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RISK FACTORS FOR POOR SLEEP QUALITY AMONG MENOPAUSAL WOMEN IN MACAO: A CROSS-SECTIONAL STUDY IN THE GREATER BAY AREA

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ABSTRACT
Introduction and aim. Sleep disturbances are a pervasive challenge during the menopausal transition. Macao, a densely populated city, presents a unique environment with a 24-hour tourism industry and prevalent shift work, which may exacerbate sleep problems in midlife women. This cross-sectional study aimed to investigate the prevalence of poor sleep quality and identify its key determinants among menopausal women in Macao.
Material and methods. A total of 360 menopausal women aged 45–59 years were recruited via a street-intercept survey. Sleep quality was assessed using the Chinese version of the Pittsburgh Sleep Quality Index (CPSQI), and data on sociodemographics, lifestyle, health status, and menopausal symptoms (Greene Climacteric Scale) were collected. Data were analyzed using descriptive statistics, chi-square tests, ANOVA, and stepwise logistic regression.
Results. The mean PSQI score for the sample was 8.07 ± 3.77, with 75.3% (n=271) of participants classified as poor sleepers. Logistic regression identified five significant predictors of poor sleep quality: difficulty falling asleep (OR = 4.54, 95% CI: 2.70–7.65, p < .001), feeling tired/lacking energy (OR = 2.24, 95% CI: 1.33–3.76, p = .002), having no regular exercise habit (OR = 2.23, 95% CI: 1.16–4.31, p = .017), experiencing muscle/joint pain (OR = 1.71, 95% CI: 1.10–2.64, p = .017), and being in a later menopausal stage (OR = 1.55, 95% CI: 1.03–2.34, p = .034). Women with severe menopausal symptoms had significantly worse mean PSQI scores than those with milder symptoms (9.71 vs. 4.00, p < .001).
Conclusion. These findings highlight a high prevalence of poor sleep quality in Macau's menopausal women, determined by a complex interplay of specific menopausal symptoms, modifiable lifestyle factors, and physiological progression through menopause, underscoring the need for integrated public health and clinical interventions.

Keywords. menopause, sleep quality, PSQI, urban health, risk factors, Greater Bay Area, cross-sectional study

Introduction

Midlife, typically spanning ages 40 to 60, marks a period of significant physiological change for women.[1] Among these transformations, the onset or exacerbation of sleep disturbances is a pervasive challenge, increasingly recognized as central to women's health during the menopausal transition.[2,3] Menopause, the natural cessation of ovarian reproductive function, usually occurs between 45 and 55 years.[4] This transition is driven by declining estrogen levels, leading to various symptoms.[5] Notably, sleep disturbance is

a primary and highly prevalent complaint, affecting an estimated 40-69% of menopausal women globally.[6,7] This is consistent with studies in specific populations, including Chinese women, which confirm this significant burden.[8] Manifestations include difficulty initiating or maintaining sleep and frequent nocturnal awakenings, often linked to vasomotor symptoms (VMS) like night sweats that disrupt sleep architecture.[9,10]

Chronic sleep disruption during menopause profoundly degrades physical and mental health, diminishing quality of life.[11,12] This struggle can persist beyond the immediate transition, and women with menopausal symptoms face a significantly increased risk of developing subsequent sleep disorders.[13] Despite this impact, many women hesitate to seek medical help, leaving their sleep issues unaddressed.[14] This is particularly relevant in Macao, a key city in the Greater Bay Area and one of the world's most densely populated regions. Macao's landscape is characterized by a high concentration of 24-hour casino hotels and entertainment complexes integrated with residential buildings. This pervasive tourism infrastructure, massive tourist influx, and extreme urban crowding generate distinct environmental and lifestyle stressors.[15] For Macao's midlife women, especially those in tourism and hospitality who often work shifts, local factors like constant noise, light pollution, and heightened ambient activity could plausibly exacerbate sleep difficulties during the vulnerable menopausal transition.[16,17]

Sleep disturbances are one of the most common and debilitating symptoms experienced by women during the menopausal transition.[8] The prevalence of sleep problems ranges from 16% to 47% during perimenopause and increases to 35% to 60% in postmenopause.[18] These disturbances are characterized by frequent nighttime awakenings, difficulty falling asleep, and increased wakefulness after sleep onset.[7] The etiology of menopausal sleep disturbance is multifactorial. Fluctuations and the eventual decline in estrogen and progesterone directly affect sleep regulation. Estrogen is involved in the metabolism of norepinephrine, serotonin, and acetylcholine, increasing REM sleep, while progesterone has sleep-inducing and anxiolytic effects.[19] The decline in these hormones disrupts normal sleep architecture. Furthermore, VMS, such as hot flashes and night sweats, are a primary driver of sleep fragmentation, causing arousals from sleep.[20]

Beyond hormonal changes, other factors contribute significantly. Psychological symptoms, such as depression and anxiety, are highly comorbid with insomnia during menopause.[21] Lifestyle factors also play a crucial role. For instance, physical inactivity is a known risk factor for poor sleep, while regular exercise can alleviate menopausal symptoms and improve sleep architecture.[22] The unique stressors of a dense urban environment, such as that of Macau, can further compound these issues. Environmental noise and light pollution from 24-hour industries, along with the prevalence of shift work, can disrupt circadian rhythms, leading to hormonal imbalances and exacerbating sleep difficulties.[16,17] A recent study highlighted that exposure to volatile organic compounds (VOCs), common in urban air pollution, was strongly associated with circadian syndrome (which includes sleep disorders) in postmenopausal women.[23] This complex interplay of physiological changes, psychological distress, and environmental stressors underscores the need for a holistic approach to understanding and managing sleep problems in this population.

Given the high global prevalence of menopausal sleep problems, their profound impact, and Macau's unique socio-environmental context, there is a compelling need to

investigate the specific prevalence and influencing factors of sleep quality in this distinct urban population. While research has established the link between menopause and sleep, there is a significant gap in understanding how these issues manifest in hyper-urbanized environments with unique industrial structures like Macau's 24-hour tourism sector. This study, therefore, aimed not only to investigate the prevalence of poor sleep quality but also to identify its key determinants among menopausal women in Macau, providing crucial, localized data to inform targeted public health interventions.

Methodology

This study employed a quantitative, cross-sectional survey design to investigate factors associated with sleep quality among menopausal women in Macao, a common approach for determining prevalence and identifying associated factors for health conditions like sleep quality.[27] Participants, women residing in Macao experiencing menopause, aged approximately 45-59 years, were recruited via street-intercept convenience sampling.

Data were collected using a structured questionnaire administered primarily through face-to-face interviews. The questionnaire included two main sections: sociodemographic and clinical variables (age, education, marital status, occupation, stress levels, BMI, health history, menopausal status, hormone use), and the Chinese version of the Pittsburgh Sleep Quality Index (CPSQI).[23] The CPSQI, a widely used 19-item self-report measure,[24] assessed subjective sleep quality over the past month across seven components, with global scores >5 indicating poor sleep quality. Its reliability for this study was confirmed (Cronbach's $\alpha = 0.82$).

Ethical approval was obtained from the Macao Polytechnic University Research Ethics Committee(Reference number: RP/AE 03/2022). After data collectors explained the study and obtained written informed consent, participants self-completed the anonymized questionnaires. Strict confidentiality was maintained, with data stored securely and planned for destruction post-study. This study was an observational cross-sectional survey andwas not registered in a clinical trial registry.

Data were analyzed using SPSS version 22.0. Descriptive statistics summarized participant characteristics and PSQI scores. Inferential analyses included Chi-square tests to explore associations between categorical demographics and PSQI scores and to describe poor sleep prevalence. ANOVA was planned to compare means across sleep quality groups. Finally, logistic regression analysis (stepwise method) was conducted to identify significant predictors of poor sleep quality (PSQI > 5), using demographic and clinical variables as potential predictors. The overall fit of the logistic regression model was evaluated by examining pseudo R-squared values (Nagelkerke R^2).Prior to conducting the logistic regression analysis, multicollinearity among the independent variables was assessed using Variance Inflation Factors (VIF) obtained from a separate linear regression model.

Results

A total of 360 menopausal women participated in the study.

Participant Sleep Quality

The overall mean score on the Pittsburgh Sleep Quality Index (PSQI) for the sample was 8.07 ± 3.77 (range 0-21), indicating generally poor sleep quality among the participants.

Further analysis of the PSQI components revealed mean scores as follows: sleep efficiency (0.77 ± 0.93), total sleep time (1.58 ± 0.83), use of sleep medication (0.31 ± 0.70), daytime dysfunction (1.04 ± 0.82), subjective sleep quality (1.53 ± 0.85), sleep disturbances (1.24 ± 0.60), and sleep latency (1.60 ± 0.84) (referring to Table 1). Based on a PSQI cut-off score of >5 indicating poor sleep quality, a substantial proportion of the participants (75.3%, n=271) were classified as poor sleepers. For instance, Table 2 indicates that for women with normal BMI (18.5-24), 73.8% (n=177) had poor sleep quality.

Table 1 Distribution of Pittsburgh Sleep Quality Index Scores for Female Sample (N = 360)

Measure (No. of items)	**Min**	**Max**	**Mean**	**SD**	**Rank**
Overall Pittsburgh Sleep Quality Index (9)	0	21	8.07	3.77	
Sleep efficiency score (3)	0	3	0.77	0.93	6
Total sleep duration (1)	0	3	1.58	0.83	2
Use of sleep medication (1)	0	3	0.31	0.70	7
Daytime dysfunction (2)	0	3	1.04	0.82	5
Sleep quality (1)	0	3	1.53	0.85	3
Sleep disturbances (9)	0	3	1.24	0.60	4
Sleep latency (2)	0	3	1.60	0.84	1

Table 2 Analysis of PSQI Grouping by Demographic Characteristics of Study Women (N = 360): Personal Basic Data

Variable	**Category**	**Good sleep quality N (%)**	**Poor sleep quality N (%)**	**χ^2**	**p**
BMI	< 18.5 (Underweight)	6 (31.6)	13 (68.4)	68.484	0.238
	18.5 – 24 (Normal weight)	63 (26.3)	177 (73.8)		
	≥ 24 (Overweight/Obese)	20 (19.8)	81 (80.2)		
Education level	Basic Education	21 (21.1)	86 (78.9)	8.951	0.111

	Secondary Education	29 (28.2)	74 (71.8)		
	Tertiary Education or Above	37 (25.0)	111 (75.0)		
Marital status	Unmarried	11 (21.2)	41 (78.8)	8.289	0.04*
	Married	74 (27.6)	194 (72.4)		
	Divorced/Widowed	4 (10.0)	36 (90.0)		
Number of children	0	14 (23.3)	50 (76.7)	3.441	0.632
	1	34 (26.8)	93 (73.2)		
	2	33 (22.3)	115 (77.7)		
	≥3	8 (38.1)	13 (61.9)		
Religious affiliation	None	54 (25.4)	159 (74.6)	3.276	0.858
	Buddhism	21 (25)	63 (75)		
	Christian	14 (22.2)	49 (77.8)		

Note: For 'BMI', categories of '24-27', '27–30', '30–35', and '≥ 35' were merged into '≥ 24 (Overweight/Obese)' for simplified presentation. For 'Education level', categories were merged into 'Basic Education' (Primary school, Junior middle school) and 'Tertiary Education or Above' (Junior college/Associate degree, University, Master's or above). For 'Marital status', 'Divorced' and 'Widowed' categories were merged into 'Divorced/Widowed'. For 'Number of children', categories '3' and '4' were merged into '≥ 3'. For 'Religious affiliation', 'Christianity' and 'Catholicism' were merged into 'Christian' for simplified presentation. All statistical analyses were performed on original categories. * p<.05; ** p<.01; *** p<.001.

Factors Associated with Sleep Quality: Bivariate Analyses

Several sociodemographic, health-related, and lifestyle factors were examined for their association with sleep quality (good vs. poor sleepers based on PSQI scores).

Significant associations were found for marital status ($\chi^2 = 8.289$, $p = 0.04$; Table 2), with divorced/widowed women showing a higher proportion of poor sleep. Work-related factors, such as long working hours, were significantly associated with poorer sleep quality ($\chi^2 = 6.244$, $p = 0.012$; Table 3).

Table 3 Analysis of Women's Demographic Characteristics and PSQI Grouping (N=360): Work Background

Variable	Category	PSQI Group (%)		x^2	p-value
		Good Sleep Quality	Poor Sleep Quality		
Occupation	Management/Professional	31 (25.4)	91 (74.6)	11.63	0.311
	Service/General Labor	38 (24.5)	117 (75.5)		
	Non-working	4 (44.4)	5 (55.6)		
Work Pressure	None	39(30)	91(70)	3.046	0.081
	Yes	50(21.7)	180(78.3)		
Source of Work Pressure	Heavy workload	46(22.4)	159(77.6)	6.244	0.012*
	Long working Hours	27(18)	123(82)		
	Poor self-Competence	19 (17.8)	88 (82.2)		

Note: For 'Occupation', categories were merged into 'Management/Professional' (Civil Servant, Professional, Management), 'Service/General Labor' (Staff, Service Industry, Unskilled Worker, Tourism Industry, Gaming Staff, Catering), and 'Non-working' (Unemployed including retired and housewife) for simplified presentation. For 'Source of Work Pressure', categories with fewer than 5 participants (e.g., Body not recovered under long-term high pressure, Intense work pace) were removed, and other less frequent categories (e.g., Poor self-Competence, Poor work atmosphere, Poor interpersonal relationships, Unemployment) were merged into 'Other Work-Related Stressors' for clarity. All statistical analyses were performed on original categories. * p<.05; ** p<.01; *** p<.001.

Lifestyle factors also played a role. Having no regular exercise habit was significantly associated with poorer sleep quality ($\chi^2 = 5.846$, $p = 0.016$; Table 4). Experiencing life stress was strongly associated with poor sleep ($\chi^2 = 20.525$, $p < .001$). Specific sources of life stress, including long-term fatigue/insufficient rest ($\chi^2 = 9.692$, $p = 0.002$), family relationship issues ($\chi^2 = 4.697$, $p = 0.03$), changes in physical condition ($\chi^2 = 20.777$, $p < .001$), financial decline ($\chi^2 = 7.032$, $p = 0.008$), and environmental noise ($\chi^2 = 4.445$, $p = 0.035$), were all significantly associated with poorer sleep quality (Table 4).

Table 4Analysis of Women's Demographic Characteristics and PSQI Grouping (N=360): Lifestyle Habits

Variable	Category	PSQI Group (%)		x^2	p-value
		Good Sleep Quality	Poor Sleep Quality		
Exercise Habit	None	60(29.6)	143(70.4)	5.846	0.016*
	Yes	29(18.5)	128(81.5)		
Weekly	None	48(29.1)	117(70.9	4.56	0.207

Exercise			)	4	
Frequency	Any exercise frequency	30 (19.0)	128 (81.0)		
Type of Exercise	Stretching (e.g., Yoga, Tai Chi)	13(22.8)	44(77.2)	0.133	0.715
	Cardiopulmonary endurance (e.g., swimming, jogging)	29(25.4)	85(74.6)		
	Other Types of Exercise	3 (15.8)	16 (84.2)		
Life Stress	None	38(42.7)	51(57.3)	20.525	0***
	Yes	51(18.8)	220(81.2)		
Source of Life Stress	Long-term fatigue, insufficient rest	34(18)	155(82)	9.692	0.002**
	Family relationship	17(16.8)	84(83.2)	4.697	0.03*
	Changes in physical condition	9(8.6)	96(91.4)	20.777	0***
	Finance decline	15(15)	85(85)	7.032	0.008**
	Environmental noise	3(9.4)	29(90.6)	4.445	0.035*
	Other Life Stressors	39 (22.4)	135 (77.6)		
Recent Major Life Events	None	63(32.1)	133(67.9)	12.73	0***
	Self-physical condition alter	9(10.6)	76(89.4)	11.944	0.001***
	Caregiver stress increase	5(11.1)	40(88.9)	5.12	0.024*
	Elders'physical condition alter	6(11.8)	45(88.2)	5.36	0.021*
	Other Major Life Events	13 (17.6)	61 (82.4)		

Note: For 'Weekly Exercise Frequency', 'Once a week', '2-3 times a week', and '3 times a week or more' were merged into 'Any exercise frequency'. For 'Type of Exercise', 'Ball sports' and 'Muscle strengthening' were merged into 'Other Types of Exercise'. For 'Source of Life Stress', 'Related to children's studies', 'Debt pressure', and 'Marital status' were merged into 'Other Life Stressors'. For 'Recent Major Life Events', 'Mishap of family/friend', 'Family/friend physical condition alter', and 'Retirement' were merged into 'Other Major Life Events' for simplified presentation. All statistical analyses were performed on original categories. * p<.05; ** p<.01; *** p<.001.

Regarding physical health, a history of chronic disease was significantly associated with poorer sleep quality ($\chi^2 = 6.276$, $p = 0.012$; Table 5), particularly for women with hypertension ($\chi^2 = 4.829$, $p = 0.028$). Being in later menopausal stages was significantly

associated with poorer sleep ($\chi^2 = 19.41$, $p < .001$; Table 5). Age was also found to be related to sleep quality, with older age groups within the sample showing higher rates of poor sleep ($\chi^2 = 11.139$, $p = 0.004$; Table 6).

Table 5 Analysis of Women's Demographic Characteristics and PSQI Grouping (N=360): Physical Condition

Variable	Category	PSQI Group (%)		x^2	p-value
		Good Sleep Quality	Poor Sleep Quality		
History of Chronic Disease	None	69(28.8)	171(71.3)	6.276	0.012*
	Hypertension	16(16.5)	81(83.5)		
	Diabetes	6(18.8)	26(81.3)		
	Heart disease	1(6.7)	14(93.3)		
	Other chronic diseases	2(11.1)	16(88.9)		
Hormone Medication	Never used	87(25.66)	252(74.34)	3.469	0.325
	Ever Used	2 (9.5)	19 (90.5)		
	Currently using	0(0)	5(100)		
Duration of Continuous Use	Never	87(25.7)	252(74.3)	7.118	0.068
	Any duration of use	2 (9.5)	19 (90.5)		
Menopausal Stage	Premenopausal	43(39.4)	66(60.6)	19.41	0***
	Perimenopausal	29(21)	109(79)		
	Postmenopausal	17(15)	96(85)		

Note: For 'History of Chronic Disease', categories with fewer than 10 participants (e.g., Hyperlipidemia, Fatty liver, Thyroid dysfunction, Gout, Chronic Cholecystitis, Asthma, Hepatitis) were merged into 'Other chronic diseases'. For 'Hormone Medication', 'Used before' and 'Currently using' were merged into 'Ever Used'. For 'Duration of Continuous Use', 'Used for 1 month', 'Used for 2-3 months', and 'Used for 3 months or more' were merged into 'Any duration of use' for simplified presentation. All statistical analyses were performed on original categories. * p<.05; ** p<.01; *** p<.001.

Table 6 Analysis of the Relationship between Sleep Quality and Age (N=360)

Variable	Category	PSQI Group (%)		x2	p-value
		Good Sleep Quality	Poor Sleep Quality		
Age (year)	45-49	56(31.8)	120(68.2)	11.139	0.004**
	50-54	14(14)	86(86)		
	55-59	19(22.6)	65(77.4)		

Note: * $p < .05$；*** $p < .001$

Relationship between Menopausal Symptom Severity and Sleep Quality

Menopausal symptom severity was significantly associated with sleep quality. A Pearson correlation analysis revealed a significant positive correlation between overall menopausal symptom frequency scores and PSQI total scores ($r = .569$, $p < .01$; Table 7), indicating that women with more frequent and severe menopausal symptoms reported poorer sleep quality.

Table 7Pearson Correlation Test of Sleep Quality and Menopausal Symptom Frequency in Women Sample (N=360)

Variable	PSQI Scale	P-value
Symptom Frequency	.569	<0.01**
Psychological Symptoms	.584**	<0.01**
Anxiety	.580**	<0.01**
Depression	.504**	<0.01**
Somatic Symptoms	.444**	<0.01**
Vasomotor Symptoms	.329**	<0.01**
Decreased Libido	.301**	<0.01**

Note: * p < .05 ; ** p < .01 ;

When participants were categorized based on menopausal symptom severity, those with more severe symptoms had significantly poorer sleep quality compared to those with milder symptoms ($X2 = 49.827$, $p < .001$; Table 8). Specifically, 89.6% of women with more severe menopausal symptoms had poor sleep (PSQI > 5), compared to 57.2% of those with milder symptoms.

Table 8Analysis of the Relationship between Menopausal Women Grouping (by Greene Menopause Scale) and Sleep Quality (N=360)

Variable	Category	PSQI Group (%)		x2	p-value
		Good Sleep Quality	Poor Sleep Quality		
GREENE Menopause Scale Indicator	Lower menopausal symptoms	68(42.8)	91(57.2)	49.827	0***
	Higher menopausal symptoms	21(10.4)	180(89.6)		

Note: * p < .05 ; ** p < .01 ; *** p < .001

Analysis of Variance (ANOVA) confirmed these findings: the mean PSQI score for women with milder menopausal symptoms was 4.00 ± 3.17 (indicating good sleep quality on average), while the mean PSQI score for women with more severe menopausal symptoms was 9.71 ± 3.39 (indicating poor sleep quality on average). Women with more

severe menopausal symptoms scored significantly worse on all seven components of the PSQI (all $p < .001$ or $p = .008$); Table 9).

Table 9 Analysis of Menopausal Symptom Severityand Sleep Quality (PSQI Components) in Women (N=360)

Item (PSQI Component)	Mild Symptoms (n=159)	Severe Symptoms (n=201)	P-value
	Mean (±SD)		
Overall Pittsburgh Sleep Quality Index	4±3.17	9.71±3.39	
Sleep Efficiency Score	0.62±0.85	0.89±0.98	0.008**
Total Sleep Time	1.38±0.84	1.75±0.79	0***
Need for Sleep Medication	0.13±0.48	0.45±0.81	0***
Daytime Dysfunction	0.58±0.67	1.41±0.76	0***
Subjective Seep Quality	1.16±0.82	1.82±0.77	0***
Sleep Disturbance	0.91±0.43	1.5±0.58	0***
Sleep latency	1.22±0.78	1.9±0.76	0***

Note: * $p < .05$; ** $p < .01$; *** $p < .001$

Predictors of Poor Sleep Quality: Logistic Regression Analysis

A stepwise forward logistic regression analysis was conducted to identify the most significant predictors of poor sleep quality (PSQI > 5) among the menopausal women, considering demographic variables and specific menopausal symptoms. The final model (Table 10) identified five significant predictors.

The Nagelkerke R^2 for the final logistic regression model was 0.468, indicating that the model explained approximately 46.8% of the variance in poor sleep quality. Multicollinearity among the predictors was assessed using Variance Inflation Factors (VIFs). All VIF values were found to be below 1.30 (maximum VIF = 1.299), indicating that no significant multicollinearity issues were present in the model.

As shown in Table 10, all five identified predictors demonstrated a statistically significant association with poor sleep quality, as their 95% confidence intervals for the odds ratios did not include 1. These factors collectively represent significant risk factors for poor sleep quality in the studied population of menopausal women.

1. Difficulty falling asleep frequency (a specific menopausal symptom) was the strongest predictor, significantly increasing the odds of poor sleep quality (OR = 4.54, 95% CI: 2.70–7.65, $p < .001$).
2. Feeling tired/lacking energy frequency (a specific menopausal symptom) also significantly increased the odds of poor sleep (OR = 2.24, 95% CI: 1.33–3.76, $p < .01$).

3. Having no regular exercise habit was associated with increased odds of poor sleep (OR = 2.23, 95% CI: 1.16–4.31, $p < .05$).
4. Experiencing muscle/joint pain frequency (a specific menopausal symptom) increased the odds of poor sleep (OR = 1.71, 95% CI: 1.10–2.64, $p < .05$).
5. Being in a later menopausal stage was associated with increased odds of poor sleep (OR = 1.55, 95% CI: 1.03–2.34, $p < .05$).

Table 10 Stepwise Forward Logistic Regression Analysis of Overall Demographic Variables, Menopausal Symptoms, and Sleep Quality

Step	Variable/Constant	B	Std.Error	Wals	df	p	Exp(B)	95% CI Lower	95% CI Upper
1[a]	Difficulty falling asleep frequency	1.767	.239	54.463	1	.000	5.85***		
	Constant	-.667	.248	7.267	1	.007	.513		
2[b]	Difficulty falling asleep frequency	1.630	.250	42.411	1	.000	5.10***		
	Muscle/joint pain frequency	.772	.204	14.350	1	.000	2.16***		
	Constant	-1.302	.315	17.123	1	.000	.272		
3[c]	Difficulty falling asleep frequency	1.538	.257	35.714	1	.000	4.65***		
	Feeling tired/lacking energy frequency	.639	.245	6.821	1	.009	1.89**		
	Muscle/joint pain frequency	.605	.212	8.121	1	.004	1.83**		
	Constant	-1.646	.354	21.565	1	.000	.193		
4[d]	Exercise habit frequency	.855	.333	6.584	1	.010	2.35**		
	Difficulty falling asleep frequency	1.538	.262	34.423	1	.000	4.65***		
	Feeling tired/lacking energy frequency	.729	.254	8.225	1	.004	2.07**		
	Muscle/joint pain frequency	.626	.216	8.363	1	.004	1.87**		
	Constant	-2.997	.657	20.809	1	.000	.050		
5[e]	Exercise habit frequency	.803	.336	5.719	1	.017	2.23*	1.16	4.31
	Current menopausal frequency	.441	.208	4.486	1	.034	1.55*	1.03	2.34

Difficulty falling asleep frequency	1.513	.266	32.382	1	.000	4.54***	2.70	7.65
Feeling tired/lacking energy frequency	.806	.264	9.307	1	.002	2.24**	1.33	3.76
Muscle/joint pain frequency	.535	.223	5.728	1	.017	1.71*	1.10	2.64
Constant	-3.776	.769	24.115	1	.000	.023		

Note: Step 5 represents the final model. B = Unstandardized Coefficient; Exp(B) = Odds Ratio. * p < .05; ** p < .01; **** p < .05；** p < .01；*** p < .001.

Discussion

This study provides valuable insights into the prevalence and associated factors of sleep quality among menopausal women in Macau, a unique urban environment. Our findings indicate a high prevalence of poor sleep quality, with an average Pittsburgh Sleep Quality Index (PSQI) score of 8.07 ± 3.77, signifying a considerable sleep burden in this demographic. This is notably higher than the typical PSQI scores (often ranging from 4 to 7) reported in general adult populations and even some menopausal cohorts elsewhere.[24] For instance, compared to women in Taiwan reporting a mean PSQI of 7.71 ± 4.66,[5] our Macanese sample demonstrates a potentially greater sleep deficit, with participants averaging only 5.83 hours of sleep per night and 35.2% experiencing sleep latency exceeding 30 minutes.

The novelty of this study lies in its examination of these factors within Macau's distinctive socio-environmental landscape. As a densely populated urban center within the Greater Bay Area, Macau's pervasive 24-hour tourism and gaming industry impacts all residential districts. This environment, characterized by high ambient activity, potential noise,[3] and light pollution, alongside the prevalence of shift work in the dominant tourism sector,[28] imposes unique stressors. Our finding that environmental noise was significantly associated with poorer sleep quality ($\chi^2 = 4.445$, $p = 0.035$) directly supports the notion that the urban environment contributes to sleep disturbances. The high percentage of working women (77.9%) in our sample, many likely juggling work and family responsibilities in a high-pressure urban environment,[26] further highlights a population particularly susceptible to stress-related sleep disturbances. This context clarifies why the prevalence of poor sleep may be higher than in other regions and underscores the importance of environment-specific research.

A critical finding of this study is the strong positive correlation ($r = .569$, $p < .001$) between the frequency/severity of menopausal symptoms and poorer sleep quality. This relationship is well-established in international literature,[1],[8] underscoring that the physiological and psychological manifestations of menopause directly impact sleep regulation. Women with more severe menopausal symptoms were overwhelmingly classified as poor sleepers (89.6% vs. 57.2% for those with milder symptoms, $\chi^2 = 49.827$, $p < .001$). Further, analysis confirmed that women with more severe symptoms scored significantly worse on all seven PSQI components, indicating widespread sleep impairment.

The logistic regression analysis highlighted several actionable targets for intervention. "Difficulty falling asleep" emerged as the strongest predictor, aligning with insomnia being a hallmark complaint during menopause.[20] "Feeling tired/lacking energy" and "experiencing muscle/joint pain" are also common menopausal complaints that directly interfere with restfulness and sleep continuity.[7],[25] The finding that "no regular exercise habit" significantly increased the odds of poor sleep is consistent with numerous studies demonstrating the benefits of physical activity for improving sleep quality in midlife women.[13],[19] Exercise can alleviate some menopausal symptoms, reduce stress, and directly improve sleep architecture. "Being in a later menopausal stage" as a predictor suggests that as women progress through menopause, the cumulative effects of hormonal changes and associated symptoms may increasingly impact sleep, highlighting the need for ongoing support.[15]

Our study identified several sociodemographic and lifestyle factors associated with sleep quality in bivariate analyses, such as marital status (divorced/widowed womenhaving poorer sleep, ($\chi^2 = 8.289$, $p = 0.04$)), Long working Hours ($\chi^2 = 6.244$, $p = 0.012$), and high life stress ($\chi^2 = 20.525$, $p < .001$). These factors often represent chronic stressors that can independently disrupt sleep or interact with menopausal changes to worsen sleep quality.[29] The finding that various sources of life stress **(**e.g., as categorized in Table 4, including long-term fatigue, strained family relations, economic decline; all $p < .05$) were linked to poor sleep emphasizes the holistic nature of sleep health, extending beyond purely physiological changes.

Strengths and Limitations

This study's strength lies in providing novel local data on sleep quality in menopausal women within the unique context of Macao, an area previously underexplored. The use of a validated, culturally adapted instrument (CPSQI) further enhances its rigor. However, its cross-sectional design precludes causal inferences, limiting our ability to determine if factors directly cause poor sleep or are merely associated with it. The convenience sampling method (street intercept) may also limit the generalizability of findings to the entire menopausal female population of Macao, potentially introducing selection bias due to a reportedly low participation rate. Additionally, the reliance solely on self-report measures introduces the possibility of recall and social desirability bias. Future research could benefit from integrating objective sleep measures (e.g., actigraphy, polysomnography) for a more comprehensive assessment.[15] Furthermore, data on economic status, specific shift work patterns, and use of dietary supplements were not comprehensively collected, which could be confounding factors. The influence of traditional Chinese medicine beliefs and practices, which are prevalent in the region,[30] also presents an area for more detailed exploration.

Conclusion

This study unequivocally demonstrates a high prevalence of poor sleep quality among menopausal women in Macao, highlighting a significant public health concern for this unique urban population. Poor sleep was significantly predicted by specific menopausal symptoms, including difficulty falling asleep, fatigue, and musculoskeletal pain, alongside modifiable lifestyle factors such as the absence of regular exercise, and non-

modifiable factors like advancing menopausal stage. These factors are compounded by the unique psychosocial and environmental stressors inherent to Macao's high-pressure, 24-hour urban environment. These results underscore the urgent need for a multifaceted approach to improve sleep health in this vulnerable demographic. Clinically, routine screening for sleep disturbances in menopausal women is essential, followed by holistic management that addresses both menopausal symptoms and lifestyle factors. Public health initiatives should focus on promoting modifiable behaviors, such as regular physical activity and stress management, with programs culturally tailored to the local context of Macao. For future research, longitudinal studies are needed to establish causality and better understand the trajectory of sleep problems across the menopausal transition. Furthermore, in-depth investigation into the specific impact of Macao's unique environmental and occupational stressors (e.g., shift work, urban density) is warranted to develop more effective, targeted interventions. Incorporating objective sleep measures, such as actigraphy, alongside qualitative methods would provide a more comprehensive understanding of this complex issue

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HIL and CSUL conceived and designed the study. HIL acquired the data and performed data analysis, interpretation, and drafted the initial manuscript. All authors critically revised the manuscript, approved the final version, and confirmed accountability for all aspects of the work. This original manuscript is not published nor under consideration elsewhere.

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