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Sleep problems and their predictors in community-dwelling older adults with diabetes in India: Evidence from the Longitudinal Ageing Study in India

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ABSTRACT

Objectives: To ascertain the prevalence and predictors of sleep disorders and poor sleep quality among older adults with Diabetes (DM) in India, and to assess the relationship between sleep quality and DM.

Methods: Data was utilized from the nationally representative Longitudinal Ageing Study in India (Wave-1, 2017–18), with a total sample of 66606 older adults (≥45 years) selected for the study. Sleep problems and sleep quality score were assessed using an adaptation based on the Jenkins Sleep Scale. Multivariate linear and logistic regressions were conducted to determine the effect of sociodemographic and clinical factors on sleep quality. Mediation analysis (Karlson-Holm-Breen) was done to assess the direct and indirect effects of independent variables on the sleep quality scores. Further, Propensity score matching (PSM) was done to assess the impact of diabetes on sleep problems.

Results: The prevalence of DM was 12.34% (n = 8564, 95% CI: 11.54, 13.20) among whom 24.38% (95% CI: 21.38, 27.65) reported sleep problems. On adjusted analysis, sleep problems were significantly associated with increasing education, higher wealth quintile, lack of physical activity, and multimorbidity. Mediation analysis showed adherence to anti-diabetes medication improved sleep quality (aB = −0.28 (95% CI: −0.54, −0.02)), while comorbidities worsened sleep quality (aB = 0.79 (95% CI: 0.67, 0.92)). Analysis from PSM indicated that DM was associated with a 6.2% higher chance of sleep problems.

Conclusions: Poor sleep quality is present in nearly one in four individuals diagnosed with DM in India and linked with certain adverse social determinants. Focused interventions to improve assessment and treatment of sleep problems in resource-limited primary care settings require prioritization.

1. Introduction

Poor quality of sleep contributes to suboptimal functioning of the human mind and body and reduces quality of life and overall well-being [1,2]. Inadequate or disrupted sleep is a consequence of failure of synchronization of a circadian rhythm and the presence of homeostatic pressure occurring subsequent to a time of alertness which may be associated with certain pathological disease states that have a detrimental effect on sleep [3,4].

Research has shown that there is a bidirectional relationship between sleep quality and diabetes mellitus (DM) [5]. On the one hand, individuals with DM often experience poor sleep quality as the symptoms and complications of the disease can disrupt sleep patterns. Conversely, poor sleep quality, characterized by insufficient sleep duration, fragmented sleep, or occurrence of sleep disorders, can significantly increase the risk of developing DM [6]. Mechanisms contributing to this complex relationship including deranged glucose metabolism and insulin sensitivity during sleep disturbances that contribute to impaired glycemic control [7]. Additionally, inadequate sleep can disrupt the hormonal balance in the body, affecting appetite regulation that may potentially lead to weight gain and obesity [8], which increase the risk of incident DM. Consequently, primary care management of sleep disorders in patients with DM with evidence influenced interventions warrants high prioritization [9].

DM is increasing worldwide due to an ongoing epidemiological, demographic, nutritional, social, and economic transition with 80% case burden concentrated in the developing world further [10,11]. Common age and BMI related sleep disorders that are concomitantly present in

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patients with DM are often untreated or insufficiently treated particularly in resource-limited settings of the developing world. It is well-established that awareness generation to enhance diagnosis and treatment of sleep disorders and improving sleep quality requires focussed efforts involving health education, capacity building of healthcare providers, monitoring and surveillance [12]. Consequently, the development of evidence-based management strategies and targeted interventions to adequately treat sleep disorders in older adults especially those with DM requires accurate estimates of their burden and relationship. However, there is paucity of epidemiological on sleep quality in patients with DM from large, standardized surveys from most low-middle income country (LMIC) settings. With persistent increase in the DM burden, understanding the relationship between sleep quality and DM in these setting becomes crucial as sleep patterns are frequently influenced by local cultural, social, environmental, and lifestyle related factors [13,14] especially sedentary lifestyles, irregular work schedules, irregular meal-timings, and high-stress levels. Moreover, they are risk factors in a common pathway in the development of DM from progression of pre-diabetes, and poor glycemic control in existing patients with DM, with further worsening of the sleep quality in a vicious cycle [15, 16].

India has the highest global burden of DM with 101 million cases [17] projected to increase to 134 million by 2045 [18] but research on sleep quality in this vulnerable population is very limited with most studies being single centered with smaller sample sizes. Therefore, we conducted this study with the objectives of ascertaining the prevalence and predictors of sleep disorders and poor sleep quality among older adults with DM in India, and to assess the relationship between sleep quality and DM. The findings of this study can provide insights for healthcare providers and policymakers in developing comprehensive strategies to improve sleep health in this vulnerable population.

2. Methods

2.1. Data source

The present study utilizes the data obtained from the Longitudinal Ageing Study in India (LASI Wave-1) which is a country-representative longitudinal survey of over 72000 individuals aged 45 years and above, and their spouses (regardless of their age) across all states and union territories of India. The survey adopted a multistage stratified probability cluster sampling design and aimed to provide vital information on the social, physical, psychological, and cognitive health of the Indian aging population. Further details about the survey tools, data collection techniques and sampling methodology can be found elsewhere [19]. We explored sleep quality in 8564 patients with DM within this cohort.

2.2. Outcome variable

In the present study, the outcome variable is 'sleep problems'. LASI utilized five questions from the Jenkins Sleep Scale [20] to evaluate sleep problems. The questions included (i) "How often do you have trouble falling asleep?" (ii) "How often did you have trouble getting back to sleep after waking up during the night?" (iii) "How often do you have trouble with waking up too early and not being able to fall asleep again?" (iv) "How often did you feel unrested during the day regardless of the number of hours of sleep you had?" (v) "How often did you take a nap during the day?". The responses for each of these questions were coded as 'never, rarely (1–2 nights per week)', 'occasionally (3–4 nights per week)', and 'frequently (5 or more nights per week)'. A participant was said to have sleep problems if the response was 'frequently' for any of the five questions, and otherwise no sleep problems. We also used the cumulative score of above five questions to estimate the sleep quality score which ranged from 5 to 20, with a lower score representing better sleep quality. The Cronbach's alpha of the sleep scale was measured as 0.82, indicating good reliability.

2.3. Predictor variables

We included individual-level predictors, including age category (45–59, 50–69, 70–79, and ≥80 years), sex (female and male), educational status (No education or less than primary, Primary complete, Secondary, Higher, Graduate and above), marital status (Never married, currently married, and Widowed/Divorced/Separated/Deserted), work status (currently working and not working) and place of residence (urban and rural). Monthly per capita consumption expenditure (MPCE) quintile was assessed using household consumption data, and categorized into five quintiles, from poorest to richest. Body mass index (BMI) was categorized according to the WHO classification [21]. Smoking and alcohol consumption were assessed using the self-reported questions "Have you ever smoked tobacco" and "Have you ever consumed any alcoholic beverages", respectively, The responses were dichotomously coded as yes and no. Physical activity was assessed by the question, "How often do you take part in sports or vigorous activities, such as running or jogging, swimming, going to a health centre or gym, cycling, or digging with a spade or shovel, heavy lifting, chopping, farm work, fast bicycling, cycling with loads?" and was coded as frequently, rarely, and never. Comorbidities were assessed using the question "Has any health professional ever diagnosed you with the following chronic conditions or diseases". Here, multimorbidity was considered as the co-occurrence of two or more chronic conditions [22]. Treatment taken for DM was dichotomized as yes or no based on the question "In order to treat or control your diabetes or high blood sugar, are you currently taking medications that you swallow?".

Other health-related variables included visited any health care facility or any health professional in past 12 months (yes or no), and duration of DM diagnosis (0–5, 6–15, 16–25, and ≥26 years).

2.4. Statistical analysis

We presented the descriptive statistics along with results of cross-tabulations. Chi-square test was performed to check the significance of the associations between predictor variables and the outcome variable. Appropriate sampling weights were applied throughout the analysis. A linear regression analysis was conducted to determine the adjusted effect of predictor variables on the sleep quality scores. Both unadjusted and adjusted estimates were reported as beta-coefficient (B) with 95% confidence intervals (CI). Additionally, multivariable logistic regression analysis was conducted to find out the association between predictor variables and the outcome variable (sleep problems), with unadjusted and adjusted odds ratio being presented along with the respective 95% CI. Models for all regression analysis were checked for assumptions and pre-requisites. Variables found to be significant ($P < 0.05$) in unadjusted analysis were included in the adjusted models. In addition to the overall analysis, a subgroup analysis was conducted by excluding individuals with self-reported neurological, or psychiatric problems such as depression, Alzheimer's/Dementia, unipolar/bipolar disorders, convulsions, Parkinson's etc.

Karlson-Holm-Breen (KHB) method was utilized to assess the direct and indirect effects of independent variables on sleep quality scores [23, 24]. The total effect of a key exposure variable was decomposed in a linear regression model into the sum of direct and indirect effects. Here, the direct effect is the association of key exposure variable with sleep quality score after controlling for mediators and other covariates, and the indirect effect refers to the mediation effect in the association of key exposure variable with physical frailty. The mediated percentage (the indirect effect divided by the total effect) is interpreted as the percentage of the association explained by the mediator variable and was only considered significant when the total and indirect effects were significant. Lastly, propensity score matching was done to assess the impact of diabetes on those who have sleep problems. Cases were individually matched to controls, with diabetes being selected as the treatment status and confounding variables as the baseline characteristics. Effect of

diabetes on sleep problems was computed while controlling the background characteristics and other biases (related to assignment of subjects in the treatment and control group). All p-values less than 0.05 were considered as statistically significant. Data analysis was conducted using Stata version 15.1 (StataCorp, Texas, USA).

Ethics approval

Our study uses a secondary data set, which was obtained after a written permission from the International Institute for Population Sciences (IIPS). Ethical approval was taken from Indian Council for Medical research (ICMR) for conducting the LASI survey, and all the methods were carried out in accordance with relevant guidelines and regulations. Informed consent was obtained from all the participants prior to the interview.

3. Results

The weighted prevalence of DM was 12.34% (95% CI: 11.54, 13.20). Table 1 reports the sample characteristics in individuals aged 45 years and above and having previously been diagnosed with DM. The sample consisted of 53.6% females and 46.4% males with mean (SD) age of 60.32 (10.80) years. More than half of the participants were not working (52.62%) and resided in urban areas (54.62%). Almost half of the participants had obesity (49.2%). A majority of the respondents were currently married (73.35%), did not smoke (74.21%) and did not consume alcohol (88.17%). More than two-thirds of the participants were not involved in any physical activity (69.6%). About 38% of the patients with DM had HTN or high cholesterol comorbidity, while 37% had multimorbidity. Almost one-fifth of the individuals with DM were not taking treatment (18.6%). A majority of the participants had DM for less than 5 years (56.5%), while 3.65% have had DM for ≥26 years.

Among those with previously diagnosed DM, 24.38% (95% CI: 21.38, 27.65) had sleep problems, and the mean (SD) sleep quality score was 8.95 (3.72). Subgroup analysis by excluding individuals with neurological or psychiatric problems revealed that among those who had DM, 23.88% (95% CI: 20.81 m 27.25) had sleep problems.Table 2 reports the results of the multivariate logistic regression analyses to find the independent predictors of sleep problems in patients with DM. Upon adjusted analysis, the following factors had a statistically significant association with sleep problems: increasing education levels (graduate and above, aOR = 0.45, 95% CI: 0.28, 0.74), richer wealth (MPCE) quintile (aOR = 1.51, 95% CI: 1.02, 2.22), no physical activity (aOR = 1.62, 95% CI: 1.21, 2.17), and multimorbidity (aOR = 1.75, 95% CI: 1.33, 2.31).

A multiple linear regression analysis observed a reduction in the mean sleep quality score with increase in education levels of the respondents (Table 3). There was a significantly higher decline among those having secondary education (aB = −0.55, 95% CI: −1.02, −0.08), higher education (aB = −0.79, 95% CI: −1.38, −0.19), graduate and above education (aB = −0.91, 95% CI: −1.47, −0.35) as compared to those with no or less than primary education. Compared to those who were never married, currently married (aB = −1.99, 95% CI: −3.34, −0.65) and widowed/divorced/others (aB = −1.51, 95% CI: −2.96, −0.07) had significantly lower mean sleep quality scores. Similarly, significantly lower mean sleep quality slower were found in those currently employed (aB = −0.56, 95% CI: −0.98, −0.14) compared to those not employed. Those having HTN or high cholesterol comorbidity (aB = 0.74, 95% CI: 0.33, 1.14) and multimorbidity (aB = 1.42, 95% CI: 1.01, 1.84) had significantly higher mean sleep quality score. Similarly, those who visited an HCP in the last 12 months also had higher mean sleep quality score (aB = 0.87, 95% CI: 0.43, 1.30).

Table 4 presents the mediated multivariable regression estimates of sleep quality score. Age, sex, education level, MPCE quintile, residence and BMI were added as control variables. The total effect of medication for DM on the sleep quality score was found to be aB = −0.28 (95% CI: −0.54, −0.02). Direct effect estimates showed that among patients previously diagnosed having DM, those who reported taking anti-diabetes medication had improved sleep quality scores compared to those who did not take anti-diabetes medication (aB = −0.34, 95% CI: −0.61, −0.09). Indirect effect of visit to any HCP in the past 12 months was aB = 0.07, 95% CI: 0.03, 0.10, indicative of poor sleep quality score. An estimated 23.6% of the association between medication for DM and sleep quality score was mediated by HCP visit (in past 12 months). Further, the total effect of comorbidities on the sleep quality score was

Table 1
Socio-demographic and lifestyle characteristics of people with DM.

Characteristics	Having DM (N = 8564)	Weighted %
Age (years)		
45–59	3630	42.08
60–69	3007	34.62
70–79	1531	18.79
80 and above	396	4.52
Sex		
Male	4122	46.41
Female	4442	53.59
Education (n = 5931)		
No education or less than primary	1011	17.32
Primary complete	1333	21.66
Secondary	2169	35.6
Higher	575	8.98
Graduate and above	843	16.43
Marital status		
Never married	70	0.54
Currently married	6412	73.35
Widowed/Divorced/Separated/Deserted	2082	26.11
Work Status (n = 5650)		
Not working	2984	52.62
Currently Working	2666	47.38
Place of Residence		
Rural	3747	45.38
Urban	4817	54.62
MPCE Quintile		
Poorest	1158	14.29
Poorer	1401	15.71
Middle	1665	18.26
Richer	1982	23.13
Richest	2358	28.62
BMI (kg/m^2) (n = 7646)		
Underweight	430	6.56
Normal	1991	26.49
Overweight	1436	17.71
Obese	3789	49.24
Smoking Status (n = 8496)		
No	6246	74.21
Yes	2250	25.79
Alcohol consumption (n = 8505)		
No	7258	88.17
Yes	1247	11.83
Physical Activity (n = 8501)		
Frequently	1856	24.16
Rarely	573	6.21
Never	6072	69.63
Comorbidity		
None	2273	24.85
HTN/Lipid comorbidity	3337	37.85
Multimorbid	2954	37.3
On treatment for DM (n = 8562)		
No	1562	18.56
Yes	7000	81.44
HCP visit in last 12 months (n = 8496)		
No	1367	14.71
Yes	7129	85.29
Duration of DM (n = 7322)		
0–5 years	4138	56.48
6–15 years	2448	31.69
16–25 years	592	8.18
≥26 years	144	3.65

Abbreviations: MPCE, monthly per capita expenditure; BMI, body mass index; DM, diabetes mellitus; HCP, healthcare professional.

Table 2
Distribution of socio-demographic and lifestyle characteristics of sleep problems in older adults with DM (Binary logistic regression).

Characteristics	No sleep problems (N = 6526) n (%)	Have sleep problems (N = 2038) n (%)	Unadjusted OR [95% CI]	Adjusted OR [95% CI]
Age (years)				
45–59	2934 (77.29)	696 (22.71)	Ref	–
60–69	2270 (76.48)	737 (23.52)	1.05 [0.69, 1.58]	
70–79	1055 (72.34)	476 (27.66)	1.30 [0.81, 2.10]	
80 and above	267 (67.09)	129 (32.91)	1.67 [0.98, 2.84]	
Sex				
Male	3194 (75.15)	928 (24.85)	Ref	–
Female	3332 (76.03)	1110 (23.97)	0.95 [0.68, 1.35]	
Education				
No education or less than primary	733 (71.34)	278 (28.66)	Ref	Ref
Primary complete	1004 (71.6)	329 (28.4)	0.99 [0.68, 1.43]	1.03 [0.74, 1.44]
Secondary	1667 (81.21)	502 (18.79)	0.58 [0.40, 0.83] *	0.72 [0.53, 0.98] *
Higher	466 (82.76)	109 (17.24)	0.52 [0.35, 0.76] *	0.54 [0.36, 0.83] *
Graduate and above	713 (85.81)	130 (14.19)	0.41 [0.25, 0.68] *	0.45 [0.28, 0.74] *
Marital status				
Never married	52 (67.05)	18 (32.95)	Ref	–
Currently married	5000 (77.38)	1412 (22.62)	0.60 [0.24, 1.50]	
Widowed/ Divorced/ Separated/ Deserted	1474 (70.86)	608 (29.14)	0.84 [0.32, 2.17]	
Work Status				
Not working	2118 (67.05)	866 (32.95)	Ref	–
Currently Working	2203 (83.18)	463 (16.82)	0.41 [0.29, 0.58]	
Place of Residence				
Rural	2830 (73.47)	917 (26.53)	Ref	–
Urban	3696 (77.41)	1121 (22.59)	0.81 [0.58, 1.12]	
MPCE Quintile				
Poorest	908 (79.77)	250 (20.23)	Ref	Ref
Poorer	1071 (73.5)	330 (26.5)	1.42 [1.06, 1.90] *	1.31 [0.87, 1.96]
Middle	1282 (74.46)	383 (25.54)	1.35 [0.97, 1.88]	1.34 [0.89, 2.02]
Richer	1486 (77.1)	496 (22.9)	1.17 [0.84, 1.63]	1.51 [1.02, 2.22] *
Richest	1779 (74.27)	579 (25.73)	1.37 [0.80, 2.34]	1.30 [0.89, 1.90]
BMI (kg/m^2)				
Underweight	301 (73.39)	129 (26.61)	Ref	–
Normal	1521 (76.32)	470 (23.68)	0.86 [0.61, 1.20]	
Overweight	1109 (74.74)	327 (25.26)	0.93 [0.65, 1.33]	
Obese	2915 (78.71)	874 (21.29)	0.75 [0.52, 1.07]	
Smoking Status				
No	4809 (76.71)	1437 (23.29)	Ref	–
Yes	1664 (72.38)	586 (27.62)	1.26 [0.96, 1.65]	
Alcohol consumption				
No	5560 (75.97)	1698 (24.03)	Ref	–
Yes	920 (72.6)	327 (27.4)	1.20 [0.90, 1.59]	
Physical Activity				
Frequently	1460 (82.77)	396 (17.23)	Ref	Ref
Rarely	466 (82.77)	107 (17.23)	1.00 [0.66, 1.51]	0.81 [0.47, 1.39]
Never	4550 (72.41)	1522 (27.59)	1.83 [1.33, 2.52] **	1.62 [1.21, 2.17] *
Comorbidity				
None	1854 (81.69)	419 (18.31)	Ref	Ref
HTN/Lipid comorbidity	2640 (77.07)	697 (22.93)	1.33 [0.87, 2.03]	0.92 [0.67, 1.25]
Multimorbid	2032 (70.12)	922 (29.88)	1.90 [1.42, 2.54] **	1.75 [1.33, 2.31] **
On treatment for DM				
No	1182 (76.04)	380 (23.96)	Ref	–
Yes	5342 (75.52)	1658 (24.48)	1.03 [0.78, 1.36]	
HCP visit in last 12 months				
No	1137 (81.81)	230 (18.19)	Ref	–
Yes	5340 (74.51)	1789 (25.49)	1.54 [0.95, 2.48]	
Duration of DM				
0–5 years	3218 (76.77)	920 (23.23)	Ref	Ref
6–15 years	1834 (74.82)	614 (25.18)	1.11 [0.86, 1.44]	1.20 [0.93, 1.55]
16–25 years	440 (78.82)	152 (21.18)	0.89 [0.61, 1.30]	0.85 [0.56, 1.29]
≥26 years	95 (32.51)	49 (67.49)	6.86 [1.51, 31.15] *	1.51 [0.77, 2.97]

Goodness of fit, P = 0.2543.
Abbreviations: OR, odds ratio; CI, confidence interval; MPCE, monthly per capita expenditure; BMI, body mass index; DM, diabetes mellitus; HCP, healthcare professional.
*P < 0.05, **P < 0.001.

found to be aB = 0.79 (95% CI: 0.67, 0.92). Indirect and direct effects were found to be aB = 0.03 (95% CI: 0.01, 0.04) and aB = 0.77 (95% CI: 0.64, 0.89), respectively. Both direct and indirect effect estimates showed poor sleep quality scores in those with higher comorbidities and reporting HCP visit in past 12 months with 3.3% of the association between comorbidities and sleep quality score being mediated by an HCP visit (in past 12 months).

The results obtained from propensity score matching is presented in Table 5. The unmatched sample estimate is the raw estimate without matching. The results indicate that older adults with DM had 6.0% higher chance to have sleep problems than those who did not have DM. The average treatment effect (ATT) values among treated and control groups were 0.237 and 0.181 respectively, indicating that in the absence of DM, the prevalence of sleep problems would have reduced among patients with DM. The average treatment effect on the untreated (ATU) values were 0.177 and 0.241 in the treated and control groups respectively, indicating that if those who do not have DM currently develop diabetes, their chances of having sleep problems will increase by 6.3%. Average treatment affect (ATE) was 0.062 signifying that on an average, there is a 6.2% higher chance of having sleep problems in patients with DM. Fig. 1 shows the balance plot of the covariates of the treatment and control group before and after matching cases, which indicates that both the treatment and control groups were balanced leading to unbiasedness in the estimated treatment effects.

4. Discussion

The significant occurrence of inadequate sleep quality and sleep disorders among individuals with diabetes in India highlights the necessity for targeted interventions to enhance sleep health in this group. Addressing sleep quality as a component of diabetes management has the potential to enhance glycemic control and overall well-being in this population [25]. The present study observed that nearly one-fourth (24.4%) of older adult patients with DM in India reported experiencing sleep disturbances when assessed with a validated instrument.

Table 3
Association of socio-demographic and lifestyle characteristics with sleep quality score in older adults with DM (Linear regression).

Characteristics	Unadjusted B [95% CI]	Adjusted B [95% CI]
Age (years)		
45–59	Ref	Ref
60–69	0.45 [0.06, 0.84] *	−0.04 [-0.42, 0.34]
70–79	0.64 [-0.23, 1.52]	0.56 [-0.03, 1.14]
80 and above	1.28 [0.61, 1.96] **	0.03 [-0.77, 0.82]
Sex		
Male	Ref	Ref
Female	0.54 [0.11, 0.97] *	0.10 [-0.37, 0.57]
Education		
No education or less than primary	Ref	Ref
Primary complete	0.07 [-0.65, 0.79]	−0.03 [-0.59, 0.53]
Secondary	−0.86 [-1.57, −0.15] *	−0.55 [-1.02, −0.08] *
Higher	−1.02 [-1.60, −0.43] *	−0.79 [-1.38, −0.19] *
Graduate and above	−1.48 [-2.27, −0.70] **	−0.91 [-1.47, −0.35] *
Marital status		
Never married	Ref	Ref
Currently married	−1.94 [-3.74, −0.14] *	−1.99 [-3.34, −0.65] *
Widowed/Divorced/Separated/ Deserted	−1.24 [-3.15, 0.66]	−1.51 [-2.96, −0.07] *
Work Status		
Not working	Ref	Ref
Currently Working	−1.35 [-1.76, −0.94] **	−0.56 [-0.98, −0.14] *
Place of Residence		
Rural	Ref	Ref
Urban	−0.72 [-1.11, −0.33] **	−0.24 [-0.60, 0.12]
MPCE Quintile		
Poorest	Ref	–
Poorer	0.15 [-0.36, 0.67]	
Middle	−0.03 [-0.67, 0.62]	
Richer	−0.11 [-0.64, 0.41]	
Richest	−0.60 [-1.29, 0.09]	
BMI (kg/m^2)		
Underweight	Ref	Ref
Normal	−1.00 [-1.64, −0.36] *	−0.46 [-1.32, 0.41]
Overweight	−0.93 [-1.57, −0.29] *	−0.31 [-1.18, 0.56]
Obese	−1.26 [-1.92, −0.60] **	−0.37 [-1.19, 0.46]
Smoking Status		
No	Ref	Ref
Yes	0.39 [0.03, 0.75] *	0.15 [-0.21, 0.51]
Alcohol consumption		
No	Ref	–
Yes	0.15 [-0.25, 0.56]	
Physical Activity		
Frequently	Ref	Ref
Rarely	0.91 [0.18, 1.63] *	0.49 [-0.29, 1.26]
Never	0.82 [0.34, 1.29] *	0.05 [-0.32, 0.41]
Comorbidity		
None	Ref	Ref
HTN/Lipid comorbidity	0.62 [0.22, 1.02] *	0.74 [0.33, 1.14] **
Multimorbid	1.93 [1.39, 2.48] **	1.42 [1.01, 1.84] **
On treatment for DM		
No	Ref	–
Yes	−0.22 [-0.68, 0.23]	
HCP visit in last 12 months		
No	Ref	Ref
Yes	1.39 [0.90, 1.87] **	0.87 [0.43, 1.30] **
Duration of DM		
0–5 years	Ref	–
6–15 years	0.14 [-0.34, 0.62]	
16–25 years	0.21 [-0.38, 0.80]	
≥26 years	−0.44 [-1.13, 0.25]	

R-squared = 0.10.
Abbreviations: CI, confidence interval; MPCE, monthly per capita expenditure; BMI, body mass index; DM, diabetes mellitus; HCP, healthcare professional.
*P < 0.05, **P < 0.001.

Table 4
Mediated multivariable regression estimates of sleep problems among diabetics.

	Sleep quality score Adjusted Coefficient[a] [95% CI]	Percent of effect mediated
Medication for DM		
Total effect	−0.28 [-0.54, −0.02] *	−23.65
Direct effect	−0.34 [-0.61, −0.09] *	
Indirect effect of **HCP visit**	0.07 [0.03, 0.10] **	
Comorbidities		
Total effect	0.79 [0.67, 0.92] **	3.34
Direct effect	0.77 [0.64, 0.89] **	
Indirect effect of **HCP visit**	0.03 [0.01, 0.04] *	

Abbreviations: CI, confidence interval; DM, diabetes mellitus; HCP, healthcare professional.
*P < 0.05, **P < 0.001.
[a] Adjusted for age, sex, education level, MPCE quintile, residence and BMI.

Nevertheless, this estimate is somewhat lower than those reported in studies from Malaysia (32%) [26], USA (29.7%) [27] and Nigeria (27%) [28], although this variability could be attributed to different scales and methods of measuring sleep quality. Furthermore, our study findings from mediation and propensity score matching methods strengthen the evidence that DM contributes to sleep disturbances in older adults as an independent risk factor [29].

In India, less than half of the existing patients with DM are initiated on treatment due to adverse health seeking behaviour and weak public health systems [30]. The present study suggests that existing patients on DM reporting adherence to anti-diabetes medication had improved sleep quality compared to those that were non-adherent to their medications. Furthermore, in this study, patients despite reporting to a healthcare provider in the previous 12 months reported experiencing inferior sleep quality suggestive of missed opportunities for treating sleep disturbances in older adults having DM. Although the prevalence of sleep disturbances among patients with DM in high-income settings is comparable to that in LMIC settings such as in India, the reduced access to specialized sleep medicine services in resource-limited settings often disproportionately compromises sleep and overall well-being in this vulnerable population.

Our study corroborates previous evidence that higher educational status but not SES was protective against poor sleep quality [31]. However, previous evidence is suggestive of increased duration of sleep in individuals with lower educational attainments which was associated with a reduced risk of depression which is an independent risk factor for suboptimal medical adherence and poor glycemic control in patients with DM [32,33]. Similarly, sedentary lifestyle was associated with poor sleep quality, which is consistent with previous evidence suggestive of metabolic, hormonal, inflammatory, and psychological alterations negatively impacting sleep in these individuals [34,35]. Higher educational status can also be linked to a healthy lifestyle especially exercise which may contribute to improved sleep quality in these settings [36,37]. Findings from another study among older adults in the USA included a notable decrease in physical activity associated with advancing age that was more pronounced in individuals with lower levels of education, along with an inverse relationship between unemployment and physical activity within this vulnerable subgroup [38].

In this study, individuals who were divorced or currently married had better sleep quality score than those who were never married. A previous study in the USA observed that individuals transitioning into marriage had improved sleep quality while those becoming divorced had subsequent risk of poor sleep quality [39]. This study found higher

Table 5
Analysis through Propensity Score Matching to show effect of diabetes on sleep problems.

Variable	Sample	Treated	Controls	Difference	Standard Error (SE)	T-stat
Sleep quality score	Unmatched	0.237	0.177	0.060	0.005	13.44
	ATT	0.237	0.181	0.057	0.055	1.05
	ATU	0.177	0.241	0.063	–	–
	ATE	–	–	0.062	–	–

Abbreviations: ATT, average treatment effect on the treated; ATU, average treatment effect on the untreated; ATE, average treatment effect.

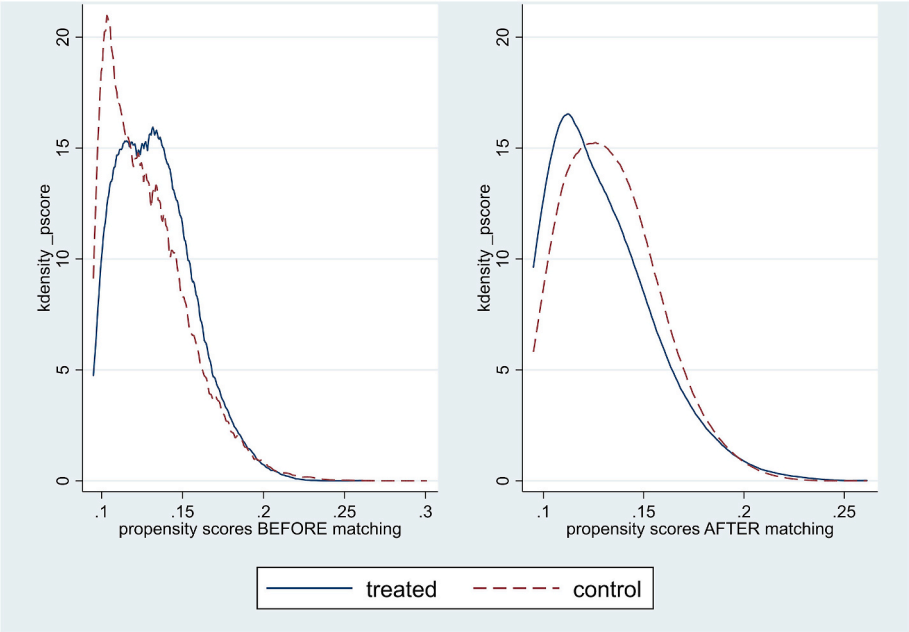

Fig. 1. Balance plot for propensity score matching. The balance plot of the covariates of the treatment and control group before and after matching cases.

odds of having sleep problems among those with DM and other multimorbid conditions, a finding consistent with that observed among individuals with similar morbidity profile in other LMICs [40,41]. Notably, our findings that richer wealth quintiles and no physical activity showed higher odds of having sleep problems, but no significant association with sleep quality score suggests potential methodological nuances. Future research should explore refined methodologies and additional confounding variables to provide a more comprehensive understanding of the relationships between socioeconomic factors, physical activity, and sleep outcomes [42,43].

Our study possesses distinct strengths. The association of diabetes mellitus (DM) with sleep quality was established in a large sample of older adults in India from a countrywide survey and a matched (control) sample was developed from the same dataset along with the application of robust statistical methods. Sleep quality was assessed using a multi-item instrument indicative of good reliability. However, this study also has certain limitations. First, the causal relationship between sleep quality and DM cannot be established due to the cross-sectional design of this study. Second, the diabetic status of the individuals was reliant on patient self-report that would omit currently undiagnosed individuals. Third, glycemic control status of the patients with DM was not available which precluded ascertaining its association with sleep quality.

In conclusion, presence of poor sleep quality in nearly one in four individuals diagnosed with DM underscores the necessity for focused interventions and preventative measures aimed at mitigating sleep disruptions and enhancing sleep well-being especially in high-risk groups such as the multimorbid, and individuals of low educational status. Diabetes prevention and management programs in primary care settings should incorporate health education and stress management practices towards improving sleep hygiene.

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Data availability

LASI Wave 1 datasets are freely available to use upon reasonable request to IIPS (https://www.iipsindia.ac.in/lasi).

CRediT authorship contribution statement

Vansh Maheshwari: Writing – original draft, Visualization, Methodology, Formal analysis. **Saurav Basu:** Writing – review & editing, Visualization, Methodology, Conceptualization.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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