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Gender disparities in physical, psychological, and cognitive multimorbidity among elderly hypertensive populations in rural regions

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Abstract

Background The prevalence of gender disparities in physical, mental, and cognitive disorders among elderly hypertensive individuals in rural areas remains unclear. This study evaluates these disparities and the factors contributing to multimorbidity in this demographic.

Methods A face-to-face survey was conducted from July 1 to August 31, 2023, involving the hypertensive population registered with the National Basic Public Health Service Program in Jia County. Physical disorder was defined as having one or more self-reported chronic conditions other than hypertension. Participants experiencing anxiety or depression were as having a psychological disorder. The 9-item Patient Health Questionnaire (PHQ-9) was used to assess depression symptomatology, and anxiety symptoms were evaluated using the 7-item Generalized Anxiety Disorder questionnaire (GAD-7). Cognitive disorders were assessed using the Brief Mental Status Examination Scale (MMSE). Multifactorial logistic regression models were used to analyze factors affecting different disorder combinations in both genders. The net difference in multimorbidity prevalence between genders was determined using the propensity score matching (PSM).

Results Out of 18,447 hypertensive individuals aged 65 years and above (42.28% men), the prevalence of multimorbidity was 30.64% in men and 38.67% in women. Outcomes included seven categories: physical disorders, psychological disorders, cognitive disorders, and four different combinations of these disorders. The primary outcome was the presence of two or more disorders. The prevalence of physical, psychological, and cognitive disorders and their four combinations were higher in women than in men; Key factors influencing multimorbidity risk included subjective health status, illness duration, medication history, blood pressure control, and lifestyle behaviors in both men and women. Post-PSM analysis revealed that women had a 6.74% higher multimorbidity prevalence than men.

Conclusions Physical, psychological, and cognitive disorders, along with their various multimorbid combinations, significantly impact the elderly hypertensive population. Prioritizing a healthy lifestyle is essential to mitigate multimorbidity risks. Considering that the prevalence of multimorbidity is higher in women than in men with hypertension, sufficient sleep, maintaining a healthy waist circumference, and medication adherence are vital for managing blood pressure and reducing multimorbidity risks.

Keywords Hypertensive populations, Multimorbidity, Gender disparities

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Background

Elevated blood pressure has become the leading risk factor for death globally. Since 1990, the number of people with high blood pressure has doubled globally, from 650 million in 1990 to 1.3 billion in 2019 [1]. Hypertension combined with its frequent co-occurrence with various physical, psychological, and cognitive disorders due to accelerated aging and improving economic standards, has become a significant global public health issue [2–4]. The development of multiple diseases in hypertensive populations increases the risk of premature death, loss of physical function, polypharmacy and deterioration in the quality of life, resulting in a heavy economic burden on patients, families, health-care systems and countries [5].

Globally, numerous countries have incorporated hypertension management into their basic public health services at the national level, and have invested significant amounts of health human, material, and financial resources in the prevention, control, and treatment of hypertension [6]. However, despite heightened awareness of the compounded burden of hypertension and other diseases in rural areas, healthcare services often remain single-disease oriented. Consequently, the incidence of multimorbidity within hypertensive population, especially in rural settings, has not shown a significant decline [7].

According to the World Health Organization's Global Report on Hypertension, approximately 33% of adults aged 30 to 79 years worldwide have hypertension, with the adult age-adjusted prevalence of hypertension being marginally higher in men (34%) compared to women (32%) in 2019 [8]. It is important to highlight that there are notable differences in the prevalence of hypertension between men and women across various age groups. Women's blood pressure exhibits a more rapid increase as they age. Beginning around the age of 50, women's blood pressure levels align with those of men but do not surpass them. However, at approximately 60 years of age, the incidence of hypertension escalates more rapidly in women compared to men, and hypertension management tends to be less effective in this demographic [9]. Gender disparities are evident in the comorbidity of hypertension with physical, psychological, and cognitive disorders. For instance, the co-occurrence of hypertension with stroke and heart failure shows gender-specific patterns [10]. Another study showed that mid-adulthood hypertension increased the risk of dementia in women, but no such association was observed among men [11]. Despite this, research has predominantly concentrated on single-disease gender disparities within hypertensive populations. There is a scarcity of studies addressing the gender-specific multimorbidity of physical, psychological, and cognitive disorders, complicating the assessment and prevention of hypertension's compounded effects [12]. This lack of data is particularly acute in rural areas, where medical resources are limited and chronic disease management is less developed, leading to a dearth of evidence on gender disparities in hypertensive comorbidities [13]. This evidence gap obstructs the delivery of tailored, precise guidance and comprehensive interventions for hypertensive individuals. Given that gender is an independent and important influence on many disease outcomes, including hypertension, this study aimed to investigate gender disparities in physical-psychological-cognition multimorbidity in a rural elderly population with essential hypertension.

Methods

Procedures and study participants

From July 1 to August 31, 2023, we conducted a cross-sectional survey in Jia County, Henan Province (one of the national demonstration areas for comprehensive prevention and control of chronic diseases). We conducted the survey simultaneously in batches, centered on the townships, with villages or communities as the units, covering 377 villages or communities across 15 townships in Jia County. Our research team consists of 70 highly trained students with a background in public health and 4–5 professional public health personnels from each township. During the survey, each of the 377 villages or communities dispatched 1 to 2 general practitioners to assist throughout the investigation. Quality control personnel regularly conduct quality control check on the questionnaire to ensure the reliability and validity of the collected data. These examinations included a random examination of questionnaire records and a feedback session with the assessment team. Utilizing whole cluster sampling, we assessed hypertensive individuals aged 65 and above registered under the National Basic Public Health Hypertension Management program. Participants gave written informed consent, answered an interview questionnaire, and underwent a physical examination by trained health personnel. Exclusion criteria included: (1) self-reported absence of hypertension ($N=2416$), and (2) indeterminate physical, psychological, and cognitive status ($N=516$). Finally, 18,447 participants were included in this study. The inclusion exclusion criteria are depicted in Fig. 1.

Assessments

Assessment of covariates

A structured questionnaire was used to collect information through face-to-face interviews, namely (1) basic demographic characteristics: sex, age, household registration, education level, marital status, occupation, annual household income, and self-reported health status; (2) disease status: duration of the disease, history

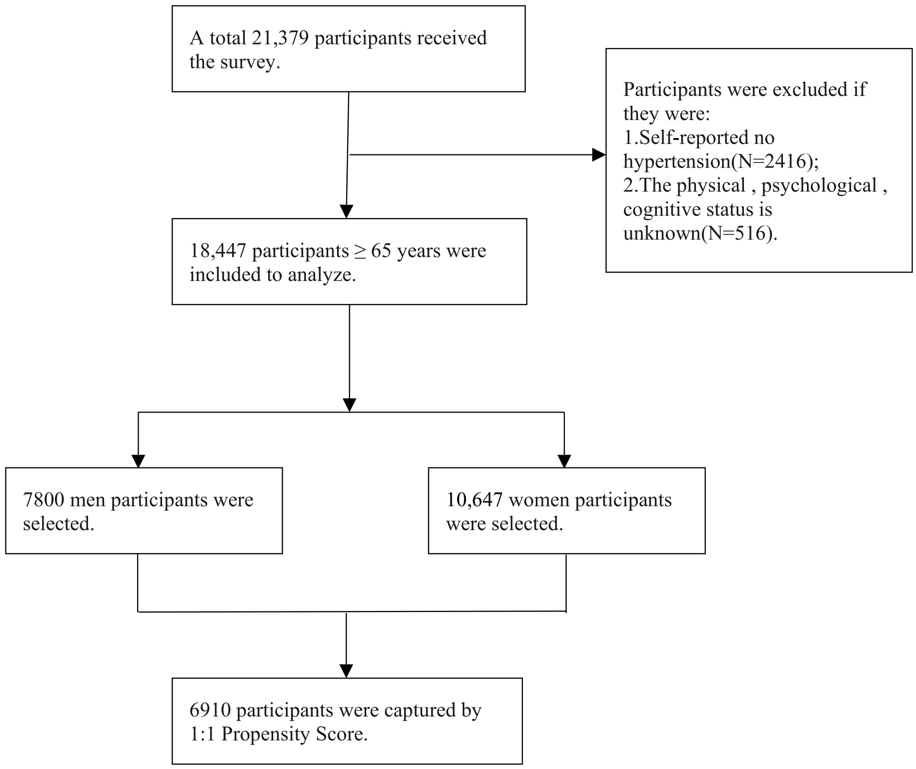


Fig. 1 The flowchart of participants selection of this study

of medication use, medication adherence, and blood pressure; (3) physical examination indicators: height, weight, and waist circumference(WC). The process of blood pressure measurement was standardized and performed by professional public health personnels using a standard Omicron electronic sphygmomanometer. Participants were required to rest in a sitting position for at least 5 min before blood pressure was measured 3 times at 1-min intervals by a professional public health personnel. The measurement error did not exceed 10 mmHg, and the mean of three measurements was used to define blood pressure level [14]. Participants were instructed to remove any accessories and outer layers of clothing such as hats, coats, or jackets during height and weight measurements. Weight and WC measurements were taken in a fasting state. WC was measured at a level 1 cm above the upper edge of the navel. Each measurement was repeated three times, and the average value was calculated. BMI was calculated as weight in kilograms divided by squared height in meters (kg/m^2) [15]; (4) Lifestyle indicators: sleep duration, physical activity, sedentary behavior, dietary habits, smoking status, alcohol consumption status, and leisure-time physical activity(LTPA); (5) Outcome indicators: anxiety, depression, and cognitive status.

People who have never smoked are considered low-risk [15]. For alcohol consumption, a low-risk group is defined as a person who has never consumed alcohol. According to the World Health Organization guidelines on physical activity, for substantial health benefits, healthy physical activity was defined as at least 150 min of moderate-intensity activity or 75 min of higher-intensity activity or an equivalent combination per week [16]. Dietary habits were assessed using the Dietary Frequency Quotient (FFQ), which collects the frequency of intake of each food (none or very little, several times a month, 1–3 times a week, 4–6 days a week, daily) for each participant over the past 12 months. Twelve (12) major food items in the FFQ (omnivorous grains, legumes, vegetables, fruits, dairy products, nuts, fish, poultry, red meat, fried foods, preserved foods, and sugary drinks) were used to create diet quality scores based on the Chinese Dietary Guidelines. For fruits and vegetables, one point was assigned if they were consumed more than three times per week; for mixed grains, legumes, nuts, dairy products, poultry, and fish, one point was assigned if they were consumed at least once per week, respectively; for red meat, one point was assigned if it was consumed less than once per week; and for preserved foods, fried foods, and sugar-sweetened beverages, one point was assigned if they were not consumed or consumed less than once per month, respectively. If the frequency of intake did not meet the corresponding criteria above, 0 points were assigned to each food. Thus, subjects' diet quality scores ranged from 0 to 12. A healthy diet was defined as a quality score of 7 and above (median), otherwise it was regarded as unhealthy diet [17]. Healthy sleep duration was defined as 7–8 h per day [18]. Healthy sedentary behavior was defined as less than 4 h per day [19]. According to the question "Are you currently engaged in/participating in any of the following activities? (housework, outdoor activities, planting flowers and keeping pets, reading books and newspapers, raising poultry and livestock, playing cards or mahjong, etc., watching TV and listening to the radio, participating in organized social activities, and how many times have you traveled in the past two years), and the frequency of each activity option (1, no; 2, sometimes; 3, at least once a month; 4, at least once a week; and 5, almost every day) was assigned a value of 1–5 points in turn". Then the scores of the 9 activities were summed up, and scores of 19 and above (median) were regarded as healthy leisure and physical activities and assigned a score of 1. Otherwise, they were regarded as unhealthy leisure and physical activities and assigned a score of 0 [20].

Outcomes

The outcome was physical, psychological, and cognitive disorders and their multimorbidity. There were seven outcomes: physical disorder, psychological disorder, cognitive disorder, physical-psychological multimorbidity (P-Ps), physical-cognitive multimorbidity (P–C), psychological-cognitive multimorbidity (Ps-C), and physical-psychological-cognitive multimorbidity (P-Ps-C), with the primary endpoints being people with two or more of the physical, psychological, and cognitive disorders. Because the survey population was exclusively self-reported and hypertensive as indicated in public health databases, physical disease in this study was identified as having a physical disease if the participant, in addition to hypertension, had at least one of the following self-reported nine chronic diseases of hypertension: coronary artery disease (coronary artery disease, angina pectoris, myocardial infarction, myocardial ischemia), chronic kidney disease, heart failure, chronic obstructive pulmonary disease, diabetes, fatty liver, stroke, dyslipidemia, and rheumatoid arthritis [21, 22]. Participants experiencing anxiety or depression were as having a psychological disorder. Psychological disorders were determined by study-specific psychological assessments (PHQ-9 and GAD-7). A combined score of greater than 4 on the respective PHQ-9 and GAD-7 entries was considered to have a psychological disorder [23]. Cognitive disorders were assessed using the Brief Mental Status Examination Scale (MMSE), which provides a comprehensive, accurate, and rapid reflection of the subject's mental status and the degree of cognitive deficits. A total of 30 items were assessed, with each correct answer scoring 1 point, and incorrect or unknown answers scoring 0. The total score of the scale ranged from 0–30 points. The total score of the scale ranges from 0 to 30. The score of the test is closely related to the literacy level, and the normal cut-off value is as follows: illiterate > 17 points, elementary school > 20 points, junior high school and above > 24 points [24]. 0 points are scored as cognitively normal, and 1 point is scored as cognitive abnormality.

Statistical analysis

Normally distributed continuous variables were expressed as mean and standard deviation (SD), and non-normally distributed continuous variables were expressed as median and interquartile spacing (IQR), and normality was tested by the Kolmogorov–Smirnov test. The distribution of categorical variables was expressed as frequencies and percentages. The χ^2 test (for categorical variables) and Wilcoxon rank sum test (for continuous variables) were used to test for disparities in the prevalence of physical, mental, and cognitive disorders, as well as their multimorbidity, between groups of men and women participants. Logistic regression analysis was used to test the correlates associated with physical, mental, and cognitive disorders as well as their multimorbidity. Univariate and multivariate logistic regression analyses were conducted separately for man and women participants. The propensity score matching (PSM) was used to minimize potential confounding bias [25]. A one-to-one nearest neighbor matching algorithm was applied with a caliper value of 0.03 in our study. Probit regression models were used to estimate propensity scores for men versus women participants. Finally, 6910 participants out of 18,447 were matched 1:1. Statistical analyses were performed using STATA 17.0 and R 4.3.2, considering *P*-values less than 0.05 as statistically significant.

Results

Prevalence of multimorbidity and characteristics among men and women participants

In this study of 18,447 elderly hypertensive individuals (age ≥ 65 years), women constituted 57.72% and men 42.28%. The prevalence of multimorbidity was 38.67% (95% CI: 37.75–39.60) in women and 30.64% (95% CI: 29.06–31.09) in men. Women also had higher rates of physical, psychological, and cognitive disorders as well as multimorbidity (Fig. 2). Illness duration, dietary status, subjective health status, sedentary time, and physical activity were significantly different (all $P < 0.05$) in physical, psychological, and cognitive disorders as well as their

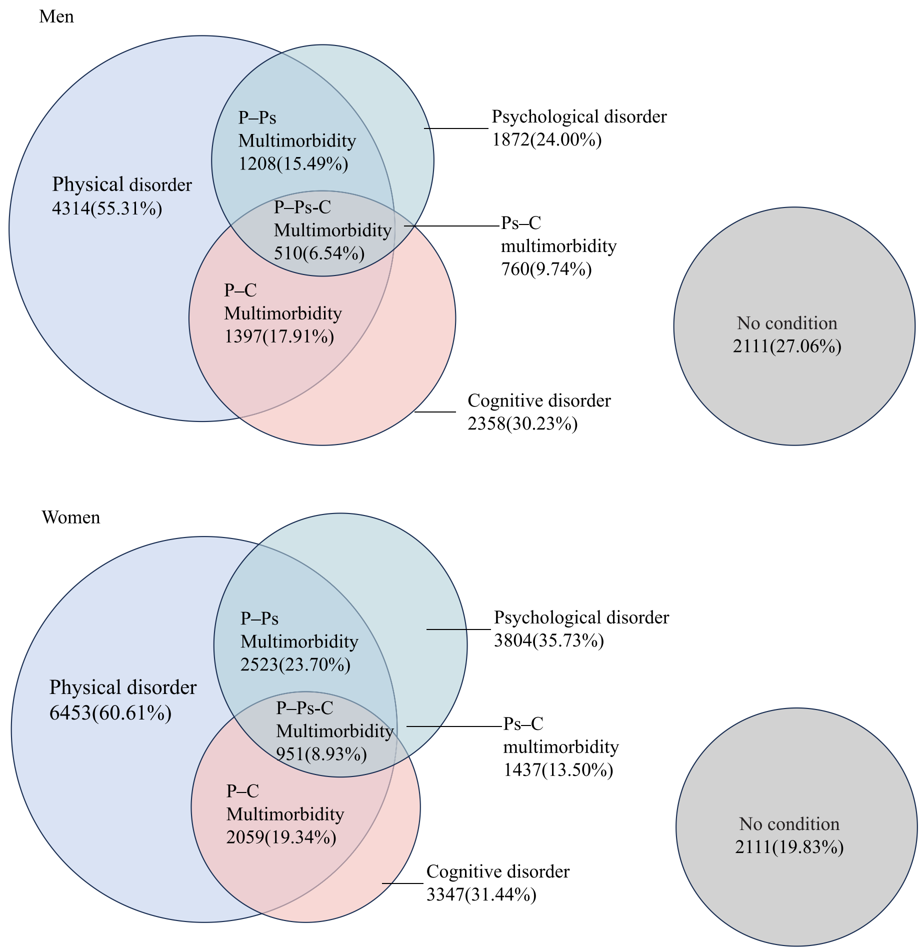


Fig. 2 Proportional Venn diagram of the prevalence of different comorbidity patterns in men and women

multimorbidity patterns between men and women. Furthermore, the rate of blood pressure control failure was higher in women than in men (63.09% vs. 59.88%). The prevalence of overweight was slightly higher in women than in men (59.64% vs. 56.21%). In terms of the duration of hypertension exceeding 16 years, the proportion of women with hypertension was significantly higher than that of men (25.13% vs. 19.99%)(Table 1). For more details, refer to the supplementary file Table S1-S5.

Factors influencing Comorbidity prevalence among men and women participants

After adjusting for potential confounding variables, we found that taking hypertension medication (men: aOR = 1.59, 95% CI [1.32–1.92], $P < 0.001$; women: aOR = 1.33, 95%CI [1.14–1.56], $P < 0.001$), longer duration of hypertension (men: 6–15 years: aOR = 1.42, 95% CI [1.32–1.92], $P < 0.001$; ≥ 16 years: aOR = 1.36, 95% CI [1.18–1.58]; women: 6–15 years: aOR = 1.30, 95% CI [1.18–1.44], $P < 0.001$; ≥ 16 years: aOR = 1.45, 95% CI [1.29–1.62], $P < 0.001$) increased the risk of multimorbidity for both men and women with hypertension. Healthy diet (men: aOR = 0.82, 95%CI [0.73–0.93], $P < 0.001$; women: aOR = 0.91, 95%CI [0.83–1.00], P = 0.042), Sufficient sleep duration (men: aOR = 0.77, 95%CI [0.70–0.86], $P < 0.001$; women: aOR = 0.75, 95%CI [0.69–0.81], $P < 0.001$), ideal physical activity (men: aOR = 0.67, 95%CI [0.59–0.74], $P < 0.001$; women: aOR = 0.75, 95%CI [0.68–0.82], $P < 0.001$) reduced the risk of multimorbidity in both men and women with hypertension. However, in women hypertensive populations, suboptimal waist circumference(aOR = 1.14, 95% CI [1.03–1.26], $P = 0.013$) and substandard blood pressure (> 130/80 mmHg) (aOR = 1.17, 95% CI [1.08–1.28], $P < 0.001$)increased the risk of multimorbidity (Fig. 3).

For the men hypertensive population, ideal sedentary behavior decreased the risk of developing P-Ps-C multimorbidity (aOR = 0.77, 95% CI [0.62–0.94], $P = 0.012$), non-farmers increased the risk of P–C multimorbidity (aOR = 1.15, 95%CI [1.01–1.31], $P = 0.039$), and healthy

Table 1 Characteristics of the hypertensive participants in relation to the multimorbidity prevalence

Variables	Total(%)	$P^{(a)}$	Men			Women		
			Number of participants (%)	Prevalence of comorbidity (95%CI)	$P^{(b)}$	Number of participants (%)	Prevalence of comorbidity (95%CI)	$P^{(c)}$
All participants	18,447 (100.00)		7800(42.28)	30.64 (29.06-31.09)		10,647(57.72)	38.67 (37.75-39.60)	
Age		<0.001			0.004			0.009
65-79	15,810 (85.70)		6731 (86.29)	29.46 (28.37-30.57)		9079 (85.27)	38.15 (37.15-39.16)	
≥80	2637 (14.30)		1069 (13.71)	33.86 (31.03-36.79)		1568 (14.73)	41.65 (39.19-44.13)	
Household registration		<0.001			<0.001			0.058
Urban	406 (2.20)		210 (2.69)	19.52 (14.39-25.54)		196 (1.84)	32.14 (25.67-39.17)	
Rural	18,041 (97.80)		7590 (97.31)	30.36 (29.32-31.40)		10451 (98.16)	38.79 (37.85-39.73)	
Marital status		0.042			0.064			0.805
Married	13,235 (71.75)		5983 (76.71)	29.53 (28.38-30.71)		7252 (68.11)	38.75 (37.62-39.88)	
Others	5212 (28.25)		1817 (23.29)	31.81 (29.67-34.01)		3395 (31.89)	38.50 (36.86-40.16)	
Occupation		0.215			0.425			0.910
Farmer	11,945 (64.75)		5289 (67.81)	29.78 (28.55-31.03)		6656 (62.52)	38.63 (37.45-39.81)	
Non-farmer	6502 (35.25)		2511 (32.19)	30.67 (28.87-32.51)		3991 (37.48)	38.74 (37.22-40.27)	
Distance		<0.001			0.002			0.001
<100	13,319 (72.20)		5669 (72.68)	29.00 (27.82-30.20)		7650 (71.85)	37.70 (36.61-38.80)	
100-300	2695 (14.61)		1131 (14.50)	34.04 (31.28-36.89)		1564 (14.69)	42.58 (40.12-45.08)	
>300	2433 (13.19)		1000 (12.82)	31.60 (28.73-34.58)		1433 (13.46)	39.57 (37.02-42.15)	
Self-reported health status (EQ-5D)	75(60.00,80.00)	<0.001	80.00 (65.00, 80.00)	70.00 (60.00, 80.00)	<0.001	70.00 (60.00, 80.00)	70.00 (60.00, 80.00)	<0.001
Medication for hypertension		<0.001			<0.001			<0.001
No	1799 (9.75)		862 (11.05)	19.61 (17.00-22.42)		937 (8.80)	29.56 (26.66-32.60)	
Yes	16,648 (90.25)		6938 (88.95)	31.36 (30.27-32.47)		9710 (91.20)	39.55 (38.57-40.53)	
Duration of hypertension		<0.001			<0.001			<0.001
0-5 years	5867 (31.80)		2719 (34.86)	24.31 (22.71-25.97)		3148 (29.57)	32.05 (30.42-33.71)	
6-15 years	8345 (45.24)		3522 (45.15)	33.30 (31.75-34.89)		4823 (45.30)	40.35 (38.96-41.75)	
≥16 years	4235 (22.96)		1559 (19.99)	32.78 (30.45-35.17)		2676 (25.13)	43.42 (41.53-45.33)	
WC		0.040			0.007			0.015
Good	7595 (41.17)		3936 (50.46)	31.45 (30.00-32.93)		3659 (34.37)	37.09 (35.52-38.68)	
Poor	10,852 (58.83)		3864 (49.54)	28.65 (27.23-30.10)		6988 (65.63)	39.50 (38.35-40.65)	
Hypertension		<0.001			0.321			0.001
Normal	7,059 (38.30)		3129 (40.12)	29.43 (27.84-31.07)		3930 (36.91)	36.67 (35.16-38.20)	

Table 1 (continued)

Variables	Total(%)	P(a)	Men			Women		
			Number of participants (%)	Prevalence of comorbidity (95%CI)	P(b)	Number of participants (%)	Prevalence of comorbidity (95%CI)	P(c)
Abnormal	11,388 (61.70)		4671 (59.88)	30.49 (29.17-31.83)		6717 (63.09)	39.84 (38.67-41.02)	
Diet quality		<0.001			<0.001			0.002
Unhealthy	13,101 (71.02)		5653 (72.47)	31.38 (30.17-32.61)		7448 (69.95)	39.65 (38.53-40.77)	
Healthy	5346 (28.98)		2147 (27.53)	26.60 (24.74-28.52)		3199 (30.05)	36.39 (34.72-38.08)	
Sleep duration		<0.001			<0.001			<0.001
Unhealthy	7083 (38.40)		2824 (36.21)	35.09 (33.33-36.88)		4259 (40.00)	44.07 (42.57-45.58)	
Healthy	11364 (61.60)		4976 (63.79)	27.21 (25.98-28.47)		6388 (60.00)	35.07 (33.89-36.25)	
Smoking		<0.001			0.960			0.390
Smoker	4508 (24.44)		4374 (56.08)	30.09 (28.73-31.47)		134 (1.26)	35.07 (27.04-43.79)	
Non-smoker	13939 (75.56)		3426 (43.92)	30.04 (28.50-31.60)		10513 (98.74)	38.71 (37.78-39.65)	
Alcohol drinking		<0.001			<0.001			0.177
Drinker	783 (4.24)		738 (9.46)	22.49 (19.53-25.68)		45 (0.42)	28.89 (16.37-44.31)	
Non-drinker	17,664 (95.76)		7062 (90.54)	30.86 (29.78-31.95)		10602 (99.58)	38.71 (37.78-39.64)	
Sedentary time		<0.001			<0.001			<0.001
Unhealthy	11,142 (60.40)		4642 (59.51)	33.02 (31.67-34.40)		6500 (61.05)	41.40 (40.20-42.61)	
Healthy	7305 (39.60)		3158 (40.49)	25.71 (24.20-27.27)		4147 (38.95)	34.39 (32.94-35.85)	
physical activity		<0.001			<0.001			<0.001
Non-ideal	5252 (28.47)		2532 (32.46)	39.93 (38.01-41.87)		2720 (25.55)	47.28 (45.39-49.18)	
Ideal	13,195 (71.53)		5268 (67.54)	25.32 (24.15-26.52)		7927 (74.45)	35.71 (34.66-36.78)	
LTPA		<0.001			<0.001			<0.001
Non-ideal	8451 (45.81)		3660 (46.92)	35.30 (33.75-36.87)		4791 (45.00)	43.35 (41.94-44.77)	
Ideal	9996 (54.19)		4140 (53.08)	25.43 (24.11-26.79)		5856 (55.00)	34.84 (33.62-36.07)	

CI Confidence interval, *LTPA* Leisure-time physical activity, *WC* Waist circumference; EQ-5D, EuroQol five dimensions questionnaire. (a) Differences between categories within each variable in total samples. (b) Differences between categories within each variable in men samples. (c) Differences between categories within each variable in women samples

diet, never smoking reduced the risk of P-Ps multimorbidity (aOR = 0.83, 95%CI[0.71–0.96], $P = 0.014$; aOR = 0.84, 95%CI[0.73–0.96]); and suboptimal waist circumference increased the risk of physical disease, and P–C multimorbidity in women with high blood pressure (aOR = 1.16, 95%CI [1.03- 1.32], $P = 0.018$), with no association in the men hypertensive population (Fig. 3). Adherence to a variety of healthy lifestyle practices correlated with a lower risk of cognitive disorders and all forms of multimorbidity in the elderly hypertensive population, regardless of gender (All $P < 0.05$)(Fig. 4).

Propensity score matching analysis

From the initial 18,447 hypertensive participants, 6910 samples were matched using PSM. After PSM for household registration, marital status, smoking, alcohol drinking, WC, no statistically significant discrepancies could be discerned between the men and women participants

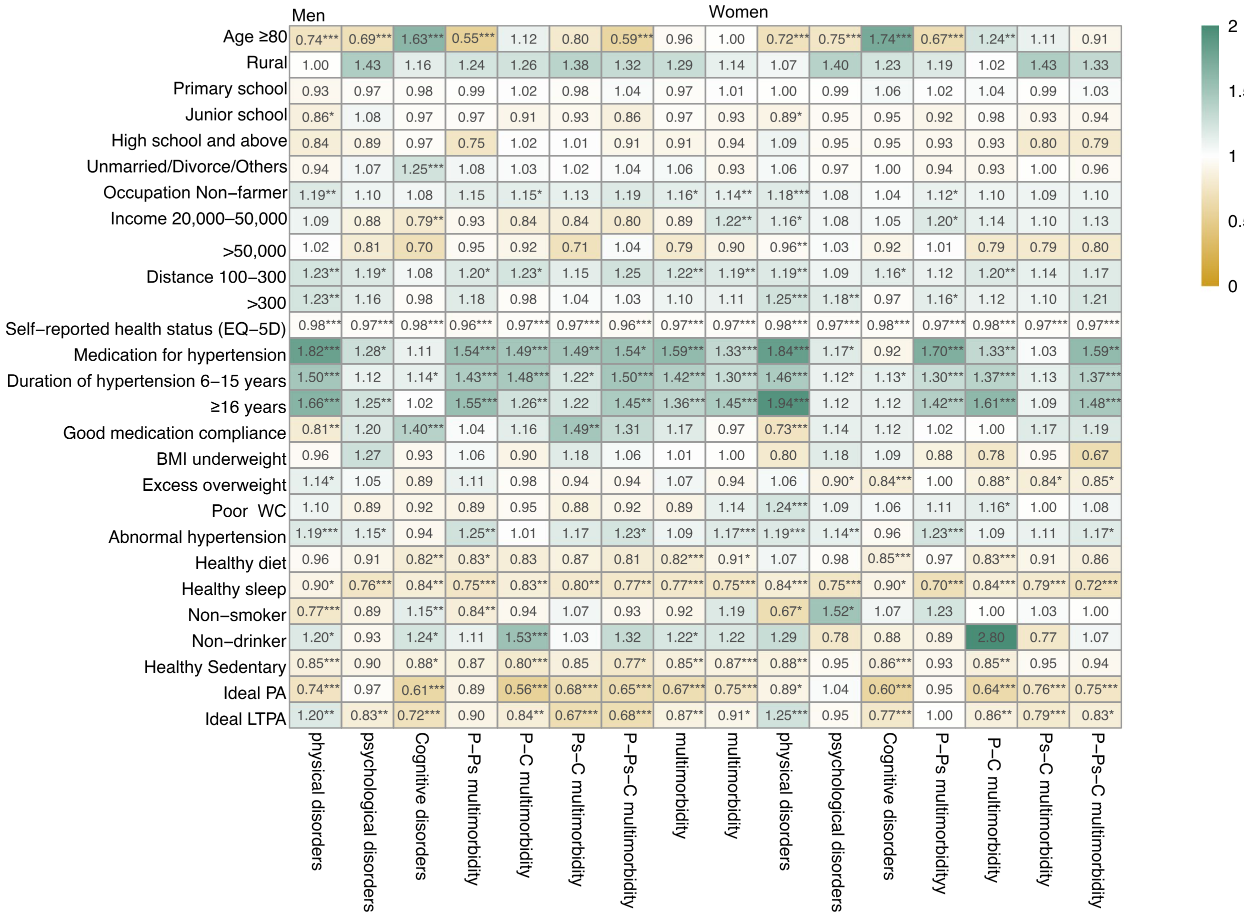


Fig. 3 Heat maps based on the associations of influencing factors with the outcomes

in all covariates (all $P > 0.05$) (balance test and common support domain of PSM for men and women samples are shown in Additional file: Table S12 and Fig.S1, respectively). Based on the balanced samples, the difference in multimorbidity prevalence among men and women participants is shown in Fig. 5, which illustrates that the prevalence of multimorbidity prevalence among women participants (37.13%,95%CI[35.54–38.76]) was still higher than that among men participants (30.39%, 95%CI [28.88–31.95]) by 6.74% ($P < 0.05$). Additionally, we found that the prevalence of multimorbidity was higher in women than in men in different age groups(Fig. 6).

Discussion

The prevalence of multimorbidity in the surveyed population was 35.03%, with 30.64% prevalence of multimorbidity in the men hypertensive population and 38.67% prevalence of multimorbidity in the women hypertensive population. After propensity-matched scores, the prevalence of physical, psychological, and cognitive disorders as well as multimorbidity remained higher in women participants than in men, where the difference in the prevalence of multimorbidity was 6.74%.

In the current study, we found that the prevalence of multimorbidity was higher in women than in men and the difference in prevalence of multimorbidity was 6.74%. Many previous studies are consistent with our findings, and a cross-sectional study from the United Kingdom showed a higher prevalence of multiple disorders in women, most notably in physical-psychological multimorbidity [26]. Another systematic evaluation study showed that gender disparities in multimorbidity were also observed in the general population, with a higher prevalence of multimorbidity in women than in men [27]. Another network-based study also revealed a significantly higher prevalence of multimorbidity, such as primary hypertension and cerebral infarction, in women with T2DM. The study found that women have a higher prevalence of multimorbid conditions, including essential hypertension and cerebral infarction, compared to men. Additionally, women exhibit a more complex network of multimorbidity and stronger interrelated

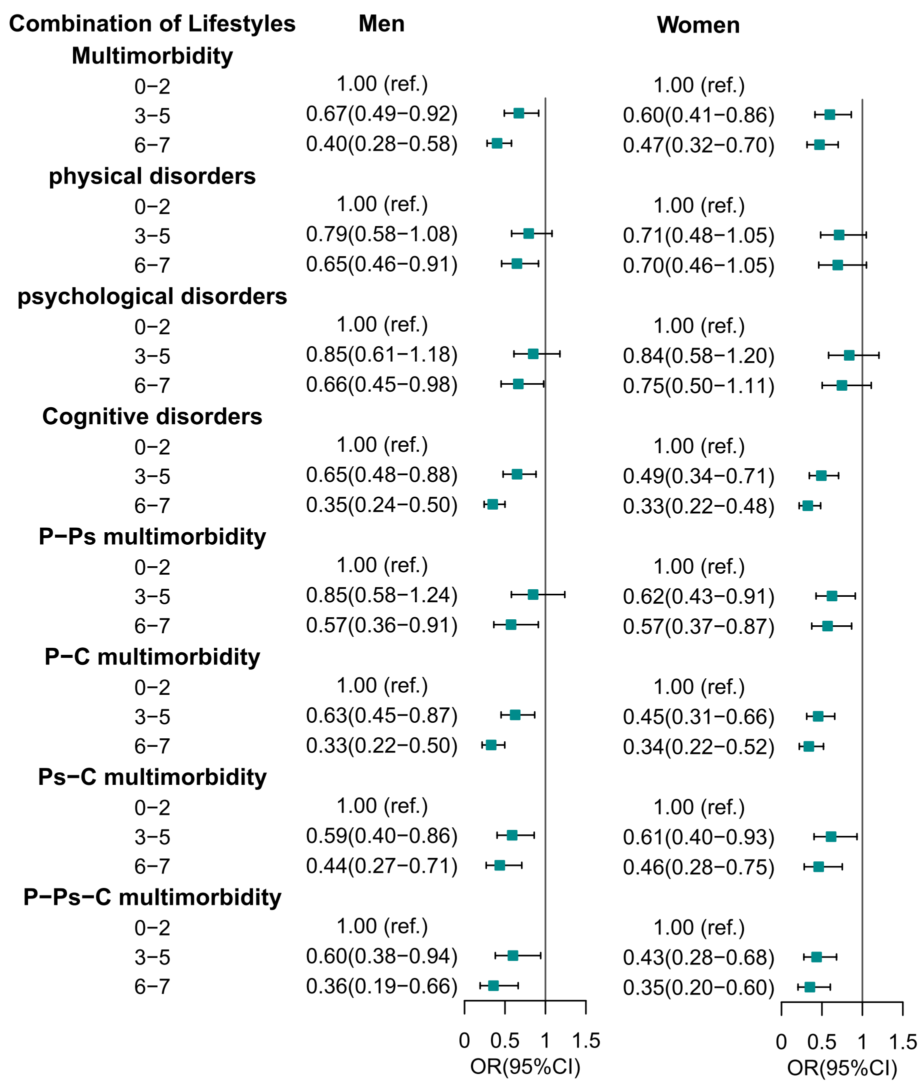
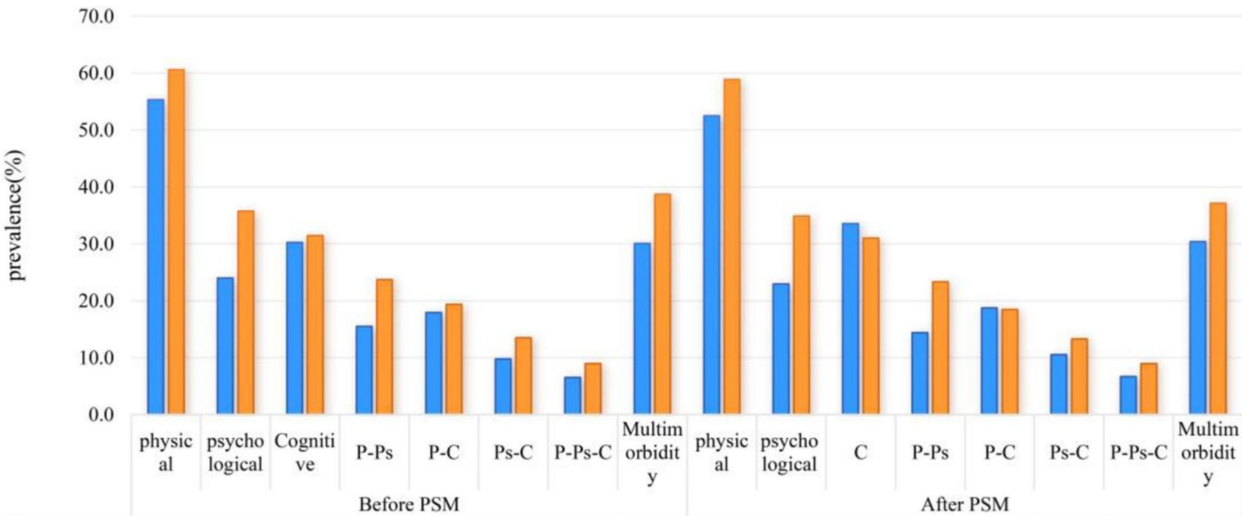


Fig. 4 Forest map based on the associations of the combination of lifestyles with the outcomes

psychiatric disorders than men [28]. Possible explanations for the disparities in the prevalence of multimorbidity between men and women may be that our findings show that with age, women have more complex blood pressures compared to men and lose their preventive and control advantage of blood pressure, have lower rates of blood pressure control (systolic BP ≥ 130 mmHg and/or diastolic BP ≥ 80 mmHg), and are at increased risk of developing multimorbidity [29]. At the same time, the use of antihypertensive drugs is a risk factor for different multimorbidity in men and women, but the prevalence of multimorbidity was higher in women participants taking antihypertensive drugs than in men due to disparities in physiological characteristics.

The current study found strong correlations between modifiable lifestyles (diet, sleep duration, sedentary behavior, physical activity, and leisure physical activity) and different patterns of multimorbidity among men and women participants in terms of physical, psychological, and cognitive disorders. And we found that the greater the variety of healthy lifestyles adhered to, the lower the risk of different combinations of multimorbidity, in addition to physical disorders and cognitive disorders, and that the results of the present study are in line with previous studies in different populations with physical disorders, psychological disorders, and cognitive disorders [30–32]. However, the strength of the association between different various lifestyles and the risk of developing multimorbidity differs between men and women. Moderate physical activity reduces the risk of P-Ps-C multimorbidity and is more protective in men. This may be due to the fact that men have a significantly higher metabolic rate during aerobic exercise compared to women, allowing them to achieve



	physical	psychological	Cognitive	P-Ps	P-C	Ps-C	P-Ps-C	Multimorbidity	physical	psychological	C	P-Ps	P-C	Ps-C	P-Ps-C	Multimorbidity
	Before PSM								After PSM							
Men(%)	55.31	24.00	30.23	15.49	17.91	9.74	6.54	30.06	52.50	22.92	33.52	14.41	18.76	10.54	6.66	30.39
Women(%)	60.61	35.73	31.44	23.70	19.34	13.50	8.93	38.67	58.87	34.88	31.03	23.33	18.44	13.31	8.97	37.13

Fig. 5 The prevalence of the outcomes between men and women populations pre- and post-PSM

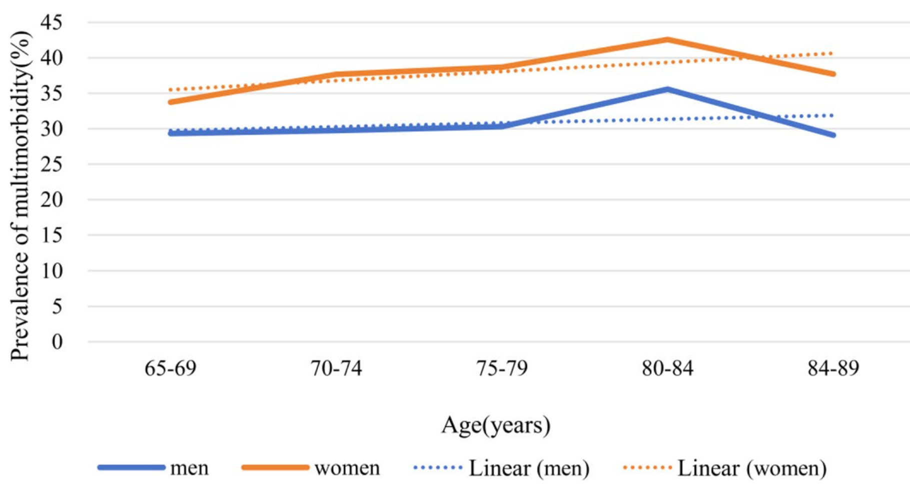


Fig. 6 The prevalence of multimorbidity in different age groups between men and women populations post-PSM

substantial health benefits with the same level of physical activity [33–35]. Healthy diet and sleep duration were associated with reduced risk of P-Ps multimorbidity in men, but in the P-Ps multimorbidity model, only healthy sleep duration was associated with reduced risk of P-Ps multimorbidity in women [36, 37]. The possible reason is that men may derive more combined benefits from a healthy diet and adequate sleep, while women may rely more on adequate sleep to regulate mood and cope with stress.

Overall, the findings of this study provide a basis for optimizing public health programs in underdeveloped areas and have important implications for public health policy and planning [38]. It is important to introduce targeted interventions to prevent physical, psychological and cognitive disorders as well as multimorbidity in older hypertensive populations.

Strengths and weaknesses of the study

First, one of the National Comprehensive Primary Health Care Experimental Areas in China was used as the investigation site, and all elderly hypertensive populations in the experimental area were investigated, resulting in a large sample containing 18,447 elderly hypertensive populations, which ensured the reliability of our study; second, our study took into account the different impacts on the physical, psychological, and cognitive disorders of the hypertensive population, which provided a basis for assessing the gender differences between different patterns of multimorbidity has a non-negligible role.

There are some limitations to this study. First, the data on physical, psychological, and cognitive disorders used in this study were self-reported by the respondents, which may introduce recall bias and subjective bias, potentially overlooking undiagnosed conditions. However, it is worth noting that previous studies have shown a high correlation between self-reported histories of physical disorders and electronic health records. Secondly, there are many factors that influence gender disparities in physical, psychological, and cognitive disorders as well as multimorbidity, and although PSM was used in this study to avoid the effects of some confounding variables, it is still not comprehensive enough.

Conclusions

The findings of this study suggest that older women hypertensive populations have a higher prevalence of physical, psychological, and cognitive disorders as well as multimorbidity compared to men. Women with hypertension should ensure they get enough sleep, maintain a healthy waist circumference, and adhere to their antihypertensive medications regimen to control their blood pressure status and reduce the risk of multimorbidity. A healthy lifestyle is protective in reducing the risk of multimorbidity in both older men and women with hypertension. The results of this study support the prioritization of good lifestyle practices through personalized, comprehensive public health and medical initiatives to reduce the risk of multimorbidity in older hypertensive populations.

Supplementary Information

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Supplementary Material 1.

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Authors' contributions

Y.M. and J.Z. conceived, designed and supervised the study; Z.S., D.Z., J.B., R.R., J.Z. M.Z., J.C., J.Z., X.L. and D.G. participated in data collection. Y.M., J.Z., Y.F., J.W., W.D and Z.S. reviewed and revised the manuscript. All authors read and approved the final manuscript.

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Data availability

No datasets were generated or analysed during the current study.

Declarations

Ethical approval and consent to participate

The study complied with the Declaration of Helsinki. Participants were informed of the benefits and risks of participating in this study, and they provided informed consent. All data were used merely for research purposes. Approval for the study was obtained from the Medical Ethics Committee of Zhengzhou University (Approval number: 2023–318).

Competing interests

The authors declare no competing interests.

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