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Sleep Health Across Geographically Diverse Regions of India: A Multisite Online Cross-Sectional Study

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Abstract

Introduction

Sleep is a modifiable determinant of cardiometabolic and mental health that remains poorly characterised in India outside urban and occupational cohorts, and almost no data exist for island and climatically distinct regions. This study estimated the prevalence of poor sleep quality and inadequate sleep duration among adults at four purposively selected, climatically contrasting Indian sites and examined their sociodemographic, lifestyle, environmental, and psychosocial correlates.

Methods

A multicentric cross-sectional online survey was conducted between May and August 2026 among adults aged 18 years and above in the Andaman & Nicobar Islands (lead site), Delhi, Jammu & Kashmir, and Rajasthan, with additional convenience responses from other Indian states and union territories. A structured, self-administered questionnaire captured sociodemographic, lifestyle, occupational, and environmental variables, together with the Pittsburgh Sleep Quality Index (PSQI), Epworth Sleepiness Scale (ESS), Patient Health Questionnaire-9 (PHQ-9), and Perceived Stress Scale-10 (PSS-10). Poor sleep quality was defined as a global PSQI score above five. Associations were examined using chi-square or Fisher's exact tests, Kruskal-Wallis tests, Spearman's correlation, and multivariable logistic regression.

Results

Of 863 responses received, one from a respondent residing outside India was excluded, leaving 862 for analysis (mean age 25.8 ± 9.0 years; 56.1% female; 66.8% students). The mean global PSQI score was 6.55 ± 3.48; 475 respondents (55.1%, 95% CI 51.8-58.4) had poor sleep quality, and 641 (74.4%) reported sleeping fewer than seven hours on a typical night. Excessive daytime sleepiness (ESS ⩾ 10) was present in 236 (27.4%), and depressive symptoms (PHQ-9 ⩾ 10) were present in 257 (29.8%); 270 (31.3%) endorsed at least "several days" on the PHQ-9 item concerning thoughts of being better off dead or of self-harm. Poor sleep quality ranged from 40.5% in Rajasthan to 60.8% in Jammu and Kashmir, a difference of borderline statistical significance ($p = 0.055$). Among the 655 respondents who completed the environmental module, poor sleep quality increased in a graded fashion with self-reported heat/humidity disturbance (43.6% to 75.6%, $p < 0.001$) and nocturnal insect disturbance (50.3% to 84.2%, $p = 0.005$); these were unadjusted associations. Poor sleep quality was more frequent among those with depressive symptoms (80.9% versus 44.1%) and excessive daytime sleepiness (76.7% versus 47.0%; both $p < 0.001$). After adjustment, shift or irregular work (adjusted OR 2.15, 95% CI 1.15-4.01) and higher perceived stress (aOR 1.93 per SD, 95% CI 1.58-2.36) remained independently associated with poor sleep quality. No association was observed with self-reported hypertension, diabetes, or obesity.

Conclusions

More than half of this predominantly young, student-heavy online sample reported poor sleep quality, which was independently associated with irregular work schedules and perceived stress and, in unadjusted analyses, with self-reported heat, humidity, and insect disturbance. Because sampling was non-probabilistic, these estimates are indicative rather than representative of Indian adults. The findings support further population-based research using objective environmental measures on sleep health in island and climatically challenging regions, as well as the integration of sleep screening into mental health and non-communicable disease (NCD) programmes.

Categories: Public Health, Preventive Medicine
Keywords: cross sectional study, india, perceived mental stress, pittsburgh sleep quality index (psqi), sleep quality & quantity

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Introduction

Sleep is a fundamental biological process and an increasingly recognised determinant of physical and mental health [1]. The National Sleep Foundation recommends seven to nine hours of sleep per night for adults, and shorter sleep has been consistently associated with cardiometabolic disease, impaired immunity, mental health disorders, and reduced productivity [2]. Sleep problems are also common in low- and middle-income countries, as shown by the INDEPTH WHO-SAGE study across Africa and Asia [3].

In India, sleep health remains understudied as a public health priority. Community-based data are sparse: a rural South Indian study using the Pittsburgh Sleep Quality Index (PSQI) reported poor sleep quality in 36.3% of adults [4]. Most other Indian studies have sampled students, healthcare workers, or individuals from single institutions, with poor sleep quality reported in about half of undergraduate medical students in Delhi [5] and adults surveyed online in Kashmir [6]. Comparable data from island, coastal, and climatically distinct regions of the country are largely absent.

The Andaman and Nicobar Islands present a distinctive context shaped by geographical isolation, high ambient heat and humidity, vector exposure, and a heterogeneous population that includes indigenous communities, mainland settlers, fisherfolk, and defence personnel. Global evidence indicates that higher night-time temperatures shorten sleep, with larger effects in hotter and lower-income settings [7,8]. Studies from other Indian Ocean island populations have also reported a substantial burden of poor sleep among young adults, with the sleep environment emerging as a key correlate [9,10]. Whether such environmental gradients operate across India's very different climatic zones has not been examined using a common methodology.

Sleep duration and quality are closely linked with hypertension, type 2 diabetes, obesity, and depression, all of which contribute to India's rising non-communicable disease (NCD) burden [11-13]. Psychosocial stress is a recognised contributor to sleep disturbance and interacts bidirectionally with sleep and mood [14]; perceived stress has also been linked to outcomes among patients with NCDs [15]. Validated instruments, namely the PSQI, the Epworth Sleepiness Scale (ESS), the Patient Health Questionnaire-9 (PHQ-9), and the Perceived Stress Scale-10 (PSS-10), allow standardised assessment across settings [16-19], and the PSQI has been validated against polysomnography in Indian university students [20].

A multicentric study was therefore designed across four purposively selected sites that differ sharply in climate and geography: a tropical maritime island territory (Andaman and Nicobar Islands), a large, hot, semi-arid metropolis (Delhi), a Himalayan region with a temperate climate (Jammu and Kashmir), and an arid western state (Rajasthan). Studying these sites using one instrument allows environmental exposures to be compared across contrasting climates while holding measurement constant, which a single-site study cannot do.

The primary objective was to estimate the prevalence of poor sleep quality and short sleep duration among adults at these sites. Inadequate sleep, defined as short sleep duration and/or a PSQI score above five, was a composite secondary outcome. The secondary objectives were to examine the associations of poor sleep quality with excessive daytime sleepiness, depressive symptoms, and self-reported hypertension, diabetes, and obesity, and to identify sociodemographic, occupational, lifestyle, environmental, and psychosocial correlates, including differences between sites.

Materials And Methods

Study design and setting

This was a multicentric, cross-sectional, non-interventional online observational study. The Andaman and Nicobar Islands served as the lead site, with Delhi, Jammu and Kashmir, and Rajasthan as additional planned sites. The sites were chosen purposively for two reasons: they represent contrasting climatic and geographic settings (tropical maritime island, hot semi-arid metropolis, Himalayan temperate region, and arid western state), and the investigators had institutional networks at each site through which recruitment could be organised. West Bengal appeared as a response option in the questionnaire but was not a protocol-designated site; respondents selecting it were classified with those from other non-designated states.

The online links also reached respondents from other Indian states and union territories. These respondents were retained as a pooled "other Indian states/union territories" category (96 respondents, 11.1%) for descriptive and comparative analyses; this group represents a convenience sample, not a study site. Data were collected through Google Forms between May and August 2026, without physical contact with participants.

An online mode was chosen for four reasons. The sites are separated by up to approximately 3,000 km, and the lead site itself is dispersed across islands with limited inter-island transport. The study had no dedicated funding for field teams. Self-administration standardised the delivery of the instruments across sites. Finally, an anonymous online format may encourage disclosure of sensitive information, such as depressive symptoms and thoughts of self-harm.

Participants

Eligible participants were adults aged 18 years and above who had lived in the study area for at least six months, could read English or Hindi, had access to an internet-connected device, and provided electronic informed consent. Individuals who were hospitalised, critically ill, or had severe cognitive impairment or a psychiatric condition that would hinder consent or reliable completion were asked not to participate.

A total of 863 responses were received. One response from a participant residing in Ireland was excluded because the study population comprised adults living in India. The final analytic sample comprised 862 respondents.

Sample size

The minimum sample size was calculated using the formula for estimating a single proportion:

$$ n = \frac{Z^2 p(1-p)}{d^2} $$

where Z = 1.96 for a 95% confidence level, p is the anticipated prevalence of poor sleep quality, and d is the absolute precision. In the absence of a published estimate for the general adult population in any of the study regions, p = 0.363 was taken from the only identified community-based Indian PSQI study [4], with d = 0.05. This gave a minimum of 356 participants per site (355.3, rounded up). Allowing for 20% non-response or incomplete responses, the per-site target was set at 450, giving a planned total of 1,800 across the four sites. The achieved sample of 862 fell short of this target at every site, and this shortfall is reported as a limitation.

Sampling technique

Purposive and snowball sampling were combined. Participants were recruited through institutional networks (colleges, hospitals, and workplaces), community channels, and digital platforms (email, WhatsApp, and social media). Response patterns were monitored during data collection to encourage representation across sociodemographic groups, although the sample retains the selection bias inherent in convenience-based online recruitment.

Data collection instrument

A structured, pre-tested, self-administered questionnaire was hosted on Google Forms (Appendix 1). The first page contained the participant information sheet and a mandatory consent checkbox. The questionnaire comprised: (i) sociodemographic characteristics; (ii) self-reported weight and height, used to compute body mass index (BMI), and physician-diagnosed comorbidities and medication use; (iii) lifestyle factors, including caffeine, tobacco and alcohol use, physical activity, screen time, and sleep environment; (iv) self-reported sleep patterns; (v) the 19-item PSQI, with a global score above five denoting poor sleep quality [16]; (vi) the eight-item ESS, with a total score of 10 or above denoting excessive daytime sleepiness [17]; (vii) the PHQ-9, scored 0-27, with a score of 10 or above denoting clinically significant depressive symptoms and severity bands of minimal (0-4), mild (5-9), moderate (10-14), moderately severe (15-19), and severe (20-27) [18]; (viii) the PSS-10, with items 4, 5, 7, and 8 reverse-scored and total scores classified as low (0-13), moderate (14-26), or high (27-40) perceived stress [19]; and (ix) study-specific occupational and environmental items. The scoring procedures, score ranges and interpretation thresholds for the four validated instruments are provided in Appendix 2.

The habitual sleep efficiency component of the PSQI was derived by converting categorical bedtime, wake time, and sleep-duration responses to interval midpoints and dividing the estimated sleep duration by the estimated time in bed. Short sleep duration was defined as fewer than seven hours on a typical weekday. The protocol-defined composite "inadequate sleep" was defined as short sleep duration and/or a global PSQI score above five. BMI was calculated from self-reported weight and height (kg/m^2) and classified using the WHO criteria: underweight <18.5, normal 18.5-24.9, overweight 25.0-29.9, and obesity ⩾30 kg/m^2 [21]. This BMI-defined obesity is distinct from the self-reported obesity recorded in the comorbidity checklist, whose item wording was "as diagnosed by a doctor or BMI ⩾30 kg/m^2"; the latter is reported separately as self-reported obesity.

Development of Study-Specific Environmental Items

The items on heat/humidity disturbance, nocturnal mosquito/insect disturbance, ventilation, access to sleep-related care, and community disruptors (Appendix 1, Sections I-J) were drafted by the investigators based on published literature on environmental determinants of sleep and local experience at the lead site. They were reviewed for content and clarity within the investigating team and pre-tested together with the rest of the questionnaire at the lead site before data collection, after which the wording was refined; pilot responses were not included in the analysis. These are single-item self-reports of perceived disturbance, not validated scales or objective measurements of temperature, humidity, or vector density.

Data quality, duplicates, and missing data

The form required consent and eligibility screening before any questions were shown. During data cleaning, responses were screened for duplicate and grossly incomplete submissions; no duplicate or grossly incomplete responses were identified. Missing data were handled by complete-case analysis for each variable, without imputation, and the denominator is reported wherever it differs from 862. The lifestyle and environmental items on caffeine within three hours of bedtime, pre-bedtime screen use, heat/humidity disturbance, and insect disturbance were available for 655 respondents (76.0%); the remaining 207 respondents did not answer these items. Self-reported weight and height could not be parsed into valid values for 29 respondents (3.4%), and the comorbidity item was unanswered by eight respondents (0.9%).

Statistical analysis

Data were analysed using Python (version 3.12) with the pandas, SciPy, and statsmodels libraries. Categorical variables are presented as frequencies and percentages, with Wilson 95% CIs for the main prevalence estimates, and continuous variables as mean ± SD or median (IQR). Associations between categorical variables were assessed using Pearson's chi-square test or Fisher's exact test when any expected cell count was below five. Scale scores were compared across sites using the Kruskal-Wallis test, and correlations between scale scores were assessed using Spearman's rank correlation.

Multivariable logistic regression was used to identify factors independently associated with poor sleep quality (PSQI >5), adjusting for age, gender, study site, occupational category, shift/irregular work status, and the standardised PSS-10 score (z-score, so that the OR is per one SD). These covariates were specified a priori. Environmental and lifestyle exposures were examined in bivariate analyses only because data were missing for 24% of respondents; their associations are therefore unadjusted. Adjusted ORs with 95% CIs are reported. A two-sided p-value of <0.05 was considered statistically significant, and no correction was made for multiple comparisons.

Ethical considerations

The protocol (ANIIMS/IEC/2026/12, "Associations between sleep hours, nightly patterns, and adverse health outcomes: evidence for Public Health Intervention," version 02 dated 23 April 2026) was approved by the Institutional Ethics Committee of the Andaman and Nicobar Islands Institute of Medical Sciences (ANIIMS), Sri Vijaya Puram, an IEC registered with the Department of Health Research, Government of India (Reg. No. EC/NEW/INST/2023/AN/0385, dated 08.12.2023). The study followed the Indian Council of Medical Research's national ethical guidelines [22]. No names, addresses, or contact details were recorded, and responses were stored in a password-protected database accessible only to the investigators. Participation was voluntary and unincentivised, and respondents could withdraw at any point before submission. Because the PHQ-9 includes an item on thoughts of self-harm, an on-screen notice with national helpline numbers was displayed alongside that section.

Results

Participant flow and sociodemographic profile

Of the 863 responses received, one out-of-scope response from outside India was excluded, leaving 862 participants for analysis (Figure *1*). The Andaman and Nicobar Islands lead site, where recruitment efforts were doubled to strengthen local precision, contributed 414 respondents (48.0%), followed by Delhi (176, 20.4%), Jammu and Kashmir (97, 11.3%), the pooled other states/union territories (96, 11.1%), and Rajasthan (79, 9.2%).

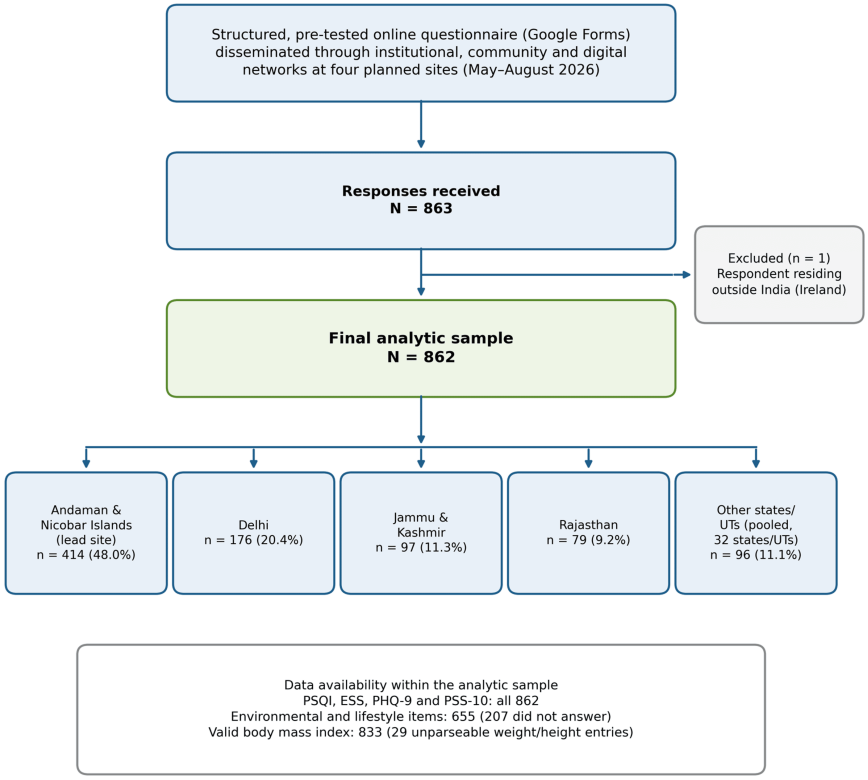


FIGURE 1: Participant recruitment and site-wise distribution of the analytic sample.

A total of 863 responses were received; one response was excluded because the participant resided outside India, leaving 862 participants for analysis. All 862 participants had complete Pittsburgh Sleep Quality Index (PSQI), Epworth Sleepiness Scale (ESS), Patient Health Questionnaire-9 (PHQ-9), and Perceived Stress Scale-10 (PSS-10) data; 655 provided responses to the environmental and lifestyle items, and 833 had valid BMI data.

The mean age, calculated from age-band midpoints, was 25.8 ± 9.0 years, and 600 respondents (69.6%) were aged 18-24 years. There were 484 women (56.1%), 372 men (43.2%), and 6 respondents (0.7%) who identified as another gender or preferred not to say. Most were unmarried (644, 74.7%) and urban residents (571, 66.2%); 87 (10.1%) lived in island, remote, or coastal areas, and none reported living in a designated tribal/indigenous community area, although 89 (10.3%) self-identified as indigenous or tribal. Students formed the largest occupational group (576, 66.8%), followed by healthcare professionals (125, 14.5%) and government employees (58, 6.7%). Shift or irregular work was reported by 95 respondents (11.0%). Among 833 respondents with valid BMI data, the mean BMI was 23.68 ± 4.58 kg/m², with 73 (8.8%) classified as obese (BMI ⩾30 kg/m²) and 201 (24.1%) as overweight (BMI 25.0-29.9 kg/m²) according to WHO criteria (Table *1*).

Characteristic	Category	n	%
Age group (years)	18-24	600	69.6
	25-34	122	14.2
	35-44	99	11.5
	45-54	26	3
	55-64	10	1.2
	≥65	5	0.6
Gender	Female	484	56.1
	Male	372	43.2

	Other/prefer not to say	6	0.7
Marital status	Unmarried/single	644	74.7
	Married/in a relationship	208	24.1
	Separated/divorced	8	0.9
	Widowed	2	0.2
Education	Higher secondary or below	470	54.5
	Graduate	154	17.9
	Professional degree	143	16.6
	Postgraduate or above	95	11
Occupation‡	Student	576	66.8
	Healthcare professional	125	14.5
	Government employee	58	6.7
	Other (free-text occupations)	34	3.9
	Homemaker	24	2.8
	Self-employed/business	20	2.3
	Unemployed	18	2.1
	Retired	7	0.8
Shift/irregular work	Yes (any pattern)	95	11
	No/not applicable	767	89
Area of residence	Urban	571	66.2
	Semi-urban/peri-urban	108	12.5
	Rural	96	11.1
	Island/remote/coastal	87	10.1
	Tribal/indigenous community area	0	0
Community/ethnicity	Mixed background	268	31.1
	Non-tribal community	243	28.2
	Prefer not to say	243	28.2
	Indigenous/tribal	89	10.3
	Other/unspecified	19	2.2
Study site	Andaman & Nicobar Islands	414	48
	Delhi	176	20.4
	Jammu & Kashmir	97	11.3
	Other Indian states/UTs*	96	11.1
	Rajasthan	79	9.2
BMI category, WHO (n = 833)	Underweight (<18.5)	87	10.4
	Normal (18.5-24.9)	472	56.7
	Overweight (25.0-29.9)	201	24.1
	Obese (≥30)	73	8.8
	Hypertension	41	4.8
	Type 2 diabetes mellitus	10	1.2

Comorbidity†	Obesity (self-reported, doctor-diagnosed)	59	6.8
	Heart disease (any)	8	0.9
	Asthma/chronic respiratory disease	22	2.6
	Thyroid disorder	47	5.5
	Anxiety disorder	48	5.6
	Depression	37	4.3
	Any other mental health condition	23	2.7
	None of the above	660	76.6
	Any physician-diagnosed comorbidity	194	22.5

TABLE 1: Sociodemographic, lifestyle, and anthropometric characteristics of the study participants (N = 862).

Sleep, sleepiness, mood and stress profile

The mean global PSQI score was 6.55 ± 3.48 (median 6, IQR 4-9), and 475 respondents (55.1%, 95% CI 51.8-58.4) had poor sleep quality. Short sleep duration (<7 hours on a typical weekday) was reported by 641 respondents (74.4%, 95% CI 71.3-77.2), and 687 (79.7%) met the composite definition of inadequate sleep.

The mean ESS score was 6.97 ± 4.75, with 236 respondents (27.4%) meeting the threshold for excessive daytime sleepiness. The mean PHQ-9 score was 7.05 ± 6.40, and 257 respondents (29.8%, 95% CI 26.9-33.0) scored 10 or above, indicating moderate or more severe depressive symptoms; the remaining 605 (70.2%) scored in the minimal or mild range.

On the PHQ-9 item concerning thoughts of being better off dead or of self-harm, 270 respondents (31.3%) endorsed a response of at least "several days." This overlaps with, but is distinct from, the PHQ-9 ⩾10 group: 182 of the 257 respondents with PHQ-9 ⩾10 (70.8%) endorsed the item, as did 88 of the 605 respondents with PHQ-9 <10 (14.5%). The mean PSS-10 score was 18.35 ± 6.09, with 120 respondents (13.9%) reporting low, 670 (77.7%) moderate, and 72 (8.4%) high perceived stress (Table *2*).

Scale	Overall	Andaman and Nicobar Islands	Delhi	Jammu & Kashmir	Rajasthan	Other states/UTs*	P-value†
PSQI global score	6.55 ± 3.48	6.42 ± 3.30	6.66 ± 3.64	6.79 ± 3.68	5.68 ± 3.11	6.96 ± 3.72	0.132
ESS total score	6.97 ± 4.75	6.93 ± 4.64	7.61 ± 5.12	6.29 ± 4.83	5.43 ± 3.98	7.99 ± 4.60	0.001
PHQ-9 total score	7.05 ± 6.40	6.56 ± 5.91	7.22 ± 6.57	8.69 ± 7.24	5.63 ± 6.10	7.39 ± 6.31	0.026
PSS-10 total score	18.35 ± 6.09	19.32 ± 5.38	17.70 ± 5.27	19.79 ± 7.44	16.33 ± 4.38	17.75 ± 7.93	<0.001

TABLE 2: Sleep quality, daytime sleepiness, depressive symptoms, and perceived stress scores (mean ± SD), overall and by study site (N = 862).

PSQI: Pittsburgh Sleep Quality Index; ESS: Epworth Sleepiness Scale; PHQ-9: Patient Health Questionnaire-9; PSS-10: Perceived Stress Scale-10; UT: Union territory.

†Kruskal–Wallis test across the five groups. *Pooled category comprising respondents from other Indian states and union territories, with each contributing no more than 10 respondents.

Site-wise variation

The prevalence of poor sleep quality ranged from 40.5% (32/79) in Rajasthan to 60.8% (59/97) in Jammu and Kashmir, with 54.5% (96/176) in Delhi, 55.6% (230/414) in the Andaman and Nicobar Islands, and 60.4% (58/96) in the pooled other-states group (Figure 2). This variation was of borderline statistical significance ($\chi^2 = 9.24$, df = 4, p = 0.055), and mean PSQI scores did not differ significantly by site (p = 0.132; Table 2). Mean ESS, PHQ-9, and PSS-10 scores did vary significantly by site (p = 0.001, p = 0.026, and p < 0.001, respectively), with the lowest scores on all three scales in Rajasthan.

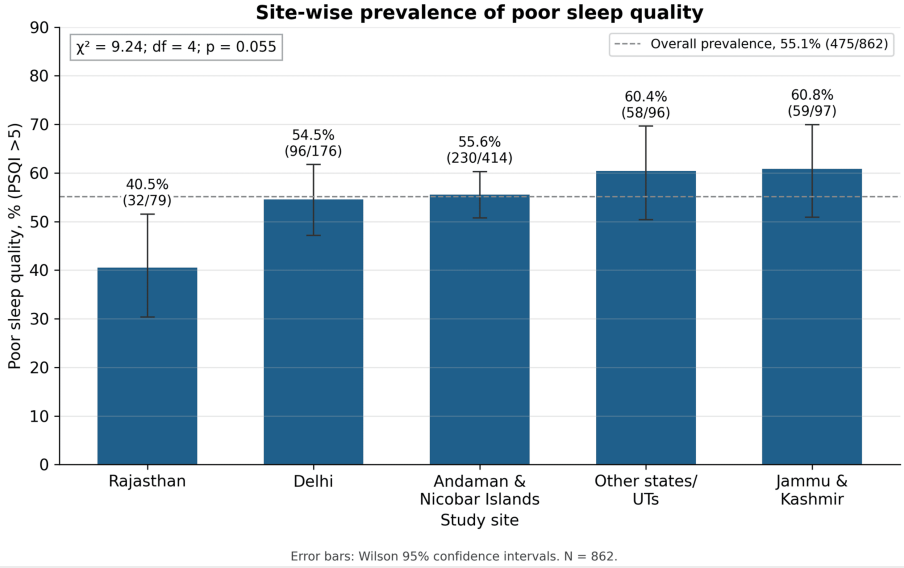


FIGURE 2: Site-wise prevalence of poor sleep quality (PSQI > 5; N = 862).

Bars represent the proportion of participants with poor sleep quality at each study site. The overall prevalence was 55.1% ($\chi^2 = 9.24$, df = 4, p = 0.055). Error bars represent Wilson 95% confidence intervals, and the dashed line indicates the overall prevalence.

PSQI: Pittsburgh Sleep Quality Index; df: Degrees of freedom.

Subgroup differences and association with health outcomes

Poor sleep quality did not differ significantly between women and men (263/484, 54.3% versus 207/372, 55.6%; $\chi^2 = 0.14$, p = 0.703) and was not associated with WHO-defined obesity (BMI ⩾30 versus <30 kg/m²; $\chi^2 = 0.10$, p = 0.756) or self-reported physician-diagnosed obesity (Fisher's exact p = 0.13). It was more frequent among respondents reporting any shift or irregular work (64/95, 67.4%) than among those without (411/767, 53.6%; $\chi^2 = 6.49$, p = 0.011).

Poor sleep quality was more frequent among respondents with depressive symptoms (208/257, 80.9%) than among those without (267/605, 44.1%; $\chi^2 = 98.75$, p < 0.001). It was likewise more frequent among those with excessive daytime sleepiness (181/236, 76.7%) than among those without (294/626, 47.0%; $\chi^2 = 61.23$, p < 0.001). No association was observed with self-reported hypertension (21/41, 51.2% versus 454/821, 55.3%; Fisher's exact p = 0.632) or diabetes (5/10, 50.0% versus 470/852, 55.2%; Fisher's exact p = 0.760).

Environmental and lifestyle correlates

These analyses included the 655 respondents with data on the environmental and lifestyle items. Self-reported heat/humidity disturbance showed a graded, unadjusted association with poor sleep quality: 43.6% (95/218) among those reporting no disturbance, 53.6% (149/278) among those reporting mild disturbance, 73.7% (84/114) among those reporting moderate disturbance, and 75.6% (34/45) among those reporting severe disturbance ($\chi^2 = 35.49$, df = 3, p < 0.001; Figure 3). A similar gradient was observed for nocturnal mosquito/insect disturbance, from 50.3% (158/314) among those never or rarely disturbed to 84.2% (16/19) among those disturbed almost every night ($\chi^2 = 12.93$, df = 3, p = 0.005).

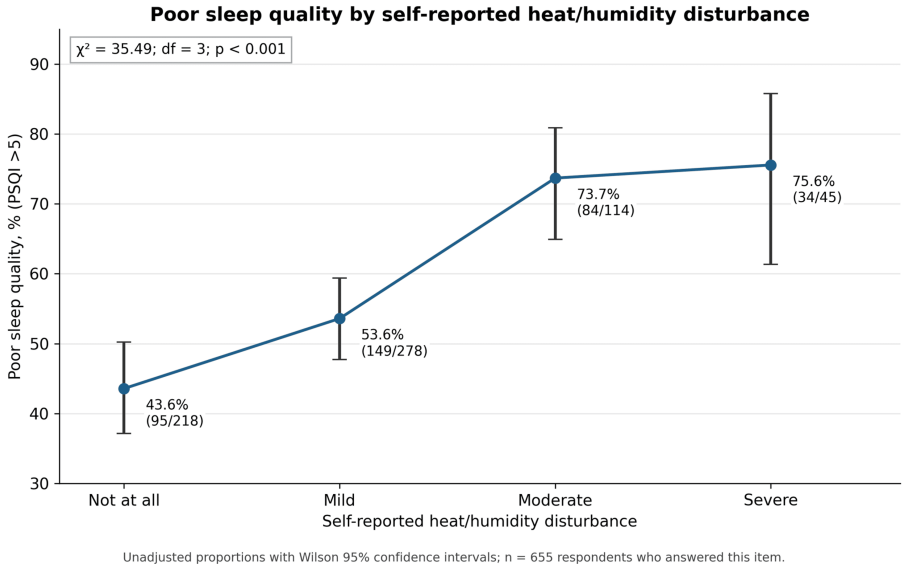


FIGURE 3: Prevalence of poor sleep quality by self-reported heat and humidity disturbance (n = 655).

Bars represent unadjusted proportions of participants with poor sleep quality, with Wilson 95% confidence intervals ($\chi^2 = 35.49$, df = 3, $p < 0.001$).

df: Degrees of freedom; PSQI: Pittsburgh Sleep Quality Index.

Caffeine consumption within three hours of bedtime was associated with poor sleep quality ($\chi^2 = 31.66$, df = 4, $p < 0.001$), although the pattern was not monotonic: prevalence was 47.6% among those who never consumed caffeine before bed and ranged from 55.6% to 78.6% across the other frequency categories. Screen use in the hour before bed was also associated with poor sleep quality ($\chi^2 = 9.05$, df = 3, $p = 0.029$), ranging from 42.9% among those avoiding screens to 67.7% among those who usually fell asleep with a screen on (Table *3*).

Variable	Category	n/N (% with poor sleep quality)	χ² (df); p-value
Study site	Rajasthan	32/79 (40.5)	9.24 (4); 0.055
	Delhi	96/176 (54.5)	
	Andaman and Nicobar Islands	230/414 (55.6)	
	Other Indian states/union territories*	58/96 (60.4)	
	Jammu & Kashmir	59/97 (60.8)	
Gender§	Female	263/484 (54.3)	0.14 (1); 0.703
	Male	207/372 (55.6)	
Shift/irregular work	No / not applicable	411/767 (53.6)	6.49 (1); 0.011
	Yes (any pattern)	64/95 (67.4)	
Hypertension (self-reported)	No	454/821 (55.3)	Fisher's exact test; 0.632
	Yes	21/41 (51.2)	
Diabetes (self-reported)	No	470/852 (55.2)	Fisher's exact test; 0.760
	Yes	5/10 (50.0)	
Depressive symptoms (PHQ-9 ≥ 10)	Absent	267/605 (44.1)	98.75 (1); <0.001
	Present	208/257 (80.9)	

Excessive daytime sleepiness (ESS ≥ 10)	Absent	294/626 (47.0)	61.23 (1); <0.001
	Present	181/236 (76.7)	
Heat/humidity disturbance‖	Not at all	95/218 (43.6)	35.49 (3); <0.001
	Mild	149/278 (53.6)	
	Moderate	84/114 (73.7)	
	Severe	34/45 (75.6)	
Mosquito/insect disturbance‖	Never/rarely	158/314 (50.3)	12.93 (3); 0.005
	Sometimes	151/267 (56.6)	
	Often	37/55 (67.3)	
	Almost every night	16/19 (84.2)	
Caffeine within 3 hours of bedtime‖	No, never	205/431 (47.6)	31.66 (4); <0.001
	Rarely	115/162 (71.0)	
	Sometimes	26/39 (66.7)	
	Most days	11/14 (78.6)	
	Every day	5/9 (55.6)	
Screen use in the hour before bedtime‖¶	Avoids screens	18/42 (42.9)	9.05 (3); 0.029
	<30 minutes	106/199 (53.3)	
	30-60 minutes	173/318 (54.4)	
	Falls asleep with screen on	65/96 (67.7)	

TABLE 3: Bivariate associations with poor sleep quality (PSQI > 5).

PSQI: Pittsburgh Sleep Quality Index.

Multivariable analysis

After adjustment for age, gender, site, occupation, shift/irregular work, and perceived stress (N = 862), two factors remained independently associated with poor sleep quality: any shift or irregular work (aOR 2.15, 95% CI 1.15-4.01, p = 0.016) and higher perceived stress (aOR 1.93 per SD of PSS-10, 95% CI 1.58-2.36, p < 0.001). Age, gender, study site, and occupational category were not independently associated with poor sleep quality (Table 4).

Variable	Reference	aOR	95% CI	p-value
Age (per SD, approximately 9.0 years)	-	0.92	0.68-1.24	0.591
Gender: male	Female	1.16	0.82-1.65	0.395
Gender: other/prefer not to say	Female	2.3	0.24-22.45	0.468
Site: Andaman & Nicobar Islands	Delhi	1.01	0.65-1.58	0.958
Site: Jammu & Kashmir	Delhi	1.13	0.65-1.96	0.666
Site: Rajasthan	Delhi	0.62	0.33-1.15	0.128
Site: other Indian states/union territories	Delhi	1.33	0.73-2.42	0.348
Occupation: government employee	Student	0.84	0.33-2.13	0.707
Occupation: healthcare professional	Student	0.66	0.34-1.29	0.223
Occupation: homemaker	Student	1.81	0.55-5.97	0.327
Occupation: other	Student	2.6	0.86-7.83	0.089
Occupation: retired	Student	3.31	0.35-31.74	0.299
Occupation: self-employed/business	Student	2.73	0.69-10.88	0.154
Occupation: unemployed	Student	0.7	0.20-2.42	0.573
Shift/irregular work: yes	No	2.15	1.15-4.01	0.016
Perceived stress (per SD of PSS-10)	-	1.93	1.58-2.36	<0.001

TABLE 4: Multivariable logistic regression analysis of factors associated with poor sleep quality (PSQI > 5; N = 862).

aOR: Adjusted odds ratio; PSQI: Pittsburgh Sleep Quality Index; PSS-10: Perceived Stress Scale-10.

Discussion

In this multicentric online survey of 862 adults, 55.1% reported poor sleep quality, and 74.4% slept fewer than seven hours on a typical night. Poor sleep quality was independently associated with shift or irregular work and perceived stress, and, in unadjusted analyses, with self-reported heat, humidity and insect disturbance. Because the sample was young, predominantly student-based and recruited non-probabilistically, these findings describe this sample and should not be extrapolated to Indian adults in general.

Comparison with similar populations

Comparisons are most meaningful against studies of similar age, setting and recruitment mode. The overall prevalence of 55.1% is close to the 56% reported among undergraduate medical students in Delhi [5], a population resembling our student-heavy sample. The prevalence at the Delhi site (54.5%) is consistent with that estimate. In Jammu and Kashmir, 60.8% of respondents had poor sleep quality, somewhat higher than the 53% reported in an online survey of the Kashmiri general population [6]. That study was conducted in April 2020, early in the COVID-19 pandemic, used a stricter PSQI cut-off (>6) and had a different respondent profile, so the difference should be interpreted cautiously.

For the island lead site, the most relevant comparators are young adults in other Indian Ocean island populations. Poor sleep quality in the Andaman & Nicobar Islands (55.6%) exceeded the 41% reported among Sri Lankan medical undergraduates [9] and the 30.7% reported among young people aged 14-29 years in Mauritius, where the sleep environment was a leading correlate [10]. Data were collected during the summer and monsoon months, when heat and humidity are generally high, which may partly explain the higher estimate. Rajasthan had the lowest prevalence (40.5%) and the lowest sleepiness, depression and stress scores, but the site sample was small (n = 79), and no general-population PSQI study from Rajasthan was identified for direct comparison. The 36.3% reported in a rural South Indian community [4], which informed the sample size calculation, comes from an older, rural, household-based population and is not directly comparable with this sample.

The high prevalence of short sleep (74.4%) is consistent with the sample's composition, since short and irregular sleep are well documented among college students [23].

Environmental correlates

The graded association between self-reported heat/humidity disturbance and poor sleep quality, and a similar gradient for insect disturbance, are consistent with evidence that warmer night-time temperatures shorten sleep, with larger effects in hotter and lower-income settings [7,8]. These associations should be interpreted with three cautions. They are unadjusted and based on the 655 respondents with environmental data, so confounding by site, housing, air conditioning, season, stress or occupation cannot be excluded. The exposures are single-item self-reports of perceived disturbance, not measured temperature, humidity or vector density. Finally, people who sleep poorly for other reasons may be more likely to attribute their sleep difficulties to heat or insects. Studies combining objective weather data with sleep measures and models adjusting for these exposures are needed before environmental interventions such as improved ventilation or vector control can be recommended on the basis of sleep outcomes.

Two other environmental influences, noise and cold, were not assessed as separate exposures. Noise was captured only within a composite sleep-environment item and a question on community events, which were not analysed as distinct exposures here. Neighbourhood factors, including noise, are established predictors of poor sleep, particularly in urban areas [24], and are likely relevant to Delhi and other urban respondents. Cold exposure could not be examined because data were collected between May and August; winter conditions in Jammu and Kashmir, Delhi and northern Rajasthan may affect sleep differently. A repeat wave in winter, with dedicated noise and temperature items, would address both gaps.

Occupational and psychosocial correlates

Shift or irregular work was associated with roughly twice the odds of poor sleep quality after adjustment (aOR 2.15), in keeping with the established effect of circadian misalignment on sleep [25,26]. Only 95 respondents reported such work, so this estimate is imprecise (95% CI 1.15-4.01).

Perceived stress showed the strongest adjusted association with poor sleep quality (aOR 1.93 per SD) and correlated most strongly with depressive symptoms (rho = 0.578). This pattern is consistent with a bidirectional relationship between stress, sleep disturbance and mood [14,27] and with evidence linking perceived stress to adverse outcomes in NCDs [15]. The cross-sectional design cannot establish whether stress precedes poor sleep, follows it or both.

Poor sleep quality was also more frequent among those with depressive symptoms (80.9% versus 44.1%) and excessive daytime sleepiness (76.7% versus 47.0%), consistent with the known overlap between disturbed sleep, mood and daytime function [13,27,28]. Part of the association with depressive symptoms is expected by construction because PHQ-9 item 3 asks about sleep difficulty; the direction of the relationship cannot be determined from these data.

The finding that 31.3% endorsed at least "several days" on the PHQ-9 self-harm item is substantial. This item is a screening question, not a diagnostic measure of suicidal ideation, and it captures passive thoughts of being better off dead as well as thoughts of self-harm; it is known to over-identify risk relative to structured assessment. The figure should nonetheless be viewed alongside evidence of a considerable burden of depression and suicidal ideation among Indian students and young adults [28,29]. Future online surveys that include this item should incorporate an active referral pathway in addition to the on-screen helpline notice used here.

Cardiometabolic outcomes

The study did not find the associations with hypertension, diabetes or obesity that it examined as a secondary objective. This contrasts with the extensive literature linking short and poor-quality sleep to these outcomes [11,30]. A possible explanation is the young age structure and correspondingly low prevalence of self-reported hypertension (4.8%) and diabetes (1.2%), which may have left the study underpowered for these comparisons; reliance on self-reported diagnoses may also have caused misclassification. By WHO criteria, 8.8% of respondents with valid BMI were obese (more than equal to 30kg/m^2) and 24.1% were overweight, but these estimates rest on self-reported weight and height.

Strengths

The study applied a single standardised instrument set, comprising four validated scales and purpose-built environmental and occupational items, across four climatically contrasting sites, including an island territory for which sleep data were previously lacking. This allowed site comparisons and context-specific environmental questions to be examined using a common methodology.

Limitations

Several limitations should be considered. First, the cross-sectional design precludes causal or temporal inference for all associations reported.

Second, online-only recruitment excluded many of the groups that motivated the study. Fisherfolk, agricultural and manual workers, defence personnel, older adults and residents of tribal areas are less likely to have reliable internet access or to be reached through institutional and social media networks. Defence personnel and fisherfolk or agricultural workers did not form distinct groups in the occupational profile. The study's rationale and its achieved sample are therefore in tension, and the findings cannot speak to these populations.

Third, the sample was convenience-based and heavily weighted towards young, unmarried students and healthcare-affiliated respondents, and site contributions were unequal (48.0% from the lead site). The achieved sample of 862 fell short of the planned 1,800 and of the per-site target at every site, so site-level estimates are imprecise, particularly for Rajasthan (n = 79) and Jammu & Kashmir (n = 97). The pooled category of respondents from other Indian states and union territories is a convenience sample and not a defined study site.

Fourth, all measures were self-reported. Environmental exposures were assessed using single, non-validated items answered by only 76.0% of respondents, so non-response bias is possible; they were not included in the multivariable model, so their associations are unadjusted. Data collection between May and August meant that seasonal effects could not be separated from site effects, and cold and noise were not assessed as separate exposures. The PSQI sleep-efficiency component was approximated from categorical responses; BMI could not be computed for 29 respondents (3.4%), and multiple bivariate comparisons were made without adjustment for multiplicity.

Conclusions

Poor sleep quality and short sleep duration were common in this young, predominantly student-based online sample drawn from four climatically contrasting Indian sites. Poor sleep quality was independently associated with shift or irregular work and higher perceived stress, and, in unadjusted analyses, with self-reported heat, humidity and insect disturbance, a pattern that merits further study in island and coastal settings such as the Andaman and Nicobar Islands. No association was found with self-reported hypertension, diabetes or obesity, most likely because few participants had these conditions.

These findings support screening for sleep problems within mental health and NCD programmes, particularly for shift workers and people reporting high stress. Population-based studies that reach offline and older populations, use objective environmental measures and include winter data are needed before environment-specific interventions can be recommended. Given the non-probability sampling, the prevalence estimates should be regarded as indicative rather than nationally representative.

Appendices

Sleep health across geographically diverse regions of India

This document contains the appendices referenced in the main manuscript: Appendix 1 (the full participant questionnaire, as administered) and Appendix 2 (the scoring and interpretation guide for the four validated instruments).

Appendix 1

Participant Questionnaire

The participant-facing questionnaire used for online data collection (Google Forms) is reproduced below, organised by section, as administered. Sections corresponding to proprietary, copyrighted validated instruments (the Pittsburgh Sleep Quality Index (PSQI), Epworth Sleepiness Scale (ESS) and Perceived Stress Scale-10 (PSS-10)) are referenced by name, source citation and scoring logic only; their item-level wording is not reproduced here, in accordance with the applicable copyright terms. The PSQI was administered in accordance with the University of Pittsburgh's applicable terms of use, while permissions for the ESS and PSS-10 were obtained through Mapi Research Trust. The Patient Health Questionnaire-9 (PHQ-9) is in the public domain (Pfizer Inc.; no permission required to reproduce, translate, display or distribute) and is reproduced in full.

Participant Information Sheet and Informed Consent (Summary)

Participants were informed of the study title, purpose, procedures, voluntary nature of participation, absence of physical risk, confidentiality safeguards and contact details of the principal investigator. They were required to tick a mandatory consent checkbox ("I have read and understood the Participant Information Sheet. I am 18 years of age or older, and I voluntarily agree to participate in this study.") before proceeding to the questionnaire. Participants under 18 years of age were not permitted to proceed.

Section A: Socio-demographic Details

Q1. Which study site/state are you responding from?

○ Andaman & Nicobar Islands (Lead Site)

○ Delhi

○ Jammu & Kashmir

○ Rajasthan

○ West Bengal

○ Other (please specify)

Note: West Bengal appeared as a response option but was not a protocol-designated site; respondents selecting it were analysed in the pooled "other Indian states/union territories" category.

Q2. What is your age (in completed years)?

○ 18-24 years

○ 25-34 years

○ 35-44 years

○ 45-54 years

○ 55-64 years

○ 65 years and above

Q3. What is your gender?

○ Male

○ Female

○ Transgender / Non-binary

○ Prefer not to say

Q4. What is your marital status?

○ Unmarried / Single

○ Married / In a relationship

○ Separated / Divorced

○ Widowed

Q5. What is the highest level of education you have completed?

○ No formal education

○ Primary (up to Class 5)

○ Secondary (Class 6-10)

○ Higher Secondary (Class 11-12)

○ Graduate (Bachelor's degree)

○ Postgraduate (Master's degree or above)

○ Professional degree (MBBS, LLB, B.Tech, etc.)

Q6. What is your current employment/occupational status?

○ Government employee (Central / State)

○ Defence / Paramilitary / Coast Guard personnel

○ Healthcare professional (doctor, nurse, paramedic, etc.)

○ Self-employed / Business owner

○ Fisherman / Agricultural / Manual labour

○ Student

○ Homemaker

○ Unemployed

○ Retired

○ Other (please specify)

Q7. Does your occupation involve shift work or irregular working hours?

○ No, I work regular day shifts

○ Yes, I work rotating shifts (day + night)

○ Yes, I work exclusively night shifts

○ Yes, I have highly irregular / variable work hours

○ Not applicable (student, homemaker, retired, etc.)

Q8. What is your approximate monthly household income?

○ Less than ₱10,000

○ ₱10,001-₱25,000

○ ₱25,001-₱50,000

○ ₱50,001-₱1,00,000

○ More than ₱1,00,000

○ Prefer not to say

Q9. What type of area do you currently live in?

○ Urban (city / town)

○ Semi-urban / Peri-urban

○ Rural

○ Tribal / Indigenous community area

○ Island / Remote / Coastal area

Q10. How long have you been residing at your current location?

○ Less than 6 months (ineligible - please exit)

○ 6 months to less than 1 year

○ 1-5 years

○ More than 5 years

○ Born and raised here / Lifelong resident

Q11. What is your community/ethnicity background?

○ Indigenous / Tribal (e.g., Andamanese, Nicobarese, Jarawa, etc.)

○ Non-indigenous mainland settler

○ Mixed background

○ Prefer not to say

Q12. What is your current body weight (in kilograms)? (Approximate is acceptable)

○ Enter in kg (free text)

Q13. What is your current height (in centimetres)? (Approximate is acceptable)

○ Enter in cm (free text)

BMI was calculated by the investigators from self-reported weight and height for research classification purposes only.

Section B: Health Status and Comorbidities

Q14. Have you been diagnosed with any of the following conditions by a doctor? (Select all that apply)

○ Hypertension (High Blood Pressure)

○ Type 2 Diabetes Mellitus

○ Obesity (as diagnosed by a doctor or BMI ⩾ 30 kg/m^2)

○ Heart disease (any)

○ Asthma or Chronic Respiratory disease

○ Thyroid disorder

○ Anxiety disorder

○ Depression

○ Any other mental health condition

○ None of the above

Q15. Are you currently taking any medications on a regular basis?

○ No, I do not take any regular medication

○ Yes, for a physical health condition

○ Yes, for a mental health condition

○ Yes, for multiple conditions

○ Prefer not to say

Q16. Have you ever been told by a doctor or health professional that you have a sleep disorder?

○ No

○ Yes - Insomnia (difficulty falling or staying asleep)

○ Yes - Sleep Apnoea (breathing interruptions during sleep)

○ Yes - Restless Legs Syndrome

○ Yes - Other sleep disorder (please specify)

Section C: Lifestyle and Behavioural Factors

Q17. How many cups of caffeinated beverages (tea, coffee, energy drinks) do you consume per day on average?

○ None

○ 1-2 cups

○ 3-4 cups

○ 5 or more cups

Q18. Do you consume caffeine within 3 hours of your usual bedtime?

○ No, never

○ Rarely (1-2 times a week)

○ Sometimes (3-4 times a week)

○ Most days

○ Every day

Q19. Do you currently use any tobacco products (cigarettes, bidis, gutka, paan, etc.)?

○ No, I have never used tobacco

○ No, I have quit in the past

○ Yes, occasionally (less than daily)

○ Yes, daily

Q20. Do you consume alcoholic beverages?

○ No, I do not drink alcohol

○ Rarely (less than once a month)

○ Occasionally (1-3 times per month)

○ Weekly (1-4 times per week)

○ Daily or almost daily

Q21. How physically active are you during a typical week?

○ Sedentary - mostly sitting, little or no deliberate physical activity

○ Lightly active - light activities (housework, light walking) on most days

○ Moderately active - moderate exercise (brisk walking, cycling) ⩾ 30 min, 3-4 days/week

○ Very active - vigorous exercise (gym, running, sport) ⩾ 5 days/week

○ Extremely active - heavy manual labour or intense training daily

Q22. How much time do you typically spend on screens (phone, TV, computer/laptop) per day in total?

○ Less than 2 hours

○ 2-4 hours

○ 4-6 hours

○ 6-8 hours

○ More than 8 hours

Q23. How much screen time do you have in the ONE HOUR before going to bed?

○ None - I avoid screens before bed

○ Less than 30 minutes

○ 30 minutes to 1 hour

○ More than 1 hour

○ I usually fall asleep with a screen on

Q24. How would you describe your sleeping environment?

○ Quiet and comfortable

○ Slightly noisy or uncomfortable at times

○ Frequently noisy (e.g., traffic, machinery, neighbours)

○ Very hot or humid at night

○ Subject to mosquitoes or insects at night

○ Multiple environmental disturbances

Q25. Do you sleep alone or share your bedroom/sleeping space?

○ Sleep alone

○ Share with a partner/spouse

○ Share with child(ren)

○ Share with other family members

○ Share with non-family members (e.g., hostel, dormitory)

Section D: Self-reported Sleep Patterns

Q26. On a typical weekday (working day), approximately how many hours of sleep do you get?

○ Less than 4 hours

○ 4-5 hours

○ 5-6 hours

○ 6-7 hours

○ 7-8 hours

○ 8-9 hours

○ More than 9 hours

Q27. On a typical weekend/off-day, approximately how many hours of sleep do you get?

○ Less than 4 hours

○ 4-5 hours

○ 5-6 hours

○ 6-7 hours

○ 7-8 hours

○ 8-9 hours

○ More than 9 hours

Q28. What is your usual bedtime on weekdays?

○ Before 9:00 PM

○ 9:00 PM-10:00 PM

○ 10:00 PM-11:00 PM

○ 11:00 PM-12:00 midnight

○ 12:00 midnight-1:00 AM

○ After 1:00 AM

Q29. What is your usual wake-up time on weekdays?

○ Before 5:00 AM

○ 5:00 AM-6:00 AM

○ 6:00 AM-7:00 AM

○ 7:00 AM-8:00 AM

○ 8:00 AM-9:00 AM

○ After 9:00 AM

Q30. How would you rate your overall sleep quality in the past month?

○ Very good

○ Fairly good

○ Fairly bad

○ Very bad

Q31. Do you take naps during the day?

○ Never

○ Rarely (once or twice a week)

○ Sometimes (3-4 times a week)

○ Most days

○ Every day

Q32. If you nap, how long do your daytime naps usually last?

○ Less than 20 minutes

○ 20-45 minutes

○ 45 minutes to 1 hour

○ More than 1 hour

○ Not applicable - I do not nap

Q33. If you had trouble sleeping for any 'other reason', please describe:

○ (free text)

Section E: PSQI - Not Reproduced

This section administered the full 19-item, self-rated PSQI (Buysse et al., 1989), covering usual bedtime, sleep latency, wake time, sleep duration, nine specific sleep-disturbance items, overall sleep-quality rating, use of sleep medication and daytime dysfunction, generating the seven component scores and the global PSQI score (range 0-21; >5 denotes poor sleep quality), exactly as described in the Methods section. Item-level wording is copyrighted by the University of Pittsburgh and is not reproduced here. The instrument was administered in accordance with the applicable terms of use. The original instrument is available from the copyright holder and is cited in full in the References [16].

Section F: ESS - Not Reproduced

This section administered the full 8-item ESS (Johns, 1991), scored 0-3 for each item (0 = would never doze; 3 = high chance of dozing) across eight everyday situations, generating a total score of 0-24 (⩾10 denotes excessive daytime sleepiness, consistent with the threshold applied in this study). Item-level wording is copyrighted by M. W. Johns and is not reproduced here. Permission for its use was obtained through Mapi Research Trust. The original instrument is cited in full in the References [17].

Section G: PHQ-9

The PHQ-9 (Kroenke, Spitzer & Williams, 2001) is in the public domain; no permission is required to reproduce, translate, display or distribute it. Respondents were asked: “Over the last 2 weeks, how often have you been bothered by any of the following problems?”, with responses rated as 0 = Not at all, 1 = Several days, 2 = More than half the days and 3 = Nearly every day.

○ 1. Little interest or pleasure in doing things (0-3)

○ 2. Feeling down, depressed, or hopeless (0-3)

○ 3. Trouble falling or staying asleep, or sleeping too much (0-3)

○ 4. Feeling tired or having little energy (0-3)

○ 5. Poor appetite or overeating (0-3)

○ 6. Feeling bad about yourself - or that you are a failure or have let yourself or your family down (0-3)

○ 7. Trouble concentrating on things, such as reading the newspaper or watching television (0-3)

○ 8. Moving or speaking so slowly that other people could have noticed? Or the opposite - being so fidgety or restless that you have been moving around a lot more than usual (0-3)

○ 9. Thoughts that you would be better off dead, or of hurting yourself in some way (0-3)

Q38. If you checked off any problems in the above list, how DIFFICULT have these problems made it for you to do your work, take care of things at home, or get along with other people?

○ Not difficult at all

○ Somewhat difficult

○ Very difficult

○ Extremely difficult

○ Not applicable - I did not check any problems above

An on-screen safety notice was displayed alongside this section: “If you are experiencing thoughts of harming yourself or others, please reach out for support immediately. National Suicide Helpline (India): iCall - 9152987821 | Vandrevala Foundation: 1860-2662-345 (24/7).”

Section H: Perceived Stress Scale-10 (PSS-10) - Not Reproduced

This section administered the full 10-item PSS-10 (Cohen, Kamarck & Mermelstein, 1983), asking how often in the past month respondents felt or thought a certain way (0 = Never to 4 = Very often), with items 4, 5, 7 and 8 reverse-scored, generating a total score of 0-40, categorised as low (0-13), moderate (14-26) or high (27-40) perceived stress. Item-level wording is copyrighted by Sheldon Cohen and is not reproduced here. Permission for its use was obtained through Mapi Research Trust on behalf of RST Assessments, LLC. The original instrument is cited in full in the References [19].

Section I: Occupational and Work-related Sleep Factors

Q39. How many hours do you work or engage in primary daily activities per day on average?

○ Less than 4 hours

○ 4-6 hours

○ 6-8 hours

○ 8-10 hours

○ More than 10 hours

Q40. Do your work or daily activities affect the time at which you go to bed?

○ No, I maintain a consistent bedtime regardless of work

○ Sometimes - work extends my bedtime on some days

○ Often - irregular work hours frequently delay my sleep

○ Almost always - my bedtime varies significantly due to work

Q41. Does work-related stress affect your sleep?

○ Never

○ Rarely

○ Sometimes

○ Often

○ Always

Q42. Does your occupation require you to work in an outdoor or physically demanding environment?

○ No - primarily desk / office based

○ Occasionally - some outdoor exposure

○ Yes - mostly outdoor, physically active work

○ Yes - work in extreme environmental conditions (heat, humidity, noise, etc.)

Q43. If you are a healthcare or defence professional, do you work on-call duties or emergency shifts?

○ Yes, frequently (weekly or more)

○ Yes, occasionally (monthly)

○ Rarely

○ No / Not applicable

Section J: Environmental and Contextual Factors

Q44. Does the heat or humidity at your location affect your ability to sleep comfortably?

○ Not at all - I sleep comfortably

○ Mildly - occasionally disturbs my sleep

○ Moderately - affects my sleep on most nights

○ Severely - significantly disrupts my sleep almost every night

Q45. Are you disturbed by mosquitoes or insects at night?

○ Never or rarely

○ Sometimes

○ Often

○ Almost every night

Q46. Is your sleeping space well-ventilated (with a fan, cooler, or air conditioning)?

○ Yes, air conditioned

○ Yes, with a ceiling / table fan

○ Partially ventilated

○ No, poorly ventilated

Q47. Do you have access to healthcare for sleep-related problems near your home?

○ Yes, easily accessible

○ Yes, but requires travel/effort

○ Limited or difficult access

○ No access at all

Q48. Are there any community festivals, social events, or environmental factors in your area that regularly disturb your night sleep?

○ No

○ Occasionally (a few times a year)

○ Frequently (monthly or more)

○ Seasonally (specific times of year)

Section K: Closing Questions

Q49. Overall, do you think the amount of sleep you get is adequate for you to function well during the day?

○ Yes, definitely adequate

○ Mostly adequate

○ Mostly inadequate

○ Definitely not adequate - I feel sleep deprived

Q50. Have you ever sought professional help for a sleep problem?

○ No, and I do not feel I need to

○ No, although I feel I should

○ Yes, and it was helpful

○ Yes, but it was not helpful

Q51. Is there anything else about your sleep or health that you would like to share with us? (optional, free text)

Appendix 2

Scoring and Interpretation Guide

PSQI: Seven components (subjective sleep quality, sleep latency, sleep duration, habitual sleep efficiency, sleep disturbances, use of sleep medication and daytime dysfunction), each scored 0-3, are summed to obtain a global score of 0-21. A global PSQI score >5 indicates poor sleep quality.

ESS: The scores of eight items (each scored 0-3) are summed to obtain a total score of 0-24. Scores of 0-10 indicate normal sleepiness; 11-12, mild; 13-15, moderate; and 16-24, severe excessive daytime sleepiness. This study applied a total-score threshold of ⩾10 to define excessive daytime sleepiness, consistent with the cut-off specified in the Methods section. Respondents scoring exactly 10 were therefore classified as having excessive daytime sleepiness in this study, although they fall within the upper “normal” band of the severity grading.

PHQ-9: The scores of nine items (each scored 0-3) are summed to obtain a total score of 0-27. Scores of 0-4 indicate minimal; 5-9, mild; 10-14, moderate; 15-19, moderately severe; and 20-27, severe depressive symptoms. A total score ⩾10 was used to denote clinically significant depressive symptoms.

Perceived Stress Scale-10 (PSS-10): Items 4, 5, 7 and 8 are reverse-scored (0 → 4, 1 → 3, 2 → 2, 3 → 1, 4 → 0), and the scores of all 10 items are summed to obtain a total score of 0-40. Scores of 0-13 indicate low; 14-26, moderate; and 27-40, high perceived stress.

Additional Information

Author Contributions

All authors have reviewed the final version to be published and agreed to be accountable for all aspects of the work.

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Acquisition, analysis, or interpretation of data: Samar Hossain, Aanchal Anand, Ajay Raj Sethuraman

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Disclosures

Human subjects: All authors have confirmed that this study did not involve human participants or tissue. **Animal subjects:** All authors have confirmed that this study did not involve animal subjects or tissue. **Conflicts of interest:** In compliance with the ICMJE uniform disclosure form, all authors declare the following: **Payment/services info:** All authors have declared that no financial support was received from any organization for the submitted work. **Financial relationships:** All authors have declared that they have no financial relationships at present or within the previous three years with any organizations that might have an interest in the submitted work. **Other relationships:** All authors have declared that there are no other relationships or activities that could appear to have influenced the submitted work.

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