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ORIGINAL RESEARCH

Sex Differences in the Associations Between Chronic Diseases and Insomnia Symptoms Among Older Adults in India

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Background: Sleep problems are a critical issue in the aging population, affecting quality of life, cognitive efficiency, and contributing to adverse health outcomes. The coexistence of multiple diseases is common among older adults, particularly women. This study examines the associations between specific chronic diseases, multimorbidity, and insomnia symptoms among older Indian men and women, with a focus on the interaction of sex in these associations.

Methods: Data were drawn from 31,464 individuals aged 60 and older in the Longitudinal Ageing Study in India, Wave-1 (2017–18). Insomnia symptoms were assessed using four questions adapted from the Jenkins Sleep Scale (JSS-4), covering difficulty falling asleep, waking up, waking too early, and feeling unrested during the day. Multivariable logistic regression models, stratified by sex, were used to analyze the associations between chronic diseases and insomnia symptoms.

Results: Older women had a higher prevalence of insomnia symptoms than men (44.73% vs 37.15%). Hypertension was associated with higher odds of insomnia in both men (AOR: 1.20) and women (AOR: 1.36). Women with diabetes had lower odds of insomnia (AOR: 0.80), while this association was not significant in men. Neurological or psychiatric disorders, stroke, and bone and joint diseases were linked to higher odds of insomnia in both sexes. Chronic lung disease was associated with insomnia in men (AOR: 1.65), but not in women. Additionally, having three or more chronic diseases significantly increased the odds of insomnia in both men (AOR: 2.43) and women (AOR: 2.01).

Conclusion: Hypertension, bone and joint diseases, lung diseases, stroke, neurological or psychiatric disorders, and multimorbidity are linked to insomnia symptoms in older Indian adults. Disease-specific management and routine insomnia screening are crucial for promoting healthy aging in this vulnerable population.

Keywords: chronic conditions, India, insomnia symptoms, multimorbidity

Introduction

The prevalence of sleep complaints and multimorbidity increases with aging.[1,2] Sufficient rest plays a crucial role in promoting the holistic wellbeing of the broader community, encompassing physical, social, and mental dimensions of health.[3] However, the swiftly expanding elderly demographic in low- and middle-income countries (LMICs) including India, coupled with a notable incidence of non-communicable diseases (NCDs) and symptoms of insomnia, presents an escalating obstacle for policymakers and researchers. This trend augments the demands on caregiving within households and communities.[4–6]

It has been found that the overall health of an older adult declines when they experience sleep disorders.[7] According to prior studies, many factors have been connected to insomnia symptoms in the aged population. Age-related medical and psychiatric conditions, for instance, raise the likelihood of insomnia symptoms, especially in the 60-year-old population.[1] Furthermore, several chronic diseases, including hypertension, diabetes, stroke, obesity, and coronary artery diseases are significant risk factors for clinical symptoms of insomnia.[8–10] However, insomnia symptoms are not always related to getting older, for example, in the United States, it has been found that being older was not associated with self-

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reported insomnia symptoms.[11] Similarly, one study reveals that about 71% of older person in Nepal had insomnia, which was associated not just to age but also to illiteracy, unemployment, economic dependence, and most notably the existence of comorbidities.[12]

The literature shows close relationships between insomnia and chronic diseases. Specifically, persons with hypertension were more likely to have shorter sleep duration[13] and sleep problems/disorders including obstructive sleep apnea (OSA), and restless legs syndrome and narcolepsy.[14,15] Likewise, diabetes was found to be associated with chronic insomnia, with a 2.95-fold increased risk for those who slept less than 6 hours a night.[16,17] It is well established by previous studies that there is a direct link between insomnia and depression[18] and comorbid nature of psychiatric disorders with sleep disturbances.[19,20] Additionally, those with arthritis were 23% more likely than people without arthritis to experience insomnia symptoms,[21] and chronic obstructive pulmonary disease (COPD) was shown to be related to poor sleep quality.[22] Another study among older Chinese adults found that heart disease, COPD and gastroenteritis were associated with short sleep, whereas hypertension was associated with long sleep.[23] Besides, systematic reviews and several longitudinal studies have suggested a strong link between cardiovascular diseases and insomnia and/or sleep disorders.[24–28] Yet, there has been limited research thus far on chronic diseases and associated insomnia symptoms in LMICs including India because of the lack of population-based data.

When examining the risk of insomnia symptoms associated with chronic conditions in Indian older adults, it is important to consider potential sex differences. Previous studies on Indian older adults found that women reported significantly higher odds of sleep problems than their men counterparts,[29] and women had greater impairments in quality of life related to insomnia symptoms compared to older men.[30,31] In the larger literature, many studies have examined sex differences in the chronic disease-insomnia link, while results are mixed depending on specific chronic diseases examined. Some studies report that older men suffer from insomnia more frequently than women and that this is related to poor health, depression, angina pectoris and limitations in daily activities.[32] On the other hand, daytime sleeplessness, one of the symptoms of insomnia, has been linked to a range of psychosocial health issues and has been proven to be more prevalent in older women and people with low educational attainment in urban areas.[33] Importantly, biological differences between male and female sexes may explain the variations in the associations between chronic diseases and insomnia symptoms among older men and women. For instance, sex hormones like oestrogen and progesterone, which decrease during menopause, significantly influence sleep architecture and vulnerability to insomnia in women.[34] Conversely, testosterone levels, which impact muscle tone and breathing, may contribute to sleep apnea and subsequent insomnia in men.[35] These hormonal influences, along with physiological, and psychosocial factors, underscore the necessity of sex-specific analyses in examining the relationships between chronic diseases and insomnia symptoms.

In this study, we examined the associations of chronic diseases (specific types, number) with insomnia symptoms with a specific focus on sex differences using large a nationally representative sample of older adults in India. We hypothesised significant sex differences in the prevalence of insomnia symptoms with a higher prevalence among older women than men. We also hypothesized that each type of and a greater number of chronic conditions would be positively associated with insomnia symptoms among older adults and women in particular.

Methods

Data

The data for this research was sourced from the wave 1 of the Longitudinal Ageing Study in India (LASI), conducted during 2017–18. It encompasses a sample of more than 72,000 individuals aged 45 and above, representing all states and union territories of India. LASI utilized a multistage stratified area probability cluster sampling approach to select the final units of observation, which included individuals aged 45 years and older, as well as their spouses, regardless of age.[36] The survey utilized a three-stage sampling strategy in rural regions and a four-stage sampling approach in urban areas. A comprehensive methodology, providing full details on the survey design and data collection, was made available in the survey report.[36] The Indian Council of Medical Research (ICMR) provided the requisite guidelines and ethical approval for conducting the LASI survey. The survey agencies responsible for fieldwork obtained informed consent from

the participants prior to data collection. The current study specifically focuses on respondents aged 60 years and older and the total sample comprises 31,464 older adults in this age group (15,098 men and 16,366 women).

Outcome Variables

The LASI survey evaluated insomnia symptoms using four questions, which were adapted from the Jenkins Sleep Scale (JSS-4).[37] The JSS scale was developed as a brief questionnaire to recognize sleep difficulties in the last month and is most commonly used sleep-related scale in epidemiological studies.[38] The items read: 1) "How often do you have trouble falling asleep?" 2) "How often do you have trouble with waking up during the night?" 3) "How often do you have trouble with waking up too early and not being able to fall asleep again?" 4) "How often did you feel unrested during the day regardless of the number of hours of sleep you had?" Response options were "never", "rarely" (1–2 nights per week), "occasionally" (3–4 nights per week), and "frequently" (5 or more nights per week). Insomnia symptoms was coded as 1 if the response was 'occasionally' or 'frequently' for any of the four symptoms (3 or more nights per week). For sensitivity analysis, a continuous scale of insomnia symptoms with a score of 0–12 was created as a summary of four items with the responses ranging 0 (never) to 3 (frequently). The JSS-4 scale of assessing insomnia symptoms has proved excellent reliability and demonstrated good construct validity.[39]" The internal consistency of JSS-4 was excellent in this study (Cronbach's alpha value: 0.88).

Main Explanatory Variables

Chronic diseases refer to self-report of physician diagnosed chronic conditions that include hypertension, diabetes, neurological/psychiatric disorders, chronic lung disease, chronic heart disease, stroke, and any bone or joint diseases. Participants self-reported these diseases in response to the query: "Has any health professional ever diagnosed you with the following chronic conditions or diseases?" Responses were coded as "yes" to indicate the presence of specific disease, and "no" otherwise. The number of chronic diseases was categorized as no disease, one, two, and three plus diseases. The specific diseases analyzed in this study are as follows:

1. *Hypertension*: Participants were reported about whether they had been diagnosed with hypertension or high blood pressure by a healthcare professional, and their responses were categorized as "no" or 'yes'.
2. *Diabetes*: Individuals were questioned regarding whether they had received a diagnosis of diabetes or high blood sugar from any healthcare provider, and their responses were categorized as "no" or 'yes".
3. *Neurological/ psychiatric disorder*: This data was gathered through inquiries regarding whether individuals had ever received a diagnosis of neurological or psychiatric conditions, such as depression, Alzheimer's/Dementia, unipolar/bipolar disorders, convulsions, Parkinson's, etc., from any healthcare provider. Their responses were categorized as "no" or "yes".
4. *Chronic lung disease*: This data originated from a question regarding whether individuals had ever been diagnosed with chronic lung disease, such as asthma, chronic obstructive pulmonary disease (COPD), chronic bronchitis, or other chronic respiratory issues by any healthcare provider. Their responses were classified as "no" or "yes".
5. *Chronic heart disease*: Participants were asked about whether they had received a diagnosis of chronic heart diseases, such as coronary heart disease (heart attack or myocardial infarction), congestive heart failure, or other chronic heart conditions from any healthcare professional, and their responses were categorized as "no" or "yes".
6. *Stroke*: Participants were questioned about whether they had been diagnosed with a stroke by any healthcare professional, and their responses were categorized as "no" or "yes".
7. *Bone or joint related diseases*: Participants were inquired about whether they had received a diagnosis of arthritis or rheumatism, osteoporosis, or other bone/joint diseases from any healthcare professional, and their responses were classified as "no" or "yes".

Control Variables

Age was categorized into three groups: 60–69 years, 70–79 years, and 80 years and above. Sex was categorized as men or women. Educational attainment was categorized as no education/primary not completed, primary, secondary, and

higher education. Marital status was categorized as currently married, widowed and others which encompassed individuals who were divorced, separated, or never married. Living arrangements were categorized as living alone, living with spouse, or living with others. Work status was categorized into never worked, currently not working, currently working and retired. Physical activity was assessed according to the WHO guidelines, using the survey questions on moderate and vigorous physical activity.[36] We categorized it into four groups: 1) none (physically inactive), 2) only moderate, 3) only vigorous, 4) and moderate and vigorous. Sleep medications was assessed using the survey question, "In the past month, have you taken any medications or used other treatments to help you sleep?" and the responses were coded as 0 "no" and 1 "yes".

The quintiles of monthly per-capita consumption expenditure (MPCE) were determined using household consumption data. Sets of 11 and 29 questions regarding expenditures on food and non-food items, respectively, were administered to the sampled households. Food expenditure was recorded over a seven-day period, while non-food expenditure was recorded over reference periods of 30 days and 365 days. Both food and non-food expenditures were adjusted to a standardized 30-day reference period. The MPCE was calculated and employed as the comprehensive measure of consumption.[36] The variable was segmented into five quintiles, ranging from the least affluent (poorest) to the most affluent (richest). Religion was reclassified into Hindu, Muslim, and Others. Caste was reclassified into Scheduled Tribe/Scheduled Caste (SC/ST), Other Backward Class (OBC), and Others. Place of residence was categorized as urban and rural.

Statistical Analysis

Descriptive statistics and bivariate analysis were employed to present the sample characteristics and to report the prevalence of insomnia symptoms. Subsequently, multivariable logistic regression analysis was conducted to assess the relationship between chronic diseases, the number of chronic diseases and insomnia symptoms. To estimate sex-specific odds ratios (ie, risks for insomnia), we used sex-stratified models. To test whether the associations between chronic diseases and insomnia symptoms differed between men and women, we included each chronic disease × sex interaction term in the multivariable model. The multivariable results were presented as unadjusted odds ratios, and adjusted odds ratios (AOR) with 95% confidence intervals (CI). Multiple multivariable logistic regression models were employed to examine the associations between chronic diseases and each insomnia symptom which adjusts for all covariates considered in the study, ie, age, education, marital status, living arrangements, work status, physical activity, sleep medications, wealth quintiles, religion, caste and place of residence.

Sensitivity analyses were conducted by employing multivariable linear regression models on a continuous scale of insomnia symptoms (score ranging 0–12) and chronic conditions. Additionally, separate logistic regression models were employed to analyse each insomnia symptom individually by chronic conditions and other background characteristics. Multivariable analyses were weighted to account for the stratified sampling and to provide the national estimates. Regression diagnostics were used to rule out any potential violation of regression assumptions. The statistical analysis was conducted using Stata 16.1.

Results

Table 1 shows the sex-specific sample distribution of respondents by background characteristics. About 11.04% of the men and 11.52% of the women belonged to the 80+ age group. Around 28% of men and 37% of women had hypertension; 2.7% of men and 2.9% of women had neurological or psychiatric disorders; 9% of men and 8% of women had lung disease; 5.81% of men and 4.64% of women had heart disease; 3.29% of men and 2.23% women had stroke; and 16.25% of men and 22.8% of women had bone and joint related disease.

Bivariate and multivariable logistic regression estimates of insomnia symptoms with chronic diseases and other background characteristics were shown in Table 2. Beginning with the associations with background characteristics, for both men and women, the prevalence of insomnia symptoms was higher among those aged 80 years and above, uneducated, those who were widowed and those who lived alone. For women only, the prevalence of insomnia symptoms was higher among those who were not working currently (AOR: 1.26; CI: 1.10–1.45), retired (AOR: 1.65; CI: 1.14–2.40), and lived in rural areas (AOR: 1.20; CI: 1.02–1.41) compared to their counterparts (who never worked and lived in urban areas).

Table 1 Socioeconomic and Health Profile of the Study Participants

Background Factors	Men (N= 15,098)	Women (N= 16,366)	Chi-square p-value
	N (%)	N (%)	
Age (in years)			<0.001
60–69	8961 (57.82)	10,013 (59.13)	
70–79	4545 (31.14)	4556 (29.35)	
80+	1592 (11.04)	1797 (11.52)	
Educational status			<0.001
None	5479 (38.6)	11,410 (72.7)	
Primary	3361 (22.36)	2479 (13.12)	
Secondary	4249 (26.22)	1857 (11.04)	
Higher	2009 (12.83)	620 (3.13)	
Marital status			<0.001
Currently married	12398 (81.09)	7522 (44.06)	
Widowed	2293 (16.49)	8426 (53.99)	
Others	407 (2.43)	418 (1.95)	
Living arrangement			<0.001
Alone	365 (2.52)	1257 (8.53)	
With spouse	3739 (26.03)	2476 (15.19)	
With others	10994 (71.45)	12,633 (76.28)	
Work status			<0.001
Never worked	759 (3.83)	8025 (46.84)	
Currently not working	5979 (40.88)	5011 (32.45)	
Currently working	6044 (42.05)	2953 (18.87)	
Retired	2316 (13.24)	377 (1.84)	
MPCE quintile			0.015
Poorest	3035 (20.83)	3449 (22.49)	
Poorer	3068 (21.32)	3409 (22.06)	
Middle	3064 (21.6)	3352 (20.35)	
Richer	2990 (19.22)	3180 (19.16)	
MPCE quintile			0.015
Poorest	3035 (20.83)	3449 (22.49)	
Poorer	3068 (21.32)	3409 (22.06)	
Middle	3064 (21.6)	3352 (20.35)	
Richer	2990 (19.22)	3180 (19.16)	
Richest	2941 (17.02)	2976 (15.93)	
Religion			0.475
Hindu	11078 (82.04)	11,959 (82.39)	
Muslim	1804 (11.72)	1927 (10.88)	
Others	2216 (6.25)	2480 (6.73)	
Caste			0.156
SC/ST	4884 (26.5)	5429 (27.5)	
OBC	5781 (45.86)	6105 (44.66)	
Others	4433 (27.63)	4832 (27.84)	
Place of residence			0.002
Urban	5021 (27.95)	5718 (30.82)	
Rural	10077 (72.05)	10,648 (69.18)	
Physical activity			<0.001
None	8109 (52.67)	11,755 (73.39)	
Only vigorous activity	915 (6.39)	730 (4.39)	
Only moderate activity	5000 (35.19)	3314 (19.45)	
Moderate and vigorous activity	808 (5.75)	358 (2.77)	

(*Continued*)

Table 1 (Continued).

Background Factors	Men (N= 15,098)	Women (N= 16,366)	Chi-square p-value
	N (%)	N (%)	
Sleep medications			<0.001
No	14632 (97.6)	15,757 (96.95)	
Yes	396 (2.4)	573 (3.05)	
Hypertension			<0.001
No	10401 (72.05)	9986 (62.9)	
Yes	4640 (27.95)	6355 (37.1)	
Diabetes			<0.001
No	12594 (85.39)	13,927 (86.06)	
Yes	2444 (14.61)	2416 (13.94)	
Neurological or psychiatric disorders			0.944
No	14636 (97.3)	15,902 (97.1)	
Yes	403 (2.7)	440 (2.9)	
Chronic lung disease			<0.001
No	13791 (90.99)	15,222 (92)	
Yes	1250 (9.01)	1120 (8)	
Chronic heart disease			<0.001
No	14155 (94.19)	15,656 (95.36)	
Yes	886 (5.81)	686 (4.64)	
Stroke			<0.001
No	14546 (96.71)	15,994 (97.77)	
Yes	495 (3.29)	347 (2.23)	
Bone or joint related disease			<0.001
No	12824 (83.75)	12,975 (77.21)	
Yes	2217 (16.25)	3368 (22.79)	
Number of chronic diseases			<0.001
None	7269 (49.32)	7147 (44.58)	
One	4272 (28.40)	4954 (30.31)	
Two	2326 (15.33)	2788 (15.75)	
Three plus	1167 (6.94)	1448 (9.36)	

Abbreviations: N, Unweighted counts; %, Weighted percentage to account for the stratified sampling and to provide the national estimates; MPCE, Monthly per capita consumption expenditure; SC/ST, Scheduled caste/scheduled tribe; OBC, Other backward class.

Turning to the main associations with chronic diseases, for both men and women, the prevalence of insomnia symptoms was higher among those who had hypertension or diabetes or had neurological or psychiatric disorders, chronic lung disease, chronic heart disease, stroke or bone and joint related diseases compared to their healthy peers in the current study. More specifically, older men (AOR: 1.20; CI: 1.06–1.36) and women (AOR: 1.36; CI: 1.20–1.53) who had hypertension had higher odds of insomnia symptoms compared to their peers with no hypertension. Older women who had diabetes had lower odds of insomnia symptoms (AOR: 0.80; CI: 0.65–0.98) than those who were not, and the association was not significant among men. Odds of insomnia symptoms were higher among men (AOR: 1.38; CI: 1.01–1.91) and women (AOR: 1.82; CI: 1.32–2.49) who had neurological or psychiatric disorders; men (AOR: 1.37; CI: 1.04–1.80) and women (AOR: 1.78; CI: 1.24–2.55) who had stroke; and men (AOR: 1.88: CI: 1.62–2.18) and women (AOR: 1.46; CI: 1.26–1.70) who had bone and joint related diseases than their peers without the disease. Older men who had chronic lung disease had higher odds of insomnia symptoms (AOR: 1.65; CI: 1.38–1.97) than their peers with no lung disease and the association was not significant among women. There was no significant association between chronic heart disease and insomnia symptoms in both men and women. Furthermore, older men (AOR: 2.43; CI: 1.97–3.02) and women (AOR: 2.01; CI: 1.48–2.74) who had three and more chronic diseases had higher odds of insomnia symptoms compared to their healthy peers.

Table 2 Bivariate and Multivariable Logistic Regression Estimates for Insomnia Symptoms by Chronic Conditions and Other Background

Variables	Men		Women		Men	Women
	%	Chi-square p-value	%	Chi-square p-value	AOR (95% CI)	AOR (95% CI)
Age (in years)		<0.001		<0.001		
60–69	34.73		43.33		Ref.	Ref.
70–79	39.27		46.04		1.08 (0.95–1.23)	1.00 (0.86–1.17)
80+	44.01		48.6		1.22* (1.01–1.52)	1.05 (0.85–1.30)
Educational status		<0.001		<0.001		
None	39.9		47.07		Ref.	Ref.
Primary	39.03		43.65		0.93 (0.80–1.08)	0.85 (0.71–1.01)
Secondary	34.28		33.23		0.77*** (0.67–0.90)	0.55*** (0.41–0.74)
Higher	31.26		35.22		0.66*** (0.53–0.82)	0.52*** (0.37–0.74)
Marital status		<0.001		<0.001		
Currently married	36.78		43.33		Ref.	Ref.
Widowed	39.87		45.88		0.99 (0.83–1.16)	0.98 (0.84–1.13)
Others	30.9		44.52		0.76 (0.54–1.06)	1.10 (0.77–1.58)
Living arrangement		<0.001		<0.001		
Alone	39.48		51.26		Ref.	Ref.
With spouse	35.29		41.79		0.82 (0.56–1.20)	0.72** (0.56–0.92)
With others	37.72		44.58		0.99 (0.69–1.42)	0.79* (0.65–0.96)
Work status		0.064		<0.001		
Never worked	34.95		42.07		Ref.	Ref.
Currently not working	42.88		50.28		1.29 (0.97–1.71)	1.26*** (1.10–1.45)
Currently working	32.58		41.28		0.98 (0.74–1.31)	0.92 (0.78–1.09)
Retired	34.93		49.8		1.09 (0.80–1.49)	1.65** (1.14–2.40)
MPCE quintile		0.831		0.13		
Poorest	36.59		45.63		Ref.	Ref.
Poorer	36.59		43.77		1.00 (0.85–1.18)	0.90 (0.76–1.07)
Middle	37.44		45.12		1.08 (0.91–1.29)	0.96 (0.81–1.14)
Richer	37.49		43.57		1.05 (0.88–1.26)	0.89 (0.73–1.07)
Richest	37.79		45.67		1.07 (0.88–1.29)	0.99 (0.81–1.22)
Religion		<0.001		<0.001		
Hindu	37.51		44.67		Ref.	Ref.
Muslim	36.17		46.77		0.89 (0.74–1.06)	1.00 (0.83–1.19)
Others	34.07		42.17		0.80* (0.65–0.98)	0.88 (0.74–1.06)
Caste		<0.001		<0.001		
SC/ST	38.63		45.64		Ref.	Ref.
OBC	37.29		43.61		0.95 (0.82–1.09)	0.95 (0.82–1.10)
Others	35.5		45.61		0.91 (0.77–1.06)	1.10 (0.93–1.31)
Place of residence		<0.001		<0.001		
Urban	34.23		40.06		Ref.	Ref.
Rural	38.24		46.81		1.15 (0.99–1.33)	1.20* (1.02–1.41)
Physical activity		<0.001		<0.001		
None	39.12		44.67		Ref.	Ref.
Only vigorous activity	42.05		48.54		1.26 (0.99–1.61)	1.30 (1.00–1.70)
Only moderate activity	34.15		44.25		1.01 (0.88–1.16)	1.10 (0.95–1.27)
Moderate and vigorous activity	33.53		40.61		1.06 (0.76–1.48)	1.13 (0.66–1.92)
Sleep medications		<0.001		<0.001		
No	36.11		43.7		Ref.	Ref.
Yes	79		77.56		6.32*** (4.36–9.17)	4.11*** (2.83–5.97)
Hypertension		<0.001		<0.001		
No	35.32		42.23		Ref.	Ref.
Yes	41.86		48.94		1.20** (1.06–1.36)	1.36*** (1.20–1.53)

(*Continued*)

Table 2 (Continued).

Variables	Men		Women		Men	Women
	%	Chi-square p-value	%	Chi-square p-value	AOR (95% CI)	AOR (95% CI)
Diabetes		<0.001		0.025		
No	36.69		45.45		Ref.	Ref.
Yes	39.81		40.23		1.14 (0.97–1.35)	0.80* (0.65–0.98)
Neurological or psychiatric disorders		<0.001		<0.001		
No	36.71		44.13		Ref.	Ref.
Yes	52.46		64.6		1.38* (1.01–1.91)	1.82*** (1.32–2.49)
Chronic lung disease		<0.001		<0.001		
No	35.78		44.12		Ref.	Ref.
Yes	50.91		51.74		1.65*** (1.38–1.97)	1.25 (0.96–1.63)
Chronic heart disease		<0.001		<0.001		
No	36.78		44.83		Ref.	Ref.
Yes	42.95		42.58		1.09 (0.83–1.43)	0.81 (0.52–1.27)
Stroke		<0.001		<0.001		
No	36.7		44.31		Ref.	Ref.
Yes	50		62.95		1.37* (1.04–1.80)	1.78** (1.24–2.55)
Bone or joint related disease		<0.001		<0.001		
No	34.35		42.48		Ref.	Ref.
Yes	51.5		52.31		1.88*** (1.62–2.18)	1.46*** (1.26–1.70)
Number of chronic diseases[¥]		<0.001		<0.001		
None	32.15		39.05		Ref.	Ref.
Single	37.75		47.62		1.27*** (1.22–1.46)	1.45*** (1.27–1.66)
Two	45.52		51.23		1.77*** (1.48–2.12)	1.77*** (1.51–2.07)
Three plus	52.43		51.36		2.43*** (1.97–3.02)	2.01*** (1.48–2.74)
Total	37.15		44.73			

Abbreviations: %, Weighted percentage; Ref, Reference; *if p<0.05, **if p<0.01, ***if p<0.001; AOR, Adjusted Odds Ratio; MPCE, Monthly per capita consumption expenditure; SC/ST, Scheduled caste/scheduled tribe; OBC, Other backward class; ¥, Individual chronic diseases were not included in controls.

The additional analysis of interaction of sex in the associations between each chronic disease and insomnia symptoms (Figure 1A–G) showed that these associations are mostly similar between men and women, except for diabetes (p-value: 0.018) and bone and joint related diseases (p-value: 0.027). Having each of these two conditions was associated with higher odds of insomnia symptoms particularly for men. The interaction of sex in the association between number of chronic diseases on insomnia symptoms (Figure 2) showed that older men and women who were having three and more diseases had similarly higher levels of insomnia symptoms. Notably, although the interactions were not significant, compared to those with no diseases, insomnia symptoms were higher among men with a single and two chronic diseases than women with single and two chronic diseases, whereas it was higher among women with three plus chronic diseases than men with three plus chronic diseases.

Sensitivity Analyses

Results from the sensitivity analysis of linear regression models of insomnia symptoms (0–12) by chronic conditions and other covariates are presented in Table S1. The results were consistent for all the chronic diseases except for diabetes, for which the association was not significant in both men and women.

Table S2 presents the adjusted odds ratios of each insomnia symptom by chronic diseases among older men and women. Older men and women who had hypertension had higher odds of all the insomnia symptoms as compared to their peers with no hypertension. The odds of each insomnia symptom were higher among those who had neurological or psychiatric disorders, greater for women than men in all the symptoms. The odds of each insomnia symptom were higher

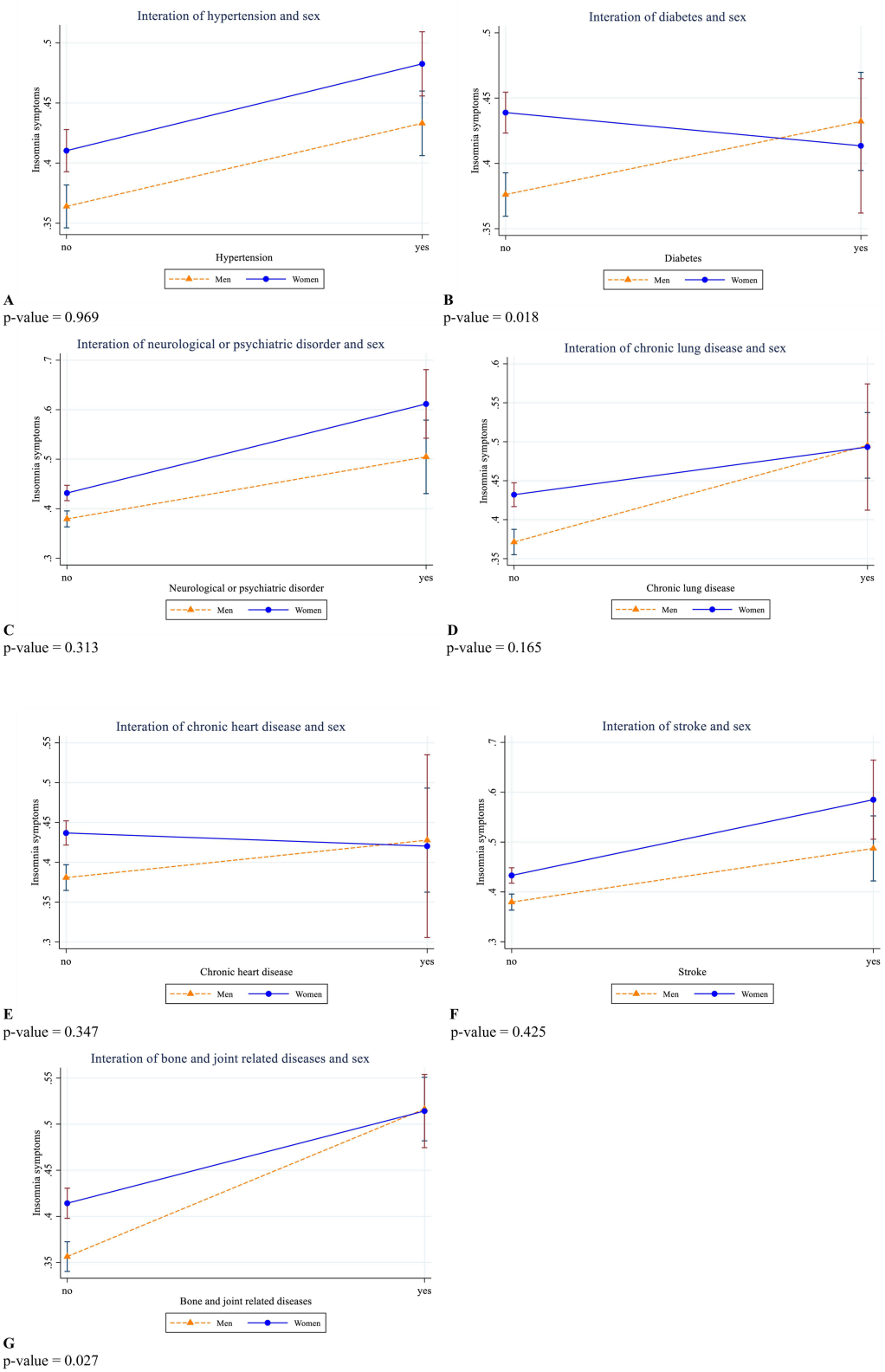

Figure 1 (**A-G**): Associations between each chronic disease and insomnia symptoms by sex after adjustment for socioeconomic and behavioural factor.

among those who had lung disease and those who had bone and joint related diseases, greater for men than women in all the symptoms. In addition, older men who had a chronic heart disease had higher odds difficulty of waking up frequently during the night (AOR: 1.46; CI: 1.08–1.96) and waking up too early (AOR: 1.50; CI: 1.11–2.02).

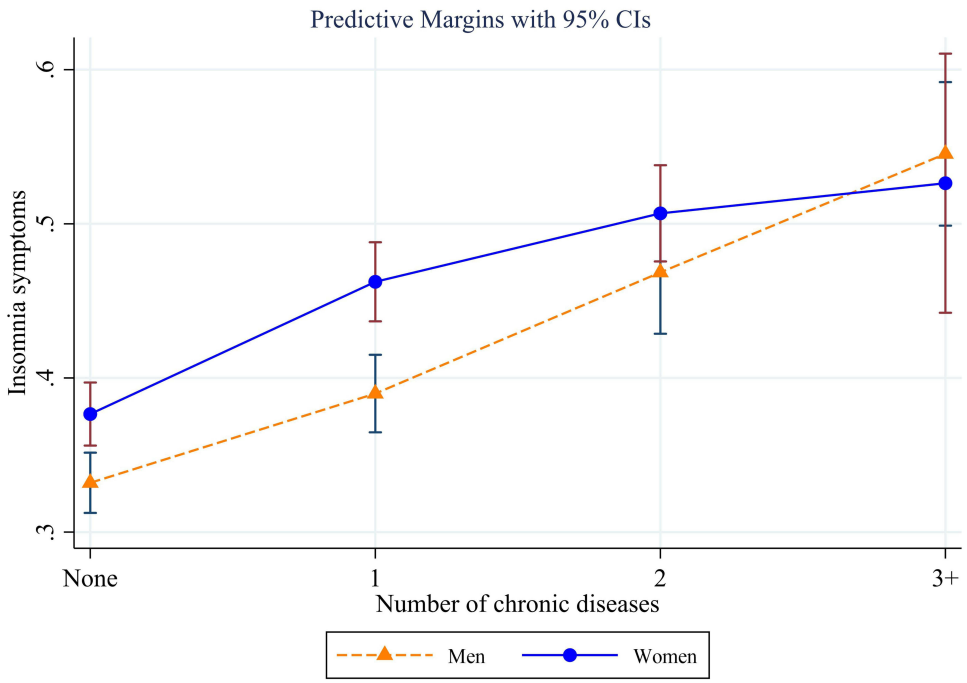

Figure 2 Association between number of chronic diseases and insomnia symptoms by sex after adjustment for socioeconomic and behavioural factor.

Discussion

The study sheds light on the associations between chronic diseases and insomnia symptoms among older adults in India. In line with our hypothesis, we found that women had higher prevalence of insomnia symptoms than men (44.73% vs 37.15%). While the overall associations between chronic diseases and insomnia symptoms did not differ much between men and women (based on sex interaction analyses), the magnitude of the insomnia risk associated with specific chronic conditions differed between men and women (based on sex stratified analyses). Together, these results highlight the need to promoting sex-tailored public health preventive measures that focus on individuals living with insomnia symptoms and comorbid conditions. Below, we discuss the implications of our findings.

Regarding the sex difference in the prevalence of insomnia symptoms found in this study sample, three explanations could be provided. First, women may experience a higher level of insomnia symptoms due to their overall socioeconomic disadvantages compared to men, viz., lower income and less education,[38] and this may be particularly true for Indian women. Second, women report sleeping difficulties due to hot flashes and stress during the postmenopausal period.[40] Third, women are more likely than men to experience physical problems, such as osteoporosis, hypertension, back pain, and hormonal disorder after menopause, which may lead to sleep disturbances and insomnia.[41,42] Unsurprisingly, we observed that women living in rural areas had a higher risk of insomnia symptoms than urban residents. Workforce petrification could be a possible reason for this. Most of the older adults in rural India are involved in physical work that may lead to muscle pain or bone disease, significant contributors to insomnia symptoms.[43,44]

This study found that having hypertension, stroke and neurological or psychiatric disorders were associated with higher risks of insomnia symptoms among older adults, with a seemingly greater risk for women than men. Proposed mechanisms behind these associations include physiological hyperarousal in persons with insomnia,[45,46] and activation of the hypothalamic-pituitary-adrenal (HPA) axis and the stress-diathesis model.[47,48] Moreover, insomnia symptoms and OSA commonly co-occur and studies have shown the effect of comorbid insomnia and sleep apnea (COMISA) on hypertension, cardiovascular events such as angina, heart disease and stroke, and all-cause mortality.[49–52] As evident in previous studies, symptoms of neurological disorders, and medications for specific diseases may lead to insomnia and/or other sleep problems.[53,54]

The insomnia risk associated with having a neurological or psychiatric disorder seemed particularly higher among women than men (AOR=1.82 vs 1.38). This sex difference could be explained by differences in depressive symptomatology and that women are more prone to ruminate than men.[55] Further, in India, majority of women depend on others in terms of economic and social support in older age.[56] Previous studies have also noted that older Indian women, especially widowed, are considered liabilities and are neglected or abused by others compared to men.[6] Consequently, older Indian women become depressed more than older Indian men, which increases the risk of insomnia symptoms.[13,57,58] Similarly, living alone may increase feeling of loneliness and psychological distress in women than in men which could lead to a greater risk of insomnia symptoms in women compared to men.[59,60] Interestingly, having diabetes was associated with a lower risk of insomnia symptoms in older Indian women, though insomnia symptoms were shown to be associated with subsequent incidence of type 2 diabetes mellitus.[61] This unexpected finding may require further investigation.

Consistent with previous studies,[62–64] we found that insomnia symptoms among older Indian men were associated with the prevalence of chronic lung diseases. This association might be related to sleep-disordered breathing as both insomnia and sleep-related breathing disorders were shown to increase collapsibility of the upper airway and lead to respiratory symptoms and COPD.[65–67] A reverse causation is also possible. For example, medical studies have shown a reduction in alveolar ventilation among lung patients, decreasing baseline oxygen saturation and ventilatory response to hypoxia.[68] During rapid eye movement (REM) sleep, breathing variability and rate may increase.[67] As a result, lung patient may have trouble falling asleep and experience night-time awakening, leading to insomnia.[69]

Older people suffer from common and frequent physical health problems including bone-related diseases viz—chronic pain in joints, arthritis, rheumatism, and osteoporosis.[5,70] In support of our hypothesis and in line with the existing evidence,[71–74] the present study observed that bone and joint related diseases were significantly associated with insomnia symptoms among older adults and men in particular. Our findings also support previous evidence that older persons with chronic joint pain are more likely to experience sleep disturbances.[16,70] Furthermore, functional impairment due to pain also limits the degree of physical activity,[75] which can exacerbate late-life insomnia symptoms.[76] More studies are required to explore potential mechanisms underlying the observed associations to better understand the nature of the associations.

When we used the number of chronic diseases, older Indian adults with three plus diseases had a higher probability of insomnia symptoms, similarly across men and women. Our findings are consistent with the previous studies that found that multimorbidity has a significant role in suffering from insomnia symptoms among older adults.[77,78] Although we found no significant interaction between multimorbidity and sex on insomnia symptoms in our sample, the influence of sex differences on this relationship warrants further investigation. This could involve examining how sex interacts with other demographic variables such as age, socioeconomic position, and cultural factors in the association between chronic diseases and insomnia symptoms. Understanding these nuances will help in developing targeted strategies to manage insomnia in older men and women with multimorbidity.

Implications for Policy, Practice and Future Research

The findings suggest an urgent need for developing preventive measures, including evidence-based strategies that may reduce sleep difficulties and improve overall health. Given the increased risk of NCDs in old age, the Government of India has launched NCD cells in all districts to reduce the burden of these diseases. However, despite these efforts, prevalence of NCDs in India has continued to grow steadily.[79] Multimorbidity in older adults is common and associated with adverse outcomes including a worsened sleep, suggesting that policymakers should intervene by targeting specific chronic diseases associated with insomnia symptoms. As such, there is a need for comprehensive management of comorbid chronic diseases, which can exacerbate insomnia symptoms. Particularly, the current study suggests that specific diseases such as hypertension, chronic lung disease and neurological or psychiatric disorders must be targeted as they were found to be significant risk factors of insomnia symptoms among older men and women alike. Clinicians should be aware of the importance of screening their patients for potential sleep disorders and insomnia symptoms. Similarly, integrated care models, which address both physical and mental health needs, may be more effective in managing insomnia symptoms in older adults with chronic diseases.

Specifically, the role of mindfulness, meditation, and relaxation techniques need to be further investigated in reducing the risk of cardiovascular diseases and insomnia symptoms in older adults.[80,81] Health practitioners should promote the use of technology, such as telemedicine and mobile health applications, to provide accessible and scalable interventions for improving sleep quality.[82,83] Community-based programs that promote social engagement, physical activity, and mental well-being, that can have a positive impact on sleep should be enhanced. Finally, non-pharmacological approaches such as cognitive behavioural therapy have potential to reduce the burden of chronic conditions comorbid with insomnia symptoms.[84–86] As such, future research is required to explore the effectiveness of these in reducing sleep problems in diverse populations of older adults. There is also a need for longitudinal studies to assess the long-term impact of various chronic diseases on sleep health in older adults.

Strength and Limitations

Using a large sample of older adults from a nationally representative survey in India is the main strength of this study. A limited number of studies have looked into the issue of insomnia, especially in LMICs,[5] and the current findings may be relevant to the broader community of older people in those countries with similar socio-demographics. The consideration of multiple different types of chronic diseases is another strength of this study. The large sample size also enabled evaluating sex differences in insomnia symptoms by chronic diseases while controlling for a large number of covariates, including sleep medications, physical activity and socio-demographics.

Although this study contributes to the literature on insomnia symptoms, it also carries some limitations. First, previous studies have reported under-diagnosis of diseases in LMICs including India, especially among lower socio-economic groups.[87,88] Therefore, we cannot ignore the possibility of under-estimation of chronic diseases. Moreover, the study was based on self-reported physician diagnosis of chronic conditions, and thus it may be prone to reporting bias due to unawareness of the existence of specific disease. Second, due to the cross-sectional nature of the dataset, we could not establish a temporal relationship between chronic diseases and insomnia symptoms among older adults, and therefore, longitudinal studies are required to draw conclusions on whether specific diseases precede insomnia symptoms or vice-versa. Third, we did not consider the chronicity and severity of insomnia symptoms and co-existence of other sleep disorders which could affect the current findings. Future studies should consider these factors while examining the associations between chronic conditions and insomnia symptoms.

Conclusions

This study found significant associations between hypertension, chronic lung disease, neurological or psychiatric disorders, stroke and bone and joint related diseases with insomnia symptoms among older men and women in India. We also found a positive association between number of chronic diseases and insomnia symptoms among older adults. Some of these associations (ie, with diabetes, bone and joint related diseases) were more apparent for men as compared to women. Yet, addressing insomnia is not a high priority for public health in developing countries like India. To achieve the Sustainable Development Goals for health and well-being, our findings suggest a critical need to raise awareness on the risk of insomnia associated with chronic diseases among all stakeholders, including health care workers, policy-makers, and the general public. Effective preventions such as disease-specific management and routine screening for insomnia symptoms are required to support the vulnerable older adult population with sleep problems to build a healthy aging society.

Ethics declarations

The analysis is based on secondary data available in public domain for research; thus, no approval was required from any institutional review board (IRB). Thereby, it is certified that all applicable institutional and governmental regulations concerning the ethical approval of human volunteers were followed during the survey. (https://www.iipsindia.ac.in/sites/default/files/LASI_India_Report_2020_compressed.pdf).

Data sharing statement

The study uses secondary data which is available on reasonable request through https://www.iipsindia.ac.in/content/lasi-wave-i

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Author Contributions

All authors contributed to data analysis, drafting or revising the article, have agreed on the journal to which the article will be submitted, gave final approval of the version to be published, and agree to be accountable for all aspects of the work.

Disclosure

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