education about the management of T1DM, including SMBG, is provided. This situation may have contributed to the improved SMBG adherence.

In our study, school-aged children had better adherence to SMBG than adolescents. This result was consistent with the results of previous studies.[26,52] School-aged children are dependent on parents, who do most of the diabetes management for them.[26] Compared with school-aged children, adolescents with T1DM are less dependent and adherent to their parent's supervision and tend to make their own decisions regarding diabetes management.[26,53] However, adolescents have more negative attitudes about diabetes than school-aged children, and 47% of adolescents felt anger or "different" from their peers or felt that diabetes disrupts their lifestyles.[54]

In addition, young people with T1DM from two-parent families had better adherence to SMBG. The result was in agreement with findings obtained from young people with T1DM in the U.S.[55] The possible reason was that these young people had more resources, which may have contributed to better diabetes management including SMBG.[56] Moreover, they gain support from both parents in terms of motivation for self-care, thus showing improved adherence to SMBG.[57]

Regarding personal factors, we found that young people with T1DM had better adherence to SMBG when they had more SMBG-related information, and the results were consistent with those reported in adults with T1DM.[33,34] Successful diabetes self-management (eg, SMBG) requires a considerable knowledge of the effects of diabetes on the body, the goals of treatment, and the effects of various behaviors on glucose regulation.[58] Therefore, increasing SMBG-related information is critical to the enhancement of SMBG adherence among young people with T1DM.

The results of our study showed that young people with less diabetes-related worry had better SMBG adherence, consistent with a study on young people with T1DM in the U.S.[27] The literature suggested that a high level of diabetes-related worry can contribute to anxiety,[59] which can impose a cognitive burden on an adolescent with T1DM. Subsequently, young people tend to ignore diabetes management tasks (eg, SMBG).[60] In addition, a prominent finding of the study was that young people with better adherence to SMBG had a higher level of pain during SMBG, indicating pain related to SMBG is a potential barrier for SMBG behavior.

## Strengths and Limitations of the Study

This study provided up-to-date and accurate data on the present status of SMBG among young people with T1DM in China. We explored the associating factors of adherence to SMBG among young people with T1DM and used the SFM framework as a guide, which compensates for the deficiencies in prior studies and provides a different comprehensive perspective on SMBG-related factors.

However, this study has some limitations. First, we included a self-report frequency of SMBG rather than the number recorded from their meters. Thus, the accuracy may have been insufficient, and biased responses may have been

included. Second, selection bias due to the absence of response might have limited the representativity of the results. Owing to limited resources, the data were collected from a high-quality single diabetes center, where structured diabetes education on SMBG is provided, and thus generalization of our findings was limited, especially in other resource-scarce areas.

## Implications

This study has important implications for future research and clinical practice. More than 40% of young people, particularly adolescents, did not reach the target level recommended by the Chinese guideline for SMBG frequency. Thus, age-specific interventions for increasing adherence to SMBG are needed. Intervention components that improve SMBG adherence through education using SMBG-related information, diabetes-related worry, and pain management strategies, are needed as well.

We suggest that health professionals raise awareness of adherence to SMBG among young people with T1DM, especially adolescents or young people from single-parent families in China. Clinical strategies can be explored according to the results of the current study. First, SMBG-related health education should be provided, including the recommendations of SMBG frequency, proper use of blood glucose meter, and the necessity of SMBG. Second, young people with T1DM should be trained to employ techniques that reduce pain during finger pricking, for example, pricking the lateral aspect of the finger, avoiding pricking the thumbs and index fingers, or pricking with shallow needle depths.[25] CGM systems, which provide rapid and painless measurements of glucose levels, are recommended for young people with T1DM.

## Conclusions

The low adherence of young people with T1DM to SMBG is alarming in China. This study offered some insights into the identification of risk factors for adherence to SMBG, especially in adolescents aged 13–18 years or from single-parent families. Providing SMBG-related information and strategies that decrease diabetes-related worry and pain level in young people during SMBG are needed.

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## Disclosure

The authors report no conflicts of interest in this work.

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