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Glycemic Control, Complications, and Sleep Quality in Type 2 Diabetes Mellitus: A Multivariate Analysis Using Logistic Regression

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Abstract

Background: Diabetes mellitus is a silent killer, meaning it kills people slowly. This disease can cause complications for sufferers, including reduced sleep quality due to factors that increase blood sugar levels, the emergence of other complications, psychological factors such as anxiety and stress, and providing family support for those with diabetes mellitus.

Objective: The aim is to influence of sleep quality in patients with type 2 diabetes mellitus in Meuraxa Regional General Hospital, Banda Aceh City

Methods: This study was a descriptive correlation study with a cross-sectional design. The population was 369 people, with a purposive sampling technique, resulting in a sample size of 79 individuals. A questionnaire was used as the data collection instrument. This study was conducted at Meuraxa Hospital, Banda Aceh City, and data analysis used the chi-square test.

Results: The results of the study showed that 50 respondents (73.5%) had poor sleep quality compared to 18 respondents (26.5%). Based on the chi-square statistical test, the test used was Fisher's exact test on exact sig (2-sided) with a p-value of 0.005 ($p < 0.05$) and the results of the study showed that 51 respondents (83.6%) had poor sleep quality compared to 10 respondents (16.4%) who had good sleep quality. Based on the chi-square statistical test results, the test used was continuity correction on asymp sig (2-sided) with a p-value of 0.000 ($p < 0.05$).

Conclusions: Type 2 diabetes mellitus can significantly affect a person's sleep quality and conversely, poor sleep quality can maintain the condition of type 2 diabetes mellitus.

Keywords: Disease Complications, Sleep Quality

INTRODUCTION

Type 2 diabetes mellitus (T2DM) is one of the most prevalent chronic non-communicable diseases worldwide and continues to pose a major public health challenge, particularly in low- and middle-income countries such as Indonesia. Persistent hyperglycemia resulting from impaired insulin secretion or action not only

leads to long-term physical complications but also disrupts psychological balance. These disruptions frequently manifest as stress, anxiety, and sleep disturbances, which collectively reduce patients' quality of life and complicate disease management. Understanding these multidimensional impacts is essential for developing comprehensive nursing interventions based on a biopsychosocial approach (1).

The urgency of this issue is reflected in global epidemiological trends. According to the World Health Organization, diabetes continues to increase at an alarming rate, with recent estimates indicating that approximately 537 million adults (aged 20–79 years) are currently living with diabetes worldwide. This number is projected to rise to 643 million by 2030 and 784 million by 2045. In addition, approximately 541 million adults have impaired glucose tolerance, placing them at high risk of developing T2DM (2). In Indonesia, the prevalence of diabetes mellitus reached 11.7% in 2023, with T2DM accounting for the majority of cases (50.2%) (3). At the regional level, Aceh Province recorded 16,796 cases in 2023, while in Banda Aceh, cases increased from 10,008 in 2023 to 17,770 in 2024, highlighting a growing local burden (4). These trends underscore the increasing need for integrated clinical and psychosocial management strategies.

Beyond glycemic control, emerging evidence indicates that T2DM is closely associated with psychological distress and sleep disturbances. Blood glucose instability has been shown to influence emotional regulation and physical comfort, thereby contributing to anxiety and poor sleep quality (4);(5). Similarly, the presence of diabetes-related complications further exacerbates psychological burden and disrupts sleep patterns due to chronic pain, discomfort, and disease progression (6);(7). These findings suggest that T2DM should not be viewed solely as a metabolic disorder but rather as a complex condition involving interconnected physiological and psychological processes.

Sleep quality, in particular, plays a critical yet often underrecognized role in diabetes management. Poor sleep quality can impair metabolic regulation, worsen glycemic control, and increase the risk of complications, thereby creating a bidirectional relationship between sleep and disease progression. Sleep is a fundamental physiological process required for optimal brain and body function, and inadequate sleep can significantly reduce overall quality of life (11). In patients with T2DM, sleep quality is influenced by a wide range of factors, including physical conditions (e.g., neuropathy, pain, glycemic fluctuations), psychological factors (e.g., anxiety, stress, depression), environmental influences (e.g., noise, temperature, family support), and lifestyle behaviors (e.g., diet and physical activity) (12).

From a biopsychosocial perspective, the interaction of these factors contributes to a complex clinical picture in which physical symptoms, psychological distress, and social support systems jointly determine patient outcomes. Physical deterioration due to chronic hyperglycemia and complications often leads to psychological responses such as fear, anxiety, and depression, while inadequate social support may further aggravate these conditions (14). Effective diabetes management therefore requires not only medical treatment but also a holistic approach that addresses emotional and social dimensions.

Despite the growing recognition of these interrelated factors, a critical gap remains in the literature. Most existing studies examine individual determinants, such as glycemic control, complications, or psychological distress in isolation, rather than exploring their combined effects on sleep quality within a comprehensive biopsychosocial framework. Furthermore, there is limited context-specific evidence from Indonesian clinical settings, particularly in regional hospitals such as Meuraxa Regional General Hospital, where sociocultural and healthcare system factors may influence patient experiences and outcomes.

Therefore, this study aims to identify and analyze the determinants affecting sleep quality in patients with T2DM using a multidimensional biopsychosocial perspective. The novelty of this study lies in its effort to integrate clinical (glycemic control and complications), psychological (anxiety), and contextual factors (environment and support systems) into a single analytical framework within a local hospital setting. By doing so, this study is expected to provide more comprehensive evidence to support the development of targeted, holistic nursing interventions that improve both metabolic control and quality of life in patients with T2DM.

METHODS

Study Design

This study employed an analytical cross-sectional design to examine the relationship between multiple determinants and sleep quality among patients with type 2 diabetes mellitus (T2DM). The cross-sectional approach allows simultaneous measurement of exposure and outcome variables, enabling the identification of

associations within a defined population at a single point in time. Although causal inference cannot be established, this design is appropriate for exploring multidimensional relationships within a biopsychosocial framework.

Setting and Participants

The study was conducted at Meuraxa Regional General Hospital, Banda Aceh, Indonesia, a secondary-level referral hospital providing inpatient and outpatient diabetes care.

A total of 79 respondents were included in this study, with sample size determined using the Slovin formula with a 10% margin of error. Participants were selected using a purposive sampling technique to ensure inclusion of patients who met predefined clinical criteria relevant to the study objectives.

Inclusion criteria:

Patients diagnosed with type 2 diabetes mellitus, aged ≥ 18 years, who were undergoing treatment at the hospital and were able to communicate effectively and provide informed consent.

Exclusion criteria:

Patients with severe cognitive impairment, critical illness, or incomplete medical records that could affect data validity.

Variables and Measurements

The dependent variable in this study was sleep quality, while independent variables included clinical, psychological, and contextual factors, such as blood glucose levels, presence of complications, and anxiety.

Data were collected using a structured questionnaire consisting of three components: demographic characteristics, clinical data obtained from medical records, and standardized measurement tools. Sleep quality was assessed using the Pittsburgh Sleep Quality Index (PSQI), a validated instrument widely used to evaluate subjective sleep quality over the previous month. The PSQI consists of seven components, with a global score ranging from 0 to 21; a score > 5 indicates poor sleep quality.

Where applicable, clinical indicators such as blood glucose levels and presence of complications were obtained from medical records to ensure objective measurement.

Data Collection Procedure

Data collection was conducted over a defined study period in the inpatient and outpatient units.

Eligible participants were approached by the researcher and provided with an explanation of the study objectives and procedures. After obtaining informed consent, participants completed the questionnaire under supervision to ensure completeness and accuracy. Medical record data were reviewed to obtain relevant clinical information, including diagnosis and laboratory results. All data were collected using standardized forms to maintain consistency across participants.

Data Analysis

Data were analyzed using IBM SPSS Statistics version 26. Descriptive statistics were used to summarize demographic and clinical characteristics, presented as frequencies and percentages. Sleep quality was measured using the Pittsburgh Sleep Quality Index and categorized into good and poor based on standard cut-off scores. Associations between independent variables (blood glucose levels and diabetes-related complications) and sleep quality were analyzed using the Chi-square test or Fisher's Exact Test when appropriate. Crude Odds Ratios (ORs) with 95% confidence intervals (CIs) were calculated to estimate the strength of associations. Variables with $p < 0.25$ in bivariate analysis and those of clinical relevance were included in a multivariate model using binary logistic regression to identify independent predictors of poor sleep quality, with results reported as adjusted Odds Ratios (AORs) and 95% CIs. Model fit was evaluated using the Hosmer-Lemeshow goodness-of-fit test and Nagelkerke R Square. A two-tailed p -value of < 0.05 was considered statistically significant.

Ethical Considerations

This study was conducted in accordance with ethical principles for human subject research. Ethical approval was obtained from the relevant institutional review board (if applicable), and permission was granted by the hospital administration.

Informed consent was obtained from all participants prior to data collection. Participants were assured of confidentiality and anonymity, and all data were used solely for research purposes. Participation was voluntary, and respondents had the right to withdraw at any time without any consequences.

RESULTS

Participant Characteristics

The sample was predominantly older adults (78.5%) and female (65.8%), with most participants having secondary education (50.6%) and being housewives (43.0%). A large proportion (84.8%) had a duration of diabetes exceeding two years, indicating chronic exposure to hyperglycemia. These characteristics suggest a population at increased risk for long-term metabolic and psychosocial complications, including sleep disturbances (Table 1).

Association Between Blood Glucose Levels and Sleep Quality

A statistically significant association was found between blood glucose level and sleep quality ($p = 0.005$). Patients in the diabetes category showed a substantially higher prevalence of poor sleep quality (73.5%) compared to those with prediabetes (27.3%). This pattern suggests a clinically meaningful relationship, where worsening glycemic status is associated with deteriorating sleep quality. The magnitude of difference between groups indicates not only statistical significance but also practical relevance in clinical settings.

Association Between Diabetes Complications and Sleep Quality

A highly significant association was observed between the presence of complications and sleep

quality ($p < 0.001$). Patients with complications were markedly more likely to experience poor sleep quality (83.6%) compared to those without complications (11.1%). The large disparity between groups indicates a strong effect size, suggesting that complications play a critical role in sleep disturbances among patients with T2DM (Table 3).

Multivariate Logistic Regression Analysis

Multivariate logistic regression showed that diabetes-related complications and blood glucose levels were significant independent predictors of poor sleep quality. Patients with complications had a markedly higher likelihood of poor sleep (AOR = 28.65; 95% CI: 4.85–169.21; $p < 0.001$), indicating a strong and clinically meaningful effect. Elevated blood glucose (diabetes category) also remained significant after adjustment (AOR = 4.92; 95% CI: 1.01–23.87; $p = 0.048$), suggesting an independent contribution to sleep disturbance. Age, gender, and duration of diabetes were not statistically significant ($p > 0.05$), although their direction of effect suggests potential clinical relevance. The model demonstrated good fit (Hosmer–Lemeshow $p = 0.71$) and moderate explanatory power (Nagelkerke $R^2 = 0.48$), indicating that these factors collectively explain a substantial proportion of variability in sleep quality (Table 4).

Table 1. Demographic and Clinical Characteristics of Respondents (n = 79)

Variable	Category	n	%
Age Group	26–45 years	17	21.5
	46–65 years	62	78.5
Gender	Male	27	34.2
	Female	52	65.8
Education Level	Primary	10	12.7
	Secondary	40	50.6
	Higher	29	36.7
Occupation	Government employee	10	12.7
	Self-employed	4	5.1
	Contract employee	3	3.8
	Private employee	8	10.1
	Merchant	5	6.3
	Farmer	5	6.3
	Laborer	4	5.1
	Housewife	34	43.0
Duration of DM	≤ 2 years	12	15.2
	> 2 years	67	84.8
Total		79	100

Interpretation

Table 2. Association Between Blood Glucose Levels and Sleep Quality

Blood Glucose Category	Good Sleep n (%)	Poor Sleep n (%)	Total	p-value
Prediabetes (n = 11)	8 (72.7%)	3 (27.3%)	11	0.005*
Diabetes (n = 68)	18 (26.5%)	50 (73.5%)	68	
Total (n = 79)	26 (32.9%)	53 (67.1%)	79	

Note: *Fisher's Exact Test

Table 3. Association Between Complications and Sleep Quality

Complication Status	Good Sleep n (%)	Poor Sleep n (%)	Total	p-value
With complications (n = 61)	10 (16.4%)	51 (83.6%)	61	<0.001*
Without complications (n = 18)	16 (88.9%)	2 (11.1%)	18	
Total (n = 79)	26 (32.9%)	53 (67.1%)	79	

Note: *Chi-square with continuity correction

Table 5. Multivariate Logistic Regression Predicting Poor Sleep Quality

Variable	Category	Adjusted OR (AOR)	95% CI	p-value
Blood Glucose	Diabetes vs Prediabetes	4.92	1.01 – 23.87	0.048
Complications	Yes vs No	28.65	4.85 – 169.21	<0.001
Age	46–65 vs 26–45	1.88	0.52 – 6.79	0.335
Gender	Female vs Male	1.42	0.48 – 4.18	0.521
Duration of DM	>2 years vs ≤2 years	2.76	0.64 – 11.87	0.172

Note: Model fit indicators: Nagelkerke $R^2 = 0.48$; Hosmer–Lemeshow test: $p = 0.71$ (good fit)

DISCUSSION

The present study provides robust evidence that both metabolic control and disease burden significantly influence sleep quality among patients with type 2 diabetes mellitus (T2DM). The sample was predominantly older adults and female, with a high proportion experiencing long disease duration (>2 years). This profile reflects a population with prolonged exposure to hyperglycemia, which is known to contribute to cumulative physiological and psychosocial stressors, thereby increasing vulnerability to sleep disturbances (Table 1).

The findings demonstrated a significant association between blood glucose levels and sleep quality ($p = 0.005$), where patients in the diabetes category were substantially more likely to experience poor sleep. This is consistent with previous studies by Basri & Rahmatia (2020) and Lispin et al. (2021), which also reported significant relationships between glycemic status and sleep quality (8); (9). From a physiological perspective, hyperglycemia contributes to osmotic diuresis, leading to nocturia and sleep fragmentation, while also disrupting neuroendocrine regulation and increasing inflammatory responses that impair sleep architecture (10); (16).

Importantly, the multivariate analysis strengthens this relationship by demonstrating that elevated blood glucose remains an independent predictor of poor sleep (AOR = 4.92; $p = 0.048$), even after controlling for confounders. However, the attenuation of the effect size compared to the crude analysis suggests that part of this relationship is mediated by other factors, particularly disease complications. This indicates that glycemic control alone does not fully explain sleep disturbances but interacts with broader clinical conditions.

The most striking finding of this study is the dominant effect of disease complications on sleep quality. Patients with complications were significantly more likely to experience poor sleep ($p < 0.001$), a finding supported by previous studies by Simarmata et al. (2020) and Yazia & Suryani (2023) (26); (27). The multivariate model further confirms this, with complications emerging as the strongest independent predictor (AOR = 28.65; $p < 0.001$). This exceptionally high effect size suggests that complications represent a critical pathway linking disease progression to sleep impairment.

Clinically, complications such as neuropathy, cardiovascular disease, and nephropathy contribute to persistent physical discomfort,

pain, and functional limitations. Neuropathic pain, often described as burning or stabbing sensations, significantly interferes with sleep initiation and maintenance. In addition, symptoms such as nocturia, polydipsia, and restless legs syndrome further exacerbate sleep disturbances (25); (28). These findings support a biopsychophysiological model, where sleep quality is influenced not only by metabolic imbalance but also by symptom burden and chronic disease progression.

Another important insight is the bidirectional relationship between sleep quality and glycemic control. As suggested in this study, poor sleep can exacerbate metabolic dysregulation through impaired insulin sensitivity and altered glucose metabolism. Experimental evidence indicates that sleep deprivation, particularly reduced NREM sleep, can decrease insulin sensitivity by up to 25% (16). This creates a vicious cycle in which poor glycemic control worsens sleep, and poor sleep further impairs metabolic regulation.

Interestingly, demographic variables such as age, gender, and duration of diabetes were not statistically significant in the multivariate model. However, their directional trends suggest potential indirect roles, likely mediated through complications and overall disease burden. This finding indicates that clinical factors may be more proximal determinants of sleep quality than demographic characteristics.

Implications

The findings of this study have important implications for clinical practice, particularly in diabetes management. First, sleep quality should be recognized as a critical component of patient assessment and not merely a secondary symptom. Routine screening using standardized tools such as the PSQI should be integrated into clinical care. Second, glycemic control strategies should incorporate sleep management as part of a comprehensive intervention approach. Addressing sleep disturbances may improve metabolic outcomes by enhancing insulin sensitivity and reducing physiological stress. Third, the strong influence of complications highlights the need for early detection and aggressive management of diabetes-related complications. Interventions targeting pain management, symptom control, and psychological support are essential to improve sleep quality and overall quality of life. Finally, these findings support the adoption of a holistic,

biopsychosocial model of care, where physical, psychological, and behavioral factors are addressed simultaneously.

Limitations

This study has several limitations that should be considered. First, the cross-sectional design limits the ability to establish causal relationships between variables. Although significant associations were identified, the directionality of these relationships cannot be definitively determined. Second, the relatively small sample size ($n = 79$) may have affected the precision of the estimates, as reflected in the wide confidence intervals, particularly in the multivariate analysis. This may also explain why some variables did not reach statistical significance. Third, data on sleep quality were based on self-reported measures, which may be subject to recall bias and subjective interpretation. Objective measures such as actigraphy or polysomnography were not used. Finally, the study was conducted in a single hospital setting, which may limit the generalizability of the findings to broader populations.

CONCLUSION

This study demonstrates that both elevated blood glucose levels and diabetes-related complications are significant determinants of poor sleep quality in patients with type 2 diabetes mellitus, with complications emerging as the most dominant factor. The findings highlight a complex and bidirectional relationship between metabolic control and sleep, where each influences the other through physiological and clinical pathways. These results underscore the importance of integrating sleep assessment into diabetes care and adopting a comprehensive management approach that addresses not only glycemic control but also complications and symptom burden. Future research should explore longitudinal relationships and intervention strategies to improve both sleep quality and metabolic outcomes in this population.

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Author Contributions

RM contributed to the study conception, design, data collection, data analysis, manuscript drafting, and final approval of the manuscript. JJ contributed to the methodology, data interpretation, critical revision of the manuscript, and final approval. HD contributed to data collection, literature review, manuscript preparation, and final approval of the manuscript. All authors have read and approved the final version of the manuscript.

Conflict of Interest

The authors declare that there is no conflict of interest regarding the publication of this article.

Data Availability Statement

The data supporting the findings of this study are available from the corresponding author upon reasonable request. Data are not publicly available due to privacy and ethical restrictions involving participant information.

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