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ORIGINAL RESEARCH

The Cross-Sectional Association Between Multimorbidity and Sleep Quality and Duration Among the Elderly Community Dwellers in Northwest China

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Background: Multimorbidity, defined as the coexistence of two or more chronic diseases, is highly prevalent among the elderly population and is associated with adverse outcomes. However, little is known about its relationship with sleep issues, particularly in this demographic. Therefore, this study aimed to investigate its association with sleep quality and duration among the elderly.

Methods: This cross-sectional study was conducted in Emin County, Xinjiang, China, which included a population aged 60 years and above. We employed the Pittsburgh Sleep Quality Index (PSQI) score to assess sleep quality and duration. Multimorbidity was determined through self-reports, physical examination, blood tests, and imaging. Logistic regression analyses were used to explore the association between multimorbidity and sleep patterns, adjusting for confounders.

Results: A total of 8205 elderly participants were included, of whom 66.8% suffered from multimorbidity. Participants with multimorbidity exhibited higher total PSQI scores [6 (3,9)], and a higher percentage of poor sleep quality (50.6%), compared to those without multimorbidity. Multimorbidity was significantly associated with the presence of poor sleep quality (OR = 1.27, 95% CI: 1.14–1.41, P < 0.001) before and after adjusting for confounders. The risk of having poor sleep quality significantly increased as the number of multimorbidities increased. The OR (95% CI) values were 1.16 (1.02,1.32) for two diseases, 1.54 (1.26,1.90) for ≥5 diseases. In the adjusted model for total participants, having four diseases (OR = 1.26, 95% CI: 1.05–1.51, p = 0.013) and five or more diseases (OR = 1.29, 95% CI: 1.03–1.61, p = 0.029) were associated with shorter sleep duration. Furthermore, those with five or more diseases associated with longer sleep duration (OR = 1.40, 95% CI: 1.00–1.95, p = 0.057).

Conclusion: There is a significant association between multimorbidity and poor sleep quality in older community dwellers, which may provide clues for disease prevention.

Keywords: multimorbidity, sleep quality, sleep duration, elderly

Introduction

The prevalence and the incidence of multimorbidity are likely to increase rapidly as the population ages and risk factors for chronic noncommunicable diseases increase.[1,2] Multimorbidity, defined as a person having two or more chronic diseases at the same time, exhibits a wide prevalence range (4.8–90.5%), influenced by factors like geography and disease definitions.[3] Based on emerging data, more than 2/3 of the elderly now suffer from multimorbidity in China.[4] Epidemiological studies have also shown that multimorbidity is associated with reduced quality of life and impaired self-

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rated health, repeated hospitalization, longer hospital stay, and higher medical costs, compared with patients with a single disease,[5,6] therefore, creating a huge healthcare burden.[7]

Recent studies have been focusing on the risk factors of multimorbidity, especially modifiable ones,[8] which may provide with clues for disease prevention.[9] On this aspect, studies reported a negative relationship between sleep problems and multimorbidity.[10] Studies have shown that different chronic diseases such as obesity,[11] hypertension,[12] diabetes,[13] stroke,[14] and cardiovascular diseases,[15] important components of multimorbidity,[16] can have an impact on sleep patterns. Studies have also confirmed that poor sleep quality and abnormal sleep duration are associated with a higher prevalence, incidence, and progression of multimorbidity as well.[17,18]

Sleep disorder is also a common problem in the elderly, affecting over half of the older population.[19,20] Unresolved sleep problems in older adults lead to a poor quality of life, cognitive impairment, and emotional distress, as well as a decline in physical function and increased risk of falling incidents.[21,22] A study based on China Health and Retirement Longitudinal Study (CHARLS) data showed that multimorbidity is associated with poor quality and short sleep duration in older adults.[18]

However, the relationship between multimorbidity and sleep quality and duration needs more evidence, especially in the elderly, since inconsistencies and uncertainties exist among current data. For example, multimorbidity is associated with prolonged sleep duration in one study,[17] whereas with short sleep duration in another study.[18] Previous studies found that improvement of sleep quality can slow the progression of some chronic diseases such as hypertension,[23] and improves quality of life.[24] Hence, to achieve healthy aging, sleep quality improvement has emerged as a key health promotion strategy.

Therefore, this study used epidemiologic survey data from Emin County, Xinjiang, Northwest China, a multi-ethnic and multi-living setting area, to assess the association between multimorbidity and sleep quality and duration in older people. In this study, we considered the ethnicity and living setting for the association between the two, since previous studies have observed that multimorbidity and sleep problems may be highly influenced by geography, ethnicity, and cultural diversity.[25,26]

Methods

Setting

Emin County, Xinjiang, China, is one of the most populous counties in Xinjiang. As a multi-ethnic area, Emin County in Xinjiang has a population consisting of Han, Kazakh, Uygur, Hui with different lifestyles and dietary habits. People live in urban or agricultural and stock raising areas, and location in Northwest China, adjacent to Central Asia,[27] it can be used as a microcosm for the whole of Xinjiang, and these geographic and cultural features provide an ideal setting for this study.

Study population: This was a cross-sectional study, conducted from April to October 2019. A multistage proportional random sampling method was used to obtain a study population of populations aged 18 years or older from Xinjiang, China, in 2019 and the methods were described in detail in previous studies.[28]

Inclusion criteria: 1) those who had lived at their current address for ≥6 months. 2) those who agreed to participate in the survey and signed an informed consent form. 3) those who were able to complete the survey, understand the investigation, and cooperate with investigators as well as those with the ability to provide informed consent and those who were unable to cooperate with the survey due to mental, hearing, mental and or other problems. 1) In describing the prevalence of the multimorbidity component, we further excluded: those aged below 60 years. 2) when analyzing the effect of multimorbidity on sleep, those without PSQI data were further excluded. See flowchart for details as given in Figure 1.

Data Collection

All participants completed face-to-face questionnaires including demographic characteristics (gender, age, ethnicity, marriage, living environment), socio-economic information (occupation, education attainment status), living habits (smoking, and alcohol consumption), medical history (hypertension, diabetes, dyslipidemia, stroke, coronary artery

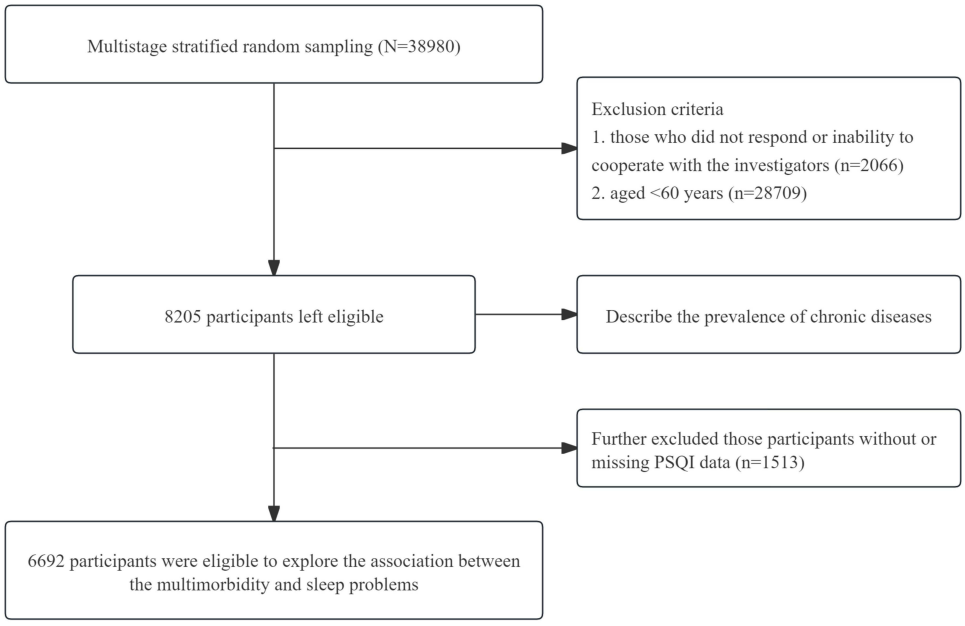

Figure 1 Flowchart for the study population.

disease, surgical history, trauma history and relevant medicine use), global physical activity questionnaire (GPAQ), Pittsburgh sleep quality index (PSQI), and Zung self-rating anxiety and depression scales (SAS, SDS).[28]

A physical examination was performed, including measurements of height, weight, neck and waist circumference, and blood pressure.[28]

Laboratory biochemical tests included measurements of serum creatinine, fasting blood glucose (FBG), hemoglobin (Hb), triglycerides (TG), total cholesterol (TC), and high- and low-density lipoprotein cholesterol (HDL and LDL).[27]

Chest X-ray test and abdominal ultrasound were performed by trained doctors. The results of the chest X-ray were read by the doctors of county-level hospital.

Assessment of Sleep Quality and Duration

Self-reported sleep quality was assessed using the PSQI scale.[29] Sleep quality was inquired using the Chinese version of PSQI, widely used in the Chinese population, which captures subjective sleep quality, sleep latency, sleep duration, habitual sleep efficiency, sleep disturbances, use of sleeping medication, and daytime dysfunction. Each domain is given a score of 0 to 3 and then combined for a total score ranging from 0 to 21.[30] A score ≥6 indicates poor sleep quality.[30] In addition, previous prospective studies and meta-analyses have reported that both short sleep (≤6 h) and sleeping more than 8–9 hours were associated with higher risks of major cardio-metabolic diseases.[31–38] Thus, we divided sleep duration into three criteria as normal sleep (6–8 hours), shorter sleep (<6 hours), and longer sleep (>8 hours) in the current study.

Assessment and Definition of Multimorbidity

Multimorbidity is defined as a person having two or more chronic diseases at the same time, according to the definition recommended by the WHO.[3] The study defined 14 chronic diseases by self-report, physical examination, blood sample testing, and imaging findings. They included: hypertension, diabetes, obesity, dyslipidemia, heart disease (coronary heart disease, myocardial infarction, coronary revascularization/stenting/ bypass, rheumatic heart disease), cerebrovascular disease (ischemic stroke, hemorrhagic stroke), lung disease (chronic bronchitis/emphysema/chronic obstructive pulmonary disease, tuberculosis, bronchiectasis, asthma), liver diseases (fatty liver, hepatic hydatid, chronic hepatitis, cirrhosis), kidney diseases (Kidney calculi, chronic renal dysfunction, chronic renal failure/uremia, nephrotic syndrome), psychiatric diseases (anxiety disorders, depressive disorders, anxiety states/depressive status), gallbladder diseases (gallbladder

stones, chronic cholecystitis), thyroid diseases (hyper/hypothyroidism, surgery), tumor (benign and malignant), anemia. Additionally, the inclusion criteria also considered a core list of chronic conditions for any multimorbidity measurement as recommended by a systematic review.[39] MM3+ is defined as a person having 3 or more chronic diseases at the same time. MM4+ is defined as a person having 4 or more chronic diseases at the same time.

Definition of the Component of Multimorbidity

Hypertension, diabetes, dyslipidemia, chronic renal dysfunction are defined as in our previous work using the same data.[28–30] Hypertension is defined as systolic BP ≥ 140 mmHg, and/or diastolic BP ≥ 90 mmHg, and/or use of antihypertensive medicine within 2 weeks. Diabetes is defined as FBG ≥ 7.0 mmol/L, and/or self-reported previous diagnosis by physicians and/or intake of hypoglycemic agents within past 2 weeks. Dyslipidemia is defined as TC ≥ 6.2 mmol/L and/or TG ≥ 2.3 mmol/L and/or HDL-C <1.0 mmol/L and/or LDL-C ≥4.2 mmol/L and/or having received treatment during the past 2 weeks. Chronic renal dysfunction is defined as a glomerular filtration rate <60 mL/min/1.73m^2. Obesity is defined as a BMI ≥ 30kg/m^2.[40] Anemia was defined as a Hb concentration of <130 g/L in men and <120 g/L in women.[41] Gallbladder diseases (Gallbladder stones, Chronic cholecystitis), fatty liver, liver cirrhosis and kidney stones are diagnosed by trans-abdominal color Doppler ultrasound with the following ultrasound manifestations: Gallbladder stones presenting as strong echoes and posterior acoustic shadows in the gallbladder.[42] Chronic cholecystitis is manifested by the thickening of the gallbladder wall (wall thickness ≥3 mm), grossness.[42] The typical manifestations of fatty liver disease were enlargement of the liver and blunt edge angle. The proximal echoes of the liver are diffusely enhanced above the spleen and kidneys, and the distal echoes are diminished. The structure of the hepatic ducts is unclear.[43] Hepatic hydatid is manifested by a large cystic mass in the liver. The wall of the cyst is mostly a double-layered structure, the outer layer is fibrous cystic wall, which is thicker and more echogenic; the inner layer is the germinal layer, which is relatively thin and slightly lower echogenicity; sub-capsules of different sizes can be seen inside the cysts, presenting as a "capsule within a capsule", and the walls of the sub-capsules can be clearly shown.[44] Kidney calculi present as strongly echogenic light spots or clusters with acoustic shadows.[45] Tuberculosis diagnosis is based on chest X-ray and self-reports.[46] Diagnoses of other diseases were obtained through self-reports by the participants during the investigation, the participants were asked whether a physician ever told them they had chronic diseases such as heart disease (coronary heart disease, myocardial infarction, coronary revascularization/stenting/ bypass, rheumatic heart disease), cerebrovascular disease (ischemic stroke, hemorrhagic stroke), lung disease (chronic bronchitis/emphysema/ chronic obstructive pulmonary disease, bronchiectasis, asthma), liver diseases (chronic hepatitis, cirrhosis), kidney diseases (chronic renal failure/uremia, nephrotic syndrome), psychiatric diseases (anxiety disorders, depressive disorders,), thyroid diseases (hyper/hypothyroidism, surgery), tumor (benign and malignant).

Covariates

Sociodemographic variables included age (60–69, 70–79, ≥80), gender (men, women), marriage status (married, widowed/divorced/single), education attainment status (primary and lower, junior high, senior high and higher), region (urban, rural), and ethnicity (Han, Kazakh, Uygur, Hui, and others). Cigarette use is defined as smoking at the time of the survey, exposure to secondhand smoking, and the year quitting smoking ≤5 years; non-smoking is defined as never smoking and the year of quitting smoking ≥5 years. Alcohol use is defined as consuming an alcoholic beverage at least once per week in the past month.[28] Physical activity was assessed using the Chinese version of GPAQ and classified into high, medium, and low levels based on WHO (2010) recommendations.[28]

Statistical Analysis

Data analysis was performed in total participants and in stratified participants by sex. Continuous variables were presented as mean ± standard deviation and compared between groups using the *t*-test if normally distributed; otherwise as median (25th, 75th percentile) and compared by Mann–Whitney *U*-test or Kruskal–Wallis test.

Categorical variables were expressed as proportion (%) and frequency (n) and compared between groups using the Chi-square test. We incorporated the corrections for multiple comparisons using Bonferroni method.[47] Trends in poorer sleep and abnormal sleep duration were assessed using chi-square trend tests for different numbers of diseases. For sleep

quality, we used a binary logistic regression model to assess the effect of multimorbidity on sleep quality. For sleep duration, multivariate logistic regression models were exploited to estimate the association between multimorbidity and sleep duration. Univariate linear or logistic regression models were performed for variable selection to be adjusted. In addition, we used a binary logistic regression model to assess the effect of sleep quality on multimorbidity. We presented results in the form of odds ratios (ORs) with 95% confidence intervals (CIs). The p-value for the trend is based on the median of each subgroup as a quasi-continuous variable in the model for trend analysis. Results were considered statistically significant for a 2-tailed value of $P < 0.05$. All statistical analyses were performed with SPSS statistical software, version 25.0 (Chicago, IL).

Results

Baseline Population Characteristics

Finally, 8205 participants were included in the current analysis as in Figure 1. The general characteristics of the study participants were shown in Table 1. The median (25th, 75th percentile) age was 67.0 (63.0,72.0) years, and the majority were in the 60–69 age group (65.4%). The prevalence of chronic diseases among the survey participants. The prevalence of multimorbidity was 66.8% in the total population, and that of MM3+ and MM4+ was 39.5% and 19.7% respectively.

The prevalence of multimorbidity in women participants was 71.5%, which was significantly higher than the 61.5% of men participants ($P < 0.001$), also consistent for that of MM3+ (women vs men: 44.3% vs 34.1%, $P < 0.001$), and for that of MM4+ (women vs men: 22.9% vs 16.0%, $P < 0.001$). The components of multimorbidity and the prevalence of these diseases were shown in Table S1. The distribution of the number of chronic diseases in the study population is shown in Table S2.

Table 1 Characteristics of Study Participants by Total and by Gender

Characteristics	Total	Men	Women	P
N	8205	3829	4376	
Age (years)	67.0 (63.0,72.0)	67.0 (63.0,72.0)	67.0 (63.0,72.0)	0.606
Age groups 60–69 years	5363 (65.4)	2467 (64.4)	2896 (66.2)	0.245
70–79 years	2326 (28.3)	1117 (29.2)	1209 (27.6)	
≥80 years	516 (6.3)	245 (6.4)	271 (6.2)	
BMI (kg/m2)	26.1 (23.5, 28.9)	25.6 (23.3, 28.1)	26.5 (23.8, 29.6)	<0.001
Education (n, %), ≤primary	4971 (60.7)	1995 (52.2)	2976 (68.1)	<0.001
Junior high	1976 (24.1)	1136 (29.7)	840 (19.2)	
≥senior high	1240 (15.1)	688 (18.0)	552 (12.6)	
Region (n, %), urban	3029 (37.6)	1461 (38.6)	1568 (36.6)	0.076
Rural	5037 (62.4)	2326 (61.4)	2711 (63.4)	
Ethnicity (n, %), Han	4710 (57.4)	2310 (60.3)	2400 (54.8)	<0.001
Kazakh	1990 (24.3)	834 (21.8)	1156 (26.4)	
Uygur	718 (8.8)	320 (8.4)	398 (9.1)	
Hui	422 (5.1)	208 (5.4)	214 (4.9)	
Others	365 (4.4)	157 (4.1)	208 (4.8)	
Marital status (n, %), married	6309 (77.0)	3328 (87.1)	2981 (68.2)	<0.001
Divorced/ widowed/ single	1882 (23.0)	494 (12.9)	1388 (31.8)	
Cigarette use (n, %)	1959 (23.9)	1522 (39.7)	437 (10.0)	<0.001
Alcohol use (n, %)	616 (7.5)	571 (14.9)	45 (1.0)	<0.001
Physical activity (n, %), low	2348 (28.6)	962 (25.1)	1386 (31.7)	<0.001
Median	2161 (26.3)	1042 (27.2)	1119 (25.6)	
High	3696 (45.0)	1825 (47.7)	1871 (42.8)	
Sleep quality (n, %), good	3425 (39.5)	2002 (52.2)	1423 (32.5)	<0.001
Poor	3267 (40.8)	1169 (30.5)	2098 (47.9)	
Sleep duration (n, %), <6h	1830 (22.3)	717 (18.7)	1113 (25.4)	<0.001

(*Continued*)

Table 1 (Continued).

Characteristics	Total	Men	Women	P
6–8	4310 (52.5)	2178 (56.9)	2132 (48.7)	
>8h	552 (6.7)	276 (7.2)	276 (6.3)	
Hb (mmol/l)	138.0 (130.0,149.0)	147.0 (138.0,156.0)	133.0 (125.0,140.0)	<0.001
FBG (mmol/l)	5.61 (5.09,6.39)	5.61 (5.09,6.36)	5.61 (5.09,6.41)	0.493
EGFR (mL/min*1.73m^2)	86.4 (72.3,94.6)	89.0 (77.7,95.8)	83.5 (69.2,93.4)	<0.001
TC (mg/dl)	5.0 (4.3,5.8)	4.8 (4.2,5.6)	5.2 (4.4,5.9)	<0.001
TG (mg/dl)	1.3 (0.9,1.8)	1.3 (0.9,1.7)	1.4 (1.0, 1.9)	<0.001
HDL-c (mg/dl)	1.5 (1.3, 1.8)	1.5 (1.2, 1.7)	1.6 (1.3, 1.8)	<0.001
LDL-c (mg/dl)	2.3 (1.7, 2.8)	2.3 (1.7, 2.8)	2.3 (1.67, 2.8)	0.88
MM2+	5483 (66.8)	2353 (61.5)	3130 (71.5)	<0.001
MM3+	3242 (39.5)	1304 (34.1)	1938 (44.3)	<0.001
MM4+	1615 (19.7)	611 (16.0)	1004 (22.9)	<0.001

Abbreviations: Hb, hemoglobin; FBG, fasting blood glucose; eGFR, estimated glomerular filtration rate; TC, total cholesterol; TG, triglycerides;HDL-c, high-density lipoprotein cholesterol; LDL-C, low density lipoprotein cholesterol.

The Association Between Sleep Characteristics and Multimorbidity

The multimorbidity group showed significantly higher PSQI global score [6 (3,9) vs 5 (3,8), P < 0.001] and the presence of poor sleep quality (50.6% vs 42.2%, P < 0.001), compared with the non-multimorbidity group (Table 2). Further gender stratification analysis showed also consistent for that of men [4 (3, 7) vs 4 (3, 6), P = 0.004] and the presence of poor sleep quality (39.0% vs 33.5%, P = 0.002), and for that of women [7 (4, 11) vs 6 (3, 9), P < 0.001] and presence of poor sleep quality (61.5% vs 54.8%, P < 0.001).

Table 2 Comparison of Sleep Duration and Prevalent Poor Sleep Quality by the Presence of Multimorbidity (n = 6692)

	Multimorbidity		P-values
	No	Yes	
N	2267	4425	
Global PSQI score			
Total	5 (3,8)	6 (3,9)	<0.001
Men	4 (3,6)	4 (3,7)	0.004
Women	6 (3,9)	7 (4,11)	<0.001
Prevalence of poor sleep quality			
Total	959 (42.2)	2308 (50.6)	<0.001
Men	412 (33.5)	757 (39.0)	0.002
Women	547 (54.8)	1551 (61.5)	<0.001
Sleep duration <6 hours			
Total	563 (24.8)	1267 (27.8)	0.007
Men	268 (21.8)	449 (23.1)	0.407
Women	295 (29.6)	818 (32.4)	0.077
Sleep duration >8 hours			
Total	184 (8.1)	368 (8.1)	0.639
Men	109 (8.9)	167 (8.6)	0.904
Women	75 (7.5)	201 (8.0)	0.433

Table 3 showed that the presence of poor sleep quality significantly increased in the population with no to five and more multimorbidity in total (no vs 2 vs 3 vs 4 vs 5+: 43.1% vs 48.4% vs 51.1 vs 56.3% vs 57.7%, P < 0.001, p for trend <0.001), men (33.5% vs 38.3% vs 36.1% vs 43.0% vs 44.1%, P = 0.003, p for trend = 0.001), women (54.8% vs 57.6% vs 62.5% vs 64.4% vs 66.0%, P = 0.001, p for trend <0.001) and showed a significantly increasing trend.

The percentage of those with sleep duration lesson 6 hours also significantly increased from no to five and more multimorbidity in women (29.6% vs 31.4% vs 32.4% vs 32.8% vs 35.3%, p for trend = 0.014) population.

As outlined in Table 4, the presence of multimorbidity was associated with elevated odds for poor sleep quality in total (OR = 1.27, 95% CI 1.14–1.41, P < 0.001), men (OR = 1.26, 95% CI: 1.09–1.47, P = 0.003), and in women (OR = 1.27, 95% CI: 1.09–1.47, P = 0.002) participants even after adjustments for confounders. In terms of sleep duration, the presence of multimorbidity was associated with the shorter sleep duration in the adjusted model (OR = 1.13, 95% CI: 1.10–1.28, P = 0.043) only in total participants.

Table 5 showed that the risk of having poor sleep quality increased as the number of multimorbidities increased. The adjusted OR (95% CI) values were 1.16 (1.02,1.32) for two diseases, 1.24 (1.08,1.43) for three diseases, and 1.47 (1.24,1.73) for four diseases, 1.54 (1.26,1.90) for ≥5 diseases. The results of the gender-stratified analyses were consistent with the results of the total population. In terms of sleep duration, having four (OR = 1.26, 95% CI: 1.05, 1.51, p = 0.013) and five or more diseases (OR = 1.29, 95% CI: 1.03–1.61, p = 0.029) was associated with shorter sleep duration in the adjusted model for total participants. Having five or more diseases (OR = 1.40, 95% CI: 1.00–1.95, p = 0.057) a tendency towards longer sleep duration, although this association is of marginal significance. The results of the gender-stratified analyses largely concurred with those obtained from the total population.

Table 3 Comparison of Sleep Duration and Prevalent Poor Sleep Quality by Number of Multimorbidity in Total and Gender-Specific Participants (n = 6692)

	0 or 1	2	3	4	5+	P value [1]	Corrected P for Multiple Comparison[2]	P for Trend
N	2227	1806	1330	835	494			
Global PSQI score								
Total	5 (3,8)	5 (3,9)	6 (3,9)	6 (3,10)	6 (3,10)	<0.001	a, b, c, d,f, g	<0.001
Men	4 (3,6)	4 (3,6)	4 (2,7)	5 (3,8)	5 (3,8)	0.010	c	<0.001
Women	6 (3,9)	6 (3,10)	7 (4,11)	7 (4,11)	8 (4,12)	<0.001	b,c,d,f,g	<0.001
Prevalence of poor sleep quality								
Total	859 (43.1)	874 (48.4)	679 (51.1)	470 (56.3)	258 (57.7)	<0.001	a, c, d, f, g	<0.001
Men	412 (33.5)	330 (38.3)	208 (36.1)	136 (43.0)	83 (44.1)	0.003	c, d	<0.001
Women	547 (54.8)	544 (57.6)	471 (62.5)	334 (64.4)	202 (66.0)	<0.001	b, c, d	<0.001
Prevalence of sleep duration <6 hours								
Total	563 (25.3)	494 (27.4)	366 (27.5)	258 (30.9)	149 (30.2)	0.008	c	<0.001
Men	268 (21.8)	198 (23.0)	122 (21.1)	88 (27.8)	41 (21.8)	0.179	/	0.272
Women	295 (29.6)	296 (31.4)	244 (32.4)	170 (32.8)	108 (35.3)	0.158	/	0.014
Prevalence of sleep duration >8 hours								
Total	184 (8.3)	135 (7.5)	111 (8.3)	68 (8.1)	53 (10.7)	0.133	/	0.055
Men	109 (8.9)	73 (8.5)	48 (8.3)	27 (8.5)	19 (10.1)	0.945	/	0.746
Women	75 (7.5)	63 (6.7)	63 (8.4)	41 (7.9)	34 (11.1)	0.057	g	0.021

Notes: 1 p-values were calculated using Kruskal–Wallis test or Pearson's chi-squared test. 2 Corrected P for multiple comparison analysis with the Bonferroni method: a, 0 or 1 versus 2; b, 0 or 1 versus 3; c, 0 or 1 versus 4; d, 0 or 1 versus 5; e, 2 versus 3; f, 2 versus 4; g, 2 versus 5; h, 3 versus 4; i, 3 versus 5; j, 4 versus 5; / not statistically significant.

Table 4 Logistic Regression for the Association Between Multimorbidity and Sleep Characteristics in Total and Gender-Specific Participants (or,95% CI, P)

	Unadjusted Model	Model 1	Model 2
Sleep Quality (Poor Versus Good)			
Total	1.41 (1.28,1.57), <0.001	1.27 (1.15, 1.42), <0.001	1.27 (1.14,1.41), <0.001
Men	1.27 (1.20,1.48), 0.002	1.25 (1.07,1.45), 0.004	1.26 (1.09,1.47), 0.003
Women	1.32 (1.13,1.53), <0.001	1.30 (1.12,1.50), 0.001	1.27 (1.09,1.47), 0.002
Sleep duration (short versus normal)			
Total	1.18 (1.05,1.32),0.007	1.11 (0.99,1.25), 0.098	1.13 (1.10,1.28), 0.043
Men	1.07 (0.90,1.28), 0.407	1.07 (0.90,1.28), 0.436	1.10 (0.98,1.32), 0.278
Women	1.16 (0.98,1.36), 0.077	1.14 (0.97,1.34), 0.119	1.16 (0.98,1.37), 0.078
Sleep duration (prolonged versus normal)			
Total	0.96 (0.79, 1.15), 0.639	1.02 (0.84,1.23), 0.838	1.00 (0.83,1.21), 1.000
Men	0.98 (0.90,1.28), 0.904	0.97 (0.75,1.25), 0.813	0.97 (0.75,1.26), 0.805
Women	1.12 (0.85,1.48), 0.433	1.09 (0.82,1.44), 0.565	1.06 (0.80,1.41), 0.704

Notes: Model 1 was adjusted for age and sex (sex was not for its stratification). Model 2 was further adjusted for education status, ethnicity, regions, marital status, cigarette use, alcohol use, physical activity.

Table 5 Logistic Regression for the Association Between Number of Multimorbidity and Sleep Characteristics in Total and Gender-Specific Participants

	Number of MM	Unadjusted Model	Model 1	Model 2
Sleep quality (Poor Versus Good)				
Total	0 or 1	Ref	Ref	Ref
	2	1.24 (1.09,1.40), 0.001	1.16 (1.02,1.32), 0.022	1.16 (1.02,1.32), 0.027
	3	1.38 (1.20,1.58), <0.001	1.24 (1.08,1.43), 0.003	1.24 (1.08,1.43), 0.003
	4	1.70 (1.45,2.00), <0.001	1.46 (1.24,1.73), <0.001	1.47 (1.24,1.73), <0.001
	5+	1.80 (1.48,2.20), <0.001	1.55 (1.26,1.90), <0.001	1.54 (1.26,1.90), <0.001
	p for trend	<0.001	<0.001	<0.001
Men	0 or 1	Ref	Ref	Ref
	2	1.23 (1.03,1.48), 0.025	1.23 (1.02,1.48), 0.028	1.23 (1.03,1.48), 0.025
	3	1.12 (0.91,1.38), 0.281	1.20 (0.89,1.35), 0.394	1.11 (0.90,1.37), 0.331
	4	1.50 (1.16,1.93), 0.002	1.46 (1.14,1.89), 0.003	1.50 (1.16,1.94), 0.002
	5+	1.57 (1.15,2.14), 0.005	1.52 (1.12,2.08), 0.008	1.57 (1.14,2.16), 0.005
	p for trend	<0.001	0.001	0.001
Women	0 or 1	Ref	Ref	Ref
	2	1.12 (0.94,1.34), 0.211	1.11 (0.93,1.33), 0.250	1.08 (0.90,1.30), 0.390
	3	1.37 (1.13,1.66), 0.001	1.36 (1.12,1.65), 0.002	1.34 (1.11,1.63), 0.003
	4	1.49 (1.20,1.85), <0.001	1.46 (1.17,1.82), 0.001	1.41 (1.13,1.75), 0.003
	5+	1.60 (1.23,2.09), 0.001	1.57 (1.20,2.05), 0.001	1.49 (1.14,1.96), 0.004
	p for trend	<0.001	<0.001	<0.001
Sleep duration (short versus normal)				
Total	0 or 1	Ref	Ref	Ref
	2	1.10 (0.96,1.27), 0.174	1.06 (0.90,1.23), 0.407	1.08 (0.93,1.24), 0.330
	3	1.13 (0.97,1.32), 0.131	1.06 (0.90,1.24), 0.473	1.09 (0.93,1.28), 0.315
	4	1.34 (1.08,1.60), 0.002	1.21 (1.02,1.46), 0.033	1.26 (1.05,1.51), 0.013
	5+	1.35 (1.08,1.67), 0.009	1.22 (0.98,1.53), 0.076	1.29 (1.03,1.61), 0.029
	p for trend	<0.001	0.001	0.001

(*Continued*)

Table 5 (Continued).

	Number of MM	Unadjusted Model	Model 1	Model 2
Men	0 or 1	Ref	Ref	Ref
	2	1.06 (0.86,1.31), 0.559	1.06 (0.85,1.31), 0.610	1.08 (0.87,1.33), 0.504
	3	0.96 (0.75,1.22), 0.714	0.93 (0.73,1.94), 0.578	0.97 (0.76,1.25), 0.833
	4	1.39 (1.05,1.85), 0.023	1.38 (1.04,1.85), 0.028	1.43 (1.07,1.92), 0.015
	5+	1.02 (0.70,1.49), 0.925	0.99 (0.68,1.45), 0.952	1.05 (0.72,1.55), 0.796
	p for trend	<0.001	0.001	0.001
Women	0 or 1	Ref	Ref	Ref
	2	1.08 (0.89,1.31), 0.459	1.08 (0.88,1.31), 0.464	1.09 (0.89,1.33), 0.409
	3	1.16 (0.94,1.43), 0.158	1.16 (0.94,1.43), 0.157	1.18 (0.96,1.46), 0.116
	4	1.18 (0.93,1.48), 0.175	1.17 (0.92,1.47), 0.199	1.20 (0.95,1.51), 0.136
	5+	1.40 (1.06,1.85), 0.018	1.40 (1.06,1.85), 0.019	1.46 (1.10,1.95), 0.009
	p for trend	0.014	0.002	0.017
Sleep duration (prolonged versus normal)				
Total	0 or 1	Ref	Ref	Ref
	2	0.93 (0.74,1.17), 0.545	0.92 (0.73,1.16), 0.481	0.89 (0.70,1.12), 0.314
	3	1.05 (0.82,1.34), 0.721	1.02 (0.80,1.31), 0.871	1.01 (0.79,1.31), 0.924
	4	1.08 (0.80,1.44), 0.721	1.04 (0.77,1.40), 0.814	1.05 (0.78,1.42), 0.749
	5+	1.46 (1.05,2.03), 0.025	1.40 (1.00,1.96), 0.046	1.40 (1.00,1.95), 0.057
	p for trend	0.05	0.094	0.098
Men	0 or 1	Ref	Ref	Ref
	2	0.97 (0.71,1.32), 0.827	0.96 (0.70,1.31), 0.779	0.95 (0.69,1.30), 0.735
	3	0.92 (0.65,1.32), 0.667	0.91 (0.63,1.30), 0.593	0.91 (0.63,1.30), 0.599
	4	1.05 (0.67,1.64), 0.831	1.02 (0.64,1.60), 0.949	1.09 (0.69,1.72), 0.722
	5+	1.16 (0.69,1.95), 0.576	1.05 (0.62,1.78), 0.858	1.13 (0.66,1.92), 0.664
	p for trend	0.746	0.824	0.672
Women	0 or 1	Ref	Ref	Ref
	2	0.90 (0.63,1.28), 0.566	0.89 (0.63,1.27), 0.523	0.84 (0.59,1.21), 0.351
	3	1.18 (0.83,1.69), 0.362	1.17 (0.82,1.67), 0.391	1.17 (0.82,1.68), 0.395
	4	1.12 (0.74,1.67), 0.599	1.08 (0.72,1.62), 0.711	1.08 (0.72,1.62), 0.724
	5+	1.74 (1.12,2.70), 0.014	1.68 (1.08,2.61), 0.022	1.65 (1.05,2.59), 0.030
	p for trend	0.020	0.043	0.037

Notes: Model 1 was adjusted for age and sex (sex was not for its stratification). Model 2 was further adjusted for education status, regions, ethnicity, marital status, cigarette use, alcohol use, physical activity.

We further analyzed logistic regressions stratified by ethnicity and residential environment (Table 6), and the effects of multimorbidity on sleep quality in the Han (OR = 1.23, 95% CI: 1.08–1.40, P = 0.002), Kazakh (OR = 1.54, 95% CI: 1.20–1.97, P = 0.001), those who live in urban (OR = 1.39, 95% CI: 1.15–1.66, P = 0.001), and rural (OR = 1.22, 95% CI: 1.06–1.39, P = 0.004) area were generally consistent with the results for the total population.

The Association Between Sleep Characteristics and Multimorbidity

As outlined in Table 7, the presence of poor sleep quality was associated with multimorbidity in total (OR = 1.27, 95% CI 1.15–1.42, P < 0.001), men (OR = 1.26, 95% CI: 1.08–1.47, P = 0.003), and in women (OR = 1.26, 95% CI: 1.09–1.47, P = 0.002) participants even after adjustments for confounders. Given in Table S3, the presence of short sleep duration was associated with the multimorbidity in the adjusted model (OR = 1.13, 95% CI: 1.01–1.28, P = 0.041) only in total participants.

Table 6 Logistic Regression for the Association Between Multimorbidity and Sleep Characteristics in Different Subgroups (or,95% CI, P)

	Unadjusted Model	Model 1	Model 2
Sleep Quality (Poor Versus Good)			
Ethnicity, Han	1.35 (1.19,1.54), 0.001	1.22 (1.07,1.39), 0.004	1.23 (1.08,1.40), 0.002
Kazakh	1.38 (1.38,2.20), <0.001	1.54 (1.21,1.95), <0.001	1.54 (1.20,1.97), 0.001
Others	1.26 (0.97,1.63), 0.080	1.16 (0.89,1.52), 0.262	1.18 (0.98,1.03), 0.649
Regions, urban	1.45 (1.22,1.72), <0.001	1.35 (1.13,1.61), 0.001	1.39 (1.15,1.66), 0.001
Rural	1.40 (1.23,1.59), <0.001	1.23 (1.08,1.40), 0.002	1.22 (1.06,1.39), 0.004
Sleep duration (short versus normal)			
Ethnicity, Han	1.18 (1.02,1.36), 0.026	1.10 (0.95,1.28), 0.190	1.12 (0.97,1.30), 0.129
Kazakh	1.32 (1.00,1.74), 0.047	1.22 (0.93,1.62), 0.158	1.22 (0.92,1.62), 0.188
Others	1.09 (0.81,1.46), 0.590	1.06 (0.78,1.43), 0.725	1.07 (0.79,1.44), 0.682
Regions, urban	1.10 (0.90,1.34), 0.348	1.05 (0.86,1.28), 0.664	1.07 (0.88,1.31), 0.484
Rural	1.23 (1.06,1.43), 0.006	1.15 (0.99,1.33), 0.068	1.15 (0.99,1.34), 0.065
Sleep duration (prolonged versus normal)			
Ethnicity, Han	1.02 (0.80,1.30), 0.869	1.00 (0.78,1.28), 0.992	1.02 (0.80,1.31), 0.890
Kazakh	0.92 (0.62,1.37), 0.669	0.90 (0.60,1.35), 0.158	0.87 (0.58,1.31), 0.514
Others	1.27 (0.79,2.02), 0.321	1.28 (0.75,1.92), 0.451	1.16 (0.72,1.87), 0.553
Regions, urban	1.29 (0.89,1.84), 0.178	1.25 (0.86,1.80), 0.233	1.21 (0.83,1.75), 0.324
Rural	0.99 (0.79,1.23), 0.897	0.96 (0.77,1.21), 0.751	0.94 (0.75,1.17), 0.559

Notes: Model 1 was adjusted for age and sex (sex was not for its stratification). Model 2 was further adjusted for education status, ethnicity (not for stratification), regions (not for stratification), marital status; cigarette use, alcohol use, physical activity.

Table 7 Logistic Regression for the Association Between Multimorbidity and Sleep Quality in Total and Gender-Specific Participants (or,95% CI, P)

	Unadjusted Model	Model 1	Model 2
Multimorbidity (No Versus Yes)			
Total	1.42 (1.28,1.57), 0.001	1.27 (1.15,1.42), 0.001	1.27 (1.15,1.42), 0.001
Men	1.27 (1.09,1.47), 0.002	1.25 (1.07,1.45), 0.004	1.26 (1.08,1.47), 0.003
Women	1.32 (1.13,1.53), 0.001	1.30 (1.12,1.51), 0.001	1.26 (1.09, 1.47), 0.002

Notes: Model 1 was adjusted for age and sex (sex was not for its stratification). Model 2 was further adjusted for education status, ethnicity, regions, marital status; cigarette use, alcohol use, physical activity; Reference category is good sleep quality.

Discussion

To our knowledge, this study is one of the few that have combined objective data to explore the relationship between multimorbidity and sleep quality in the elderly population from northwest China.

The main findings are as follows: First, a total of 66.80% of participants had multimorbidity, with a higher prevalence in women than in men. Second, participants with multimorbidity had a higher PSQI global score and a higher prevalence of poor sleep quality. Third, PSQI global scores and the prevalence of poor sleep quality increased with the number of multimorbidities, consistently for both genders. In addition, the presence of multimorbidity was associated with poor sleep quality, and there was a notable dose–response relationship between the number of multimorbidities and sleep quality, as well as abnormal sleep duration. Fourth, the presence of poor sleep quality was also associated with multimorbidity.

In terms of sleep characteristics, this study observed that poor sleep quality was prevalent among multimorbidity patients and that the prevalence of poor sleep quality and abnormal sleep duration increased with the number of multimorbidity. This may be due to the accumulation of disease-related symptoms and the use of multiple medications.[48] In addition, our study showed that women had higher PSQI scores, indicating poorer sleep quality and shorter sleep duration compared to men. These findings may be attributable to physiological differences between the sexes as well as specific factors such as postmenopausal estrogen decline, family responsibilities, economic contributions, and social roles.[49]

A study based on a representative sample from a region in northern Peru showed that multimorbidity was associated with poor sleep quality and prolonged sleep, but not with short sleep duration.[17] Data from CHARLS indicated that multimorbidity was linked to poor sleep quality and shorter sleep duration.[18] However, due to the reliance on self-reported multimorbidity information or the lack of multi-perspective assessment of sleep quality in these studies, there is potential bias in the results. Our study observed that the presence of multimorbidity is associated with poor sleep quality, and the risk of having poor sleep quality increased with the number of multimorbidities. This may be attributed to several factors, including chronic disease-related symptoms (eg, diabetes can lead to obstructive sleep apnea, nocturia, and disease-related pain), multiple medication-related adverse effects (eg, bronchodilators, beta-blockers, central nervous system stimulants, gastrointestinal drugs, and cardiovascular drugs have all been observed to exacerbate sleep problems), and disease-related mood disorders (eg, anxiety, depression), which may all impact sleep.[50] In addition, in analyzing the impact of multimorbidity on sleep quality, we observed that significant differences between different ethnic groups and regions. Han Chinese, as the main ethnic group in China, live all across China.[51] Kazakh population are not only widely distributed in Xinjiang, northwest China but also live in other countries such as Kazakhstan, Kyrgyzstan, Russia, and Mongolia,[52] since these ethnic groups share common cultural background, and lifestyles.[53] Therefore, our findings can be generalized to those populations with similar living environments and lifestyles.

In terms of sleep duration, the participants with 4 or ≥5 diseases were significantly associated with both shorter sleep duration. Only participants with ≥5 diseases were significantly associated with longer sleep duration. On the one hand, these results may be affected by sample size or biased by the subjective nature of participants self-reported sleep duration, which may be influenced by participants individual psychological states and other factors.[54] On the other hand, it is clear that as the cumulative number of multimorbidity increases, so does the burden of multimorbidity symptoms and functional impairments borne by the patients, which may lead to abnormalities in sleep duration, both as a result of the pain associated with the disease itself and as a result of the increased discomfort associated with certain body positions.[49]

We further analyzed and observed that poor sleep was associated with multimorbidity, suggesting a bidirectional association between multimorbidity and sleep quality. On the one hand, sleep disorders have been linked to abnormalities in various physiological markers, such as higher levels of C-reactive protein and interleukin-6, which are inflammation markers often present in populations with higher chronic disease accumulation.[50] On the other hand, sleep disorders have also been associated with impaired metabolic function.[55] Specifically, poor sleep quality enhances hypothalamic–pituitary–adrenal axis (HPA) axis responsiveness and is linked to elevated daytime cortisol levels. HPA axis hyperactivation is considered a key mechanism in the development of diabetes, cardiovascular disease, and neuropsychiatric disorders.[56] Conversely, multimorbidity can also contribute to sleep problems, creating a vicious circle where one condition exacerbates the other. Thus, sleep may be both a response to and a causative agent of disease. As sleep is a modifiable risk factor, we should focus on improving sleep disorders to break this cycle and promote health.

In this study, the prevalence of multimorbidity in the elderly population of Xinjiang was 63.46%, and this prevalence rate differed from that reported by Hongmei Wang et al.[26] The reason for this may be that their study was based on self-reporting only, which may have underestimated the true prevalence rate due to recall bias. It is consistent with previous studies that the prevalence of multimorbidity was higher in women than in men.[57] Differences in the prevalence of multimorbidity between men and women may be attributable to differences in physiological structure and function as well as psychosocial characteristics. Therefore, future strategies for the prevention of multimorbidity should consider gender specificity.

The study is strengthened by the larger sample, encompassing different living settings and several ethnic groups, and the findings can potentially be extrapolated to other regions with comparable conditions. However, there are several

limitations that should be kept in mind. First, this was a cross-sectional study, which prevented us from directly establishing causal and temporal associations between multimorbidity and sleep problems. However, supportive of current observation, longitudinal studies have shown a bidirectional association between sleep issues and multimorbidity,[18] thus lending credibility to our findings. Second, some chronic diseases, such as gastrointestinal disorders, were not encompassed within the multimorbidity (eg, monitoring methodology). Nevertheless, liver, gallbladder, and kidney diseases diagnosed through objective testing methods were included in this research. Third, sleep quality and duration were evaluated using PSQI scores rather than objective measures, PSQI scores are limited by individual self-report and recall bias, which may affect the accuracy of PSQI scores.[54] Therefore, it is crucial to introduce objective sleep assessments (eg, PSG, body movement recorder) in future studies to provide more accurate and comprehensive sleep data. Fourth, differences in PSQI scores between the two groups with and without multimorbidity may be influenced by some specific components of the PSQI (eg, sleep efficiency and soporific drug use). However, this is out of the scope of the current study; therefore, we did not perform specific analysis on this aspect. In addition, objective sleep assessment data may be suitable for this purpose.

Conclusion

There is a significant association between multimorbidity and poor sleep quality in older community dwellers, which may provide clues for disease prevention.

Ethics Approval and Consent to Participate

This study was conducted according to the guidelines laid down in the Declaration of Helsinki, and all procedures involving research study participants were approved by The Independent Ethics Committee of People's Hospital of Xinjiang Uygur Autonomous Region. Signed informed consent was obtained from all of the eligible participants.

Author Contributions

All authors made a significant contribution to the work reported, whether that is in the conception, study design, execution, acquisition of data, analysis and interpretation, or in all these areas; took part in drafting, revising or critically reviewing the article; gave final approval of the version to be published; have agreed on the journal to which the article has been submitted; and agree to be accountable for all aspects of the work.

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Disclosure

The authors declare no conflict of interest.

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