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Biopsychosocial Determinants of Sleep Quality in Community-Dwelling Older Adults With Type 2 Diabetes and Mild Cognitive Impairment

Chakrit Sattayarom[1], Aekkachai Fatai[2*], Supaporn Voraroon[1], Umakorn Jaiyungyuen[1], Phenrung Wandee[1], Purin Srisasaluk[1], Sureewan Sawangha[1], Trakulwong Luecha[3], Jason Rydberg[4]

[1] Department of Community Health Nursing, Boromarajonani College of Nursing Suphanburi, Praboromarajchanok Institute, Suphan Buri, Thailand

[2] Department of Adult and Geriatric Nursing, Princess Agrarajakumari Faculty of Nursing, Chulabhorn Royal Academy, Bangkok, Thailand

[3] Department of Community Nursing, Faculty of Nursing, Burapha University, Chon Buri, Thailand

[4] Center for Program Evaluation, School of Criminology and Justice, University of Massachusetts Lowell, Massachusetts, US

Abstract

Background: Community-dwelling older adults with type 2 diabetes mellitus (T2DM) and mild cognitive impairment (MCI) often report poor sleep, which may aggravate metabolic control and functional decline; yet sleep problems and their biopsychosocial drivers are underrecognized in primary care.

Objectives: To describe sleep quality, examine biopsychosocial correlates, and identify significant predictors of sleep quality in older adults with T2DM and MCI.

Methods: A cross-sectional study was conducted in 6 primary care units in Suphan Buri province, Thailand. Sleep quality was measured using the Pittsburgh Sleep Quality Index (PSQI). Biological factors included age, sex, body mass index, hemoglobin A_{1c} (HbA_{1c}), diabetes duration, hypertension, comorbidities, and probable obstructive sleep apnea (OSA). Psychological factors were depressive symptoms (TGDS-15), diabetes-related distress (DDS-17), and diabetes self-efficacy. Social/environmental factors included perceived social support and environmental disturbance. Behavioral factors were diabetes self-care behaviors (SDSCA). Pearson's correlations and hierarchical multiple regression were performed.

Results: Poor sleep was common (82.3%; PSQI > 5). Sleep quality correlated with depressive symptoms (r = 0.46), diabetes distress (r = 0.39), self-efficacy (r = -0.41), environmental disturbance (r = 0.34), and self-care (r = -0.32) (all P < .001). In the final model, HbA_{1c} (β = 0.11), probable OSA (β = 0.14), depressive symptoms (β = 0.28), diabetes distress (β = 0.17), self-efficacy (β = -0.22), environmental disturbance (β = 0.19), and self-care (β = -0.12) independently predicted PSQI, explaining 47% of variance (adjusted R^2 = 0.45).

Conclusions: Sleep quality in older adults with T2DM and MCI reflects a biopsychosocial profile dominated by psychological, environmental, and behavioral factors, with selected biological risks. Primary care nurses should integrate sleep screening with assessment of mood, diabetes distress, self-efficacy, OSA risk, and home sleep conditions to guide multicomponent interventions.

Keywords: Sleep quality, Type 2 diabetes, Mild cognitive impairment, Biopsychosocial, Older adults

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*** Corresponding Author:** aekkachai.fat@cra.ac.th

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Introduction

Thailand, like much of Asia, is ageing fast. As the older population grows, so do chronic conditions that are difficult to manage in everyday life. One of the most challenging constellations in late life is type 2 diabetes mellitus (T2DM) accompanied by mild cognitive impairment (MCI), a prodromal stage of dementia characterized by measurable cognitive decline with largely preserved daily function. This combination is becoming more common and places a heavier load on older adults, families, and primary care teams.[1] Ageing also brings multimorbidity, frailty, and social vulnerability, which together can limit access to care and undermine self-management.[2, 3] Within this landscape, sleep stands out as a daily behavior that is both clinically meaningful and, importantly, modifiable.

There is consistent evidence that T2DM increases the risk of cognitive decline and dementia through several biological routes such as cerebrovascular injury, disruption of the blood-brain barrier, and amyloid-β accumulation.[4, 5] Studies highlight a high prevalence of sleep dysfunction in diabetic populations, with 69% of Asian Indians reported as 'poor sleepers'; similarly, older adults with both T2DM and MCI face a cumulative disease burden — including suboptimal glycemic control and vascular comorbidities — that increases their vulnerability to functional decline and institutionalization.[4-6] Sleep quality sits at the intersection of these processes. Short or fragmented sleep is linked to impaired glucose regulation, insulin resistance, low-grade inflammation, daytime dysfunction, and lower quality of life.[7] In people with cognitive disorders, disturbed sleep is also a core component of behavioral and psychological symptoms of dementia, including nighttime wandering, agitation, and reversed sleep-wake cycles, which disrupt caregiving and often precipitate health-care use.[8-10] Yet sleep problems often go unrecognized in community settings until they begin to interfere with daily routines or caregiving. The biopsychosocial model offers a practical lens for studying sleep in this population because it considers how biological, psychological, social, and environmental influences interact in real life.[11] From a biological perspective, age, sex, body mass index (BMI), hemoglobin A_{1c} (HbA_{1c}), diabetes complications, medication use (including hypnotics and diuretics), and sleep-disordered breathing such as obstructive sleep apnea (OSA) have each been associated with sleep disturbances or poor sleep quality.[12-16] Psychological influences — depressive symptoms, diabetes-related distress, and self-efficacy for diabetes self-care — have shown consistent links with how well older adults sleep.[15, 16] Social and environmental conditions, including perceived social support, access to services, and bedroom factors such as noise, light, temperature, odors, pests, or crowding, can shape sleep patterns and next-day functioning.[17-20] At the behavioral level, lifestyle patterns — dietary habits, physical activity, caffeine and alcohol consumption, and adherence to diabetes self-care recommendations — add further variability to sleep outcomes and provide modifiable targets for intervention.[21-23]

Sleep problems — insomnia symptoms and OSA in particular — are common in later life and have been linked with faster cognitive decline and greater risk of dementia, including Alzheimer's disease.[10, 11] In older adults with T2DM, these sleep disorders complicate day-to-day management and may raise cardiometabolic risk by worsening glycemic variability, blood pressure control, and inflammatory profiles.[12, 14, 15, 24-26] OSA is frequently observed in T2DM and is a clear management target; identifying and treating OSA can support better metabolic control and fewer complications.[12] At the same time, insufficient or nonrestorative sleep can impair attention, executive function, and memory, which may exacerbate existing MCI and reduce the capacity to engage in complex self-care tasks such as medication management or blood glucose monitoring.[11, 27, 28] At the social level,

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adequate support can ease distress, strengthen adherence to self-care, and is associated with better sleep.[27, 29]

Despite a growing literature, important gaps remain. Much of the existing work focuses on general older populations or caregivers rather than community-dwelling older adults who simultaneously live with T2DM and MCI — a group likely to face distinctive barriers and care needs.[7, 8] Evidence from rural or semi-rural Thai contexts is also limited, even though environmental conditions, social resources, and service access differ meaningfully from urban areas.[5] Moreover, sleep is seldom assessed systematically in Thai primary care, and sleep complaints in older adults with multiple chronic conditions may be overshadowed by more familiar cardiometabolic problems.[9, 15, 21] In addition, heterogeneity in sleep measurement and analytic approaches reduces comparability across studies.[28] Some Thai evidence has reported inconclusive associations between T2DM and dementia, underscoring the need for studies that account for confounding and apply an integrative theoretical framework.[29]

Primary care nurses are well positioned to address these gaps. Routine screening for mood problems and sleep disturbance, brief behavioral counseling, attention to sleep environment, and coaching to strengthen self-efficacy are all feasible in community clinics and have been associated with better clinical outcomes and more efficient use of services.[28, 30-33] For older adults with T2DM and MCI, such biopsychosocial informed care must also recognize cognitive limitations, involve family or care partners when appropriate, and coordinate with community resources to support adherence and environmental modifications in the home.[8, 32, 33] Considering the multilevel drivers of sleep and the realities of Thai primary care, a biopsychosocial approach is appropriate for explaining — and ultimately improving — sleep quality among community-dwelling older adults with T2DM and MCI.[11]

Therefore, this study aimed to describe sleep quality among community-dwelling older adults with T2DM and MCI; examine associations between biological, psychological, social, environmental, and behavioral factors and sleep quality; and identify significant predictors of sleep quality using standardized measures and hierarchical multiple regression within a biopsychosocial framework tailored to Thai primary care.

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Methods

Study Design and Setting

This study employed a cross-sectional descriptive design combined with a predictive correlational approach, grounded in the biopsychosocial model proposed by Engel[34] and further elaborated by Borrell-Carrió.[13] The biopsychosocial perspective assumes that health and illness emerge from dynamic interactions between biological, psychological, and social and environmental factors, and this framework guided the selection, grouping, and analysis of study variables.[13, 35-36] The research was conducted in primary care settings, including Subdistrict Health-Promoting Hospitals and community health centers that provided chronic disease and older adult clinics in Suphan Buri province, Thailand (Figure 1).

Participants and Sampling

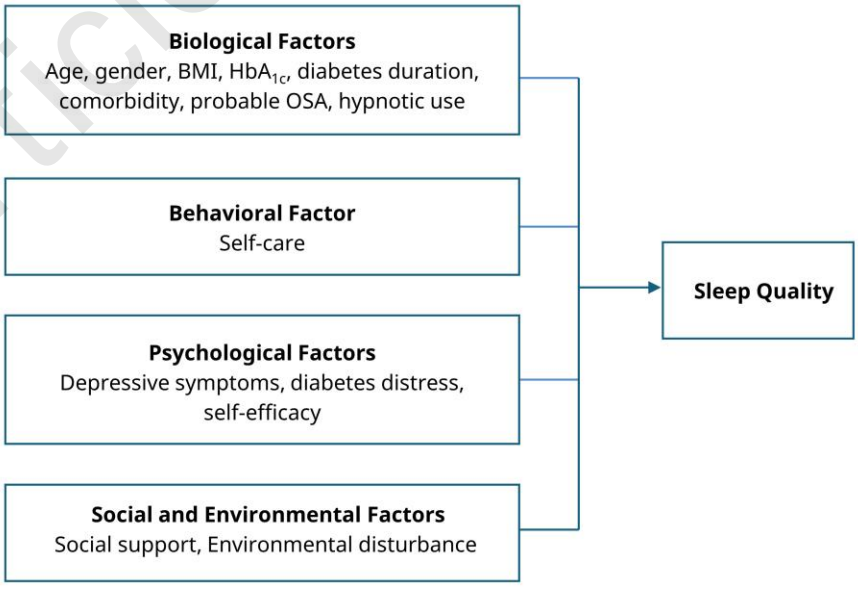
The target population comprised community-dwelling older adults aged 60 years and above who had been diagnosed by a physician with T2DM and MCI. Older adults registered as patients in primary care units in Song Phi Nong and U-Thong districts formed the sampling frame, consistent with the provincial chronic disease registry. Inclusion criteria

were: 1) age ≥ 60 years at the time of recruitment; 2) physician-diagnosed T2DM; 3) a purely cognitive screen-based diagnosis of MCI present for at least 6 months, identified using the Mini-Mental State Examination (MMSE)-Thai version with established education-adjusted cutoffs to account for literacy levels (≤ 14/23 for illiterate individuals and ≤ 17/30 for those with primary education), without requiring a clinically confirmed diagnosis by a specialist;[34] 4) residence in the community and receipt of care from participating primary care units; 5) ability to communicate in Thai or having a caregiver who could support communication; and 6) willingness to provide written informed consent or consent from a legal caregiver according to the ethics-approved procedure. Exclusion criteria were: 1) severe physical frailty or acute medical instability preventing participation; 2) severe visual or hearing impairment that limited participation; 3) current treatment for acute critical illness (eg, acute stroke, terminal heart failure); 4) history of recent use (within the past 3 months) of psychoactive substances that could markedly affect central nervous system function; and 5) refusal to participate.

A multistage sampling strategy was used. First, 2 districts (Song Phi Nong and U-Thong) were selected from 10 districts in Suphan Buri province using simple random sampling to enhance external validity. Second, within each district, 3 primary care units with chronic disease and older adult clinics were randomly selected from the list of eligible units: Ban Long Tong, Bo Suphan, and Ban Phai Rong Wua in Song Phi Nong District, and Chedi, Krachan, and Ban Srayai Som in U-Thong District. Third, proportionate stratified sampling was applied to allocate the sample across these 6 units based on the size of their T2DM registries, and eligible participants were then recruited consecutively on clinic days using systematic consecutive recruitment from each registry list until the target number for that unit was reached.

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Figure 1. Conceptual Framework of the Study



Abbreviations: BMI, body mass index; HbA_{1c}, hemoglobin A_{1c}; OSA, obstructive sleep apnea.

Sample size was calculated using G*Power for multiple regression with an anticipated medium effect size (f^2 = 0.15), α = 0.05, power (1 – β) = 0.80, and 29 predictors, yielding a minimum of 184 participants.[37] To satisfy assumptions for parametric statistics, enhance representativeness, and account for potential nonresponse or incomplete data, this study increased the target by 10%,[38] resulting in a planned sample size of 203 participants. The final sample consisted of 203 older adults distributed proportionally across the 6 primary care units: 26 from Ban Long Tong, 39 from Bo Suphan, 30 from Ban Phai Rong Wua, 33 from Chedi, 36 from Krachan, and 39 from Ban Srayai Som.

Measures and Biopsychosocial Domains

Measures were organized according to the biopsychosocial model.[11, 34] Based on theory and existing literature, a total of 29 independent variables were identified a priori and grouped into 3 domains — biological, psychosocial, and social/environmental-behavioral factors — with sleep quality serving as the dependent variable.

Biological Factors

Biological variables reflected physiological and clinical status and included age (years), sex, BMI (kg/m^2), duration of diabetes (years), HbA_{1c}, presence of hypertension (yes/no), presence of dyslipidemia (yes/no), number of comorbidities, presence of diabetes-related complications (yes/no), use of sleep medication (yes/no), use of diuretics and other antihypertensive agents (yes/no), suspected OSA symptoms (yes/no), and self-reported pain or physical discomfort interfering with sleep (yes/no), in line with previous work linking these factors to sleep quality in older adults with chronic illness. These variables were collected using a structured demographic and clinical questionnaire (25 items) developed by the researchers based on the theoretical framework and literature.

Psychosocial Factors

Depressive symptoms were measured using the Thai Geriatric Depression Scale-15 items (TGDS-15), developed from the original Geriatric Depression Scale by Sheikh and Yesavage[39] and validated in Thai older adults by Wongpakaran.[40] The 15 items are scored 0 (no) or 1 (yes), with total scores ranging from 0 to 15; higher scores indicate more severe depressive symptoms. Scores of 0-4 indicate normal mood, 5-8 mild depression, and 9-15 moderate to severe depression.[39, 40] In the present study, the depressive symptoms score demonstrated good internal consistency (Cronbach α = 0.84).

Diabetes-related distress was assessed using the 17-item Diabetes Distress Scale (DDS-17), which evaluates emotional burden, regimen-related distress, physician-related distress, and interpersonal distress.[41] Items are rated on a 6-point Likert scale from 1 (not a problem) to 6 (a very serious problem) and averaged to yield a mean distress score; higher scores indicate greater distress. Mean scores < 2.0, 2.0-2.9, and ≥ 3.0 represent low, moderate, and high distress, respectively.[41] In this sample, the diabetes distress score had excellent internal consistency (Cronbach α = 0.92).

Diabetes self-efficacy was measured using the Thai Diabetes Mellitus Self-Efficacy Scale (T-DMSES), adapted from the Stanford self-efficacy instruments[41] and validated in Thai patients with T2DM.[40] Items are rated from 0 (not at all confident) to 10 (extremely confident), and higher mean scores reflect greater self-efficacy for managing diet, physical activity, health monitoring, and medication. The self-efficacy score in the current study showed excellent internal consistency (Cronbach α = 0.93).

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Social and Environmental Factors

Social factors included education level, marital status, income sufficiency, living arrangement, participation in community activities, and perceived social support. Perceived social support was measured with the Multidimensional Scale of Perceived Social Support (MSPSS), a 12-item instrument assessing support from family, friends, and significant others[27] and validated in Thai patients by Wongpakaran et al.[27] Each item is scored from 1 (very strongly disagree) to 7 (very strongly agree), with higher scores indicating greater perceived support; mean scores 1-2.9, 3-5, and 5.1-7 indicate low, moderate, and high support. In this study, the social support score had excellent internal consistency (Cronbach α = 0.91).

Access to health services and community participation (12 items) were captured using a researcher-developed questionnaire covering travel distance to health facilities, perceived barriers to accessing care, receipt of health education from providers, participation in community clubs, perceived community safety, and roles in community activities. These items used categorical and short-answer formats, and the summary access/participation score demonstrated acceptable internal consistency (Cronbach α = 0.78), similar to previous Thai community-based studies.[17]

Environmental and physical conditions were evaluated using a 12-item environmental disturbance checklist adapted from work on sleep and housing conditions in Thai older adults.[17] To establish the construct validity of this researcher-adapted tool, the initial item pool was grounded in established literature on sleep hygiene and gerontology, and reviewed by an expert panel to ensure content relevance (content validity index [CVI] = 0.91). The checklist assessed the frequency of specific sleep-disrupting conditions in the sleeping environment, including: 1) noise from family members, neighbors, animals, or traffic; 2) excessive light; 3) uncomfortable room temperature (too hot or too cold); 4) unpleasant odors or stuffiness; 5) presence of insects or pests; 6) poor housing conditions; 7) sharing a bed or room with others; 8) crowding in the household; 9) having animals in the bedroom; 10) unsafe surroundings; 11) disruptive household routines at night; and 12) other disturbances reported by the participant. Each item was rated on a 5-point scale (0 = never, 1 = once per week, 2 = twice per week, 3 = three or more times per week, 4 = every night), and total scores were summed, with higher scores indicating more frequent environmental disturbances. In the present study, the environmental disturbance score showed good internal consistency (Cronbach α = 0.82), further supporting the reliability of the underlying construct.

Behavioral Factors

Diabetes self-care behaviors were captured using the Summary of Diabetes Self-Care Activities (SDSCA), a widely used 15-item measure of self-care practices over the previous 7 days, including diet, physical activity, blood glucose monitoring, foot care, and smoking[22] and validated in Thai by Wattanakul.[25] Items are rated from 0 to 7 days, with higher scores reflecting more frequent self-care. In this study, the overall self-care score and its subscales demonstrated acceptable internal consistency (Cronbach α = 0.79 for the total score).

Outcome Variable: Sleep Quality

Sleep quality was measured using the Pittsburgh Sleep Quality Index (PSQI), a widely used instrument for assessing sleep in clinical and community settings.[42] The Thai version

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of the PSQI has demonstrated good reliability and validity.[43] The instrument comprises 19 self-rated items that generate 7 component scores (subjective sleep quality, sleep latency, sleep duration, habitual sleep efficiency, sleep disturbances, use of sleep medication, and daytime dysfunction). Component scores are summed to a global score ranging from 0 to 21; higher scores indicate worse sleep quality. A global score > 5 denotes poor sleep.[42] In this sample, the sleep quality score showed good internal consistency (Cronbach α = 0.83), supporting its use with older adults with T2DM and MCI.

Instrument Development and Validation

The researcher-developed questionnaires (demographic and clinical data, access to health services and community participation, and the environmental disturbance checklist) were constructed through an extensive review of the literature and the theoretical framework on sleep and chronic disease in Thai community settings. A panel of 5 experts — including 2 nurse specialists in primary care and gerontological nursing, one geriatrician, one clinical pharmacist, and one chronic disease nurse specialist — evaluated content validity using the item-objective congruence method described by Streiner et al.[38] Items with item-objective congruence values < 0.66 were revised or removed, and the final instruments achieved indices ≥ 0.80, indicating adequate content validity. A pilot test was conducted with 30 older adults with T2DM who were not part of the main sample to assess clarity and reliability; Cronbach α coefficients from the pilot ranged from 0.76 to 0.90 across scales, indicating satisfactory internal consistency before full data collection.[36]

Data Collection Procedures

Ethical approval for the study was obtained from the Ethics Committee of the Suphanburi Provincial Public Health Office before data collection commenced. Formal permission was also granted from the Suphanburi Provincial Administrative Organization and the directors of all participating primary care units. After approval, trained nurse practitioners working in the chronic disease clinics were invited to serve as research assistants. They received training on the study objectives, eligibility criteria, informed consent procedures, and standardized administration of the questionnaires, including both paper-based forms and a secure Google Form version.

Data collection took place between 25 August and 31 October 2025, on scheduled clinic days for chronic disease and older adult services. On clinic days, the research assistants screened clinic registers to identify potentially eligible older adults. Eligible individuals were approached in the waiting area, briefly informed about the study, and invited to participate, following recommended strategies to minimize coercion in clinical recruitment. Those who expressed interest were taken to a private room, where the researcher or trained assistant provided more detailed information and obtained written informed consent. For participants with MCI who could not sign for themselves, consent was obtained from a legally authorized caregiver in accordance with approved ethical procedures. After consent, participants completed the MMSE-Thai version to confirm eligibility and then completed the full questionnaire battery through face-to-face interviewer administration. Average completion time was 30-45 minutes, and short breaks were offered to reduce fatigue. All completed questionnaires were checked for completeness before participants left the clinic. Data were anonymized using study codes, double-entered into an electronic database, and stored on password-protected computers accessible only to the research team.

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Statistical Analysis

This study summarized participant characteristics using means (SD) or frequencies with percentages, as appropriate. All analyses were conducted using JASP version 0.95.4 (JASP Team). Prior to modeling, assumptions were checked: normality (Shapiro-Wilk, Q-Q plots), linearity and homoscedasticity (residual plots), independence (Durbin–Watson≈2), multicollinearity (variance inflation factors [VIF] < 10, tolerance > 0.10), and influential observations (Cook's distance < 1). Missingness was inspected; if < 5% and missing completely at random (Little's test). This study used pairwise deletion; otherwise, multiple imputation with fully conditional specification was considered.[44, 45] Bivariate associations with PSQI (continuous) used Pearson correlation for continuous predictors and *t* tests/analysis of variance or chi-square/Fisher exact tests for categorical variables, applying nonparametric alternatives as needed. To identify independent predictors of sleep quality, hierarchical multiple regression was performed in theory-driven blocks — biological, psychological, social/environmental, and behavioral — to evaluate incremental contributions. Statistical significance was set at a 2-tailed $P < .05$, reporting standardized coefficients (β), 95% CIs, adjusted R^2, ΔR^2, and effect sizes.

Results

A total of 203 participants were included in the analysis. The mean (SD) age was 69.8 (6.2) years, and 61.6% were women, indicating that nearly two-thirds of community-dwelling older adults with T2DM and MCI receiving care in these primary care units were female. The mean (SD) diabetes duration was 10.6 (7.1) years, with a mean (SD) HbA_{1c} of 7.8 (1.2)%. Hypertension and dyslipidemia were present in 64.0% and 58.1% of participants, respectively, and 18.2% had chronic kidney disease. Most participants were treated with oral glucose-lowering agents, and 14.3% reported hypnotic medication use, whereas 72 participants (35.5%) were receiving diuretic therapy as part of their antihypertensive regimen. Symptoms suggestive of OSA were reported by 41.4% of participants. The mean (SD) global PSQI score was 8.24 (3.01), and 82.3% met the threshold for poor sleep quality (PSQI > 5), confirming a high burden of sleep disturbance in this population (Table 1).

Biopsychosocial Measures

Biopsychosocial measures reflected mild to moderate psychological and environmental burden (Table 2). The mean (SD) TGDS-15 score was 5.48 (3.12) (95% CI, 5.05-5.91), placing the average participant in the range of mild depressive symptoms. The mean (SD) DDS-17 score was 2.84 (0.74) (95% CI, 2.74-2.94), indicating moderate diabetes-related distress on average. Diabetes self-efficacy (T-DMSES) showed a mean (SD) item score of 6.75 (1.22) (95% CI, 6.58-6.92), consistent with moderate confidence in managing diabetes self-care. Perceived social support (MSPSS) had a mean (SD) item score of 4.95 (1.01) (95% CI, 4.81-5.09), reflecting moderate levels of perceived support from family, friends, and significant others. The environmental disturbance index had a mean (SD) item score of 1.92 (0.87) (95% CI, 1.80-2.04), suggesting that sleep-disrupting environmental conditions such as noise, light, temperature, and crowding were experienced between "once per week" and "three or more times per week" on average. The SDSCA showed a mean (SD) item score of 4.12 (1.05) (95% CI, 3.97-4.27), indicating that most participants engaged in core diabetes self-care behaviors on approximately 4 days per week.

The Pearson correlation matrix among the study variables was determined (Table 3). Higher PSQI scores reflected poorer sleep quality.

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Bivariate analyses revealed that poorer sleep quality was significantly positively correlated with depressive symptoms (TGDS-15; $r = 0.46$, $P < .001$), diabetes-related distress (DDS-17; $r = 0.39$, $P < .001$), and environmental disturbances ($r = 0.34$, $P < .001$). In contrast, better sleep quality was associated with higher diabetes self-efficacy (T-DMSES; $r = -0.41$, $P < .001$), better self-care behaviors (SDSCA; $r = -0.32$, $P < .001$), and greater perceived social support (MSPSS; $r = -0.19$, $P < .05$).

Among predictors, depressive symptoms and diabetes distress showed the strongest intercorrelation ($r = 0.55$, $P < .001$), while diabetes self-efficacy was strongly positively related to self-care behaviors ($r = 0.55$, $P < .001$). These moderate intercorrelations support the inclusion of all variables in subsequent multivariate models without substantial multicollinearity concerns.[46]

Table 1. Participants Characteristics

Characteristic	No. (%)
Gender	
Female	125 (61.6)
Male	78 (38.4)
Age, y	69.8 (6.2)
Body mass index, mean (SD), kg/m^2	26.1 (4.3)
Diabetes duration, mean (SD), y	10.6 (7.1)
HbA_{1c}, mean (SD), %	7.8 (1.2)
Hypertension	130 (64.0)
Dyslipidemia	118 (58.1)
Chronic kidney disease	37 (18.2)
Hypnotic medication use	29 (14.3)
Diuretic medication use	72 (35.5)
Symptoms suggestive of OSA	84 (41.4)
Daily caffeine consumption (≥1/day)	102 (50.2)
Alcohol intake (≥ 1-2 times/week)	36 (17.7)
PSQI total score, mean (SD)	8.24 (3.01)
Poor sleep quality (PSQI > 5)	167 (82.3)

Abbreviations: HbA_{1c}, hemoglobin A_{1c}; OSA, obstructive sleep apnea; PSQI, Pittsburgh Sleep Quality Index.

Table 2. Descriptive Statistics of Biopsychosocial Measures

Measure	Scale Range	Mean (SD)	95% CI
Depressive symptoms (TGDS-15)	0-15	5.48 (3.12)	5.05-5.91
Diabetes distress (DDS-17; item mean)	1-6	2.84 (0.74)	2.74-2.94
Self-efficacy (T-DMSES; item mean)	0-10	6.75 (1.22)	6.58-6.92
Social support (MSPSS; item mean)	1-7	4.95 (1.01)	4.81-5.09
Environmental disturbance (item mean)	0-4	1.92 (0.87)	1.80-2.04
Self-care (SDSCA; item mean)	0-7	4.12 (1.05)	3.97-4.27
Sleep quality total (PSQI)	0-21	8.24 (3.01)	7.82-8.66

Abbreviations: DDS-17, Diabetes Distress Scale-17; MSPSS, Multidimensional Scale of Perceived Social Support; PSQI, Pittsburgh Sleep Quality Index; SDSCA, Summary of Diabetes Self-Care Activities; T-DMSES, Thai Diabetes Mellitus Self-Efficacy Scale; TGDS-15, Thai Geriatric Depression Scale-15.

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Table 3. Pearson Correlations With Sleep Quality

Variable	1	2	3	4	5	6	7
1) Sleep quality (PSQI)	1.00						
2) Depressive symptoms (TGDS-15)	0.46***	1.00					
3) Diabetes distress (DDS-17; item mean)	0.39***	0.55***	1.00				
4) Self-efficacy (T-DMSES; item mean)	-0.41***	-0.45***	-0.50***	1.00			
5) Social support (MSPSS; item mean)	-0.19*	-0.35***	-0.25***	0.30***	1.00		
6) Environmental disturbance (item mean)	0.34***	0.30***	0.35***	-0.20*	0.15*	1.00	
7) Self-care (SDSCA; item mean)	-0.32***	-0.40***	-0.45***	0.55***	0.35***	0.25***	1.00

Abbreviations: DDS-17, Diabetes Distress Scale-17; MSPSS, Multidimensional Scale of Perceived Social Support; PSQI, Pittsburgh Sleep Quality Index; SDSCA, Summary of Diabetes Self-Care Activities; T-DMSES, Thai Diabetes Mellitus Self-Efficacy Scale; TGDS-15, Thai Geriatric Depression Scale-15.

Positive *r* indicates higher PSQI (worse sleep); 2-tailed tests, * $P < .01$, ** $P < .05$, *** $P < .001$.

Hierarchical Multiple Regression Predicting Sleep Quality

Hierarchical multiple regression examined biopsychosocial predictors of sleep quality (Table 4). Biological variables entered in Block 1 (age, sex, BMI, HbA_{1c}, diabetes duration, hypertension, probable OSA, and hypnotic use) explained 18% of the variance in PSQI scores ($\Delta R^2 = 0.18$, $P < .001$); higher HbA_{1c} (B = 0.28, β = 0.11, $P = .041$) and probable OSA (B = 0.74, β = 0.14, $P = .008$) predicted poorer sleep, whereas other biological variables were not independently associated with sleep quality. Adding depressive symptoms, diabetes-related distress, and diabetes self-efficacy in Block 2 increased the explained variance to 37% ($\Delta R^2 = 0.19$, $P < .001$). Greater depressive symptoms (B = 0.27, β = 0.28, $P < .001$) and higher diabetes distress (B = 0.66, β = 0.17, $P = .004$) were associated with worse sleep, whereas higher diabetes self-efficacy (B = -0.54, β = -0.22, $P < .001$) was associated with better sleep. Social and environmental variables in Block 3 (perceived social support and environmental disturbance) raised R^2 to .44 ($\Delta R^2 = 0.07$, $P < .001$); environmental disturbance remained a significant predictor (B = 0.61, β = 0.19, $P = .001$), while social support showed a small, nonsignificant association with PSQI (B = -0.18, β = -0.09, $P = .086$). In Block 4, self-care behaviors contributed an additional 3% of variance ($R^2 = 0.47$, adjusted $R^2 = 0.45$; $\Delta R^2 \approx 0.03$, $P = .029$), with better diabetes self-care predicting better sleep (B = -0.29, β = -0.12, $P = .029$).

Overall, poorer sleep quality was independently associated with higher HbA_{1c}, probable OSA, more severe depressive symptoms and diabetes distress, more frequent environmental disturbances, and lower diabetes self-efficacy and self-care. Robust standard errors, bootstrapped bias-corrected 95% CI (5000 resamples), and model diagnostics supported the stability of these estimates and indicated no major violations of normality, independence, homoscedasticity, or multicollinearity assumptions.

While the full hierarchical model included 14 variables across biological, psychological, social/environmental, and behavioral domains, a reduced final model including only the statistically significant predictors ($P < .05$) is presented to enhance clinical utility. The simplified predictive model is represented by the following equation: $PSQI_i = \beta_0 + 0.02(\text{Age}) + 0.21(\text{Female}) + 0.05(\text{BMI}) + 0.28(HbA_{1c}) + 0.01(\text{Diabetes duration}) + 0.32(\text{Hypertension}) + 0.74(\text{Probable OSA}) + 0.49(\text{Hypnotic use}) + 0.27(\text{Depressive symptom}) + 0.66(\text{Diabetes distress}) - 0.54(\text{Self-efficacy}) - 0.18(\text{Social support}) + 0.61(\text{Environmental disturbance}) - 0.29(\text{Self-care}) + \varepsilon_i$

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Table 4. Hierarchical Multiple Regression Predicting Pittsburgh Sleep Quality Index

Block/Predictor	B	SE	95% CI	β	*P* Value	VIF
Block 1: Biological						
Age	0.02	0.02	-0.02 to 0.06	0.06	.292	1.28
Female (ref: male)	0.21	0.23	-0.24 to 0.66	0.05	.361	1.11
BMI	0.05	0.04	-0.03 to 0.12	0.07	.214	1.35
HbA_{1c}	0.28	0.14	0.01 to 0.55	0.11	.041	1.24
Diabetes duration	0.01	0.02	-0.03 to 0.05	0.04	.478	1.31
Hypertension (yes = 1)	0.32	0.23	-0.13 to 0.77	0.08	.169	1.18
Probable OSA (yes = 1)	0.74	0.28	0.19 to 1.29	0.14	.008	1.22
Hypnotic use (yes = 1)	0.49	0.31	-0.12 to 1.10	0.09	.113	1.09
Block 1 fit	$R^2 = 0.18$; $\Delta R^2 = 0.18$; $P < .001$					
Block 2: Psychological						
Depressive symptoms	0.27	0.05	0.17 to 0.37	0.28	< .001	1.56
Diabetes distress	0.66	0.23	0.21 to 1.10	0.17	.004	1.42
Self-efficacy	-0.54	0.12	-0.78 to -0.30	-0.22	< .001	1.49
Block 2 fit	$R^2 = 0.37$; $\Delta R^2 = 0.19$; $P < .001$					
Block 3: Social/Environmental						
Social support	-0.18	0.10	-0.3 to 0.02	-0.09	.086	1.37
Environmental disturbance	0.61	0.18	0.25 to 0.97	0.19	.001	1.33
Block 3 fit	$R^2 = 0.44$; $\Delta R^2 = 0.07$; $P < .001$					
Block 4: Behavioral						
Self-care	-0.29	0.13	-0.54 to -0.03	-0.12	.029	1.41
Final model fit	$R^2 = 0.47$; Adjusted $R^2 = 0.45$; $P < .001$					

Abbreviations: β, standardized coefficient; B, unstandardized coefficient; BMI, body mass index; HbA_{1c}, hemoglobin A_{1c}; OSA, obstructive sleep apnea; SE, standard error; VIF, variance inflation factors.

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Translating these unstandardized regression coefficients into practical clinical meaning reveals the direct impact of each factor on sleep quality. For example, a one-unit increase in depressive symptoms corresponded to a 0.27-point worsening in the PSQI score. Similarly, a 1% increase in HbA_{1c} and a one-unit increase in diabetes distress or environmental disturbance were associated with a 0.28-point, 0.66-point, and 0.61-point worsening in sleep quality, respectively. Furthermore, the presence of probable OSA contributed to a 0.74-point increase in the PSQI score. Conversely, protective factors demonstrated a beneficial clinical effect: a one-unit increase in self-efficacy corresponded to a 0.54-point improvement (decrease) in the PSQI score, and a one-unit increase in self-care behaviors resulted in a 0.29-point improvement.

Discussion

This study applied a biopsychosocial lens to sleep quality among community-dwelling older adults with T2DM and MCI in Thai primary care. Consistent with prior work in diabetic and cognitively vulnerable populations, sleep problems were highly prevalent and reflected the combined influence of psychological distress, self-management beliefs, environmental conditions, and selected biological risks rather than traditional biomedical variables alone.[8, 14, 15]

From a biological perspective, only HbA_{1c} and probable OSA emerged as meaningful contributors to sleep quality, whereas age, sex, BMI, diabetes duration, and most comorbidities were not independently associated. Earlier studies have linked older age, female sex, obesity, and multimorbidity to poorer sleep in both community and clinic samples.[14, 21, 22] The absence of significant associations for these factors in our final model may reflect the relative homogeneity of this sample: most participants were older, multimorbid, and already engaged in chronic disease clinics, which narrows variability and reduces statistical contrast.

In addition, individuals with very advanced frailty or unstable disease in the Thai system are more likely to be managed in hospitals rather than primary care, further constraining the range of biological severity captured here.[32, 33] By contrast, poor glycemic control and symptoms suggestive of sleep-disordered breathing remained salient even in this more homogeneous group, underscoring current recommendations to integrate screening for hyperglycemia and OSA into diabetes care for older adults.[9, 12, 14]

Psychological and behavioral factors emerged as significant, albeit moderate, predictors of sleep, showing greater predictive utility than most biological variables. This is in line with research describing the important interplay between depression, diabetes distress, self-efficacy, and sleep among older adults with diabetes.[15, 17] Older adults in this study lived with both T2DM and MCI, making them particularly vulnerable to behavioral and psychological symptoms of dementia such as nocturnal agitation, reversed sleep-wake cycles, and nighttime wandering.[8, 10, 11] Emotional distress and low perceived control may amplify these symptoms by increasing arousal at night and undermining routines that support sleep. Conversely, higher diabetes self-efficacy and better self-care behaviors likely stabilize daily structure, medication use, and activity patterns, which can reinforce circadian regulation and mitigate the impact of cognitive lapses on sleep and self-management.[24, 25, 43] In practice, this suggests that psychosocial interventions that address mood, diabetes-related distress, and self-efficacy may have disproportionate benefits for sleep in this cognitively impaired group.

The hierarchical regression pattern further illuminates these dynamics. Biological variables explained a modest proportion of variability in sleep quality, but the addition of psychological variables produced a large gain in explanatory power, followed by smaller yet meaningful contributions from social/environmental and behavioral domains. This stepwise improvement aligns with the biopsychosocial model, in which biological vulnerability interacts with psychological appraisal, social resources, and daily behaviors to shape health outcomes.[13, 35] In this context, depressive symptoms, diabetes distress, self-efficacy, environmental disturbances, and self-care behaviors collectively overshadowed traditional risk markers such as age or BMI. For older adults with MCI, whose cognitive reserve is already compromised, these modifiable psychosocial and behavioral factors may be particularly important buffers against sleep disruption and subsequent neurocognitive decline.[8, 10]

Social and environmental findings highlight the specific realities of Thai primary care. Participants lived in semi-rural communities where multigenerational households, thin walls, nearby livestock, and limited climate control are common. Environmental disturbances such as noise, heat, mosquitoes, and crowding were systematically associated with poorer sleep, echoing Thai studies showing that household and neighborhood conditions are central to older adults' sleep quality.[17] Perceived social support was associated with better sleep at the bivariate level but did not remain in the final model, suggesting that its influence

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may operate indirectly by reducing distress and facilitating self-care rather than through a direct effect on sleep.[20, 27] In primary care practice, this pattern argues for combined attention to emotional support and concrete environmental modifications in and around the bedroom, ideally through nurse-led home visits and coordination with family caregivers and village health volunteers.

These findings also emphasize how community-based determinants of sleep may differ from those in hospital populations. Hospital studies often focus on acute disease severity, in-hospital procedures, and institutional routines as major sleep disruptors.[19] By contrast, sleep for community-dwelling older adults with T2DM and MCI is shaped more by chronic stressors — ongoing metabolic control, mood symptoms, caregiving arrangements, and household conditions — within resource-constrained primary care systems.[19, 31]

Nurses in Thai primary care are therefore well positioned to implement comprehensive biopsychosocial assessments and targeted brief interventions. To translate these findings into practice, clinics could integrate stepwise screening algorithms; for example, initiating routine screening for sleep quality (eg, using the PSQI) and psychological well-being (eg, depression and diabetes distress) during standard diabetic follow-ups, followed by specific evaluations for high-risk conditions like probable OSA. Furthermore, structured nurse-led interventions should be developed, incorporating counseling techniques such as motivational interviewing to build self-efficacy, promote effective self-care behaviors, and establish consistent sleep-wake routines. Importantly, given the significant impact of physical surroundings on sleep, nurses must actively provide environmental modification strategies. This includes guiding patients and their families on optimizing the home environment for safer, more restorative sleep by minimizing nighttime noise, managing light exposure and room temperature, improving ventilation, and negotiating shared sleeping arrangements or household crowding.[15, 28, 31]

Taken together, this study reinforces that sleep quality in older adults with T2DM and MCI cannot be understood solely through a biomedical lens. Instead, sleep emerges from intersecting biological risks, emotional states, cognitive limitations, social supports, environmental stressors, and self-care practices. By prioritizing modifiable psychological, environmental, and behavioral targets within Thai primary care, nurses and multidisciplinary teams can address sleep problems more proactively, potentially slowing cognitive decline and improving quality of life for this vulnerable population.[8, 33]

Limitations

Several limitations should be considered. First, the cross-sectional design precludes causal inference and the directionality between sleep quality and biopsychosocial factors cannot be established. Second, MCI was identified using the MMSE-Thai education-adjusted cutoffs; although appropriate for screening in primary care, this approach may misclassify some participants compared with a comprehensive clinical diagnosis. Third, several measures relied on self-report and are subject to recall bias, which may be amplified in individuals with cognitive impairment; this study minimized this risk through interviewer administration and caregiver support when needed. Finally, the study was conducted in 6 primary care units in a single province, which may limit generalizability to urban settings or other regions of Thailand.

Implications

This study implies that primary care teams should treat sleep as a core component of diabetes and cognitive care, not an optional symptom check. Nurses can integrate brief,

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routine screening for sleep quality alongside depressive symptoms, diabetes-related distress, self-efficacy, glycemic control, and probable obstructive sleep apnea. Recommended practice is a nurse-led, multicomponent approach that blends simple psychoeducation, coaching to strengthen self-efficacy, support for consistent daily routines, and practical home-based strategies to reduce bedroom environmental disturbances (e.g., noise, light, temperature, clutter, nighttime interruptions). In Thai community settings, engaging family caregivers and village health volunteers to monitor sleep patterns and implement low-cost environmental adjustments can extend care beyond the clinic and improve continuity. Directions for future research include longitudinal studies to clarify causal and bidirectional pathways between sleep, emotional distress, self-care, glycemic control, and cognitive decline; randomized trials testing feasible nurse-led biopsychosocial sleep interventions in primary care; and implementation studies examining acceptability, scalability, and cost-effectiveness, especially among diverse rural and urban Thai populations.

Conclusions

This study shows that sleep quality in community-dwelling older adults with T2DM and MCI is shaped by a constellation of biological, psychological, social, environmental, and behavioral factors, rather than by biomedical risks alone. Depressive symptoms, diabetes-related distress, diabetes self-efficacy, environmental disturbances in and around the bedroom, glycemic control, probable obstructive sleep apnea, and diabetes self-care behaviors emerged as key determinants of how well this vulnerable group sleeps.

These findings reinforce that sleep problems in older adults with diabetes and cognitive impairment cannot be treated as a minor symptom or an inevitable part of ageing. For nurses in primary care, sleep assessment should be integrated into routine diabetes and cognitive care, alongside evaluation of mood, distress, and self-efficacy. Brief, nurse-led interventions that combine psychoeducation, support for structured daily routines, coaching to strengthen self-efficacy, and guidance on modifying the home sleep environment may help older adults and family caregivers manage nocturnal behaviors and reduce the impact of disturbed sleep on daily functioning. By addressing sleep proactively in community clinics, nurses can contribute to better metabolic control, slower cognitive decline, and improved quality of life for older adults and their families.

This work also highlights the role of family caregivers and village health volunteers in Thai primary care. Engaging them in assessing sleep patterns, identifying environmental barriers, and implementing practical changes at home can extend the reach of primary care teams and tailor support to real-life living conditions. Given that cognitive impairment often coexists with behavioral and psychological symptoms of dementia, improving sleep may benefit not only the person with diabetes but also those who provide daily care.

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Additional Information

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Author Contributions:
Conceptualization: Chakrit Sattayarom, Aekkachai Fatai, Trakulwong Luecha
Formal Analysis: Chakrit Sattayarom, Aekkachai Fatai, Jayson Rydberg
Investigation: Chakrit Sattayarom, Supaporn Voraroon, Umakorn Jaiyungyuen, Sureewan Sawangha, Jayson Rydberg
Methodology: Chakrit Sattayarom, Supaporn Voraroon, Umakorn Jaiyungyuen, Sureewan Sawangha, Jayson Rydberg
Supervision: Supaporn Voraroon, Umakorn Jaiyungyuen, Jayson Rydberg
Writing – Original Draft: Chakrit Sattayarom, Aekkachai Fatai
Writing – Review & Editing: All authors

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