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The Trend of Changes in Insulin Treatment Adherence among Young and Middle-Aged Patients with Type 2 Diabetes Mellitus within Two Months after Discharge: A Longitudinal Observational Study

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Abstract

Objective: The study aimed to investigate the trend of insulin treatment compliance among young and middle-aged patients with type 2 diabetes (T2DM) over time after discharge, providing theoretical basis for clinical practice. **Methods:** General information questionnaires were collected at the time of discharge. Clinical data were obtained at discharge and two months post-discharge. The Insulin Treatment Adherence Scale was administered at four time points: at discharge, one week post-discharge, one month post-discharge, and two months post-discharge. **Results:** The overall insulin treatment adherence score and scores across all subscales exhibited a progressive decline over time. Differences in total and subscale scores across time points were statistically significant. **Conclusion:** Insulin treatment adherence among young and middle-aged T2DM patients progressively declines during the first two months after discharge. Healthcare professionals should implement targeted follow-up protocols and evidence-based interventions for this patient population to improve treatment adherence.

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Keywords

Middle-Aged and Young Adults, Type 2 Diabetes, Insulin Therapy, Treatment Adherence, Influencing Factors

1. Introduction

According to the 2021 data from the International Diabetes Federation (IDF) [1], the global prevalence of diabetes mellitus (DM) has reached 537 million individuals. Compared with the ninth edition of the IDF report, the overall prevalence has increased by 12.9%. In China, the number of people living with diabetes has reached 140 million, with a prevalence rate of 12.8%, ranking first globally in terms of disease burden [1] [2]. Notably, 79% of diabetic patients fall within the middle-aged and young adult population [3]. However, research indicates that glycemic control rates among this age group remain suboptimal [4].

Existing evidence confirms that adherence to insulin therapy significantly reduces mortality risk in patients with diabetes [5], and early intensive insulin intervention may help restore impaired pancreatic β-cell function [6]. Despite these benefits, studies have shown that treatment adherence among young and middle-aged patients with type 2 diabetes mellitus (T2DM) is generally poor [3]. Optimize diabetes management strategies to enhance treatment adherence among patients and thereby improve their overall health outcomes and quality of life [7].

Currently, although observational studies have reported on insulin treatment adherence among patients with type 2 diabetes, there remains a paucity of longitudinal observational evidence regarding insulin treatment adherence specifically in young and middle-aged individuals with type 2 diabetes residing in the economically underdeveloped western regions of Guangxi, China. Therefore, it is necessary to conduct a longitudinal investigation into insulin treatment compliance during the post-discharge period. To determine the trend of compliance and provide a theoretical basis for subsequent nursing interventions.

This study aimed to examine the trend in insulin treatment compliance among young and middle-aged T2DM patients at multiple time points: during hospitalization, at one week, one month, and two months after discharge. Additionally, the study analyzed the primary factors influencing treatment adherence to inform future intervention strategies and nursing practices.

2. Materials and Methods

2.1. Research Object

The design plan of this study has been approved by the Ethics Committee of Rightjiang Medical University. The approval number is 2022111103. It follows the principles of voluntariness, confidentiality, fairness, and no harm. Before

collecting the data, the purpose and significance of this study were explained to the patients, and their consent was obtained and an informed consent form was signed. The patients' data were properly kept. Using the convenience sampling method, 400 young and middle-aged patients with type 2 diabetes mellitus (T2DM) who were hospitalized in the endocrinology department of a tertiary hospital in Baise City from October 2022 to February 2024, had their first insulin treatment, and used an insulin pen as the injection tool after discharge, were selected.

Sample size determination: This study adopted a longitudinal design and utilized convenience sampling to recruit participants who met the predetermined inclusion criteria. Sample size estimation followed the established methodology guidelines for multivariate regression analysis, as outlined by Professor Sun Zhenqiu in the third edition of "Medical Statistics", suggesting that the sample size for a survey study should be 5 - 10 times the total number of questionnaire items. Here, a conservative ratio of 8:1 was adopted. The total number of questionnaire items in this study was 40: 18 items for general demographic information and disease data, and 22 items for the insulin treatment compliance scale. To address potential issues of participant dropout and incomplete questionnaires, a 20% contingency margin was employed. Therefore, the required sample size calculation is as follows: $n = 40 \times 8 \times (1 + 20\%) = 384$, rounded up to 400 cases.

Inclusion criteria were as follows: 1) diagnosis of T2DM according to the "Chinese Guidelines for the Prevention and Treatment of Type 2 Diabetes (2020 Edition)" (6); 2) age between 18 and 59 years; 3) first-time initiation of insulin therapy during hospitalization in the Department of Endocrinology; 4) use of insulin pens post-discharge; 5) understood and agreed to participate in the study; 6) possessing normal cognitive function, the individual is capable of cooperating with the investigation and completing the study.

Exclusion criteria included: 1) presence of severe psychiatric or psychological disorders; 2) serious comorbid physical illnesses; 3) diagnosis of malignant tumors; 4) pregnancy or lactation; 5) requirement of family assistance for insulin injections. Additional exclusion during follow-up applied to: 1) patients lost to follow-up; 2) those who withdrew from the study or were unable to cooperate with data collection; and 3) individuals who developed acute, life-threatening conditions affecting major organs (e.g., heart, brain, or kidneys) during the study period.

2.2. Research Tools

2.2.1. General Information, Disease Characteristics

General Information: This includes gender, age, marital status, living arrangement, long-term residence, educational attainment, employment status, financial capacity, and monthly household income.

Disease-Related Information: This encompasses duration of illness, frequency

of daily insulin injections, types of coexisting chronic conditions, categories of oral hypoglycemic agents used, frequency of hypoglycemic episodes, body mass index (BMI), smoking status, alcohol consumption, and sources of insulin-related knowledge acquisition.

2.2.2. Insulin Treatment Adherence

The insulin treatment compliance scale (ITAQ) developed by Li Yan [8] was adopted. This scale consists of 5 dimensions: dietary compliance, exercise compliance, medication compliance, self-monitoring, and regular check-ups, with a total of 22 items. Each item was scored using a 3-level rating system. The first 13 items and the 17th to 20th items were scored using a positive rating method, with 1, 2, and 3 points assigned for "often", "occasionally", and "never" respectively. The 14th to 16th items were scored using a negative rating method, with 3, 2, and 1 points assigned for "often", "occasionally", and "never" respectively. The total score of the scale ranges from 22 to 66, with a higher score indicating better compliance. The insulin treatment compliance assessment method: a total score of 40 is considered the critical point. A total score of ≥53 indicates good compliance, a score of 40 to 52 suggests average compliance, and a score of <40 indicates poor compliance.

The Cronbach's α coefficient of the scale is 0.870. In this study, 330 valid questionnaires from patients with type 2 diabetes were selected for reliability testing of the scale. The total Cronbach's α coefficient of the scale was 0.933, and the Cronbach's α coefficients for each dimension were 0.817, 0.893, 0.837, 0.930, and 0.933, indicating that the questionnaire has good reliability.

The calculation method for the insulin treatment compliance rate in this study is:

Insulin compliance rate = (total score of the insulin treatment compliance scale assessment ÷ total score of the insulin treatment compliance questionnaire) × 100%.

2.3. Data Collection

2.3.1. Informed Consent

For patients who meet the inclusion criteria, on the day of discharge, the researchers obtain the patients' consent. They introduce the content and purpose of this survey to the patients and inform them that they have the freedom to participate and to withdraw from the study at any time. The research subjects sign the informed consent form, provide their mobile phone numbers and add the researchers' WeChat accounts. They are informed that a questionnaire survey will be conducted upon discharge, and follow-up visits will be conducted one week, one month, and two months after discharge, using a combination of telephone follow-up, outpatient follow-up, and WeChat follow-up methods.

2.3.2. Data Collection Methods

At discharge: 1) General information and disease data questionnaires were dis-

tributed; 2) Insulin treatment compliance scale was provided. This survey will take approximately 6 minutes.

One week after discharge: The Insulin Treatment Compliance Scale was administered using an online platform (Questionnaire Star). Researchers contacted participants by telephone to explain the survey instructions and subsequently sent the questionnaire's QR code via WeChat for self-completion. Participants were instructed to report on their insulin treatment compliance behaviors occurring from the time of discharge to the time of completing the survey. This assessment required approximately three minutes.

One month after discharge: Researchers conducted a follow-up call and communicated via WeChat to remind participants of their scheduled outpatient visit. The Insulin Treatment Compliance Scale was again distributed via Wenjuanxing (an online survey tool). After reviewing the instructions over the phone, participants received the QR code via WeChat to complete the questionnaire independently. They were instructed to report on compliance behaviors occurring between the previous survey and the current response. The estimated completion time was three minutes.

Two months after discharge: The investigators conducted follow-up calls and used WeChat communication to remind patients to return to the outpatient clinic for follow-up visits on time. Questionnaires were distributed in the form of Qianlixing, including 1) disease information, 2) insulin treatment compliance scale. The researchers explained that this was the last questionnaire, and the purpose of this questionnaire was to obtain longitudinal data from the patients, so as to analyze the trajectory of insulin treatment compliance of the research subjects, provide theoretical basis for clinical practice, and the start and end time of patients' answering the questionnaire questions was the period from the last submission of the questionnaire to the time of answering this questionnaire when the insulin treatment compliance behavior occurred during insulin treatment. This survey approximately takes 10 minutes. The BMI of the patients was measured by the follow-up personnel in the outpatient clinic after measuring their height and weight, and then calculated according to the formula. See **Table 1**.

2.4. Quality Control

Feasibility of the research: During the preparatory stage of the research, based on extensive literature review, the scientific and feasibility of the design of this research topic were repeatedly discussed through two rounds of consultations with experts (two chief nurse practitioners, two deputy chief nurse practitioners, and one doctoral student). A pre-survey was conducted on the insulin treatment compliance scale for diabetic patients and the related questionnaires selected for the influencing factors. The general demographic questionnaire was revised, and the reliability of the insulin treatment compliance scale was evaluated. A unified diabetes education skills training was provided to nurses, and insulin

knowledge and injection skills guidance were given to patients after their admission.

Collection of general information and disease information: All objective data involving the general information and disease information were filled in after enrollment by consulting electronic medical records. Subjective data and questionnaire scales that could not be obtained from the cases were collected by investigators through face-to-face interviews, telephone follow-ups, outpatient follow-ups, and WeChat in combination.

During the follow-up stage, measures were taken to reduce the dropout rate: The investigators introduced themselves well to obtain the patients' trust and ensure the acquisition of true data during the follow-up; all patients were required to provide two or more valid contact methods to ensure smooth communication and the accuracy of data collection.

Data management and accuracy assurance: During data processing, double data entry was performed using SPSS 25.0 by two independent operators. All datasets underwent logical validation and secondary verification.

2.5. Data Analysis

(1) The general information and disease data of the research subjects were described using frequency and constituent ratio (n, %).

(2) For the insulin treatment compliance scores that follow a normal distribution, they were described using ($\overline{x} \pm s$). A line graph was drawn to illustrate the dynamic changes of insulin treatment compliance scores over time in different periods.

(3) The comparison between two groups of count data was conducted using the 2-test for the fourfold table of groups, and the comparison for more than three groups was conducted using the 2-test for R × C table data; the comparison between groups of ranked data was conducted using the rank sum test.

(4) The insulin treatment compliance rates at four time points—at discharge, one week after discharge, one month after discharge, and two months after discharge—of the research subjects were described using percentages. A line graph was drawn to illustrate the changes of insulin treatment compliance rates over time in different periods.

In this study's statistics, $\alpha = 0.05$ was used as the test level, and the P values were both bilateral probabilities.

3. Results

3.1. Data Collection

A total of 400 young and middle-aged patients with type 2 diabetes who met the inclusion criteria were enrolled in this study between October 2022 and February 2024. Details regarding participant enrollment and attrition are provided in **Figure 1**.

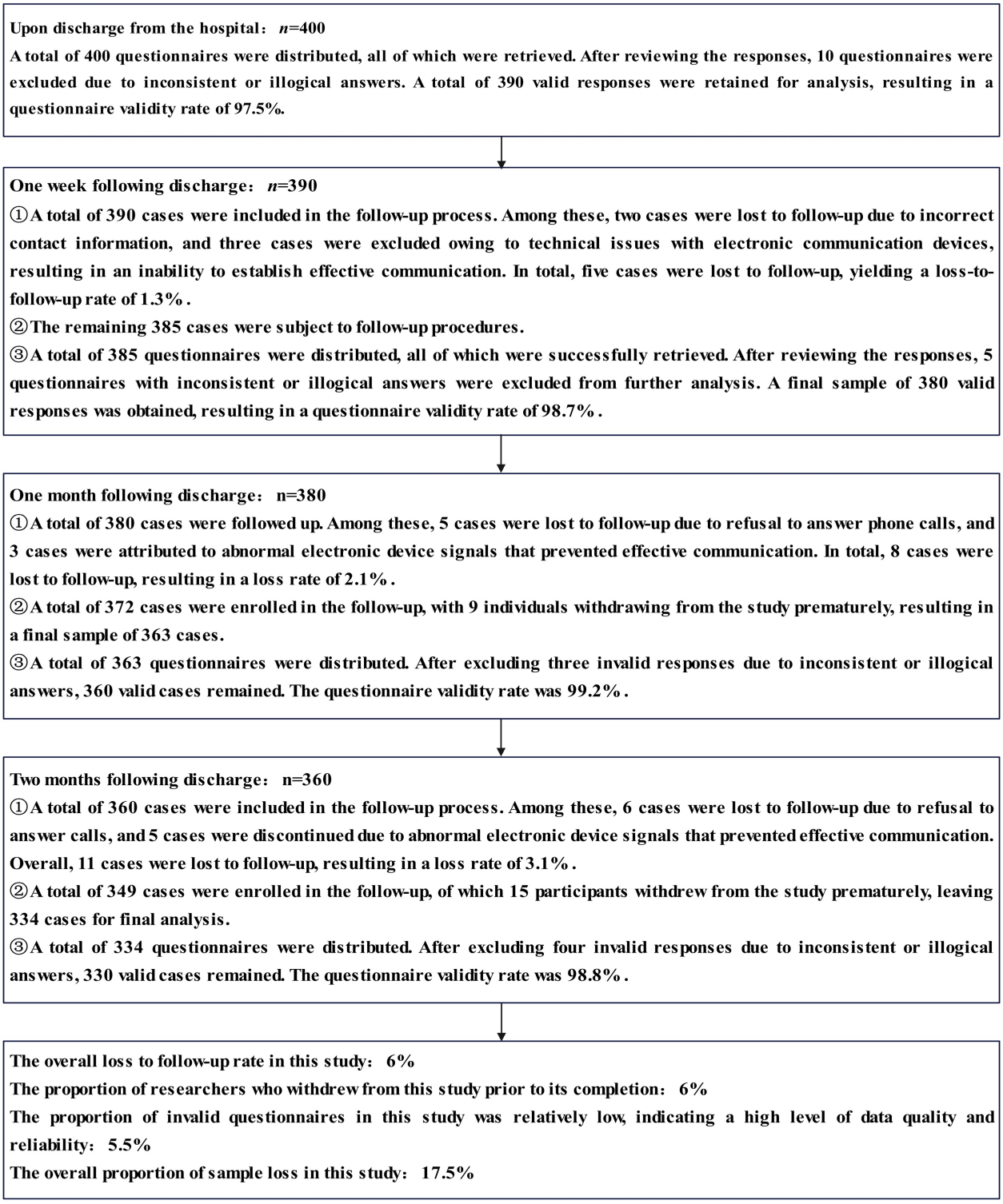


Figure 1. Flowchart illustrating sample attrition in this study.

3.2. General Information and Disease Data of the Research Subjects

3.2.1. General Information

A total of 330 research subjects completed all follow-up visits and submitted valid

questionnaires. With regard to demographic characteristics, 215 were male (65.2%) and 115 were female (34.8%). The age range was from 20 to 59 years, with a mean age of 47.35 ± 8.3 years. Detailed general information is presented in Table 1.

Table 1. Demographic characteristics of the study participants (n = 330).

Variable	Category	Number of Cases	Composition Ratio (%)
Gender	Male	215	65.2
	Female	115	34.8
Age	Youth (18 - 44 years)	105	31.8
	Middle-aged individuals (45 - 59 years)	225	68.2
Marriage	Single	17	5.2
	Married	309	93.6
	Divorce	4	1.2
Residential status	Living independently	17	5.2
	Reside with one's spouse	234	70.9
	Living with children	10	3
	Reside with one's spouse and children	67	20.3
	Others	2	0.6
Long-term residency	Town	97	29.4
	Rural areas	233	70.6
Educational attainment	Junior high school or lower educational attainment	251	76.1
	Secondary education	42	12.7
	Junior college	21	6.4
	A bachelor's degree or higher	16	4.8
Current Work Status	None specified	79	23.9
	Retirement or departure due to old age	19	5.8
	Employed	224	67.9
	Student	8	2.4
The capacity to meet financial obligations	Streamlined payment process	86	26.1
	Minimal compensation	244	73.9
Per capita monthly household income	<2000 RMB	216	65.5
	2000 - 3000 RMB	88	26.7
	3001 - 5000 RMB	13	3.9
	≥5001 RMB	13	3.9

3.2.2. Disease Data

As shown in Table 2, comparative analysis of disease-related parameters between young and middle-aged patients with type 2 diabetes mellitus (T2DM) revealed

statistically significant differences in body mass index (BMI) and the frequency of hypoglycemia at discharge and two months post-discharge ($P < 0.05$). No statistically significant differences were observed in other disease-related variables at these time points ($P > 0.05$).

Note: This study adheres to the diagnostic criterion for hypoglycemia specified in the "Chinese Guidelines for the Prevention and Treatment of Type 2 Diabetes (2020)", which defines hypoglycemia as a blood glucose level below 3.9 mmol/L in diabetic patients undergoing pharmacological treatment. The incidence of hypoglycemia was calculated as follows:

Incidence of hypoglycemia = (Number of individuals experiencing hypoglycemia during insulin therapy/Total number of research subjects during the same period) × 100%.

Table 2. Disease-related clinical characteristics of the study participants at discharge and at the two-month follow-up ($n = 330$).

Variable	Category	Upon discharge from the hospital		Two months following discharge		χ^2/Z	P
		Number of Cases	Compositio n Ratio (%)	Number of Cases	Compositio n Ratio (%)		
Disease progression	<5 Years	264	80	260	78.8		
	5 - 10 Years	43	13	47	14.2		
	>10 Years	23	7	23	7	0.208	0.901
The frequency of insulin injections	1	29	8.8	33	10		
	2	208	63	204	61.8		
	3	26	7.9	27	8.2		
	4	67	20.3	66	20	−0.246	0.806
Types of chronic diseases	One type	38	11.5	37	11.2		
	Two types	39	11.8	40	12.1		
	Three types	252	76.4	251	76.1		
	≥Four types	1	0.3	2	0.6	0.361	0.948
Classification of Oral Hypoglycemic Agents	Zero types	141	42.7	142	43		
	≥One type	189	57.3	188	57	0.006	0.937
The frequency of hypoglycemic episodes	Zero instances	268	81.2	247	74.8		
	≥Once	62	18.8	83	25.2	3.898	<0.05
BMI	Emaciated (<18.5)	11	3.3	11	3.3		
	Normal (18.5 - 23.9)	131	39.7	169	51.2		
	Overweight (24 - 25)	58	17.6	72	21.8		
	Obesity (>25)	130	39.4	78	23.6	19.321	<0.05
Smoking	Never	220	66.7	220	66.7		
	Occasionally	76	23	75	22.7		

Continued

	Frequently	29	8.8	29	8.8		
	Discontinue smoking	5	1.5	6	1.8	0.098	0.992
Alcohol consumption	Never	199	60.3	199	60.3		
	Occasionally	102	30.9	102	30.9		
	Frequently	22	6.7	20	6		
	Discontinue alcohol consumption	7	2.1	9	2.7	0.345	0.951
Methods for Acquiring Knowledge in Data Mining	Healthcare professionals in the field of endocrinology	323	97.9	324	98.2		
	Medical personnel outside the field of endocrinology	7	2.1	6	1.8	1.627	0.202

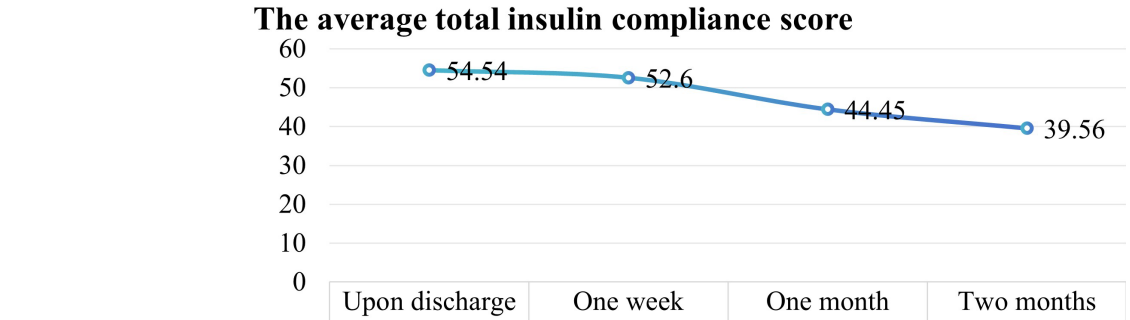
3.3. Current Status and Changes in Insulin Treatment Compliance among Young and Middle-Aged T2DM Patients at Different Time Points

3.3.1. Changes in Insulin Treatment Compliance Scores at Different Time Points

Insulin treatment compliance scores, including scores across individual dimensions, followed a normal distribution among young and middle-aged T2DM patients at different time points. A line graph was drawn to illustrate the dynamic changes of insulin treatment compliance scores over time in different periods. Results indicated that both the total compliance score and dimension-specific scores exhibited a progressive downward trend over time following discharge. Refer to Table 3, Figure 2, and Figure 3 for detailed data.

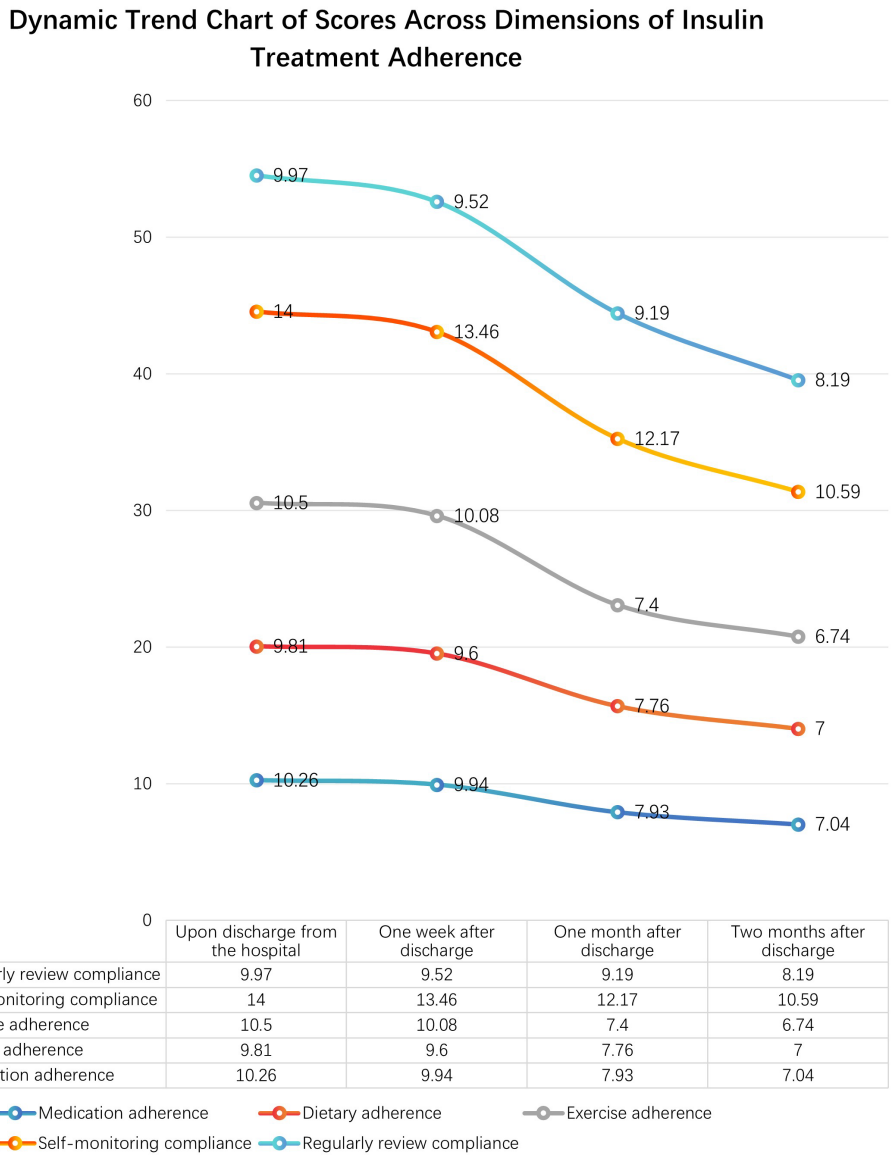
Table 3. Insulin treatment adherence scores among young and middle-aged patients with type 2 diabetes mellitus across multiple time points (n = 330).

Variable	Scores at Various Time Points			
	Upon discharge from the hospital	One week following discharge	One month following discharge	Two months following discharge
Total ITAQ Score	54.54 ± 4.50	52.60 ± 14.8	44.45 ± 3.63	39.56 ± 4.49
Medication adherence	10.26 ± 1.36	9.94 ± 1.30	7.93 ± 1.46	7.04 ± 2.39
Dietary adherence	9.81 ± 1.23	9.60 ± 1.09	7.76 ± 1.43	7.00 ± 2.12
Exercise adherence	10.50 ± 0.80	10.08 ± 1.00	7.40 ± 1.24	6.74 ± 2.05
Self-monitoring	14.00 ± 0.76	13.46 ± 1.34	12.17 ± 1.38	10.59 ± 2.39
Periodic evaluation and assessment	9.97 ± 1.74	9.52 ± 1.56	9.19 ± 1.78	8.19 ± 2.93



	Upon discharge from the hospital	One week following discharge	One month following discharge	Two months following discharge
The average total insulin compliance score	54.54	52.6	44.45	39.56

Figure 2. Dynamic change chart of the total score for insulin treatment compliance.



	Upon discharge from the hospital	One week after discharge	One month after discharge	Two months after discharge
Regularly review compliance	9.97	9.52	9.19	8.19
Self-monitoring compliance	14	13.46	12.17	10.59
Exercise adherence	10.5	10.08	7.4	6.74
Dietary adherence	9.81	9.6	7.76	7
Medication adherence	10.26	9.94	7.93	7.04

Figure 3. Dynamic trend chart of scores across dimensions of insulin treatment adherence.

3.3.2. Trends in Insulin Treatment Compliance Rates among Young and Middle-Aged Patients with Type 2 Diabetes Mellitus at Different Time Points

Based on the formula: Insulin Compliance Rate = (Total Score of Insulin Treatment Compliance Questionnaire ÷ Maximum Possible Score) × 100%, the insulin treatment compliance rates during the T1, T2, T3, and T4 periods were calculated as 82.6%, 79.7%, 67.3%, and 59.9%, respectively. A line graph was constructed to illustrate the trend in insulin treatment compliance rates from T1 to T4 (Figure 4). As shown in Figure 4, the insulin treatment compliance rate exhibits a gradual decline with increasing time since discharge.

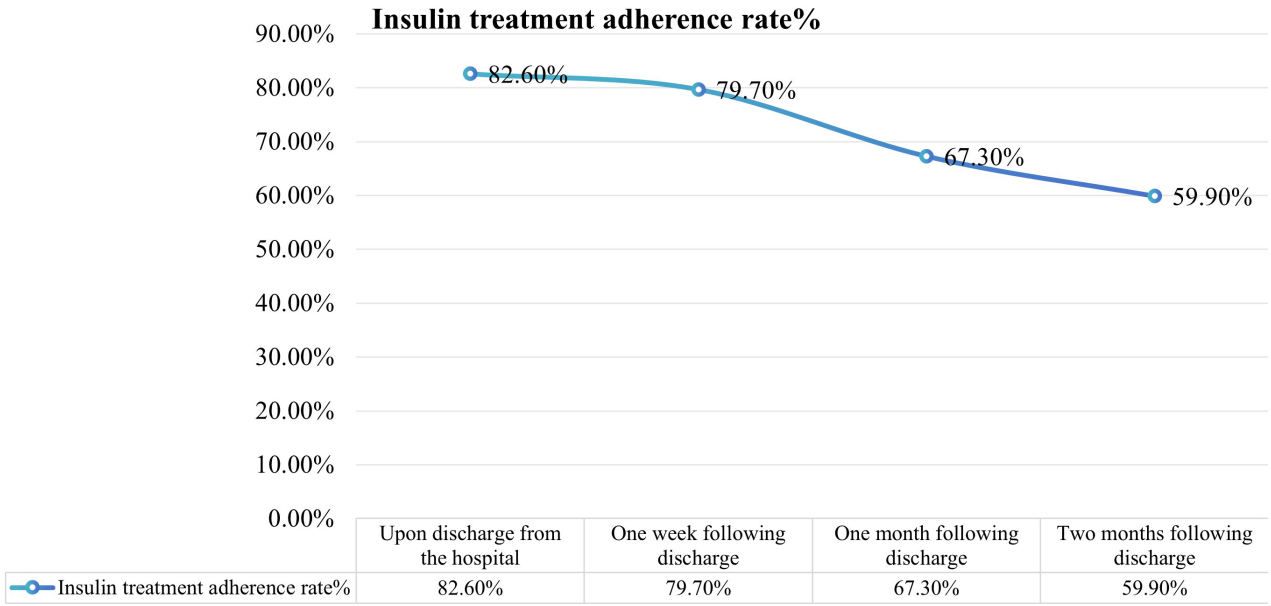


Figure 4. Dynamic change of insulin treatment compliance rate.

3.3.3. Changes in Insulin Treatment Compliance Levels among Young and Middle-Aged Patients with Type 2 Diabetes Mellitus at Different Time Points

Table 4. Changes of insulin treatment compliance levels in young and middle-aged T2DM patients at different time points (n = 330, %).

Category	Upon discharge from the hospital	One week following discharge	One month following discharge	Two months following discharge
Low compliance (scoring below 40 points)	1 (0.3)	1 (0.3)	5 (1.5)	110 (33.3)
Compliance is at an average level (40 - 52 points).	135 (40.9)	204 (61.8)	301 (91.2)	211 (63.9)
Good compliance (≥53 points)	194 (58.8)	125 (37.9)	24 (7.3)	9 (2.7)
	$\chi^2 = 638.504$	$P < 0.001$		

Using a score of 40 as the threshold, insulin treatment compliance was catego-

rized into three levels—good, moderate, and poor—based on total scores. A total score of ≥53 was classified as good compliance, a score between 40 and 52 as moderate compliance, and a score below 40 as poor compliance. Categorical data were used to describe and analyze changes in insulin treatment compliance levels among young and middle-aged patients with type 2 diabetes mellitus (T2DM) from T1 to T4. The results of the linear trend chi-square test indicated a statistically significant linear trend in compliance deterioration over time ($P < 0.001$), suggesting that treatment adherence progressively declined with increasing time since discharge. See Table 4.

4. Discussion

4.1. General Demographic, Sociological, and Disease-Related Data Analysis of the Study Participants

4.1.1. Analysis of General Demographic and Sociological Characteristics of the Study Participants

As shown in Table 1, A total of 330 young and middle-aged patients with type 2 diabetes mellitus (T2DM) completed all follow-up procedures and submitted valid questionnaires. The mean age of the participants was 47.35 ± 8.3 years. Table 1 shows that 31.8% are young people, 68.2% are middle-aged people, 215 cases are male (65.2%), and 115 cases are female (34.8%). This result is basically consistent with many domestic studies [9] [10], and it conforms to the epidemiological characteristics of T2DM in China. The educational level of the research subjects is the highest among those with junior high school or below (251 cases, 76.1%), which is higher than the results of studies by Yan Man *et al.* in Guangxi [9] and Li Feng *et al.* in China [10] (31.3% and 24.8%, respectively). This indicates that the educational level of middle-aged and young T2DM patients in Baise City, Guangxi is at a relatively low level. The reason is that the survey area is located in the border region of Guangxi, and the majority of the research subjects are middle-aged people (68.2%), and most of the patients live in rural areas (70.6%). Compared with developed cities in China and within the region, the opportunities for the research subjects to obtain educational resources are less than those in developed cities in China. Among the 330 middle-aged and young T2DM patients in this study, 23.9% have no occupation, which is higher than the results of studies by Li Feng *et al.* in China [10] (14.6%) and Yan Man *et al.* in Guangxi [9] (34%). In terms of the average monthly household income, 65.5% of the research subjects have an income of less than 2000 yuan per month, which is the majority. The proportion of low-income groups is higher than that in studies by Yan Man *et al.* in Guangxi [9] and Li Feng *et al.* in China [10] (22.1%). This suggests that the cultural level and economic level of this region are relatively behind those of developed cities, and the average monthly income of patients' families is low, with no stable economic source. The patients' families are under heavy economic pressure. In the future, when conducting related research on insulin treatment compliance nursing intervention, more attention should be paid to the general sociological data of patients, and a nursing intervention measure suitable for this region should be formulated based

on the patients' needs.

4.1.2. Analysis of Disease-Related Data of the Research Subjects

Table 2 shows that among 330 young and middle-aged patients with type 2 diabetes mellitus (T2DM), there were no statistically significant differences in the disease course, daily insulin injection frequency, types of chronic diseases, whether oral hypoglycemic drugs were taken, smoking status, drinking status, and the ways of obtaining diabetes knowledge at discharge and 2 months after discharge ($P > 0.05$). The differences in the incidence of hypoglycemia and BMI at discharge and 2 months after discharge were statistically significant ($P < 0.05$). The results of the two disease data (Table 2) show that the proportion of diabetes patients with a course of less than 5 years is 78.8% and 80% respectively, both higher than the research results of Yang Xiaodi *et al.* [11] (39%) in China and also higher than the research results of Yan Man *et al.* [9]. In Guangxi (28.36%). It is indicated that the number of young and middle-aged patients with T2DM in this region is increasing rapidly, which is in line with the current epidemic characteristics of the younger prevalence of T2DM in China. Among the young and middle-aged T2DM patients in this study, the proportion of those treated with oral hypoglycemic drugs combined with insulin was 57.3% and 57% respectively. Both were higher than those in the study by Yan Man *et al.* [9] (49.6%) in Guangxi and the study by Yang Xiaodi *et al.* [11] (42.8%) in China, but lower than those in the study by Li Feng *et al.* [10] (85.7%) in China. The possible reason for the analysis is that the treatment plans for different diabetic patients are slightly different, which is in line with the recommendation in the "Chinese Guidelines for the Prevention and Treatment of Type 2 Diabetes (2020 Edition)" that the blood glucose control plan should be oriented towards individualized treatment.

In this study, the BMI level of young and middle-aged T2DM patients at discharge was generally overweight. There was a statistically significant difference 2 months after discharge compared with that at discharge ($P < 0.05$), but the mean was still higher than the normal range, suggesting that the weight loss effect of the research subjects was not good. This may be related to the decline in treatment compliance after discharge and the risk of weight gain associated with insulin therapy [12]. The incidences of hypoglycemia at discharge and 2 months after discharge in young and middle-aged T2DM patients in this study were 18.8% and 25.2% respectively, which were similar to the previous investigation results of Wu Ailin *et al.* [13]. In China. The incidence of hypoglycemia at 2 months after discharge was higher than that at discharge, and the difference was statistically significant ($P < 0.05$). Among them, 83 cases (25.2%) of young and middle-aged T2DM patients had hypoglycemic events during self-insulin injection after discharge, which was higher than 62 cases (18.8%) during hospitalization. The possible reason for the analysis is that after two months of insulin treatment, the pancreatic islet function of the research subjects recovered compared to when they were discharged from the hospital, and their own insulin secretion increased. Coupled with daily insulin injections, hypoglycemia was more likely to occur. It is sug-

gested that medical staff should strengthen off-hospital follow-up for young and middle-aged T2DM patients who are using insulin for the first time, maintain close contact with patients, such as establishing WeChat groups, making phone calls, and having regular outpatient follow-ups. For patients who frequently experience off-hospital hypoglycemia, the blood glucose control plan should be adjusted in a timely manner. For instance, in the randomized controlled study conducted by Dai Limin *et al.* [14], the Internet + home care mobile APP follow-up intervention model was applied to the intervention group to provide remote continuous care intervention for patients. The results showed that the incidence of out-of-hospital hypoglycemia in the intervention group was significantly lower than that in the control group.

4.2. The Insulin Treatment Compliance Score among Young and Middle-Aged Patients with Type 2 Diabetes Mellitus (T2DM) Exhibits a Progressively Declining Trend over Time

4.2.1. Characteristics of Changes in the Total Insulin Treatment Compliance Score and Dimensional Scores

As shown in Table 3 and Figure 2, the total insulin treatment compliance scores at time points T1 to T4 were (54.54 ± 4.50), (52.60 ± 14.80), (44.45 ± 3.63), and (39.56 ± 4.49), respectively. Both the total compliance score and the scores across all dimensions demonstrated a statistically significant dynamic downward trend from discharge to two months post-discharge ($P < 0.05$). The overall compliance level declined from "good compliance" at discharge (T1) to "moderate compliance" one month after discharge (T3), further deteriorating to "poor compliance" by the two-month follow-up (T4).

Table 3 and Figure 3 indicate that each dimension of insulin treatment compliance also followed a consistent downward trajectory. Specifically, medication adherence scores were (10.26 ± 1.36), (9.94 ± 1.30), (7.93 ± 1.46), and (7.04 ± 2.39) across the four time points; dietary adherence scores were (9.81 ± 1.23), (9.60 ± 1.09), (7.76 ± 1.43), and (7.00 ± 2.12); exercise adherence scores were (10.50 ± 0.80), (10.08 ± 1.00), (7.40 ± 1.24), and (6.74 ± 2.05); self-monitoring adherence scores were (14.00 ± 0.76), (13.46 ± 1.34), (12.17 ± 1.38), and (10.59 ± 2.39); and regular follow-up adherence scores were (9.97 ± 1.74), (9.52 ± 1.56), (9.19 ± 1.78), and (8.19 ± 2.93), respectively.

The total insulin treatment compliance score one month after discharge in this study was comparable to findings reported by Jiang Min *et al.* [15] in China (52.12 ± 12.84), whereas the compliance score two months after discharge was slightly lower than that reported by Wang Cui *et al.* [16] (40.1 ± 5.8).

In Figure 2, the mean total score of insulin treatment compliance shows a gradually decreasing trend. It reaches the highest score at discharge, then declines slowly in the week after discharge, rapidly decreases in the month after discharge, and reaches the lowest score two months after discharge.

In Figure 3, the mean scores of each dimension also show a general downward trend, indicating that the insulin treatment compliance of patients decreases grad-

ually over time. The possible reason is that during hospitalization, there were doctors and nurses conducting daily rounds and providing regular diabetes education. The patients were confident about the treatment, so they left the hospital with hope and a positive outlook. Therefore, their compliance was relatively good.

However, one week after discharge, the decrease in insulin treatment compliance was not significant. This might be because the time since discharge was relatively short, and the patients could still cope with the changes brought by insulin treatment calmly. However, since the research subjects were young adults, they also had to deal with the huge pressure brought by work and life, and even sometimes had too much work to neglect injecting pre-meal insulin. The possible reason is that with the extension of home treatment time, there were no daily rounds by doctors and nurses, and family members did not monitor as closely as before.

In addition, the results of self-monitoring of micro blood glucose showed improvement compared to the period in the hospital. Therefore, the patients began to relax their vigilance, ate foods they liked at will, failed to adhere to exercise therapy, did not inject insulin as prescribed (including missing injections, reducing injection doses, etc.), did not monitor blood glucose on their own and regularly review as instructed after discharge.

This also explains that the results of the repeated four measurements of insulin treatment compliance showed a general downward trend in the dietary compliance dimension, medication compliance dimension, exercise compliance dimension, self-monitoring compliance dimension, and regular review compliance dimension.

4.2.2. Trends in Insulin Treatment Adherence Rate

Figure 4 shows that the insulin treatment compliance rates of young and middle-aged patients with type 2 diabetes (T2DM) during periods T1 to T4 were 82.6%, 79.7%, 67.3%, and 59.9% respectively. That is, as the time of discharge increased, the insulin treatment compliance rate of young and middle-aged T2DM patients gradually decreased. This suggests that effective intervention measures should be formulated, targeting multiple dimensions such as the drug dimension, diet dimension, exercise dimension, self-monitoring compliance dimension, and regular re-examination dimension, to conduct multi-dimensional and all-round intervention, in order to improve the insulin treatment compliance of young and middle-aged T2DM patients. References such as Wang Guozhen [17] who applied the hospital-community-family alliance intermittent aerobic exercise intervention model to improve the exercise treatment compliance of T2DM patients, and Guo Xiaohui [18] who applied the mobile medical management model to implement 12 weeks of intervention for T2DM patients and effectively improved the patient's cooperation in self-blood glucose monitoring and treatment compliance, and Liu Yijun [19] who applied the shared decision-making assistance system of doctors and nurses to effectively improve the medication treatment compliance of community T2DM patients can also be referred to.

4.2.3. Trends in the Grade Distribution of Insulin Treatment Compliance

The results in Table 4 show that the proportion of patients with good insulin treatment compliance (≥53 points) gradually decreased from 58.8% at discharge to 2.7% two months after discharge. The proportion of patients with poor compliance (<40 points) increased from 0.3% at discharge to 33.3% two months after discharge. The majority of patients had a moderate level of compliance. This is similar to the research result of Yan Chunyan [3] (30.7%), suggesting that it is necessary to strengthen the out-of-hospital follow-up for this specific group of young and middle-aged T2DM patients, and jointly supervise the patients' insulin treatment outside the hospital with their families, in order to improve the patients' treatment compliance and treatment effect. The existing effective intervention measures can be referred to, such as the intervention of Geng Yingjie *et al.* [20] using the evidence-based nursing model for young and middle-aged T2DM patients, which effectively improved the patients' treatment compliance. In addition, there is a study reporting that the application of the remote service model can improve the self-management ability of T2DM patients and the insulin injection compliance, effectively improve the blood glucose control level of T2DM patients during home care, and reduce the incidence of negative events related to insulin injection [21].

5. Conclusion

This study found that in the underdeveloped areas of Guangxi, China, the insulin treatment compliance scores of young and middle-aged patients with type 2 diabetes gradually deteriorated at the time of discharge, one week after discharge, one month after discharge, and two months after discharge. The treatment compliance rate also gradually decreased. Therefore, relevant medical staff should pay more attention to and conduct follow-up tracking of this group of people in order to improve the treatment compliance of this group and thereby enhance the treatment effect.

6. The Limitations of This Study

This study can only observe the trend of treatment compliance of the research subjects within two months after their discharge. The conclusions drawn from this study have certain limitations. The conclusion cannot represent the long-term changing pattern of the research object. It is suggested that in the future, when conducting similar research, colleagues should extend the observation period so as to reach more convincing conclusions.

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Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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