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ORIGINAL RESEARCH

# Latent Profile Analysis of Fear of Hypoglycemia in Middle-Aged and Elderly Hospitalized Patients with Type 2 Diabetes and Its Relationship with Sleep Quality

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**Introduction:** Hypoglycemia is an acute complication that can appear in people with type 2 diabetes treated with drugs which are associated with a risk of hypoglycemia, and it may lead to individual's fear of hypoglycemia (FoH). FoH adversely affects diabetic self-management, psychological well-being, and quality of life, and it is associated with sleep quality. Nevertheless, this problem is often underestimated. The purpose of this study was to explore the heterogeneous characteristics of FoH in middle-aged and elderly hospitalized patients with type 2 diabetes and assess its relationship with the sleeping quality.

**Patients and Methods:** A cross-sectional study was performed on 263 middle-aged and elderly patients with type 2 diabetes hospitalized at the Zhejiang Veteran Hospital in Jiaxing, China, from May to August 2022, selected by a convenient sampling method. A questionnaire containing general information, fear of hypoglycemia scale-15 (FH-15) and the Pittsburgh sleep quality index (PSQI) was provided to the participants. Latent profile analysis was performed to examine the potential latent groups in the distribution of answers on the individual FoH items.

**Results:** The results identified three latent classes: Class 1 – Low FoH group (33%); Class 2 – No FoH group (61%); Class 3 – High FoH group (6%). The latent FoH class was the influencing factor of sleep quality, which was better in the No FoH group than in the Low FoH group, while the sleep quality of the Low FoH group was better than that in the High FoH group.

**Conclusion:** A heterogeneity was found in the FoH of middle-aged and elderly hospitalized patients with type 2 diabetes. Health-care providers should pay more attention to these patients with high FoH and develop intervention strategies to mitigate it and improve their sleep quality.

**Keywords:** fear of hypoglycemia, sleeping quality, middle-aged and older adults, type 2 diabetes, latent profile analysis

## Introduction

Diabetes has emerged as a major health issue worldwide in recent years because of its increasing prevalence. Diabetes is the seventh leading cause of death in the world among the top ten causes of death according to the 2019 Global Health Assessment issued by the World Health Organization. The tenth edition of the Global Diabetes Atlas released by the International Diabetes Federation shows the existence of 537 million (10.5%) diabetic people among adults aged 20~79 years, meaning one diabetic person in every 10 people.[1] Diabetes is one of the most common chronic diseases in China, where the number of patients has increased from 90 million to 140 million in the past 10 years, which is an increase of more than half.[1] Therefore, diabetes prevention and control in China is of utmost importance at present.

Patients with diabetes often suffer from a variety of complications due to poor blood glucose control. Hypoglycemia is one of the most important complications and is the most concerning problem for patients in clinical practice. Hypoglycemia in patients with type 2 diabetes is associated with different therapeutic options, such as insulin and oral

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hypoglycemia agents.[2] A multinational non-interventional study revealed that 46.5% of patients with type 2 diabetes had at least one hypoglycemic episode in a 4-week period.[3] As a result of hypoglycemia, patients and their families may experience various negative consequences, such as disrupted daily activities and psychological problems.[4] Indeed, hypoglycemia may lead to individual and family members' fear of hypoglycemia (FoH), which is a negative emotional experience of diabetic patients, including unpleasant tension, anxiety and discomfort due to the threat of hypoglycemia in the course of disease management, accompanied by related behavior changes caused by it,[5] such as "over-compensatory behaviors" (eg, intentionally under-dosing insulin or frequent snacking) "avoidance behaviors" (eg, restricting physical or social activities, avoiding being alone).[6] Diabetic self-management, psychological well-being, and quality of life are adversely affected by FoH.[7] Rowe et al[8] found that more than 80% of patients who experienced severe hypoglycemia have FoH. A cross-sectional survey of patients with diabetes in 9 countries also showed that nearly half of them with a hypoglycemia history suffer from FoH.[9] The presence of a history of hypoglycemia is indeed a recognized risk factor for the development of fear of hypoglycemia; however, it should be noted that fear can also manifest in individuals without experiencing actual episodes of hypoglycemia.[6] Nevertheless, this problem is often underestimated in everyday clinical practice.[10,11]

Insufficient sleep is linked to the development and management of several chronic diseases and conditions including diabetes. Thus, sleep has become a parameter that can be modified to prevent chronic diseases,[12] with the relationship between diabetes and sleep attracting more and more attention. In 2018, the Medical Care Standards for diabetes issued by the American Diabetes Association also proposed to pay attention to the evaluation of patients' sleep patterns and duration.[13] Sleep quality is one of the most relevant complaints of diabetes patients related to sleep experience, including sleep satisfaction and the resulting sense of vitality.[14,15] A meta-analysis revealed that inadequate sleep quality is associated with impaired glycemic control and decreased insulin sensitivity in individuals with diabetes.[16] In addition, FoH and actual episodes of hypoglycemia tend to be greater at night.[17] FoH may lead to increased sleep disruption due to several reasons, including checking blood sugar throughout the night, overnight sugar consumption, and/or finger blood glucose monitoring,[18,19] all actions that affect sleep quality and cause blood glucose instability. The correlation between sleep quality and FoH has been confirmed by many research. A cross-sectional study of 400 patients with type 2 diabetes showed that FoH was significantly positively correlated with sleep quality of patients, that is, FoH would lead to decreased sleep quality.[20] A retrospective secondary analysis of pooled data from two previous cross-sectional studies also confirmed that individuals with poor sleep quality exhibited heightened nocturnal blood sugar fluctuations and experienced increased FoH, and a significant interaction was observed between blood sugar fluctuations, FoH, and sleep quality.[21]

The influencing factors for FoH in diabetes patients are complex and include age,[9,22,23] gender,[9,22] education level,[22] age at diagnosis,[23] disease duration,[24] hypoglycemia frequency,[22] severity of hypoglycemia,[22] hypoglycemia unawareness,[23] training of hypoglycemia prevention, complications, medications,[9,22] anxiety-prone personality[23] and glycated hemoglobin (HbA1c).[9] Previous studies used a variable-centered perspective to explore the previous specific variables and their effects, and that perspective ignored the heterogeneity of individual FoH. Latent profile analysis (LPA) is a statistical analysis method with an individual-centered approach. It consists of a classification method that classifies the population to analyze the unique characteristics of various sub-groups. Thus, LPA allows researchers to understand the mix of variables and the results produced by specific groups, determining the different types of sub-groups based on the difference in the nature and extent of explicit variables. In addition, it captures the unequal nature of the groups that cannot be observed in variable centered research. Therefore, this perspective of individual-centered study enables us to explore the potential classes of FoH in patients with type 2 diabetes, objectively identifying FoH subtypes, conducting more in-depth quantitative analysis, and considering sleep quality as an indicator to measure the health level of patients with type 2 diabetes. It also discusses the differences in sleep quality between different types of FoH in patients with type 2 diabetes, laying a theoretical foundation for further intervention to combat FoH.

We hypothesized through that based on a comprehensive analysis of FoH in middle-aged and elderly hospitalized patients with type 2 diabetes, a heterogeneity could be found, and FoH is closely associated with sleep quality. The aim of this study was to explore the heterogeneous characteristics of fear of hypoglycemia in middle-aged and elderly hospitalized patients with type 2 diabetes and assess its relationship with the sleeping quality.

# Materials and Methods

## Design and Participants

This study was a cross-sectional study performed from May to August 2022 at the Zhejiang Veteran Hospital in Jiaxing, a city in eastern China, using the convenience sampling to collect the data from hospitalized patients in endocrinology department and geriatric department. The most frequent causes of hospitalization among these patients were hyperglycemia and chronic complications, while others were hospitalized due to acute complications, infections, and hypoglycemia. Patients were eligible for the study if they met the following criteria: (a) All patients had a diagnosis of type 2 diabetes according to the practice guidelines of the American Diabetes Association; (b) patients suffering from type 2 diabetes longer than 1 year (diagnosis confirmed by medical record and/or A1C); (c) patients of 45 years of age or older; (d) patients with a history of hypoglycemia within 1 year; (d) no presence of obstacle in cognition; (e) ability to communicate fluently in Mandarin. The sample size was calculated as 5 to 10 times the number of variables, which is a general rule of thumb.[25] A total of 26 variables were considered in the study. Furthermore, robust statistical analysis results are only obtained when the sample size of LPA is not less than 200[26] and the average sample size of each profile reaches 50.[27] A sample size ≥200 was appropriate considering a 20% invalid questionnaire rate.

Ethical approval was obtained by the Ethics Committee of Zhejiang Veteran Hospital. All participants signed a written consent prior to participating in the research according to the principles of the Declaration of Helsinki.

## Measurements

### General Information

The general information considered in this study included two aspects, one was demographic information, including age, gender, education level, marital status, mode of residence, medical payment method, and primary caregivers; the other was disease-related information including body mass index (BMI), disease duration (years), hypoglycemia frequency, severity of hypoglycemia, awareness of hypoglycemia, training of hypoglycemia prevention, complications, medications and HbA1c. The HbA1c levels were obtained through laboratory tests conducted during the patient's hospitalization.

### Fear of Hypoglycemia Scale-15

FoH was evaluated by the hypoglycemia scale-15 (FH-15). The original FH-15 scale was developed by Anarte,[28] and the Chinese version was developed by Liu et al.[29] It is used to screen patients with diabetes suffering from FoH. The scale consists of 3 categories, 7 items of fear dimension, 5 items of interference dimension, and 3 items of avoidance dimension. The Likert 5-level scoring method was used. The total score of the scale ranged from 15 to 75 points, and the best cut-off value was 30.5 points.[30] Instruments with good reliability and validity verified in the Chinese population were used to ensure the rigor of the study. The Cronbach's α coefficient for the Chinese version of the FH-15 was 0.918.[30] The items of the scale are concise and easy to understand, with a clear cut-off value and good reliability and validity, thus helping health-care providers to quickly and accurately identify FoH and its severity.

### Pittsburgh Sleep Quality Index (PSQI)

Sleep quality was evaluated by PSQI. The original PSQI scale was developed by Buysse,[31] and the simplified Chinese version was developed by Liu et al.[32] It consists of 7 factors, including sleep quality, sleep time, sleep efficiency, sleep disorder, hypnotic drug use and daytime dysfunction, with a total of 18 items. Each factor is scored according to the 4-level scoring method, with 0~3 points and a total score of 0~21 points. The total score higher than 8 points indicates the presence of a sleep disorder. The higher the score, the worse the sleep quality. The Cronbach's α coefficient for the Chinese version of the PSQI was 0.842.

## Data Collection

The questionnaires were distributed and recycled by the researchers who received the same training. On-site surveys were conducted after explaining the study objectives with the unified guide words and obtaining the informed consent from the participants. The questionnaire was completed by the researcher with the assistance of the patient. The whole process was performed anonymously through subsequent studies using numbers, and all the collected information was

kept confidential. Participants with missing data were excluded; consequently, 263 participants were enrolled in this study.

## Statistical Analysis

The LPA was performed using Mplus 8.0 to explore the most likely number of classes based on the 15 items of FoH. The key to the generation of the latent class models was to specify the number of latent classes. A single category growth model was first set, then the number of classes to compare the fitting indices between models was gradually increased and the best model in combination with practical significance and statistical indices was determined to select the best number of latent classes. Several factors were taken into consideration to determine which profile model fitted best, including relative model fit, parsimony, item identification, and interpretability of the item responses. The model fitting indices included: 1) Akaike information criterion (AIC), Bayesian information criterion (BIC) and adjusted Bayesian information criterion (aBIC). The smaller the values of the three indices, the better the data fitting the model; 2) the entropy index indicated the accuracy of the classification, with a range value of 0~1. The larger the entropy value, the higher the accuracy of the classification. Generally, the average posterior probability of each profile (ie, the probability that the subject belongs to the specified profile rather than other profiles) should be >0.7.[33] 3) Likelihood ratio test (LMR) and Bootstrap based likelihood ratio test (BLRT). When the P value corresponding to LMR and BLRT reached a significant level ($P < 0.05$); it meant that the model of k categories was better than the model of k-1 categories.[34]

The relationship between latent class membership and sleep quality was examined using ANOVA. The influencing factors of the latent class membership of FoH were analyzed using Chi-square test and multivariate regression analysis. The odds ratio (OR) and 95% confidence interval (CI) were calculated using regression analysis. The results are expressed as mean ± standard deviation (SD). A value of P0.05 was considered statistically significant.

# Results

## LPA of FoH

Two to five classes were tested by LPA. The results indicated that the three-class model produced an optimal model. It demonstrated a largest value of entropy (ie, close to 1; E0.958) compared to other models, and the P value of LMR and BLRT was statistically significant. Nevertheless, the two-class, four-class and five-class models were empirically unidentified, further indicating that the three-class model emerged as the best-fitting model. The fit indices for two-class to five-class model are listed in Supplementary Table 1.

The three classes of FoH are shown in Table 1 and Figure 1 according to the LPA results. Three classes were analyzed and named according to the order of FoH total scores from low to high. The mean value of the total FoH scores of the class 2 was below the cut-off value 30.5, indicating that the hospitalized patients with type 2 diabetes in this group had no FoH; thus, this group was designated as "No FoH group". The mean of the total FoH scores of class 1 and class 3 was above the cut-off score in both classes, suggesting that the hospitalized patients with type 2 diabetes in these two groups had FoH. Among them, class 1 has a relatively low mean of the total FoH score and all dimensions, and its total score was approximately in the lower value position; thus, this group was designated as "Low FoH group". Class 3 had the

**Table 1** FoH Scores in Different Classes (N = 263, Mean SD)

| Classes | N | FoH | Fear Dimension | Interference Dimension | Avoidance Dimension |
|---|---|---|---|---|---|
| Class 1 (Low FoH group) | 88 | 41.82±5.725 | 19.97±3.218 | 13.60±2.327 | 8.25±1.333 |
| Class 2 (No FoH group) | 160 | 20.43±5.510 | 9.98±3.027 | 6.36±1.904 | 4.09±1.310 |
| Class 3 (High FoH group) | 15 | 62.53±8.017 | 29.33±3.579 | 20.80±2.757 | 12.40±1.957 |
| Total | 263 | 29.98±14.008 | | | |

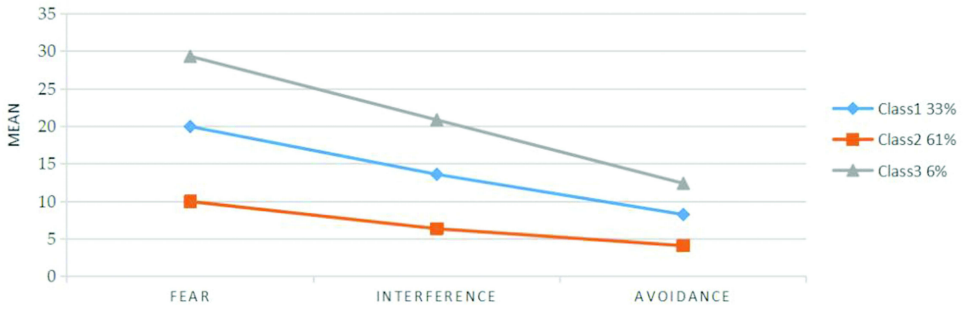


**Figure 1** Mean of Three Latent Classes of FoH in Three Dimensions.

highest mean of the total FoH score and all dimensions compared with the other two groups, and its total score was approximately in the higher value position; thus, this group was designated as "High FoH group".

Table 2 summarizes the score of each item in High FoH group and Low FoH group. The three items with the highest average FH-15 scores for the Low FoH group were: how often are you afraid of having hypoglycemia while alone, how often do you fear not recognizing the symptoms of hypoglycemia, how often do you worry about losing consciousness due to hypoglycemia. The three items with the highest average FH-15 scores for High FoH group were: how often do you fear not recognizing the symptoms of hypoglycemia, how often are you afraid of having hypoglycemia outside of a hospital/health care setting, how often do you worry about losing consciousness due to hypoglycemia.

**Table 2** FoH Scores in the Low FoH Group and High FoH Group (Mean ± SD)

| **Low FoH Group** | | **High FoH Group** | |
|---|---|---|---|
| **Items** | **M±SD** | **Items** | **M±SD** |
| Item 5: how often are you afraid of having hypoglycemia while you are alone | 3.02±0.694 | Item 1: how often do you fear not recognizing the symptoms of hypoglycemia | 4.33±0.488 |
| Item 1: how often do you fear not recognizing the symptoms of hypoglycemia | 2.90±0.845 | Item 4: how often are you afraid of having hypoglycemia outside of a hospital/health care setting | 4.33±0.488 |
| Item 13: how often do you worry about losing consciousness due to hypoglycemia | 2.90±0.588 | Item 13: how often do you worry about losing consciousness due to hypoglycemia | 4.27±0.458 |
| Item 7: how often do you stop doing things you used to do for fear of having a hypoglycemic episode | 2.89±0.685 | Item 15: how often are you afraid of taking a trip/holiday for fear of experiencing hypoglycemia | 4.27±0.458 |
| Item 4: how often are you afraid of having hypoglycemia outside of a hospital/health care setting | 2.85±0.838 | Item 5: how often are you afraid of having hypoglycemia while you are alone | 4.20±0.676 |
| Item 2: how often are you afraid of not knowing what to do in the event of hypoglycemia | 2.84±0.756 | Item 10: how often do you have hypoglycemia that interferes with your leisure activities | 4.20±0.561 |
| Item 10: how often do you have hypoglycemia that interferes with your leisure activities | 2.77±0.601 | Item 11: how often do you have from hypoglycemia that interferes with your family life | 4.20±0.561 |
| Item 8: how often do you have from hypoglycemia that makes you unable to drive or use machinery | 2.75±0.715 | Item 12: how often do you have hypoglycemia that interferes with your social life | 4.20±0.561 |
| Item 14: how often are you afraid of falling asleep for fear of having hypoglycemia at night | 2.75±0.572 | Item 14: how often are you afraid of falling asleep for fear of having hypoglycemia at night | 4.20±0.561 |

(*Continued*)

**Table 2** (Continued).

| Low FoH Group | | High FoH Group | |
|---|---|---|---|
| **Items** | **M±SD** | **Items** | **M±SD** |
| Item 6: how often do you avoid social situations (meetings, outings, etc.) due to fear of having a hypoglycemic episode | 2.73±0.582 | Item 7: how often do you stop doing things you used to do for fear of having a hypoglycemic episode | 4.13±0.640 |
| Item 9: how often do you have hypoglycemia that makes you unable to work | 2.73±0.690 | Item 8: how often do you have from hypoglycemia that makes you unable to drive or use machinery | 4.13±0.640 |
| Item 3: how often are you afraid of having hypoglycemia at work | 2.70±0.681 | Item 2: how often are you afraid of not knowing what to do in the event of hypoglycemia | 4.07±0.704 |
| Item 12: how often do you have hypoglycemia that interferes with your social life | 2.70±0.697 | Item 9: how often do you have hypoglycemia that makes you unable to work | 4.07±0.704 |
| Item 11: how often do you have from hypoglycemia that interferes with your family life | 2.65±0.626 | Item 6: how often do you avoid social situations (meetings, outings, etc.) due to fear of having a hypoglycemic episode | 4.00±1.000 |
| Item 15: how often are you afraid of taking a trip/ holiday for fear of experiencing hypoglycemia | 2.64±0.730 | Item 3: how often are you afraid of having hypoglycemia at work | 3.93±1.033 |

**Note**: Copyright © 2011 by American Psychological Association. Adapted with permission from Anarte Ortiz MT, Caballero FF, de Adana MS R, et al. Development of a new fear of hypoglycemia scale: FH-15. *Psychol Assess*. 2011;23(2):398–405.[28]

The line chart shows that middle-aged and elderly hospitalized patients with type 2 diabetes belonging to No FoH group accounted for 61%, while 33% of them were categorized into Low FoH group and 6% of them were categorized into High FoH group. These results indicated that the prevalence of FoH in the middle-aged and elderly hospitalized patients with Type 2 diabetes was 39%.

## General Characteristics of Different Latent FoH Classes

The results obtained from the chi-square analysis on the general characteristics among the three classes are listed in Table 3 and Table 4. Significant differences were found in the latent FoH classes of different age, education level, primary caregivers, severity of hypoglycemia, hypoglycemia awareness, complications, and HbA1C (P0.05), while no significant difference was found in the latent FoH classes of different gender, marital status, status of residence, medical payment method, BMI, disease duration, hypoglycemia frequency, receiving a training on hypoglycemia prevention, and medication.

Three latent FoH classes were considered as dependent variables, with the Low FoH group as the reference group, and six characteristics statistically significant by the Chi-square analysis were used as independent variables (age, education level, primary caregivers, severity of hypoglycemia, hypoglycemia awareness, and complications). Logistic regression analysis was performed, and the results shown in Table 5 revealed that the middle-aged and elderly hospitalized patients with type 2 diabetes, elementary school education level and below (OR = 0.320, P = 0.016), and hypoglycemia awareness (OR = 2.239, P = 0.015), were the predictors of the No FoH group compared with the Low FoH group. Furthermore, type 2 diabetes with complications (OR = 7.163, P = 0.006) in middle-aged and elderly hospitalized patients was a predictor of the High FoH group.

## PSQI Scores of Latent FoH Classes

The results of ANOVA analysis of PSQI total and each factor scores of the latent FoH classes shown in Table 6 revealed that the total scores of PSQI were statistically significant in three latent classes of the Low FoH group (10.43 ± 3.55), No FoH group (7.91 ± 3.33), and High FoH group (13.53 ± 4.19). The total scores suggested that the middle-aged and elderly hospitalized patients with type 2 diabetes belonging to the Low FoH group and High FoH group had sleep disorders. Further multiple comparisons indicated that the sleep quality of the No FoH group was better than that of the

**Table 3** Demographic Information of Different Latent FoH Classes (N = 263)

| Characteristics | N | Low FoH group | No FoH Group | High FoH Group | $x^2$ | p-value |
|---|---|---|---|---|---|---|
| Age | | | | | | |
| 45~60 | 34(12.9) | 5(5.7) | 27(16.9) | 2(13.3) | 12.994 | 0.043 |
| 61~70 | 59(22.4) | 15(17.0) | 42(26.3) | 2(13.3) | | |
| 71~80 | 71(27.0) | 31(35.2) | 35(21.9) | 5(33.3) | | |
| ≥81 | 99(37.6) | 37(42.0) | 56(35.0) | 6(40.0) | | |
| Gender | | | | | | |
| Male | 138(52.5) | 40(45.5) | 90(56.3) | 8(53.3) | 2.658 | 0.265 |
| Female | 125(47.5) | 48(54.5) | 70(43.8) | 7(46.7) | | |
| BMI | | | | | | |
| <18.5 | 22(8.4) | 13(14.8) | 9(5.6) | 0(0.0) | 9.341 | 0.155 |
| 18.5–23.9 | 125(47.5) | 39(44.3) | 78(48.8) | 8(53.8) | | |
| >24 | 96(36.5) | 29(33.0) | 60(37.5) | 7(46.7) | | |
| Unmeasurable* | 20(7.6) | 7(8.0) | 13(8.1) | 0(0.0) | | |
| Education Level | | | | | | |
| Elementary school and below | 160(60.8) | 64(72.7) | 84(52.5) | 12(80.0) | 12.249 | 0.016 |
| Middle school | 63(24.0) | 15(17.0) | 46(28.7) | 2(13.3) | | |
| High school and above | 40(15.2) | 9(10.2) | 30(18.8) | 1(6.7) | | |
| Marital status | | | | | | |
| Married | 215(81.7) | 69(78.4) | 134(83.8) | 12(80.0) | 1.118 | 0.572 |
| Single/divorced/widowed | 48(18.3) | 19(21.6) | 26(16.3) | 3(20.0) | | |
| Status of residence | | | | | | |
| Living alone | 32(12.2) | 14(15.9) | 17(10.6) | 1(6.7) | 1.934 | 0.380 |
| Not living alone | 231(87.8) | 74(84.1) | 143(89.4) | 14(93.3) | | |
| Medical payment method | | | | | | |
| Medical insurance | 228(86.7) | 78(88.6) | 136(85.0) | 14(93.3) | 6.355 | 0.174 |
| New rural cooperative medical care | 26(9.9) | 10(11.4) | 15(9.4) | 1(6.7) | | |
| Self-paying | 9(3.4) | 0(0.0) | 9(5.6) | 0(0.0) | | |
| Primary caregivers | | | | | | |
| Spouse | 74(28.1) | 13(14.8) | 57(35.6) | 4(26.7) | 17.439 | 0.002 |
| Children | 49(18.6) | 25(28.4) | 20(12.5) | 4(26.7) | | |
| Others | 140(53.2) | 50(56.8) | 83(51.9) | 7(46.7) | | |

**Note**: *Lie in bed/sit in wheelchair.

Low FoH group, that of the Low FoH group was better than that of the High FoH group, and the sleep quality of the High FoH group was the worst among the three classes. In addition, the scores of each factor of the three latent FoH classes were statistically significant different.

**Table 4** Disease-Related Information of Different Latent FoH Classes (N = 263)

| Characteristics | N | Low FoH Group | No FoH Group | High FoH Group | $x^2$ | p-value |
|---|---|---|---|---|---|---|
| Disease duration (years) | | | | | | |
| <1 | 31(11.8) | 12(13.6) | 18(11.3) | 1(6.7) | 6.475 | 0.372 |
| 1–5 | 72(27.4) | 28(31.8) | 39(24.4) | 5(33.3) | | |
| 6–10 | 50(19.0) | 10(11.4) | 36(22.5) | 4(26.7) | | |
| >10 | 110(41.8) | 38(43.2) | 67(41.9) | 5(33.3) | | |
| Hypoglycemia frequency (within 6 months) | | | | | | |
| 1–2 | 250(95.1) | 81(92.0) | 155(96.9) | 14(93.3) | 7.922 | 0.094 |
| 3–6 | 10(3.8) | 6(6.8) | 4(2.5) | 0(0.0) | | |
| >6 | 3(1.1) | 1(1.1) | 1(0.6) | 1(6.7) | | |
| Severity of hypoglycemia | | | | | | |
| Mild | 217(82.5) | 65(73.9) | 141(88.1) | 11(73.3) | 16.619 | 0.011 |
| Moderate | 14(5.3) | 10(11.4) | 3(1.9) | 1(6.7) | | |
| Severe | 29(11.0) | 12(13.6) | 15(9.4) | 2(13.3) | | |
| Very severe | 3 | 1 | 1 | 1 | | |
| Hypoglycemia awareness | | | | | | |
| Yes | 126(47.9) | 35(39.8) | 89(55.6) | 2(13.3) | 13.337 | 0.001 |
| No | 137(52.1) | 53(60.2) | 71(44.4) | 13(86.7) | | |
| Receiving a training on hypoglycemia prevention | | | | | | |
| Yes | 197(74.9) | 68(77.3) | 118(73.8) | 11(73.3) | 0.396 | 0.820 |
| No | 66(25.1) | 20(22.7) | 42(26.3) | 4(26.7) | | |
| Complications | | | | | | |
| Yes | 72(27.4) | 26(29.5) | 36(22.5) | 10(66.7) | 13.769 | 0.001 |
| No | 191(72.6) | 62(70.5) | 124(77.5) | 5(33.3) | | |
| Medications | | | | | | |
| OAD | 150(57.0) | 49(55.7) | 92(57.5) | 9(60.0) | 3.927 | 0.416 |
| Insulin | 54(20.5) | 14(15.9) | 36(22.5) | 4(26.7) | | |
| OAD & insulin | 59(22.4) | 25(28.4) | 32(20.0) | 2(13.3) | | |
| HbA1C | | | | | | |
| ≤7% | 172(65.4) | 65(73.9) | 99(61.9) | 8(53.3) | 4.629 | 0.099 |
| >7% | 91(34.6) | 23(26.1) | 61 (38.1) | 7(46.7) | | |

## Discussion

Person-oriented analyses use patterns of scores across cases to identify groups of individuals compared with variable-centered approaches that look for relationships among variables.[35] LPA is a special case of person-oriented mixture

**Table 5** Logistic Regression Analysis of Different Latent FoH Classes (N = 263)

| Characteristics | No FoH group vs Low FoH group | | | | High FoH group vs Low FoH group | | | |
|---|---|---|---|---|---|---|---|---|
| | β | OR | 95% CI | P-value | β | OR | 95% CI | P-value |
| **Age** | | | | | | | | |
| 45~60 | 0.742 | 2.100 | 0.647~6.818 | 0.217 | 0.521 | 1.684 | 0.145~19.625 | 0.677 |
| 61~70 | 0.133 | 1.142 | 0.480~2.715 | 0.764 | −0.509 | 0.601 | 0.077~4.725 | 0.629 |
| 71~80 | −0.296 | 0.744 | 0.361~1.534 | 0.423 | −0.191 | 0.826 | 0.188~3.637 | 0.800 |
| ≥81 | Referent | | | | Referent | | | |
| **Education Level** | | | | | | | | |
| Elementary school and below | −1.139 | 0.320 | 0.127~0.809 | 0.016 | 0.317 | 1.372 | 0.129~14.598 | 0.793 |
| Middle school | −0.404 | 0.668 | 0.234~1.904 | 0.450 | 0.159 | 1.172 | 0.072~19.182 | 0.911 |
| High school and above | Referent | | | | Referent | | | |
| **Primary caregivers** | | | | | | | | |
| Spouse | 0.729 | 2.074 | 0.882~4.876 | 0.094 | 1.548 | 4.701 | 0.726~30.434 | 0.104 |
| Children | −0.568 | 0.566 | 0.258~1.246 | 0.158 | 0.259 | 1.295 | 0.216~7.758 | 0.777 |
| Others | referent | | | | referent | | | |
| **Severity of hypoglycemia** | | | | | | | | |
| Mild | 0.565 | 1.760 | 0.046~67.575 | 0.761 | −2.358 | 0.095 | 0.004~2.445 | 0.155 |
| Moderate | −1.058 | 0.347 | 0.007~16.750 | 0.593 | −1.393 | 0.248 | 0.006~10.208 | 0.463 |
| Severe | −0.205 | 0.814 | 0.019~34.246 | 0.914 | −1.127 | 0.324 | 0.011~9.860 | 0.518 |
| Very severe | Referent | | | | Referent | | | |
| **Hypoglycemia awareness** | | | | | | | | |
| Yes | 0.806 | 2.239 | 1.168~4.293 | 0.015 | −1.902 | 0.149 | 0.020~1.092 | 0.061 |
| No | Referent | | | | Referent | | | |
| **Complications** | | | | | | | | |
| Yes | −0.319 | 0.727 | 0.376~1.407 | 0.344 | 1.969 | 7.163 | 1.781~28.814 | 0.006 |
| No | Referent | | | | Referent | | | |

modelling that identifies latent subpopulations within a sample of data by analyzing patterns of responses to observed variables. This study used the LPA to explore the FoH classes of middle-aged and elderly hospitalized patients with type 2 diabetes, which revealed the differences in the characteristics of different FoH classes of middle-aged and elderly hospitalized patients with type 2 diabetes. This approach could provide a reference for the effective formulation of intervention programs aiming at alleviating FoH among them. Although few studies proved that FoH is heterogeneous, several studies confirmed that a series of negative emotions associated with diabetes are heterogeneous, ie, diabetes-related distress,[36,37] depression,[38–40] and anxiety.[39]

This study showed that FoH classes were classified into three different types: No FoH group, Low FoH group, and High FoH group, differing in the three dimensions of fear, interference, and avoidance. Additionally, the three latent FoH classes showed hierarchical changes and did not intersect in the three dimensions. This result indicated that FoH performed consistently in all dimensions, with clear grouping characteristics, and that each classification index supported

**Table 6** PSQI Scores of Latent FoH Classes (N = 263, $\bar{x} + s$)

| Variables | Low FoH Group | No FoH Group | High FoH Group | Average Score | F-value | P-value | Multiple Comparisons |
|---|---|---|---|---|---|---|---|
| Factor 1 | 1.11±0.576 | 0.89±0.604 | 1.40±0.632 | 0.99±0.612 | 7.800 | 0.001 | Class 1<Class 2< Class 3 |
| Factor 2 | 0.84±0.500 | 0.38±0.559 | 1.40±0.507 | 0.59±0.610 | 38.682 | 0.000 | |
| Factor 3 | 0.98±1.194 | 0.77±0.926 | 1.93±1.163 | 0.90±1.068 | 8.978 | 0.000 | |
| Factor 4 | 0.97±1.129 | 0.95±1.068 | 2.00±0.926 | 1.02±1.105 | 6.592 | 0.002 | |
| Factor 5 | 2.31±0.533 | 1.76±0.555 | 2.60±0.507 | 1.99±0.618 | 38.170 | 0.000 | |
| Factor 6 | 2.07±1.267 | 1.57±1.147 | 2.27±1.280 | 1.78±1.220 | 6.293 | 0.002 | |
| Factor 7 | 2.16±0.709 | 1.59±0.703 | 1.93±0.884 | 1.80±0.761 | 17.963 | 0.000 | |
| Total | 10.43±3.55 | 7.91±3.33 | 13.53±4.19 | 9.08±3.80 | 28.327 | 0.000 | |

the model of three latent classes. Among the three classes of FoH in this study, the No FoH group was the largest, with 61% of all patients, suggesting that the prevalence of FoH in middle-aged and elderly hospitalized patients with type 2 diabetes was 39%, slightly higher compared with that reported by previous studies.[10,41] This might be due to the fact that the population considered in this study was middle-aged and elderly hospitalized patients, which was susceptible to hypoglycemia. Previous studies demonstrated that an older age is one of the most important correlates for FoH,[22,23,41] and it is also probable that older adults are experiencing increased psychological symptoms because of fear or worry surrounding the COVID-19 pandemic.[42] Since the Low FoH group represented the 33% of the study population, which was not the largest group, it included a significant majority of patients with FoH. This result suggested that FoH of most hospitalized patients with type 2 diabetes was still at a low level, and active intervention should be given at an early stage to prevent its occurrence. It should be taken into consideration the existence of a significant subgroup of patients expressing low FoH levels rather than only screening FoH because these patients could be at risk of increasing over time, while they might benefit from early detection and treatment. The High FoH group included the smallest percentage (6%), and the patients in this class had high scores in all dimensions, especially fear dimension, which reflected that the patients in this group had a strong sense of fearlessness towards hypoglycemia and were the focus group of the intervention.

The top three items in the High FoH group and Low FoH group revealed that the impact of FoH on patients in High FoH group was not only the concern about hypoglycemia but also the avoidance of certain aspects of the daily life due to FoH. In addition, these items revealed that the lack of knowledge or specific measures to prevent and relieve hypoglycemia might lead the fear in patients or might cause them to behave in a way that is detrimental to their treatment. A previous study demonstrated that it is of great importance that patients have the ability to recognize and cope with hypoglycemia to achieve better outcomes with FoH,[10] and our results were in accordance with this study. It should be advisable that health-care providers make an effort to reduce the fear of patients and reduce the interference and avoidance of fear in daily life through various intervention measures according to the characteristics of various FoH types, ie, diabetes health education, peers support,[43] eye movement desensitization and reprocessing,[44] video-based telemedicine,[45] cognitive behavioral therapy,[46] blood glucose awareness training,[18,47] and new technology (ie, insulin bolus calculator[48]).

The present study revealed that multiple factors were correlated with latent FoH classes in hospitalized patients with type 2 diabetes, and three predictors were found by further logistic regression analysis. Firstly, the most evident finding that emerged from the analysis was that middle-aged and elderly hospitalized patients with type 2 diabetes with education level of elementary school and below were less likely to enter the No FoH group, which was in agreement with the findings of a previous work.[22] The potential explanation for this result was that middle-aged and elderly hospitalized patients with type 2 diabetes and an education level of elementary school and below could not understand the training for the knowledge of hypoglycemia. This aspect consequently suggested that patient-friendly health education measures

should be considered, so that even less educated patients can understand the relevant knowledge. Secondly, another important finding of this work was that middle-aged and elderly hospitalized patients with type 2 diabetes who were aware of the hypoglycemia onset were more likely to enter the No FoH group than the Low FoH group. This finding indicated that realizing the onset of hypoglycemia was beneficial to FoH, while hypoglycemia unawareness could lead to FoH, which was consistent with a previous study.[23] In addition, older patients might have an increased hypoglycemic unawareness than younger patients.[49,50] It is of utmost importance that health-care providers consider suitable structured education programs focusing on the clinical management of hypoglycemia to improve its awareness, ie, The Diabetes Teaching and Treatment program, Dose Adjusted for Normal Eating, Blood Glucose Awareness Training, and Hypoglycemia Treatment Program.[51] Lastly, this study found that middle-aged and elderly hospitalized patients with type 2 diabetes with complications were more likely to be distributed into the High FoH group than in the Low FoH group. Complications aggravate the psychological burden of patients, affect their emotions, and further aggravate FoH. Severe hypoglycemia is the most serious acute complication in patients with FoH, which can lead to a variety of adverse consequences, such as epilepsy, coma, fracture, and even fatal arrhythmia,[52] consequently aggravating FoH. Health-care providers should also track the psychological status of patients after a hypoglycemic event to prevent and mitigate FoH.[10]

The results of this study showed that the total PSQI scores of patients with different FoH latent classes were statistically significant; the PSQI score of the No FoH group was the lowest, the score of the Low FoH group was the second, and the score of the High FoH group was the highest. This result meant that the worse the FoH, the worse the sleep quality.[21,53] Previous studies also confirmed that FoH may disrupt sleep quality, and a systematic review reported that sleep quality is negatively affected by FOH. Moreover, it is worth noting that hypoglycemic episodes, as well as FoH[2], are more likely to occur at night.[17] Indeed, FoH specifically associated with sleep episodes has a negative impact on sleep quality.[54] These findings indicate that the intervention on the psychological state associated to FoH has a more significant impact on individual sleep quality than the hypoglycemic event itself. In this study, the impact of hypoglycemic events at night on sleep quality was not explored. A further follow-up study should consider the use of a continuous glucose monitoring system to monitor the blood glucose of patients in real time to further analyze the impact of FoH caused by hypoglycemic events on sleep quality.

Nevertheless, the presented results are exploratory and preliminary, several study limitations need to be considered. Firstly, the sample consisted solely of patients who were hospitalized at a single general hospital. Hence, the generalizability of the findings is limited, and it is necessary to replicate the proposed FoH classes on different samples in order to gain a better understanding of their relevance. In addition, the inclusion criteria for the sample required that patients have a documented history of experiencing hypoglycemic episodes within the past year. However, the absence of hypoglycemia symptoms in an individual does not necessarily indicate the absence of a fear of hypoglycemia.[6] Further qualitative studies should be performed to assess FoH of patients who do not experience hypoglycemia. Furthermore, we did not investigate possibly relevant information that might have had an impact on the observed results, such as medical and psychiatric comorbidities (eg, chronic kidney disease, depression), the specific type of oral hypoglycemic drugs used, and alcohol consumption. Lastly, the availability of dependable laboratory data characterizing the health condition of patients is insufficient.

## Conclusion

A heterogeneity was found in the FoH of middle-aged and elderly hospitalized patients with type 2 diabetes, which were divided into three classes: Low FoH group, No FoH group, and High FoH group. The latent FoH classes were the influencing factor for sleep quality. Health-care providers might improve the sleep quality of middle-aged and elderly hospitalized patients with type 2 diabetes by mitigating their FoH; thus, they should develop intervention strategies to mitigate it and improve their sleep quality. In the future, large sample multicenter longitudinal studies should be considered to confirm the causal relationship between FoH class membership and sleep quality. In addition, further research is needed to explore the influence of new diabetes-related technology.

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## Disclosure

The authors report no conflicts of interest in this work.

## References

1. International Diabetes Federation. *IDF Diabetes Atlas*. 10th ed. Brussels: International Diabetes Federation; 2021.
2. Zhang Y, Li S, Zou Y, et al. Fear of hypoglycemia in patients with type 1 and 2 diabetes: a systematic review. *J Clin Nurs*. 2021;30(1–2):72–82. doi:10.1111/jocn.15538
3. Khunti K, Alsifri S, Aronson R, et al. Rates and predictors of hypoglycaemia in 27 585 people from 24 countries with insulin-treated type 1 and type 2 diabetes: the global HAT study. *Diabetes Obes Metab*. 2016;18(9):907–915. doi:10.1111/dom.12689
4. Amiel SA, Aschner P, Childs B, et al. Hypoglycaemia, cardiovascular disease, and mortality in diabetes: epidemiology, pathogenesis, and management. *Lancet Diabetes Endocrinol*. 2019;7(5):385–396. doi:10.1016/s2213-8587(18)30315-2
5. Krawczyk J, Duda-Sobczak A, Zozulińska-Ziółkiewicz D. Fear of hypoglycaemia—from normality to pathology. Diagnostic criteria and therapeutic directions. *Clin Diabetol*. 2020;9(6):487–492. doi:10.5603/dk.2020.0046
6. Hendrieckx C, Halliday J, Beeney L, Speight J. *Diabetes and Emotional Health: A Practical Guide for Health Professionals Supporting Adults with Type 1 or Type 2 Diabetes*. San Mateo, CA: American Diabetes Association; 2020.
7. Martyn-Nemeth P, Schwarz Farabi S, Mihailescu D, et al. Fear of hypoglycemia in adults with type 1 diabetes: impact of therapeutic advances and strategies for prevention-a review. *J Diabetes Complications*. 2016;30(1):167–177. doi:10.1016/j.jdiacomp.2015.09.003
8. Rowe BH, Singh M, Villa-Roel C, et al. Acute management and outcomes of patients with diabetes mellitus presenting to Canadian emergency departments with hypoglycemia. *Can J Diabetes*. 2015;39(1):55–64. doi:10.1016/j.jcjd.2014.04.001
9. Bradley C, Eschwège E, de Pablos-Velasco P, et al. Predictors of quality of life and other patient-reported outcomes in the PANORAMA multinational study of people with type 2 diabetes. *Diabetes Care*. 2018;41(2):267–276. doi:10.2337/dc16-2655
10. Huang J, Peng W, Ding S, et al. Fear of hypoglycemia and associated factors in hospitalized patients with type 2 diabetes: a cross-sectional study. *Sci Rep*. 2022;12(1):20338. doi:10.1038/s41598-022-24822-1
11. Przezak A, Bielka W, Molęda P. Fear of hypoglycemia-An underestimated problem. *Brain Behav*. 2022;12(7):e2633. doi:10.1002/brb3.2633
12. Wang J, Kwok MK, Au Yeung SL, et al. Sleep duration and risk of diabetes: observational and Mendelian randomization studies. *Prev Med*. 2019;119:24–30. doi:10.1016/j.ypmed.2018.11.019
13. Wang J, Kwok MK, Au Yeung SL, et al. Comprehensive medical evaluation and assessment of comorbidities: standards of medical care in diabetes-2018. *Diabetes Care*. 2018;41(Suppl 1):S28–s37. doi:10.2337/dc18-S003
14. Dehghankar L, Ghorbani A, Yekefallah L, et al. Association of sleep quality with socio-demographic characteristics in elderly referred to health centers in Qazvin, Iran. *Sleep Hypn*. 2018;20(3):227–232. doi:10.5350/Sleep.Hypn.2017.19.0154
15. Narisawa H, Komada Y, Miwa T, et al. Prevalence, symptomatic features, and factors associated with sleep disturbance/insomnia in Japanese patients with type-2 diabetes. *Neuropsychiatr Dis Treat*. 2017;13:1873–1880. doi:10.2147/NDT.S134814
16. Lee SWH, Ng KY, Chin WK. The impact of sleep amount and sleep quality on glycemic control in type 2 diabetes: a systematic review and meta-analysis. *Sleep Med Rev*. 2016;31:91–101. doi:10.1016/j.smrv.2016.02.001
17. Gjerløw E, Bjørgaas MR, Nielsen EW, et al. Fear of hypoglycemia in women and men with type 1 diabetes. *Nurs Res*. 2014;63(2):143–149. doi:10.1097/nnr.0000000000000020
18. Cox DJ, Gonder-Frederick L, Polonsky W, et al. Blood glucose awareness training (BGAT-2): long-term benefits. *Diabetes Care*. 2001;24(4):637–642. doi:10.2337/diacare.24.4.637
19. Tanenbaum ML, Gonzalez JS. The influence of diabetes on a clinician-rated assessment of depression in adults with type 1 diabetes. *Diabetes Educ*. 2012;38(5):695–704. doi:10.1177/0145721712452795
20. YekeFallah L, Namdar P, Jalalpour A, et al. The relationship between fear of hypoglycemia and sleep quality among type 2 diabetic patients. *Clin Diabetol*. 2021;10(1):149–154. doi:10.5603/dk.2020.0057
21. Martyn-Nemeth P, Phillips SA, Mihailescu D, et al. Poor sleep quality is associated with nocturnal glycaemic variability and fear of hypoglycaemia in adults with type 1 diabetes. *J Adv Nurs*. 2018;74(10):2373–2380. doi:10.1111/jan.13765
22. Rossi MC, Nicolucci A, Ozzello A, et al. Impact of severe and symptomatic hypoglycemia on quality of life and fear of hypoglycemia in type 1 and type 2 diabetes. Results of the Hypos-1 observational study. *Nutr Metab Cardiovasc Dis*. 2019;29(7):736–743. doi:10.1016/j.numecd.2019.04.009
23. Castellano-Guerrero AM, Guerrero R, Relimpio F, et al. Prevalence and predictors of depression and anxiety in adult patients with type 1 diabetes in tertiary care setting. *Acta Diabetol*. 2018;55(9):943–953. doi:10.1007/s00592-018-1172-5
24. Shi L, Shao H, Zhao Y, et al. Is hypoglycemia fear independently associated with health-related quality of life? *Health Qual Life Outcomes*. 2014;12(167). doi:10.1186/s12955-014-0167-3
25. Norman G, Monteiro S, Salama S. Sample size calculations: should the emperor's clothes be off the peg or made to measure? *BMJ*. 2012;345:e5278. doi:10.1136/bmj.e5278

26. Nylund KL, Asparouhov T, Muthén BO. Deciding on the number of classes in latent class analysis and growth mixture modeling: a Monte Carlo simulation study. *Struct Equ Modeling*. 2007;14(4):535–569. doi:10.1080/10705510701575396
27. Yang -C-C. Evaluating latent class analysis models in qualitative phenotype identification. *Comput Stat Data An*. 2006;50(4):1090–1104. doi:10.1016/j.csda.2004.11.004
28. Anarte Ortiz MT, Caballero FF, de Adana MS R, et al. Development of a new fear of hypoglycemia scale: FH-15. *Psychol Assess*. 2011;23(2):398–405. doi:10.1037/a0021927
29. Liu YQ, Lei MJ, Li YF, et al. Translation and psychometric evaluation of a new Fear of Hypoglycemia Scale (FH-15) in type 2 diabetes patients. *J Nurs Sci*. 2018;33(17):28–32. doi:10.3870/j.issn.1001-4152.2018.17.028
30. Liu YQ, Xiong SQ, Sang M, et al. Reliability and validity of the Chinese version of the new fear of hypoglycemia scale: FH-15. *Int J Nurs Sci*. 2018;5(4):343–351. doi:10.1016/j.ijnss.2018.09.008
31. Buysse DJ, Reynolds CF, Monk TH, et al. The Pittsburgh sleep quality index: a new instrument for psychiatric practice and research. *Psychiatry Res*. 1989;28(2):193–213. doi:10.1016/0165-1781(89)90047-4
32. Liu XC, Tang MQ, Hu L, et al. Reliability and validity of the Pittsburgh Sleep Quality Index. *Chin J Psychiatry*. 1996; 2:103–107.
33. Stanley L, Kellermanns FW, Zellweger TM. Latent profile analysis: understanding family firm profiles. *Fam Bus Rev*. 2017;30(1):84–102. doi:10.1177/0894486516677426
34. Muthén LK, Muthén BO. *Mplus: Statistical Analysis with Latent Variables; User's Guide [Version 7]*. Los Angeles, CA: Muthén et Muthén; 2012. doi:10.1111/j.1751-5823.2010.00122_5.x
35. Ghosh JK. Latent class and latent transition analysis: with applications in the social, behavioral, and health sciences by Linda M. Collins, Stephanie T. Lanza. *Int Statist Rev*. 2010;78(3):449–450. doi:10.1111/j.1751-5823.2010.00122_5.x
36. Iturralde E, Rausch JR, Weissberg-Benchell J, et al. Diabetes-related emotional distress over time. *Pediatrics*. 2019;143(6):e20183011. doi:10.1542/peds.2018-3011
37. de Wit M, Pouwer F, Snoek FJ. How to identify clinically significant diabetes distress using the Problem Areas in Diabetes (PAID) scale in adults with diabetes treated in primary or secondary care? Evidence for new cut points based on latent class analyses. *BMJ Open*. 2022;12(3):e056304. doi:10.1136/bmjopen-2021-056304
38. Whitworth SR, Bruce DG, Starkstein SE, et al. Depression symptoms are persistent in Type 2 diabetes: risk factors and outcomes of 5-year depression trajectories using latent class growth analysis. *Diabet Med*. 2017;34(8):1108–1115. doi:10.1111/dme.13372
39. Starkstein SE, Davis WA, Dragovic M, et al. Diagnostic criteria for depression in type 2 diabetes: a data-driven approach. *PLoS One*. 2014;9(11):e112049. doi:10.1371/journal.pone.0112049
40. Abuhegazy H, Mujairi A, Banah F, et al. Depression and associated risk factors among type 2 diabetic patients: a cross sectional study on a convenience sample from the diabetic center, Khamis Mushait; Saudi Arabia. *Neuropsychiatr Dis Treat*. 2022;18:1975–1984. doi:10.2147/NDT.S374752
41. Sakane N, Kotani K, Tsuzaki K, et al. Fear of hypoglycemia and its determinants in insulin-treated patients with type 2 diabetes mellitus. *J Diabetes Investig*. 2015;6(5):567–570. doi:10.1111/jdi.12340
42. Kim MJ, Park C, Sharp LK, et al. Impact of worries associated with COVID-19 on diabetes-related psychological symptoms in older adults with Type 2 diabetes. *Geriatr Nurs*. 2022;43:58–63. doi:10.1016/j.gerinurse.2021.11.006
43. Dehghankar L, Namdar P, Yekefallah L, et al. The effect of peers support on fear of hypoglycemia in Iranian patients with type 1 diabetes: a clinical trial study. *Iran J Nurs Midwifery Res*. 2021;26(2):162–167. doi:10.4103/ijnmr.IJNMR_277_19
44. Sheikhi M, Moradi M, Shahsavary S, et al. The effect of eye movement desensitization and reprocessing on the fear of hypoglycemia in type 2 diabetic patients: a randomized clinical trial. *BMC Psychol*. 2020;8(1):82. doi:10.1186/s40359-020-00450-0
45. Marker AM, Monzon AD, Nelson EL, et al. An intervention to reduce hypoglycemia fear in parents of young kids with type 1 diabetes through video-based telemedicine (REDCHiP): trial design, feasibility, and acceptability. *Diabetes Technol Ther*. 2020;22(1):25–33. doi:10.1089/dia.2019.0244
46. Martyn-Nemeth P, Duffecy J, Quinn L, et al. A cognitive behavioral therapy intervention to reduce fear of hypoglycemia in young adults with type 1 diabetes (FREE): study protocol for a randomized controlled trial. *Trials*. 2019;20(1):796. doi:10.1186/s13063-019-3876-4
47. Rondags SM, de Wit M, Snoek FJ. HypoAware: development and pilot study of a brief and partly web-based psychoeducational group intervention for adults with Type 1 and insulin-treated Type 2 diabetes and problematic hypoglycaemia. *Diabet Med*. 2016;33(2):184–191. doi:10.1111/dme.12876
48. Vallejo Mora MDR, Carreira M, Anarte MT, et al. Bolus calculator reduces hypoglycemia in the short term and fear of hypoglycemia in the long term in subjects with type 1 diabetes (CBMDI Study). *Diabetes Technol Ther*. 2017;19(7):402–409. doi:10.1089/dia.2017.0019
49. Bremer JP, Jauch-Chara K, Hallschmid M, et al. Hypoglycemia unawareness in older compared with middle-aged patients with type 2 diabetes. *Diabetes Care*. 2009;32(8):1513–1517. doi:10.2337/dc09-0114
50. Martín-Timón I, Del Cañizo-Gómez FJ. Mechanisms of hypoglycemia unawareness and implications in diabetic patients. *World J Diabetes*. 2015;6(7):912–926. doi:10.4239/wjd.v6.i7.912
51. Farrell CM, McCrimmon RJ. Clinical approaches to treat impaired awareness of hypoglycaemia. *Ther Adv Endocrinol Metab*. 2021;12:20420188211000248. doi:10.1177/20420188211000248
52. Graveling AJ, Frier BM. Impaired awareness of hypoglycaemia: a review. *Diabetes Metab*. 2010;36:S64–S74. doi:10.1016/s1262-3636(10)70470-5
53. Polonsky WH, Fisher L, Hessler D, et al. Identifying the worries and concerns about hypoglycemia in adults with type 2 diabetes. *J Diabetes Complications*. 2015;29(8):1171–1176. doi:10.1016/j.jdiacomp
54. Suteau V, Saulnier PJ, Wargny M, et al. Association between sleep disturbances, fear of hypoglycemia and psychological well-being in adults with type 1 diabetes mellitus, data from cross-sectional VARDIA study. *Diabetes Res Clin Pract*. 2020;160:107988. doi:10.1016/j.diabres