

Preplanned Studies

Fear of Hypoglycemia and Behavioral Patterns Among Patients with Diabetes — Beijing, China, September–December 2024

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Summary

What is already known about this topic?

Hypoglycemia is a frequent complication among diabetic patients and can lead to serious clinical consequences. Increasing attention has been paid to the role of psychological factors, particularly fear of hypoglycemia, in blood glucose management.

What is added by this report?

Hypoglycemia management behavioral patterns among diabetic patients demonstrated notable aggregation and heterogeneity, with 35.94% classified into the low-management pattern (Class 1), 37.50% into the exercise-based pattern (Class 2), and 26.56% into the monitoring-based pattern (Class 3). Fear of hypoglycemia was positively associated with the monitoring-based pattern but negatively associated with the exercise-based pattern (both $P < 0.05$).

What are the implications for public health practice?

Personalized prevention and intervention strategies should be tailored to individual behavioral patterns. Community and healthcare institutions should strengthen health education and integrate psychological interventions alongside cognitive improvement. Interventions should aim to guide patients in channeling their fear of hypoglycemia into positive management motivation, thereby reducing hypoglycemia risk and enhancing overall management quality.

Methods: A community-based cross-sectional survey was conducted in Beijing, China, from September–December 2024, enrolling 704 patients with diabetes. Latent class analysis (LCA) was used to identify behavioral patterns associated with hypoglycemia management, and a structural equation model (SEM) was constructed to examine the associations of hypoglycemic events, fear, and cognition with these behavioral patterns.

Results: Three distinct categories of hypoglycemia-related behaviors were identified among patients with diabetes: Class 1 (35.94%, 253/704), Class 2 (37.50%, 264/704), and Class 3 (26.56%, 187/704). Fear of hypoglycemia had a positive effect on Class 3 ($\beta = 0.081$) but a negative effect on Class 2 ($\beta = -0.123$). Previous hypoglycemic events directly affected behavioral patterns (e.g., direct effect on Class 3, $\beta = 0.067$) and also exerted an indirect effect through fear of hypoglycemia (indirect effect, $\beta = 0.218 \times 0.081 = 0.018$). Higher levels of hypoglycemia-related cognition were positively associated with Class 3 ($\beta = 0.118$).

Conclusion: The heterogeneous patterns of hypoglycemia management behavior underscore the need for tailored interventions. Targeted hypoglycemia education combined with psychological support may help patients channel fear into positive management motivation, thereby improving self-management and reducing hypoglycemia risk.

ABSTRACT

Introduction: Hypoglycemia remains a critical challenge in diabetes management, with potentially severe consequences, including seizures, loss of consciousness, and death. Fear of hypoglycemia influences self-management behaviors among patients with diabetes. This study aimed to identify behavioral patterns of hypoglycemia management and examine how hypoglycemia-related fear and cognitive level affect these patterns.

Diabetes-related hypoglycemia, particularly hypoglycemia unawareness, can cause severe consequences, including loss of consciousness, seizures, and death (1), with approximately 21% of insulin-treated patients experiencing severe hypoglycemia annually (2). Current diabetes guidelines emphasize five key components of blood glucose management (the "five carriages") comprising health education, pharmacotherapy, glucose monitoring, dietary

management, and exercise (3). Psychological factors have garnered increasing attention, and the American Diabetes Association recommended incorporating psychological interventions into clinical practice guidelines in 2016 (4). However, research on fear of hypoglycemia has mainly focused on individual self-management behaviors, with limited evidence regarding broader behavioral patterns. Therefore, this study used latent class analysis (LCA) and structural equation modeling (SEM) to identify management patterns and examine the associations between fear of hypoglycemia and behavioral patterns, providing evidence for optimizing prevention and diabetes management.

The data were obtained from the "Survey of Hypoglycemia Cognition and Incidence in Community Diabetic Patients in Beijing Area." The required sample size was calculated using a formula for cross-sectional surveys, based on the reported misperception rate regarding hypoglycemia among people with diabetes ($p=34.36\%$) (5), $\alpha=0.05$, and a permissible error of $\delta = 0.1 \times p=0.034$. After accounting for a 10% nonresponse rate, the calculated sample size was 806 people. From September to December 2024, one community health center was randomly selected from each of five Beijing districts, and eligible patients were recruited according to predefined criteria.

Participants had confirmed diabetes, recent community follow-up records, complete medical information, and provided informed consent. Patients with an incomplete diabetes history, communication difficulties, or acute critical illness were excluded. A total of 806 community-dwelling diabetic patients were initially enrolled. After screening, 53 questionnaires with incomplete information and 49 participants who were uncertain whether they had experienced hypoglycemic events were excluded, yielding a final analytic sample of 704 subjects. The study was approved by the Ethics Committee of Beijing Hospital (Ethics No.: 2024BJYYEC-KY322-01), and all participants provided written informed consent.

A blood glucose level ≤ 70 mg/dL (3.9 mmol/L) accompanied by corresponding symptoms is typically regarded as hypoglycemia (1). In this study, hypoglycemic events were reported by participants after diabetes diagnosis, based on hypoglycemic symptoms or blood glucose < 3.9 mmol/L. Data were collected using a self-designed questionnaire that was reviewed by an expert panel and demonstrated good

internal consistency (Cronbach's $\alpha > 0.81$). The questionnaire assessed hypoglycemia history, education, medication risk, exercise, and dietary supplementation. Regular management was defined as blood glucose self-monitoring at least once per week or attending a diabetes-related medical visit at least once every three months. Fear of hypoglycemia was assessed using a self-reported item ranging from 0 to 10, with higher scores indicating greater fear. This approach was used to provide a brief assessment of overall fear while reducing respondent burden. Hypoglycemia-related cognitive level was evaluated using nine items covering diagnostic criteria, intervention strategies, appropriate food selection, fasting blood glucose targets, 2-hour postprandial blood glucose targets, glycosylated hemoglobin control goals, symptom recognition, awareness of precipitating factors, and awareness of serious complications. Each item was scored on a scale of 0 to 6, yielding a maximum total score of 54.

Statistical analyses were performed using R software (version 4.5.1; the R Foundation for Statistical Computing, Vienna, Austria). LCA was used to identify distinct behavioral patterns related to hypoglycemia management among diabetic patients. The optimal number of latent classes was determined based on entropy, Akaike Information Criterion (AIC), Bayesian Information Criterion (BIC), and adjusted BIC (aBIC). Entropy values closer to 1 indicate superior classification accuracy, whereas lower AIC, BIC, and aBIC values reflect better model fit. Class 1 served as the reference group in subsequent analyses. An SEM was then constructed to examine the associations of hypoglycemic events, fear, and cognition with these behavioral patterns. Model fit was evaluated using the following indices: chi-square to degrees of freedom ratio (χ^2/df), Standardized Root Mean Square Residual (SRMR), Root Mean Square Error of Approximation (RMSEA), Comparative Fit Index (CFI), and Tucker-Lewis Index (TLI). Acceptable model fit was defined as $\chi^2/\text{df} < 3.00$, SRMR < 0.08 , RMSEA < 0.08 , CFI > 0.90 , and TLI > 0.90 . Statistical significance was set at $P < 0.05$.

Among 704 diabetic patients, the mean age was 64.98 ± 10.71 years; 47.59% (335/704) were female (Table 1). Nearly half (48.15%, 339/704) reported experiencing hypoglycemic events. Hypoglycemia was more common among patients with lower education level, suburban residence, resident medical insurance, use of high-risk medications, inadequate monitoring, dietary supplementation, and higher fear and cognition scores.

TABLE 1. Basic characteristics of study subjects.

Variable	Total (N=704)	Hypoglycemic event		t/χ^2	P
		No (n=365)	Yes (n=339)		
Age (years)	64.98±10.71	64.74±10.32	65.24±11.13	0.62	0.53
Age group				0.09	0.77
<65 years old	293 (41.62)	150 (51.19)	143 (48.81)		
≥65 years old	411 (58.38)	215 (52.31)	196 (47.69)		
Gender				0.74	0.39
Male	369 (52.41)	197 (53.39)	172 (46.61)		
Female	335 (47.59)	168 (50.15)	167 (49.85)		
Education level				4.50	0.03
Junior high school and below	335 (50.43)	170 (47.89)	185 (52.11)		
High school or above	349 (49.57)	195 (55.87)	154 (44.13)		
Occupation				2.75	0.10
Unemployed	590 (83.81)	314 (53.22)	276 (46.78)		
Employed	114 (16.19)	51 (44.74)	63 (55.26)		
Living alone				0.04	0.85
No	637 (90.48)	331 (51.96)	306 (48.04)		
Yes	67 (9.52)	34 (50.75)	33 (49.25)		
Residential location				35.57	<0.01
Suburban	315 (44.74)	124 (39.37)	191 (60.63)		
Urban	389 (55.26)	241 (62.95)	148 (38.05)		
Medical insurance				31.94	<0.01
Residents' insurance	420 (59.66)	181 (43.10)	239 (56.90)		
Urban employee basic medical insurance	284 (40.34)	184 (64.79)	100 (35.21)		
Disposable annual income				5.08	0.17
Unclear	28 (3.98)	18 (64.29)	10 (35.71)		
0-49,999	261 (37.07)	126 (48.28)	135 (51.72)		
50,000-99,999	232 (32.95)	117 (50.43)	115 (49.57)		
≥100,000	183 (25.99)	104 (56.83)	79 (43.17)		
Health education				0.86	0.36
No	359 (50.99)	180 (50.14)	179 (49.86)		
Yes	345 (49.01)	185 (53.62)	160 (46.38)		
Hypoglycemic low-risk drug				30.20	<0.01
No	234 (33.24)	87 (37.18)	147 (62.82)		
Yes	470 (66.76)	278 (59.15)	192 (40.85)		
Regular management				4.65	0.03
No	274 (38.92)	156 (56.93)	118 (43.07)		
Yes	430 (61.08)	209 (48.60)	221 (51.40)		
Physical activity/Exercise				2.03	0.15
No	243 (34.52)	117 (48.15)	126 (51.85)		
Yes	461 (65.48)	248 (53.80)	213 (46.20)		
Snacking				5.39	0.02
No	310 (44.03)	176 (56.77)	134 (43.23)		
Yes	394 (55.97)	189 (47.97)	205 (52.03)		

Continued

Variable	Total (N=704)	Hypoglycemic event		t/χ^2	P
		No (n=365)	Yes (n=339)		
Smoking				1.12	0.57
Never smoked	425 (60.37)	225 (52.94)	200 (47.06)		
Previous smoker	116 (16.47)	55 (47.41)	61 (52.59)		
Smoking now	163 (23.15)	85 (52.15)	78 (47.85)		
Drinking alcohol				0.62	0.73
Never drank alcohol	450 (63.92)	232 (51.56)	218 (48.44)		
Once drank alcohol	74 (10.51)	36 (48.65)	38 (51.35)		
Drinking alcohol now	180 (25.57)	97 (53.89)	83 (46.11)		
Diabetes type				3.51	0.06
Type 1	51 (7.24)	20 (39.22)	31 (60.78)		
Type 2	653 (92.76)	345 (52.83)	308 (47.17)		
Fear of hypoglycemia (point)	4.00 (0.00, 7.00)	3.00 (0.00, 6.00)	5.00 (2.00, 8.00)	6.13	<0.01
Hypoglycemia-related knowledge (point)	24.00 (18.00, 30.00)	22.50 (15.00, 28.50)	25.50 (19.50, 30.00)	4.34	<0.01

LCA was conducted using hypoglycemia-related behavioral indicators aligned with the "five carriages" framework. The optimal number of latent classes was determined based on AIC, BIC, aBIC, and entropy values (Figure 1). Class 1 (35.94%, 253/704) showed low probabilities of engaging in all management behaviors. Class 2 (37.50%, 264/704) exhibited a higher probability of using low-risk medications and engaging in physical activity or exercise. Class 3 (26.56%, 187/704) was characterized by regular monitoring but relatively low probabilities of engaging in other behaviors.

SEM was used to examine relationships among behavioral classes, hypoglycemic events, fear, cognition, and demographics. All path coefficients reached significance ($P < 0.05$), with good model fit (Figure 2): $\chi^2/df = 0.756$ (18.889/25), SRMR = 0.017, RMSEA = 0.000, CFI = 1.000, TLI = 1.025. Fear of hypoglycemia was positively associated with Class 3 (the monitoring-based pattern, $\beta = 0.081$) but negatively associated with Class 2 (the exercise-based pattern, $\beta = -0.123$). Hypoglycemic events influenced behavioral patterns both directly (Class 3, $\beta = 0.067$) and indirectly through fear (Class 2, $\beta = 0.218 \times -0.123 = -0.027$; Class 3, $\beta = 0.218 \times 0.081 = 0.018$). Cognitive level was directly and positively associated with Class 3 ($\beta = 0.118$).

DISCUSSION

The proportion of participants reporting hypoglycemic events was 48.15%, higher than the

32.18% reported among patients with type 2 diabetes in Xi'an (6). The inclusion of patients with type 1 diabetes, who had a higher proportion of reported hypoglycemic events than those with type 2 diabetes (60.78%/47.17%), as well as the use of self-reported events, may have contributed to the higher proportion observed in this study. Our findings align with Finn et al. (7) and Polonsky et al. (8), indicating that hypoglycemic events heighten patients' fear, and that fear exerts a double-edged effect. Specifically, concern about exercise-induced hypoglycemia reduces physical activity, whereas fear may promote glucose monitoring behaviors, albeit potentially leading to over-monitoring. These results imply that patients' awareness of hypoglycemia risk and their self-management practices require further optimization. Patients' hypoglycemia awareness level was positively associated with Class 3. Accurate diabetes-care knowledge may facilitate appropriate self-care behaviors (9), highlighting the importance of health education. However, even in the behavioral pattern with the highest proportion of patients receiving hypoglycemia-focused education, fewer than 60% received such education, indicating insufficient emphasis on non-pharmacological management.

Future diabetes management should integrate glucose monitoring, hypoglycemia risk assessment, symptom recognition, exercise guidance, hypoglycemia self-management skills, and psychological interventions, with enhanced health education for patients and caregivers (1). Polonsky et al. (8) proposed the "Four FEEL SAFE strategies" to address fear of

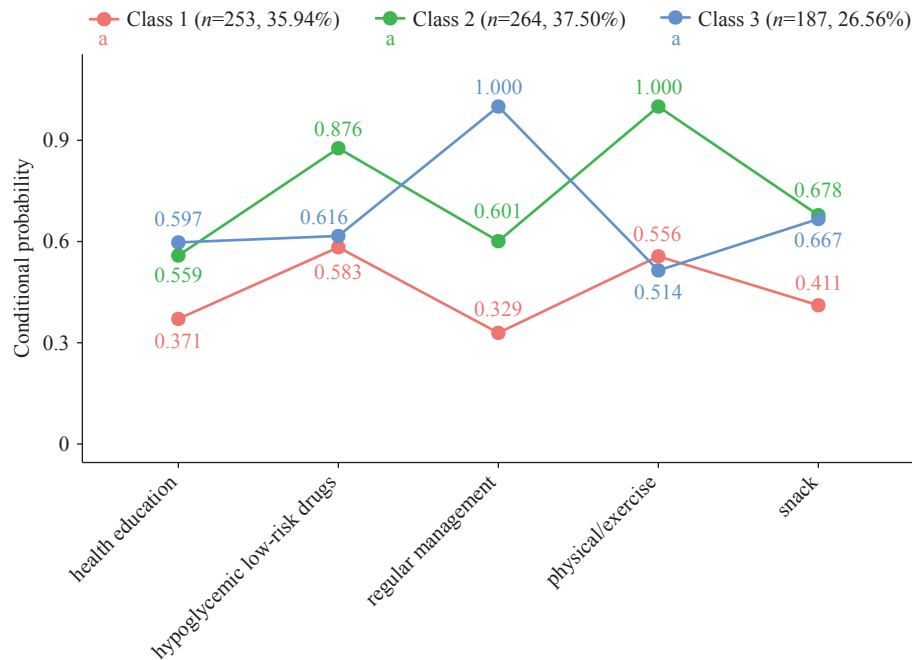


FIGURE 1. Latent class analysis (LCA) results.

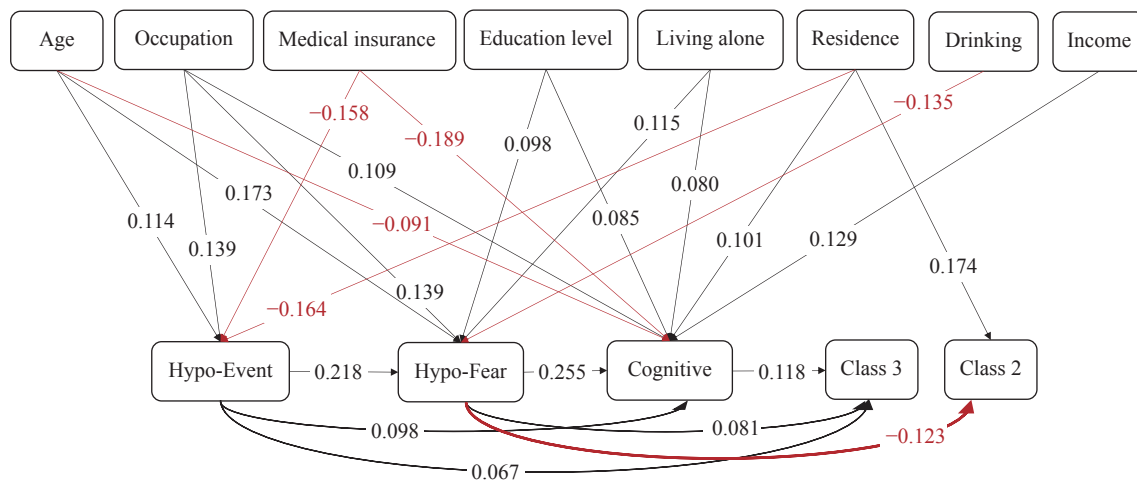


FIGURE 2. Structural equation model of factors influencing the hypoglycemia management model.

Abbreviation: Hypo-Event=hypoglycemic events; Hypo-Fear=fear of low blood sugar; Residence=residential location classified by community economic level.

hypoglycemia, including appropriate use of diabetes technologies, training to identify hypoglycemia symptoms, mastery of hypoglycemia management techniques, and incremental behavioral exposure. These strategies provide a pathway for hypoglycemia risk management and psychological intervention. Given that older patients are more prone to hypoglycemia unawareness (*1*), leveraging intelligent, individualized, and safe glucose monitoring tools, such as real-time continuous glucose monitoring (rt-CGM) systems, may help detect occult hypoglycemic events

through timely alerts, thus improving risk recognition and self-management and enhancing independent diabetes management (*10*). Healthcare professionals should strengthen awareness of hypoglycemia health education and enhance guidance on patient behavior management and health literacy to foster a rational understanding of hypoglycemia risk, balancing risk reduction with quality of life.

This study has several limitations. First, hypoglycemic events were assessed through participant self-report, which may have introduced recall bias,

particularly among middle-aged and older adults. Consequently, the occurrence of hypoglycemic events may have been overestimated or underestimated. Second, fear of hypoglycemia was assessed using a single item, which may not capture its multidimensional nature. Third, this study was conducted exclusively in Beijing communities, which limits sample representativeness and restricts the generalizability of the conclusions to other populations and settings. Finally, type 1 diabetes accounted for only 7.24% of participants, preventing subgroup comparisons between type 1 and type 2 diabetes.

This study identified distinct latent categories of hypoglycemia management behaviors among diabetic patients and demonstrated that hypoglycemic events, fear, and cognitive level exert direct or indirect effects on patients' behavioral patterns. These findings provide an evidence base for reducing hypoglycemia risk and optimizing personalized management strategies.

Ethical statement: The study was approved by the Ethics Committee of Beijing Hospital (Ethics No.: 2024BJYYEC-KY322-01), and all participants provided written informed consent.

Conflicts of interest: No conflicts of interest.

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