Effects of Depression, Diabetes Distress, Diabetes Self-efficacy, and Diabetes Self-management on Glycemic Control among Chinese Population with Type 2 Diabetes Mellitus

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Abstract

Aim: To examine the direct and indirect effects of depression, diabetes distress, diabetes self-efficacy and diabetes self-management on glycemic control among a group of T2DM patients in China.

Method: A convenience sample of 254 participants were selected from three outpatient departments in Beijing, China. They were surveyed using a self-administered questionnaire. Diabetes-related information was retrieved from their medical records. Descriptive statistics, independent student t tests, Chi-square tests, correlation analyses and Generalized Structural Equation Modeling were used.

Results: Only 91 (35.82%) participants achieved optimal glycemic control of HbA1c<7.0% (53mmol/mol). Only diabetes self-management had a direct effect on glycemic control (OR=0.95, P<0.001). Depression and diabetes distress had only indirect effects on glycemic control through diabetes self-efficacy and diabetes self-management. Diabetes self-efficacy only had an indirect effect on glycemic control through diabetes self-management.

Conclusions: Glycemic control among Chinese population with T2DM was suboptimal. Future interventions should focus on decreasing depressive symptoms and diabetes distress levels, and, therefore, improve diabetes self-efficacy and self-management practices and, ultimately, reach the optimal goal of glycemic control.

Keywords: Diabetes; Glycemic control; Diabetes self-management; Diabetes self-efficacy; Depression; Diabetes distress

1. Introduction

China has the largest population of people with diabetes in the world. It is estimated that an approximately 109.6 million people aged 20-79 in China were diagnosed with diabetes by the end of 2016[1]. Diabetes and its comorbidities have placed heavy economic burdens on Chinese families[2]. It has been well established [3,4] that strict glycemic control leads to decreased risk of diabetes complications. However, large-scale studies[5-8] have shown that glycemic control was suboptimal among Chinese patients with type 2 diabetes (T2DM). Only 26.21% to 39.7% of participants in those studies achieved optimal glycemic control and met the goal of an HbA1c<7.0% (53mmol/mol). Therefore, it is critically important to understand the factors influencing glycemic control to guide interventions for preventing diabetes related complications.

So far a number of studies have been conducted to investigate glycemic control and the psychological and behavioral factors influencing it. By using regression analyses, researchers have found diabetes distress[9-11], diabetes self-efficacy[12-15], and diabetes self-management behaviors[13,15-18] were independent predictors of glycemic control. Structural equation modeling enables researchers to examine the direct and indirect effects of the aforementioned factors on glycemic control. For example, they found that diabetes distress[19,20], and diabetes self-efficacy[20,21] had direct impacts on glycemic control. Moreover, a few studies found that diabetes self-efficacy[22,23] and diabetes distress [24,25] may have indirect effects on glycemic control through diabetes self-management behaviors. Furthermore, diabetes distress[24,25] also influenced glycemic control through diabetes

self-efficacy. However, researchers[20] found that depression was not associated with self-efficacy nor with HbA1c among 615 T2DM patients in the US.

Based on the aforementioned literature review, the majority of the literature focused on bivariate relationships and used regression analyses to examine relationships, and ignored the interplay between factors. More importantly, there has been limited research in China investigating psychological and behavioral factors and their collective impacts on glycemic control in spite of the large amount of populations with diabetes. Given the complexity of glycemic control, it is speculated that there is a variety of interplay among these factors. Examining the mechanisms leading to inadequate glycemic control is beneficial for clinicians developing interventions targeting modifiable factors. The purpose of the study is to identify the direct and indirect effects of depression, diabetes distress, diabetes self-efficacy and diabetes self-management on glycemic control in a group of T2DM patients residing in China. A model was proposed based on the literature review to guide the analyses (figure 1). In this model, it is hypothesized that depression, diabetes distress, diabetes self-efficacy and diabetes self-management have direct impacts on glycemic control; and that depression and diabetes distress have indirect effects on glycemic control through diabetes self-efficacy and diabetes self-management. Additionally, it is expected that the effect of diabetes self-efficacy on glycemic control will be mediated by diabetes self-management.

2. Research subjects and methods

2.1 Sample

This study employed a cross-sectional correlational design. A convenience sample of 254 participants were recruited into the study. According to G*Power 3[26], a total of 254 participants ensures the statistical power of 0.96, much higher than the acceptable power of 0.8[27]. To be eligible, participants had to meet the following criteria: 1) diagnosed with type 2 diabetes for more than one year; 2) had a HbA1c value obtained in the past three months; 3) able to read and write Chinese; and 4) were willing to participate in the study. Participants were excluded if they were pregnant, or had major complications that might affect their ability to perform diabetes self-management activities, such as blindness, end-stage renal disease and limb amputation.

2.2 Data collection

This study was approved by the research review committee of the School of Nursing, Peking University, China. Data were collected in three outpatient departments in Beijing between April, 2012 and November, 2013. Two sites were located in suburban areas and one was in the urban area. Before the study began, the principal investigator (PI) talked to the endocrinologists in the three outpatient departments for recruitment procedures. They were given an information sheet regarding the inclusion and exclusion criteria. Participants who came in for regular visits and met the inclusion criteria were referred to the research assistant (RA). The RA led the eligible participants to a private area for the informed consent process. Participants were given an informed consent sheet regarding the study. The RA was available to answer any questions from the participants. After the written informed consents were

obtained, participants were given a questionnaire to complete. The RA double checked with participants when they submitted the questionnaire to minimize missing data. A pamphlet regarding how to manage diabetes was given to participants as a token of appreciation. The RA then retrieved the HbA1c, height, weight, treatment modality, and diabetes complications data from the medical records.

2.3 Study measures

The self-administered questionnaire contained 74 questions in three sections: 1) Demographic information: gender, age, employment status, marital status, educational level, household monthly income per capita, insurance coverage and diabetes-related health expenditure per year. 2) Diabetes related information: family history of diabetes, duration of diabetes, whether they participated in diabetes related education classes or consultations, and whether they received instructions on diet planning and exercise. 3) Four major scales to measure the key concepts of depression, diabetes distress, diabetes self-efficacy, and diabetes self-management.

To measure depression, the Patient Health Questionnaire-9 (PHQ-9)[28] was employed. This scale contains 1 item for each of the 9 criteria in the Diagnostic and Statistical Manual of Mental Disorders, Fourth Edition (DSM-IV MDD) on which diagnoses are based. The PHQ-9 asks about frequency of the nine listed problems over the last two weeks, ranging from not at all (0) to nearly every day (3). The total score ranges from 0 to 27, with higher scores indicating more depression. A typical item is “how often have you been bothered by having little interest or pleasure in doing things”. The reported reliability of this scale among Chinese Americans is high

(Cronbach' *a*=0.91). In this study, the Cronbach' *a*=0.79.

The most frequently used Diabetes Distress Scale (DDS) was adopted to measure diabetes distress in our participants. The Chinese version of the scale [29] consists of 17 items and four subscales: emotional burden, regimen-related distress, physician-related distress, and interpersonal distress. Patients rated the degree to which each item was currently problematic for them on a 6-point Likert scale from 1 (no problem) to 6 (serious problem). A preliminary analysis (results not shown) of construct validity using the current study data showed two items were not associated with the total scale and were therefore excluded. The score for each of the remaining fifteen items was summed to indicate a total distress score in this study. The possible total score range for this scale was 15 to 90. A typical item is "feeling that diabetes is taking up too much of my mental and physical energy every day". This scale has good reliability (Cronbach's *a*=0.81) in this study.

The Chinese version of the Diabetes Empowerment Scale (C-DES-20)[30] was employed to measure diabetes self-efficacy. This 20-item scale is composed of five subdomains: overcoming barriers, determining suitable methods, achieving goals, obtaining support, and coping. The respondents rated their answers on a five-point Likert scale with 1 indicating strongly disagree and 5 strongly agree. The possible scores ranged from 20-100. A high DES score corresponds to high empowerment. A typical item of the scale is "in general, I believe that I can think of different ways to overcome barriers to my diabetes goals". Good reliability and validity of the scale were established among patients with diabetes in Hong Kong where the Cronbach's

alpha coefficient for the five subscales was 0.76~0.89 [30]. In our study the internal consistency was acceptable, with Cronbach's *a* coefficients of 0.69~0.79.

Diabetes self-management was assessed using the Revised Summary of Diabetes Self-Care Activities (SDSCA) [31]. This scale has reasonable reliability and validity and has been widely applied across different studies concerning diabetes self-management and glycemic control. The SDSCA asks about the number of days during the past seven days participants followed a specific type of self-management behavior. In this study, a Chinese version containing a total of 14 items was used to evaluate participants' adherence to diet (4 items), exercise (2 items), medication (2 items), foot care (3 items) and SMBG (3 items). A mean score of the two items was used to form the average score for the medication adherence due to different treatment modalities for participants. Therefore, the possible total score for the entire scale was 0-91, with higher total scores showing better self-management practices. A typical item is "how many of the last seven days have you followed a healthful eating plan". The Cronbach's *a* coefficient for the entire scale was 0.75 in this study.

Glycosylated Hemoglobin A1C (HbA1c), the outcome measurement in the current study, was used as an indicator of glycemic control levels. The values of HbA1c were obtained from the medical records by the RA. If there was no record of the HbA1c value recorded in the chart during the past three months, venous blood was drawn and analyzed using high pressure liquid chromatography. Glycemic control variables were categorized using the American Diabetes Association (ADA) guidelines[32]. Values less than 7.0% were regarded as optimal glycemic control and coded as 0 in

the data analysis while values of 7.0% and above were considered as suboptimal glycemic control and coded as 1.

2.4 Data analysis

Data were managed and analyzed using STATA 13 (StataCorp LP, Texas, USA). Data were double-checked for entry errors and missing data before analyses began. Descriptive statistics were used to calculate the frequency, mean, and standard deviation of demographic and diabetes related information. Independent student t tests and Chi-square tests were conducted to compare the demographic and diabetes related information between different glycemic control groups. Correlation analyses were performed to examine the relationships among variables to select covariates of the model. Generalized Structural Equation Modeling (GSEM) was used to explore the structural relationships between study variables because the outcome variable HbA1c was treated as a dichotomous variable. An HbA1C value less than 7.0% (53mmol/mol) was coded as 0 and 7.0% or above as 1. Model specification error, outliers, influential observations, missing data and multicollinearity were checked before testing the model. No outliers, influential observations, missing data or multicollinearity were identified. A p value of less than 0.05 was considered as statistically significant (two-tailed).

3. Results

3.1 Demographic characteristics

Demographic data were listed for the aggregate sample and by optimal glycemic control (HbA1c<7.0%, or 53mmol/mol) and suboptimal glycemic control groups

(HbA1c≥7.0%, or 53mmol/mol), respectively (Table 1). Only 91 (35.82%) participants achieved optimal glycemic control. The mean age for all participants was 55.26 ± 10.11 years, and for those who achieved optimal glycemic control and suboptimal glycemic control were 52.85 ± 10.90 years and 56.60 ± 9.41 years, respectively. The majority of the subjects were married (*n* = 228, 89.76%) and had less than a senior high school level education (*n* = 232, 91.34%). Approximately half of the participants were unemployed; spent 1001 to 5000 Chinese dollars (156 to 774 US dollars) per year on diabetes care; had average family income of 2000 Chinese dollars (311 US dollars) or above per month; and were covered by medical insurance for urban residents. Patients in the optimal glycemic control group were more likely coming from the suburban sites and were more likely to be unemployed. There were no significant differences between optimal and suboptimal control group in terms of marital status, educational level, household monthly income per capita, insurance coverage, and health expenditure on diabetes per year.

3.2 Diabetes related information

Two hundred and six (81.10%) participants reported having a family history of diabetes. Only 62.2% (*n* =158) of the participants had attended diabetes-related education lectures or consulting sessions. However, over 80% of participants indicated that they had received instructions on diet or exercise from health professionals. One hundred and three participants took oral anti-diabetes drugs (OADs) as well as injected insulin. One hundred and fifty-one participants only used OADs. The entire sample had an average BMI greater than 25, indicating they were

overweight. The mean time for having been diagnosed with T2DM was around 8 years. Participants had an average of 2 diabetes complications. Compared to the optimal control group, the suboptimal control group had significantly longer duration of diabetes, more complications, and less optimal diabetes self-management practices. No statistically significant differences were found between the two groups in terms of BMI, depression, diabetes distress, and diabetes self-efficacy scores. Please refer to Table 2 for more details.

3.3 Correlations between study variables

As shown in table 3, diabetes self-efficacy was negatively associated with the number of complications, depression, and diabetes distress. Diabetes self-management was positively associated with the urban site, employment status and diabetes self-efficacy but negatively related to the number of complications. For HbA1c, better diabetes self-management practices were associated with improved glycemic control. By contrast, older age, urban site, more complications, longer duration of diabetes and higher BMI were associated with suboptimal glycemic control. Therefore, age, site, the number of complications, duration of diabetes and BMI were treated as covariates of HbA1c.

3.4 Effects of depression, diabetes distress, self-efficacy, Self-management on glycemic control

As indicated by Figure 2, only diabetes self-management had a direct effect on glycemic control. Depression and diabetes distress only had indirect effects on glycemic control through diabetes self-efficacy and self-management. Similarly,

diabetes self-efficacy only had an indirect effect on glycemic control through diabetes self-management. Although depression was associated with diabetes self-management in the bivariate analysis, the path coefficient from depression to diabetes self-management was not significant in the final model. Site and duration of diabetes were significant covariates of glycemic control and site and number of complications were significant covariates of diabetes self-management.

4. Discussion

HbA1c is recommended by ADA to measure glycemic control during the past three months[32]. In our study, 91 (35.82%) participants achieved the glycemic control target of an HbA1c less than 7.0% (53mmol/mol). This result is consistent with the findings from large-scale studies in China[5-8]. Patients in the urban site had worse glycemic control than those in the suburban sites. In China, people always favor using hospitals in urban areas, especially when they feel they are severely ill, which could account for the low number of participants achieving optimal glycemic control at the urban site. The relatively low number of participants from the urban hospital may be another possible explanation for the low number of participants who achieved adequate glycemic control. Having had diabetes for a longer time may also be responsible for the worse glycemic control. These findings are supportive of those obtained elsewhere in China[5,22].

Diabetes self-management is crucial for controlling blood glucose levels. Our results highlight this well. As depicted in Table 2, the optimal glycemic control group had significantly higher diabetes self-management scores than the suboptimal control

group. The results from the final model further confirmed this. After controlling for the site and the duration of diabetes, diabetes self-management was the only factor which had a direct effect. Specifically, a one point score increase on the diabetes self-management scale leads to a 5% drop in the risk for suboptimal glycemic control (Figure 2). In other words, if patients adhered to even only one diabetes self-management behavior which was listed in the SDSCA for only one day, the risk of suboptimal glycemic control would have been decreased by 5%, indicating the important role the diabetes self-management plays in controlling glycemic levels. Nevertheless, adherence to DSMP in our study was suboptimal. The average diabetes self-management score of 47.70 for the aggregate sample was approximately half of the full possible score. Even for the optimal control group, the average score of 52.26 was only 57% of the full possible score (Table 2). These findings are similar to those in the Diabetes Attitudes, Wishes and Needs (DAWN) study across the US[33] and studies in China[34,35]. As a results, it is vital to examine underlying mechanisms which influence patients' diabetes self-management behaviors and glycemic control levels.

Prior studies suggested that diabetes self-efficacy can impact glycemic control directly[20,21] or indirectly[22,23]. The current study indicates that it only influences glycemic control indirectly through diabetes self-management behaviors. With a one point score increases in patients' diabetes self-efficacy, diabetes self-management score increases significantly by 0.26(0.28?) points. The combination of site, number of complications and diabetes self-efficacy explains approximately 18.4% variance in

diabetes self-management score. This echoes the finding of a study in Shanghai, China[22]. When educating Chinese individuals with type 2 diabetes, clinicians should be mindful the indirect effect of diabetes self-efficacy on glycemic control, as improving diabetes self-efficacy alone may not lead to better glycemic control. As has been supported by another study[36], incorporating the education to enhance the adherence to diet, exercise, medication, SMBG and foot care into the education to improve patients' diabetes self-efficacy turned out to be successful to achieve better health outcomes.

The current study also shows that diabetes distress and depression only affect HbA1c indirectly. They are both negatively associated with diabetes self-efficacy and explain 18.0% of variance in diabetes self-efficacy scores. Meanwhile, their impacts on glycemic control are further mediated by diabetes self-management. Although the association between depression and diabetes self-management is significant in the bivariate analysis, the relationship is attenuated and become non-significant after taking diabetes self-efficacy into account in the final model. Conflicting findings were indicated in a study[20] in the US that found diabetes distress had a direct impact on glycemic control yet depression was not associated with diabetes self-efficacy. Nevertheless, that study[20] paralleled our findings that depression was not associated with HbA1c. Therefore, when designing programs to improve patients' glycemic control level, clinicians should incorporate psychological assessment and interventions into the educational programs. In addition, psychological interventions alone may not result in better glycemic control. Comprehensive interventions to

promote diabetes self-efficacy and self-management, along with psychological interventions should be considered.

There are some limitations worth noting in this study. First, the nature of convenience sampling limits the generalizability of findings to the whole T2DM population in China. Secondly, this study used cross-sectional design, so a causal relationship between glycemic control and its influencing factors cannot be determined. Thirdly, our study used a self-reported questionnaire. Therefore, the results are subject to social desirability and recall response bias. Lastly, due to the lack of model fit estimation capabilities of GSEM, the final model used to examine the relationships among variables may not be the best model to fit the data. However, we established the model based on a comprehensive literature review and included as many paths among the variables of interest as possible. The large sample size in our study enabled us to achieve sufficient statistical power when incorporating all possible paths into the model, thereby achieving reliable results.

5. Conclusions

Findings from this study add to the current literature about how depression, diabetes distress, diabetes self-efficacy, and diabetes self-management collectively impact glycemic control among Chinese T2DM patients. Our study highlights the importance of good diabetes self-management in achieving optimal glycemic control levels. Meanwhile, depression, diabetes distress, and diabetes self-efficacy impact glycemic control levels indirectly via diabetes self-management. Clinicians should target future interventions to improve diabetes self-efficacy through decreasing depressive

symptoms and diabetes distress levels when educating patients about how to manage their diabetes; and, in turn, improve their adherence to diabetes self-management practices, and ultimately reaching the optimal goal of glycemic control.

Conflicts of Interest

No potential conflicts of interest relevant to this article were reported.

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Contributors

Conducted data analysis and drafted the manuscript (K.Lin); Analyzed and interpreted data(C. Park); Designed/supervised the study, interpreted data (M. Li), Collected Data (X. Wang, X. Li and W. Li), Interpreted data and revised the paper (L. Quinn). All authors have approved the final article.

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Table 1 Descriptive Analyses for Demographic Characteristics (N, %)

Characteristics	Overall (N=254)	Optimal control group(N=91)	Suboptimal control group(N=163)	X^2
Site				14.81***
Suburban site1 and 2	174 (68.50)	76(83.52)	98(60.12)	
Urban site1	80(31.50)	15(16.48)	65(39.88)	
Marital status				3.47
Single/Divorced/Widowed	26(10.24)	5(5.49)	21(12.88)	
Married	228(89.76)	86(94.51)	142(87.12)	
Educational level				5.33
Junior high school and less	121(47.64)	38(41.76)	83(50.92)	
Senior high school or equivalent	111(43.70)	48(52.75)	63(38.65)	
College/university and above	22(8.66)	5(5.49)	17(10.43)	
Employment status				6.45*
Full or part-time	53(20.87)	14(15.38)	39(23.93)	
Unemployed	124(48.82)	54(59.34)	70(42.94)	
Retired	77(30.31)	23(25.27)	54(33.13)	
Household monthly income per capita				3.13
500 Chinese dollars (80 US dollars) and less	28(11.02)	6(6.59)	22(13.50)	
501 to 1999 Chinese dollars (81 to 310 US dollars)	88(34.65)	35(38.46)	53(32.52)	
2000 Chinese dollars (311 US dollars) and above	138(54.33)	50(54.95)	88(53.99)	
Insurance coverage				6.91
Self-insured	8(3.15)	0(0)	8(.91)	
Medical insurance for urban residents	119(46.85)	46(50.55)	73(44.79)	
New cooperative insurance for rural residents	95(37.40)	37 (40.66)	58(35.58)	
Governmental insurance	32(12.60)	8(8.79)	24(14.72)	
Health expenditure on diabetes per year				3.12
1000 Chinese dollars (155 US dollars) and less	24(9.45)	9(9.89)	15(9.20)	
1001 to 5000 Chinese dollars (156 to 774 US dollars)	133(52.36)	47(51.65)	86(52.76)	
5001 to 9999 Chinese dollars (775 to 1547 US dollars)	67(26.38)	28(30.77)	39(23.93)	
10000 Chinese dollars (1548 US dollars) and above	30(11.81)	7(7.69)	23(14.11)	

* $p<0.05$ *** $p<0.01$

Table 2 Descriptive Analyses for Diabetes-related Information (mean ± SD)

Characteristics(possible range of values)	**Overall (N=254)**	**Optimal control group(N=91)**	**Suboptimal control group(N=163)**	***t value***
BMI	24.99 ± 3.40	24.61 ± 3.37	25.21 ± 3.41	-1.36
Duration of diabetes	8.15 ± 6.70	5.53 ± 5.00	9.62 ± 7.08	-4.86***
Number of diabetes complications	2.02 ± 1.53	1.51 ± 1.20	2.31 ± 1.62	-4.16***
Depression score (0-27)	4.62 ± 4.04	3.96 ± 3.34	4.99 ± 4.32	-1.94
Diabetes distress score(15-90)	38.94 ± 12.85	38.30 ± 11.05	39.30 ± 13.77	-0.60
Diabetes self-efficacy score(20-100)	74.72 ± 15.43	76.58 ± 14.19	73.69 ± 16.04	1.43
Diabetes self-management score(0-91)	47.70 ± 15.00	52.26 ± 12.55	45.15 ± 15.69	3.71***

*** p<0.001

Table 3 Correlations among Study Variables (*N* = 254)

	1	2	3	4	5	6	7	8	9	10	11	12
1. Age	1.00											
2. Site	*0.03*	1.00										
3. Gender	*0.13*	*-0.05*	1.00									
4. Employment status	*0.36****	*0.20***	*0.16**	1.00								
5. N. of complications	*0.31*	*0.04*	*0.02*	*0.06*	1.00							
6. Duration	*0.50****	*0.25****	*0.08*	*0.21****	*0.41****	1.00						
7. BMI	*0.04*	*0.16***	*0.04*	*-0.05*	*0.16***	0.03	1.00					
8. Depression	*-0.05*	*0.24****	*0.002*	*-0.01*	*0.26****	0.07	-0.02	1.00				
9. Diabetes distress	*-0.09*	*0.01*	*0.12**	*-0.11*	*0.15**	-0.03	0.06	0.52***	1.00			
10. Diabetes self-efficacy	*-0.06*	*0.03*	*0.04*	*0.11*	*-0.19***	0.10	-0.01	-0.33***	-0.39***	1.00		
11. Diabetes self-management	*-0.11*	*0.22****	*0.01*	*0.15**	*-0.20***	0.04	-0.05	-0.14*	-0.12	0.33***	1.00	
12. HbA1c	*0.16**	*0.20***	*-0.02*	*0.002*	*0.25****	*0.30****	*0.16***	*0.10*	*0.02*	*-0.06*	*-0.24****	1.00

Note: The numbers on the top of the table denote as follows: 1. Age 2. Site 3. Gender 4. Employment status 5. Number of complications 6. Duration 7. BMI 8. Depressive symptom 9. Diabetes distress 10. Diabetes self-efficacy 11. Diabetes self-management 12. HbA1c

* p<0.05 ** p<0.01 *** p<0.001 Data in italics means Spearman coefficient.

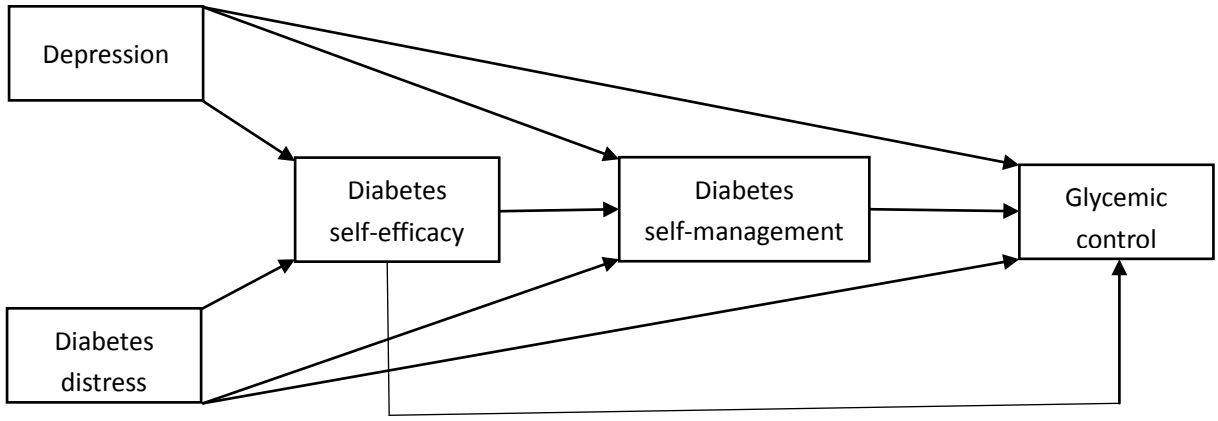

Figure 1 The hypothesized model to examine the direct and indirect effects of depression, diabetes distress, diabetes self-efficacy and self-management on glycemic control

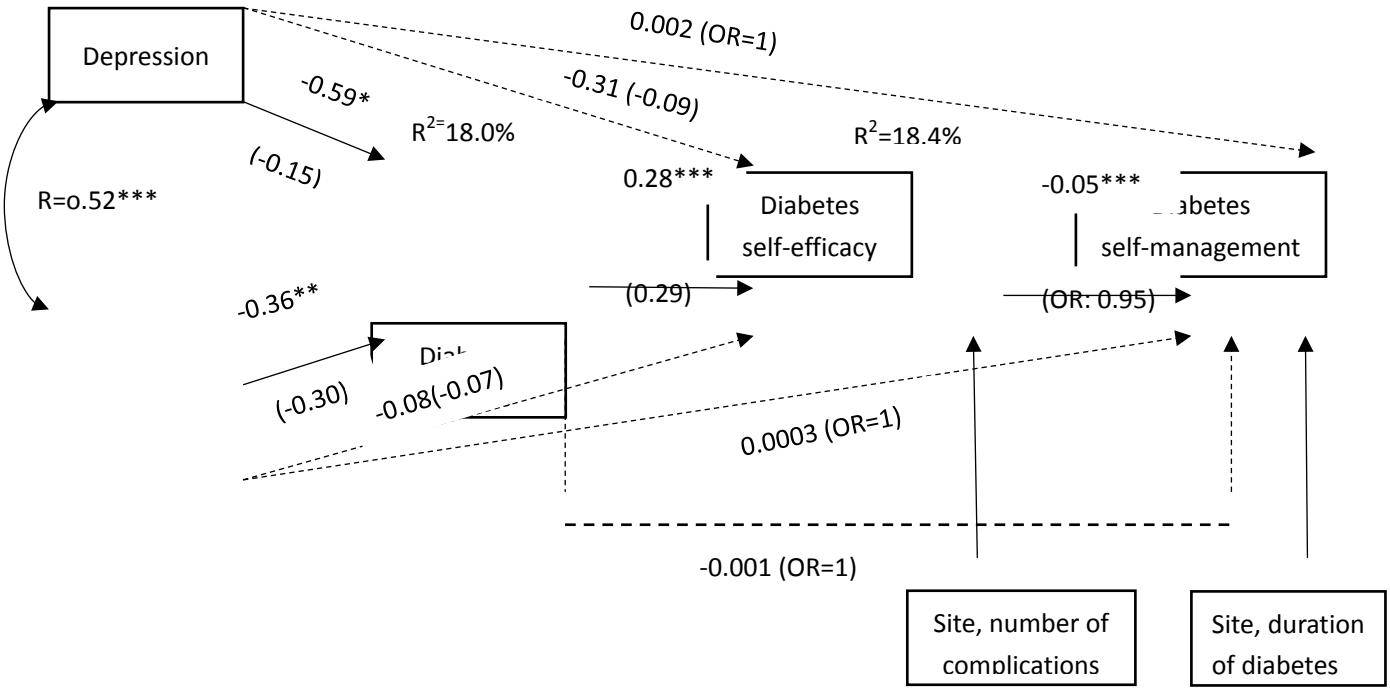

Figure 2 The estimated model to examine the direct and indirect effects of depression, diabetes distress, diabetes self-efficacy and self-management on glycemic control

Note: Values in parentheses are the standardized path coefficients unless otherwise specified. Dotted lines denote paths in which the coefficient are not significant.
* p<0.05 ** p<0.01 *** p<0.001