

3 ORIGINAL ARTICLE

4 Gastrointestinal symptoms and sleep 5 quality in the general population of the 6 Jazan region, Saudi Arabia: a cross-sectional 7 community-based study

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14 ABSTRACT

15 **Background:** Poor sleep and gastrointestinal symptoms are each common in the general population. Studies
16 from Korea, Japan, and Norway link the two conditions, but the mechanism remains unclear, and no data exist
17 from an Arab population.

18 **Methods:** This cross-sectional, community-based study surveyed adults aged 18 years and above in the Jazan
19 region, Saudi Arabia. Sleep quality was measured with the Pittsburgh Sleep Quality Index, and gastrointestinal
20 symptoms with the Gastrointestinal Symptom Rating Scale (GSRS). Rome IV screening items and the Patient Health
21 Questionnaire-4 (PHQ-4) were also administered. Associations were tested by multivariable logistic regression.

22 **Results:** Of 422 responses submitted, 416 were analyzed. Poor sleep quality affected 88 participants [21.15%, 95%
23 confidence interval (CI): 17.50-25.33]. Mean GSRS total score was 1.48 (SD 0.29). Each SD increase in this score
24 was associated with 84% higher adjusted odds of poor sleep [odds ratio (OR) 1.84, 95% CI: 1.35-2.50, $p < .001$].
25 Abdominal pain carried the strongest cluster association (OR 1.79), not reflux (OR 1.44). Nocturnal gastrointestinal
26 symptoms showed complete separation from the outcome; all 10 participants woken weekly by a gastrointestinal
27 symptom were poor sleepers (Firth-penalized OR 29.18, $p = 0.002$). Nonetheless, this discovery is derived from
28 merely 10 participants and must be regarded with caution. Adding PHQ-4 attenuated the primary estimate by only
29 5.92%, and PHQ-4 was not independently associated with poor sleep (OR 1.10, 95% CI: 0.85-1.42, $p = 0.462$).

30 **Conclusion:** Gastrointestinal symptom burden is independently associated with poor sleep quality among
31 Jazan adults.

32 **Keywords:** Gastrointestinal diseases, irritable bowel syndrome, Saudi Arabia, sleep quality, sleep-wake disorders,
33 surveys and questionnaires.

34 Introduction

35 Sleep problems and digestive complaints are two of the
36 most common reasons adults seek medical advice. Poor
37 sleep quality, most often measured with the Pittsburgh
38 Sleep Quality Index (PSQI), is reported widely across
39 different populations [1]. Gastrointestinal symptoms,
40 captured well by the Gastrointestinal Symptom Rating
41 Scale (GSRS), are similarly frequent in community

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42 samples [2]. These two conditions rarely stand apart.
 43 A person who sleeps poorly often also reports stomach
 44 pain, bloating or reflux, and the reverse holds too.
 45 Large studies support this link. A community cohort
 46 of 5,792 Korean adults found that higher GSRS scores
 47 were tied to sleep disturbance, even after adjusting for
 48 age, sex, smoking, and other habits [3]. Abdominal pain,
 49 acid regurgitation, bloating and belching carried most of
 50 that association. A smaller Japanese study of 151 adults
 51 reported a similar pattern. It pointed to trouble falling
 52 asleep as the sleep feature most closely tied to symptom
 53 severity [4]. In Norway, the Trøndelag Health Study cohort
 54 followed more than (25,000 adults over a decade. Sleep
 55 disturbance and reflux symptoms predicted each other in
 56 both directions [5]. A recent meta-analysis of reflux disease
 57 studies reached the same conclusion. Reflux and poor
 58 sleep reinforce one another rather than one simply causing
 59 the other [6].
 60 The relationship is not limited to reflux. A systematic
 61 review of sleep disturbance in irritable bowel syndrome
 62 (IBS) found that broken sleep and frequent waking are
 63 common in this condition. Poor subjective sleep quality
 64 also tracked with worse daytime symptoms [7]. Functional
 65 dyspepsia (FD) shows a similar pattern. A systematic
 66 review describes this relationship as bidirectional, working
 67 through gut motility and central nervous system signaling
 68 [8]. In the United States, an analysis of national survey data
 69 found that adults with gastrointestinal disease had higher
 70 odds of trouble sleeping and diagnosed sleep disorders.
 71 Depression carried only part of that effect [9]. This last
 72 point matters. Depression and anxiety often coexist with
 73 poor sleep and gut symptoms alike. A short screening tool
 74 such as the Patient Health Questionnaire-4 (PHQ-4) can
 75 capture this overlap without lengthening a survey [10].
 76 Whether such distress explains the gut-sleep link, or only
 77 travels alongside it, is not settled by these studies.
 78 A second open question concerns diagnosis. Most studies
 79 above measured symptom scores rather than applying
 80 diagnostic criteria. The Rome IV framework offers
 81 defined criteria for IBS and FD, built around symptom
 82 pattern and duration [11]. Applying these criteria, instead
 83 of symptom scores alone, would show whether the
 84 gut-sleep association spreads across the population or
 85 concentrates in people who meet formal thresholds.
 86 None of this evidence comes from an Arab population.
 87 Diet, meal timing, and the sleep schedule shaped by
 88 dawn prayer differ from the East Asian, European, and
 89 American settings studied so far. One regional survey of
 90 670 adults in the Jazan region reported that 28.8% had a
 91 sleep disorder, using a study-built checklist rather than
 92 a validated scale [12]. A national Saudi study likewise
 93 found that a third of adults slept fewer than 7 hours a night
 94 [13]. Neither study measured gastrointestinal symptoms.
 95 A validated Arabic translation of the PSQI exists [14],
 96 but it has not been paired with a gastrointestinal symptom
 97 measure in this region.
 98 This study was designed to close that gap. It reports the
 99 prevalence of poor sleep quality and gastrointestinal
 100 symptoms among Jazan adults. It tests their association
 101 after adjustment for relevant covariates, and it examines
 whether nocturnal gastrointestinal symptoms and
 psychological distress account for the link.

Subjects and Methods

A cross-sectional, community-based questionnaire study
 was carried out between 2 and 15 August 2026 in the
 Jazan region, one of the 13 administrative regions of
 the Kingdom of Saudi Arabia, located in the southwest
 of the country along the Red Sea coast. The region has
 about 5,000 towns and villages and a population of about
 1.4 million. The target population included all residents
 of the Jazan region who were at least 18 years of age,
 regardless of sex, who could read Arabic and gave
 informed consent. Individuals under the age of 18 years,
 those residing outside the region, and those who declined
 to participate were excluded.
 The sample size was calculated for the primary logistic-
 regression association, using the regional poor-sleep
 prevalence of 28.8% reported by Hakami et al. [12] and
 a variance inflation factor of 1.25 for the covariates. With
 a 95% confidence level and 80% power, 423 participants
 were required to detect an adjusted odds ratio (OR) of
 1.40 per SD of GSRS total score, and the target was
 set at 400, giving power for an OR of ~1.42. A pre-
 specified contingency stated that if the observed number
 of poor sleepers fell below 100, the primary model
 would be fitted with a reduced covariate set of age, sex,
 body mass index (BMI), current smoking, and PHQ-
 4 total score. Recruitment used convenience sampling:
 the questionnaire link was distributed via social media
 platforms and community networks across the region,
 targeting individuals who met the inclusion criteria,
 with posting deliberately spread across all governorates
 and across weekday and weekend times to reduce the
 concentration of respondents in a single locality.
 Data were collected using a 34-item bilingual
 questionnaire covering 60 individual questions,
 combining sociodemographic and lifestyle items with
 four instruments: the PSQI (19 items, sleep over the
 past month), the GSRS (15 items, symptoms over the
 past week), Rome IV-based screening items for IBS
 and FD, and the PHQ-4 (four items, distress over 2
 weeks), together with three further items on nocturnal
 gastrointestinal symptoms and meal timing and two on
 symptom ordering and health-care-seeking; completion
 took 7-8 minutes. The Arabic PSQI used the version
 validated by Suleiman and colleagues [14]; the GSRS,
 PHQ-4, and study-written items underwent forward and
 back translation - two independent forward translations,
 reconciliation into a single version, independent back-
 translation, and expert panel review of any discrepancy
 - followed by a pilot test with 40 participants whose
 responses were not included in the final analysis.
 Sleep quality was scored as a PSQI global score (0-21)
 built from seven components, with a global score above
 five defining poor sleep quality, the original cut-off from
 the source instrument. Gastrointestinal symptom burden
 was the mean of all 15 GSRS items on a 1-7 scale, with
 five symptom clusters (reflux, abdominal pain, indigestion,
 diarrhea, and constipation) derived as item means and
 a cluster score of 3 or above defining clinically relevant

symptoms. PHQ-4 total ranged from 0 to 12, split into a two-item anxiety subscale and a two-item depression subscale. IBS under Rome IV required abdominal pain at least once weekly, at least two of three pain-relationship features, and onset 6 months or more before assessment, with organic bowel disease excluded from this group; FD required postprandial fullness, early satiation, or epigastric pain or burning, with the same onset requirement. Nocturnal gastrointestinal symptoms were defined as waking from sleep due to a gastrointestinal symptom, using two thresholds (any frequency, and at least once or twice weekly), and late-evening eating was defined as eating within 2 hours of bedtime at least three times a week. Two clock-entry corrections were needed before scoring: 61 respondents had recorded a bedtime between 09:00 and 16:59 together with a normal morning wake time, so 12 hours were added to these entries, consistent with each respondent's own reported sleep pattern, and time in bed outside a plausible 3-14-hour range was then set to missing.

Of 422 submitted questionnaires, six were excluded: two recorded a sleep duration outside a plausible 0-14 hour range, and four had a derived time in bed outside a plausible 3-14 hour range after the clock-entry correction. The final analytic sample comprised 416 participants (98.6% of submissions). Data entry was automatic, with no manual transcription step; responses were stored in a spreadsheet accessible only to the investigators, and complete anonymity was ensured as no personal identifiers were collected.

Statistical analysis was performed using IBM Statistical Package for the Social Sciences Statistics, version 29. Descriptive statistics were used to summarize the data, with categorical variables presented as frequencies and percentages, and continuous variables expressed as mean $\pm$ SD, or median and interquartile range where distributions were skewed; prevalence estimates carried Wilson 95% confidence intervals (CIs). Group comparisons of categorical variables used the Pearson chi-square test, or Fisher's exact test where an expected cell count fell below five; continuous variables were compared with the Mann-Whitney *U* test, since the Shapiro-Wilk test rejected normality for every continuous measure, and associations between continuous measures used Spearman rank correlation.

The primary analysis was a binary logistic regression, with poor sleep quality as the outcome and standardized GSRS total score as the exposure (Model A), adjusted for age, sex, BMI, current smoking, and PHQ-4 total score; this reduced covariate set was applied because the number of observed poor sleepers fell under the pre-specified threshold. Five further models substituted each symptom cluster for the total score, one at a time, with Benjamini-Hochberg correction across the five (Model B). A generalized linear model, with a gamma distribution and log link, regressed GSRS total on all seven PSQI components entered together (Model C). A fourth model added nocturnal gastrointestinal symptoms to Model A and was compared with it by likelihood-ratio test (Model D); because the pre-specified nocturnal symptom variable was completely separated from the outcome, it was estimated by Firth penalized logistic regression, with profile-likelihood confidence limits. Mediation by psychological distress was tested by the product-of-coefficients method, using bias-corrected bootstrap CIs from 5,000 resamples.

Linearity of continuous predictors on the logit was checked by the Box-Tidwell procedure. Multicollinearity was assessed using variance inflation factors; all values were below 1.5. Model calibration was evaluated using the Hosmer-Lemeshow test, and influential observations were assessed using Cook's distance. Sensitivity analyses repeated the primary model after excluding participants with organic gastrointestinal disease, those on acid-suppressing or hypnotic medication, and those with diagnosed sleep apnea. The prevalence objective and the primary association were pre-specified as confirmatory and reported without adjustment for multiplicity; all other analyses were exploratory, with Benjamini-Hochberg false discovery rate correction applied within each family of tests. A two-sided *p* value below 0.05 was taken as statistically significant.

Results

Of 422 responses submitted, six were excluded. Two had a habitual sleep duration outside the plausible 0-14-hour range. Four had a derived time in bed that could not be reconciled with reported sleep, even after clock correction. The final analytic sample was 416. Adjusted regression models used 414 participants, after two biologically implausible BMI values were set to missing.

Participants had a mean age of 33.17 years (SD 9.43). Two hundred seventy-nine (67.1%) were male, and 223 (53.6%) lived in urban areas. Mean BMI was 27.48 kg/m² (SD 4.15). Sample characteristics, overall and by sleep quality status, are shown in Table 1. Poor sleepers had a lower BMI than good sleepers (26.63 vs. 27.70 kg/m², *p* = 0.012). They also had longer sleep latency (20.93 vs. 12.80 minutes, *p* = 0.007) and shorter sleep duration (5.98 vs. 6.87 hours, *p* < 0.001).

Poor sleep quality affected 88 of 416 participants (21.15%, 95% CI: 17.50-25.33) (Table 2). Mean global PSQI score was 4.22 (SD 1.95). Sleep disturbances were the most commonly impaired component (92.55%), followed by sleep latency (85.10%) and sleep duration (75.96%).

Gastrointestinal symptom burden was low across the sample. Mean GSRS total score was 1.48 (SD 0.29), on a 1-7 scale. Only 18 of 416 participants (4.33%) reached a clinically relevant score in any cluster. Constipation was the most common (3.13%) (Table 2). Under full Rome IV criteria, no participant met criteria for IBS (0.00%, 95% CI: 0.00-0.91). One participant (0.24%) met criteria for FD. Twenty-nine participants endorsed at least one qualifying symptom, but 14 of these 29 (48.28%) could not recall symptom onset. The full-criteria figures are therefore lower bounds, not population estimates. Using symptom criteria alone, without the onset requirement, FD reached 3.61% (15 of 416). Eleven of these 15 (73.3%) were poor sleepers, giving an adjusted OR of 8.12 (95% CI: 2.31-28.48, *p* = 0.001) (Table 2).

In bivariate comparison, GSRS total score was higher in poor sleepers than in good sleepers (1.64 vs. 1.43, *U* =

Table 1. Characteristics of the study sample, overall and by sleep quality status (N = 416).

Characteristic	Total (N = 416)	Good sleep (n = 328)	Poor sleep (n = 88)	Test statistic	p	Effect size
Age, years	33.17 (9.43)	33.39 (9.58)	32.35 (8.84)	U = 15,200	0.443	d = -0.11
Sex				$\chi^2(1) = 0.02$	0.902	v = 0.01
Male	279 (67.1)	219 (66.8)	60 (68.2)			
Female	137 (32.9)	109 (33.2)	28 (31.8)			
Marital status				$\chi^2(3) = 8.08$	0.044	v = 0.14
Single	77 (18.5)	53 (16.2)	24 (27.3)			
Married	320 (76.9)	262 (79.9)	58 (65.9)			
Divorced	17 (4.1)	12 (3.7)	5 (5.7)			
Widowed	2 (0.5)	1 (0.3)	1 (1.1)			
Children (married respondents)				$\chi^2(2) = 7.03$	0.030	v = 0.13
Yes	292 (70.2)	239 (72.9)	53 (60.2)			
No	53 (12.7)	41 (12.5)	12 (13.6)			
Not married	71 (17.1)	48 (14.6)	23 (26.1)			
Residence				$\chi^2(1) = 0.10$	0.749	v = 0.02
Urban	223 (53.6)	174 (53.0)	49 (55.7)			
Rural	193 (46.4)	154 (47.0)	39 (44.3)			
Nationality				Fisher's exact	1.000	v = 0.00
Saudi	415 (99.8)	327 (99.7)	88 (100.0)			
Non-Saudi	1 (0.2)	1 (0.3)	0 (0.0)			
Education				$\chi^2(2) = 5.15$	0.076	v = 0.11
Secondary or less	202 (48.6)	165 (50.3)	37 (42.0)			
Bachelor/diploma	200 (48.1)	155 (47.3)	45 (51.1)			
Postgraduate	14 (3.4)	8 (2.4)	6 (6.8)			
Monthly household income, SAR				$\chi^2(3) = 5.70$	0.127	v = 0.12
<5,000	83 (20.0)	63 (19.2)	20 (22.7)			
5,000-9,999	223 (53.6)	185 (56.4)	38 (43.2)			
10,000-15,000	102 (24.5)	75 (22.9)	27 (30.7)			
>15,000	8 (1.9)	5 (1.5)	3 (3.4)			
BMI, kg/m ²	27.48 (4.15)	27.70 (4.27)	26.63 (3.55)	U = 16,710	0.012	d = -0.26
Physical activity ≥ 3 d/wk	299 (71.9)	235 (71.6)	64 (72.7)	$\chi^2(1) = 0.00$	0.947	$\phi = 0.00$
Current smoker	36 (8.7)	32 (9.8)	4 (4.5)	$\chi^2(1) = 1.77$	0.183	$\phi = 0.07$
Caffeine after sunset	334 (80.3)	263 (80.2)	71 (80.7)	$\chi^2(1) = 0.00$	1.000	$\phi = 0.00$
Night or shift work	96 (23.1)	74 (22.6)	22 (25.0)	$\chi^2(1) = 0.12$	0.734	$\phi = 0.02$
Child < 2 years in household	237 (57.0)	190 (57.9)	47 (53.4)	$\chi^2(1) = 0.41$	0.523	$\phi = 0.03$
Any physician-diagnosed chronic disease	7 (1.7)	6 (1.8)	1 (1.1)	Fisher's exact	1.000	$\phi = 0.00$
Organic GI disease	5 (1.2)	0 (0.0)	5 (5.7)	Fisher's exact	< 0.001	$\phi = 0.19$
Diagnosed sleep apnea	2 (0.5)	1 (0.3)	1 (1.1)	Fisher's exact	0.379	$\phi = 0.01$
Acid-reducing medication	6 (1.4)	2 (0.6)	4 (4.5)	Fisher's exact	0.020	$\phi = 0.11$
Hypnotic or sedative medication	6 (1.4)	1 (0.3)	5 (5.7)	Fisher's exact	0.002	$\phi = 0.16$
Sleep duration, h/night	6.68 (1.52)	6.87 (1.52)	5.98 (1.35)	U = 19,276	< 0.001	d = -0.60
Sleep latency, min	14.52 (15.08)	12.80 (13.35)	20.93 (19.03)	U = 11,744	0.007	d = 0.55

Continuous variables are presented as mean (SD) and compared with the Mann–Whitney U test. Categorical variables are presented as n (%) and compared with the Pearson χ^2 test, or Fisher's exact test where any expected cell count was below 5.

Effect sizes: d = Cohen's d; V = Cramér's V; ϕ = phi coefficient. Poor sleep quality was defined as a PSQI global score > 5.

Organic gastrointestinal disease = physician-diagnosed peptic ulcer, inflammatory bowel disease, or coeliac disease.

18,733.0, $p < 0.001$, Cohen's $d = 0.76$). It correlated with the PSQI global score (Spearman $\rho = 0.219$, $p < 0.001$) (Table 3). All five symptom clusters differed significantly between the two groups.

Internal consistency in this Arabic-language sample was acceptable for the GSRS total (Cronbach's $\alpha = 0.725$) and for the two-item PHQ-4 anxiety subscale ($\alpha = 0.658$). The full PHQ-4 showed poor internal consistency ($\alpha = 0.049$), driven by one item behaving differently from the other three.

In the primary adjusted model, each SD increase in GSRS total score was associated with 84% higher odds of poor sleep (adjusted OR 1.84, 95% CI: 1.35-2.50, $p < 0.001$). The crude OR was 2.01 (95% CI: 1.55-2.60) (Table 4, Figure 1). Model fit was adequate (Hosmer–Lemeshow $\chi^2(8) = 9.85$, $p = 0.276$; area under the receiver operating characteristic curve = 0.676), with no relevant multicollinearity (all variance inflation factors ≤ 1.46).

The CIs for nocturnal gastrointestinal symptoms and for symptom-based FD are wide because only 22 and 15 respondents, respectively, were exposed; those estimates

Table 2. Prevalence of sleep, gastrointestinal, psychological, and behavioral outcomes, with Wilson 95% CIs (N = 416).

Outcome	n/N	%	95% CI
Sleep quality (PSQI)			
Poor sleep quality (PSQI global score > 5)	88/416	21.15	17.50-25.33
PSQI component impairment (component score ≥ 1)			
C1 Subjective sleep quality	192/416	46.15	41.42-50.96
C2 Sleep latency	354/416	85.10	81.35-88.20
C3 Sleep duration	316/416	75.96	71.63-79.82
C4 Habitual sleep efficiency	76/416	18.27	14.85-22.27
C5 Sleep disturbances	385/416	92.55	89.62-94.70
C6 Sleep medication	74/416	17.79	14.41-21.75
C7 Daytime dysfunction	75/416	18.03	14.63-22.01
Clinically relevant gastrointestinal symptoms (GSRS cluster score ≥ 3)			
Reflux	3/416	0.72	0.25-2.10
Abdominal pain	2/416	0.48	0.13-1.74
Indigestion	5/416	1.20	0.51-2.78
Diarrhea	1/416	0.24	0.04-1.35
Constipation	13/416	3.13	1.84-5.27
Total score ≥ 3	1/416	0.24	0.04-1.35
Any cluster ≥ 3	18/416	4.33	2.75-6.74
Rome IV-based diagnostic categories			
IBS (full criteria, incl. ≥ 6-month onset)	0/416	0.00	0.00-0.91
FD (full criteria, incl. ≥ 6-month onset)	1/416	0.24	0.04-1.35
IBS (symptom criteria only)	1/416	0.24	0.04-1.35
FD (symptom criteria only)	15/416	3.61	2.20-5.86
Nocturnal gastrointestinal symptoms (past month)			
Woken by GI symptoms at any frequency	22/416	5.29	3.52-7.88
Woken by GI symptoms ≥ once or twice weekly	10/416	2.40	1.31-4.37
Waking symptom: heartburn or acid reflux	9/416	2.16	1.14-4.06
Waking symptom: abdominal pain	12/416	2.88	1.66-4.97
Waking symptom: bloating or wind	10/416	2.40	1.31-4.37
Behavioral and psychological measures			
Eating within 2 hours of bedtime, any frequency	73/416	17.55	14.19-21.50
Eating within 2 hours of bedtime, ≥ 3 times weekly	16/416	3.85	2.38-6.16
Positive anxiety screen (GAD-2 ≥ 3)	11/416	2.64	1.48-4.67
Positive depression screen (PHQ-2 ≥ 3)	50/416	12.02	9.24-15.50
Any psychological distress (PHQ-4 total ≥ 3)	70/416	16.83	13.54-20.72
Health-care-seeking behavior (past year)			
Consulted a physician for digestive or sleep problems	10 / 416	2.40	1.31-4.37

PHQ-4 = four-item Patient Health Questionnaire (GAD-2 anxiety subscale + PHQ-2 depression subscale). CIs are Wilson score intervals for a binomial proportion.

Full Rome IV criteria require symptom onset ≥ 6 months before assessment.

Multi-select items (waking symptom type, lifestyle and medication items) permit more than one response per respondent, so the sub-categories do not sum to the category total.

should be read as evidence of direction rather than of magnitude.

The association was not a smooth gradient. Poor sleep prevalence was 17.31%, 13.46% and 16.35% across the lowest three quartiles of symptom burden. It rose to 37.50% in the highest quartile ($\chi^2(3) = 22.71$, $p < 0.001$; trend $z = 3.54$, $p < 0.001$) (Figure 2). The highest quartile carried an adjusted OR of 2.60 (95% CI: 1.49-4.56, $p < 0.001$) against the lower three combined.

Among the five symptom clusters, abdominal pain carried the strongest adjusted association (OR 1.79, 95% CI: 1.36-2.37, $p < 0.001$). Diarrhea (OR 1.55, $p = 0.006$), reflux (OR 1.44, $p = 0.003$) and constipation (OR 1.35, $p = 0.021$) followed. Indigestion did not remain significant after Benjamini-Hochberg correction (adjusted $p = 0.078$) (Table 4). In the reverse model, with symptom score as the outcome, two PSQI components were independently linked to symptom severity: sleep disturbances ($B = 0.050$, adjusted $p < 0.001$) and sleep latency ($B = 0.025$, adjusted $p = 0.004$) (Figure 3).

Nocturnal gastrointestinal symptoms were reported by 22 of 416 participants (5.29%) at any frequency, and by 10 (2.40%) at least once or twice weekly. All 10 participants in the weekly group were poor sleepers. This is a complete separation from the outcome. The group was therefore analyzed by Firth penalized logistic regression, giving an OR of 29.18 (95% profile-likelihood CI 2.84-4006.32; penalized likelihood-ratio $\chi^2(1) = 9.45$, $p = 0.002$). For the broader, any-frequency definition, the adjusted OR was 17.44 (95% CI: 4.11-74.02, $p < 0.001$). Adding nocturnal symptoms to the primary model improved fit significantly (likelihood-ratio $\chi^2(1) = 19.26$, $p < 0.001$). The GSRS total remained significant within this expanded model (OR 1.55, 95% CI: 1.11-2.17, $p = 0.010$) (Table 5).

PHQ-4 total score correlated with GSRS total (Spearman $\rho = 0.355$, $p < 0.001$), but not with the PSQI global score ($\rho = 0.027$, $p = 0.581$). Adding PHQ-4 to the primary model changed the adjusted OR by only 5.92%, from 1.95 (95% CI: 1.50-2.54) to 1.84 (95% CI: 1.35-2.50). PHQ-4 total was not independently associated with poor sleep (adjusted OR 1.10, 95% CI: 0.85-1.42, $p = 0.462$). In mediation analysis, the indirect effect through PHQ-4 was 0.060 on the log-odds scale. Its bootstrap 95% CI, -0.098 to 0.227, spanned zero (Table 5).

Late-evening eating, at least three times weekly, was reported by 16 of 416 participants (3.85%). It was not significantly associated with poor sleep after adjustment (OR 1.97, 95% CI: 0.55-7.05, $p = 0.299$) (Table 5).

The primary association held across twelve sensitivity analyses. Adjusted ORs ranged from 1.72-2.13, all $p \leq 0.003$ (Table 5). These included a fully adjusted model with eleven covariates (OR 1.84, 95% CI: 1.33-2.55, $p < 0.001$), the outcome redefined without the sleep-efficiency component (OR 1.84, 95% CI: 1.37-2.46, $p < 0.001$), and repetition after excluding participants with organic gastrointestinal disease, acid-reducing or hypnotic medication use, diagnosed sleep apnea, or identical responses across all GSRS items.

Table 3. Gastrointestinal symptom scores, psychological distress and nocturnal symptoms by sleep quality status (N = 416).

Measure	Total (N = 416)	Good sleep (n = 328)	Poor sleep (n = 88)	U	p	Cohen's d	ρ with PSQI
Panel A. Continuous measures, mean (SD)							
Reflux	1.13 (0.36)	1.08 (0.25)	1.31 (0.58)	16,891.0	<0.001	0.65	0.158*
Abdominal pain	1.13 (0.36)	1.07 (0.23)	1.36 (0.58)	18,137.0	<0.001	0.85	0.247*
Indigestion	1.75 (0.43)	1.72 (0.43)	1.88 (0.42)	17,651.0	<0.001	0.38	0.191*
Diarrhea	1.34 (0.35)	1.30 (0.31)	1.49 (0.42)	18,310.0	<0.001	0.58	0.258*
Constipation	1.82 (0.50)	1.77 (0.51)	1.97 (0.46)	17,525.5	0.001	0.40	0.167*
GSRS total score	1.48 (0.29)	1.43 (0.24)	1.64 (0.38)	18,733.0	<0.001	0.76	0.219*
PHQ-4 total (0-12)	1.79 (1.14)	1.67 (0.89)	2.24 (1.73)	15,987.5	0.098	0.51	0.027
GAD-2 anxiety (0-6)	0.31 (0.69)	0.27 (0.57)	0.49 (1.01)	15,179.0	0.297	0.33	0.050
PHQ-2 depression (0-6)	1.48 (0.88)	1.40 (0.81)	1.75 (1.06)	17,009.0	0.005	0.40	0.077
Panel B. Binary measures, n (%)							
	n	Good sleep	Poor sleep	Test	p	ϕ	
Any GSRS cluster ≥ 3	18	12 (3.7)	6 (6.8)	Fisher	0.234	0.05	
Symptom-based FD	15	4 (1.2)	11 (12.5)	Fisher	<0.001	0.23	
Nocturnal GI symptoms (any)	22	3 (0.9)	19 (21.6)	Fisher	<0.001	0.36	
Nocturnal GI symptoms (≥ 1 -2/week)	10	0 (0.0)	10 (11.4)	Fisher	<0.001	0.28	
Nocturnal reflux	9	2 (0.6)	7 (8.0)	Fisher	<0.001	0.19	
Late-evening eating (≥ 3 /week)	16	9 (2.7)	7 (8.0)	Fisher	0.053	0.10	

GSRS cluster and total scores range from 1 (no discomfort) to 7 (very severe discomfort). Groups were compared with the Mann–Whitney *U* test.

ρ = Spearman rank correlation with the PSQI global score, computed across the full analytic sample.

Panel B comparisons used Fisher's exact test throughout; ϕ is the phi coefficient.

* $p < .05$.

Table 4. Binary logistic regression models for poor sleep quality: overall gastrointestinal symptom burden (Model A) and individual GSRS symptom clusters (Model B).

Exposure	Crude OR (95% CI)	$\ast$ p	Adjusted OR (95% CI)	p	P (BH)	Wald z
Model A — confirmatory						
GSRS total score, per 1 SD	2.01 (1.55–2.60)	<0.001	1.84 (1.35–2.50)	<0.001	—	3.85
Model B — five separate models, one per cluster (exploratory)						
Abdominal pain cluster, per 1 SD	1.93 (1.52–2.44)	<0.001	1.79 (1.36–2.37)	<0.001	<0.001	4.09
Diarrhea cluster, per 1 SD	1.76 (1.35–2.31)	<0.001	1.55 (1.14–2.10)	0.006	0.009	2.77
Constipation cluster, per 1 SD	1.48 (1.17–1.87)	0.001	1.35 (1.05–1.75)	0.021	0.027	2.30
Reflux cluster, per 1 SD	1.65 (1.34–2.04)	<0.001	1.44 (1.13–1.83)	0.003	0.009	2.92
Indigestion cluster, per 1 SD	1.43 (1.14–1.80)	0.002	1.25 (0.97–1.61)	0.078	0.078	1.76

Outcome: poor sleep quality (PSQI global score > 5). Crude models n = 416 (88 events); adjusted models n = 414 (87 events) after two implausible BMI values were set to missing. Exposures are standardized, so each OR expresses the change in odds per one SD of the score (GSRS total SD = 0.29). Bold values indicate statistical significance ($p < 0.05$); for the cluster models, significance is based on Benjamini-Hochberg-corrected p values.

Adjusted for age, sex, BMI, current smoking, and PHQ-4 total score.

p (BH) = p value after Benjamini–Hochberg false-discovery-rate correction applied across the five cluster models of Model B.

BH = Benjamini–Hochberg.

Discussion

This study aimed to describe the prevalence of poor sleep quality and gastrointestinal symptoms among adults in the Jazan region. It also tested whether the two conditions were linked, after adjusting for relevant covariates.

Poor sleep quality affected one in five participants. Gastrointestinal symptom burden was independently tied to it, with each SD rise in symptom score associated with 84% higher odds. This direction of association matches findings from Saudi university students, where poor

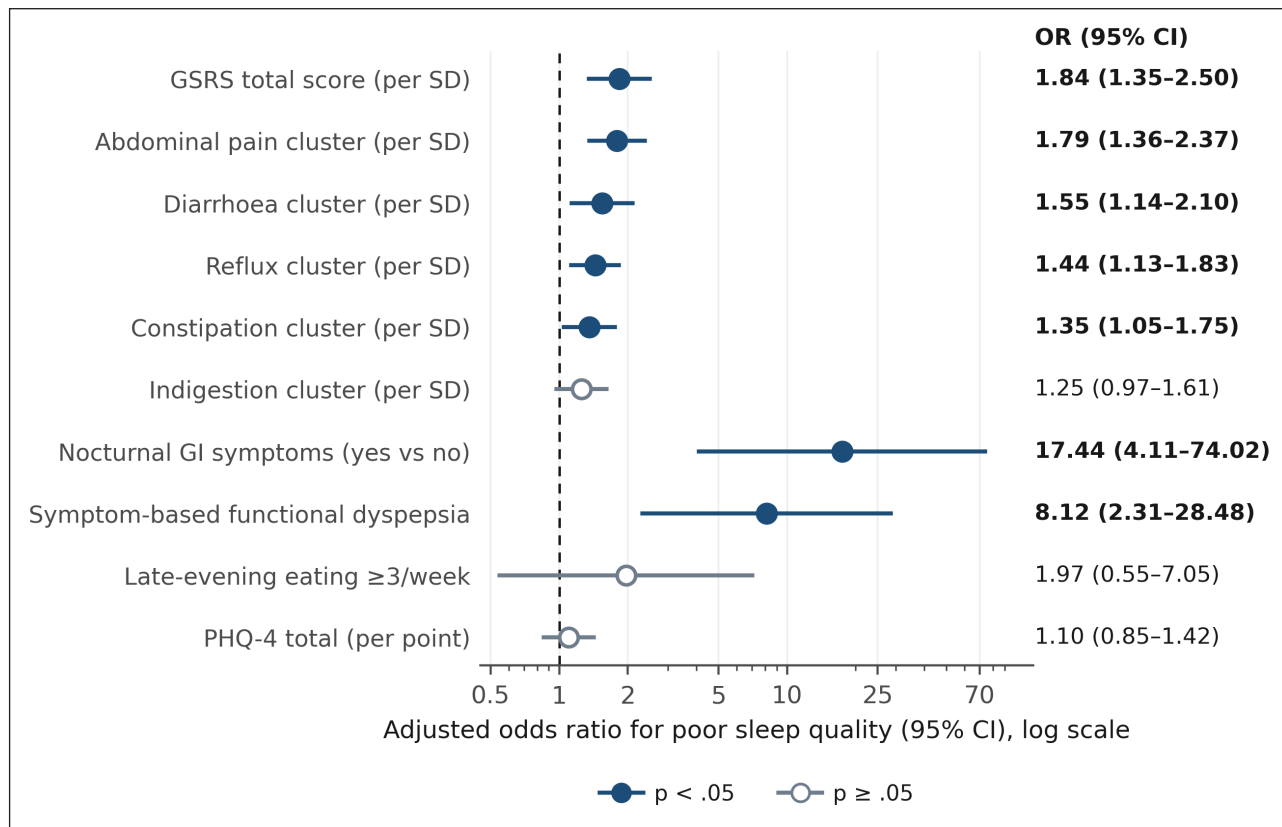


Figure 1. Adjusted ORs for poor sleep quality across gastrointestinal, nocturnal, behavioral, and psychological exposures ($n = 414$). Each row is a separate binary logistic regression model with poor sleep quality (PSQI global score > 5) as the outcome, adjusted for age, sex, BMI, current smoking, and PHQ-4 total score. Markers are adjusted ORs and horizontal lines are 95% CIs; the x-axis is on a logarithmic scale, and the dashed vertical line marks the null value of 1. Filled markers indicate $p < 0.05$; open markers indicate $p \geq 0.05$. Nocturnal gastrointestinal symptoms are coded as any waking from sleep attributed to a gastrointestinal symptom in the past month ($n = 22$). The pre-specified definition of at least weekly waking is completely separated from the outcome and is not plotted here. Symptom-based FD applies Rome IV symptom criteria without the ≥ 6 -month onset requirement ($n = 15$).

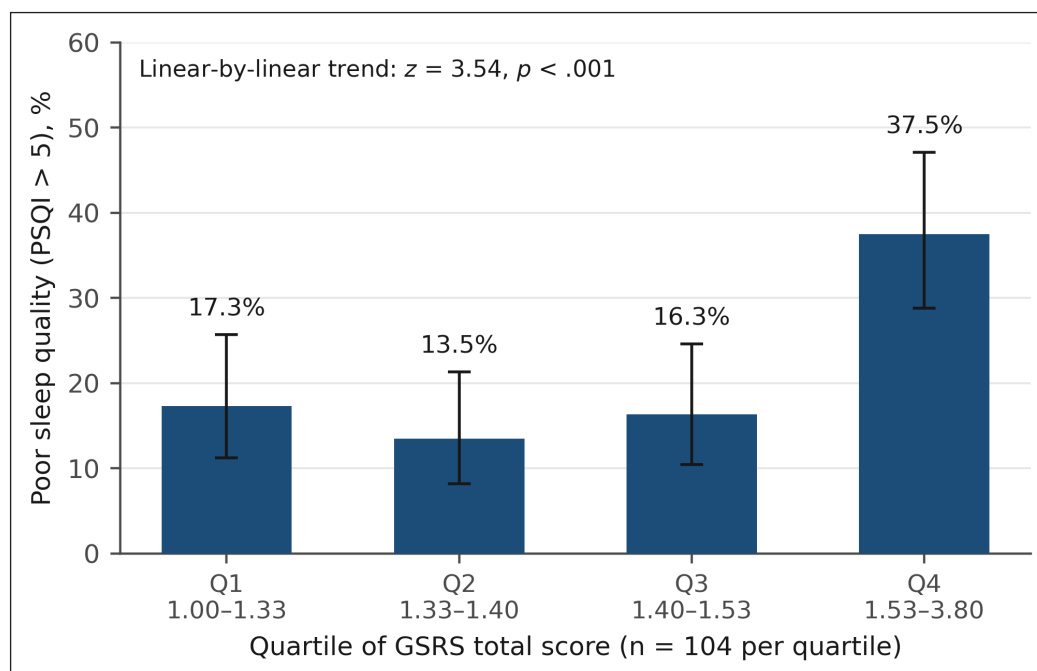


Figure 2. Prevalence of poor sleep quality across quartiles of the GSRS total score ($N = 416$). Poor sleep quality was defined as a PSQI global score > 5 . Quartiles of the GSRS total score contain 104 respondents each; the GSRS range within each quartile is printed beneath the axis label. Error bars are Wilson 95% CIs for the proportion.

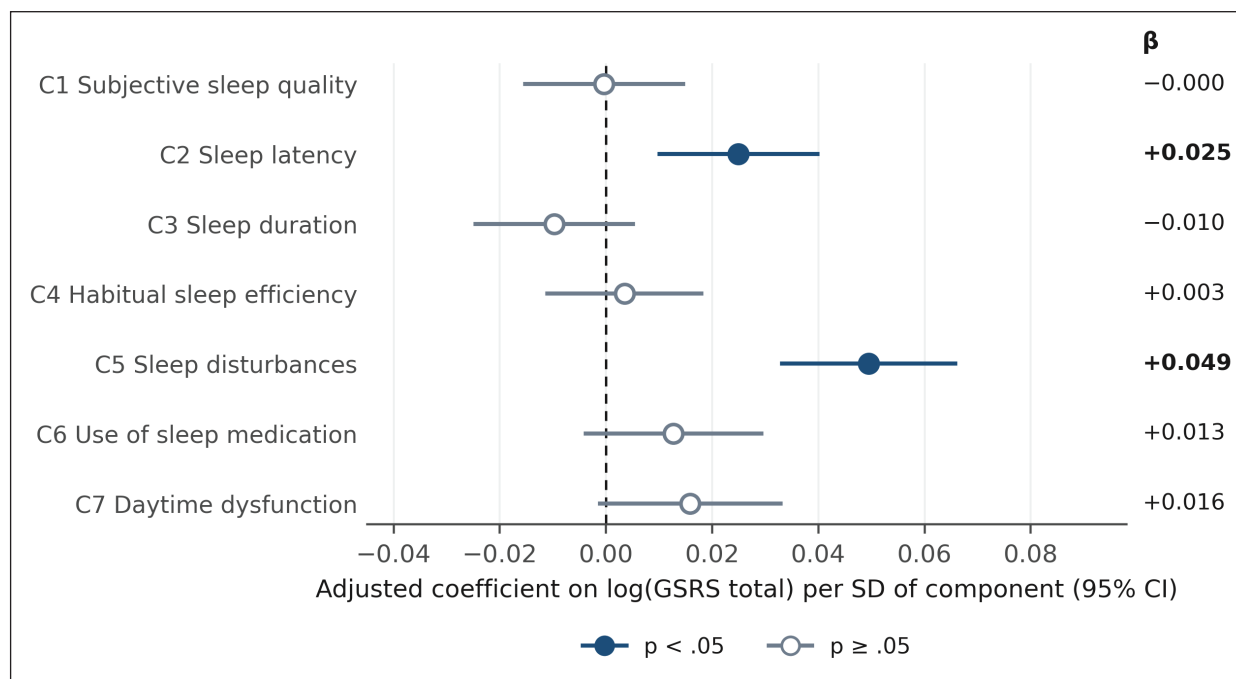


Figure 3. Adjusted association of each PSQI component with gastrointestinal symptom severity (Model C, $n = 414$). Estimates come from a single generalized linear model with GSRS total score as the outcome, all seven PSQI components entered simultaneously as standardized predictors, and adjustment for age, sex, BMI, current smoking, and PHQ-4 total score. Markers are point estimates and horizontal lines are 95% CIs. Filled markers indicate significance after Benjamini-Hochberg correction across the seven components. VIF = variance inflation factor; AIC = Akaike information criterion.

370 sleep quality was itself a strong, independent risk factor
371 for IBS, more than tripling the odds [15].

372 Abdominal pain carried the strongest association with
373 poor sleep among the five clusters, stronger than reflux.
374 This fits mechanistic work from outside our region. A
375 Taiwanese study of university students found that poorer
376 sleep quality correlated with greater rectal compliance,
377 a change linked to altered bowel sensation [16]. A
378 manometry study of patients with functional constipation
379 found that those with sleep deficiency had lower rectal
380 sensory thresholds and more disordered autonomic
381 function than those without [17]. A Japanese cohort of
382 older adults showed a clear dose-response pattern too:
383 risk of new-onset constipation rose steadily across sleep-
384 quality quartiles, from 7.8% to 13.8% [18]. Our own
385 quartile analysis showed a comparable jump, from around
386 15%-37.5%. Reflux, by contrast, has usually been linked
387 to sleep through nocturnal arousal from acid exposure. A
388 large American cohort found that heartburn during sleep
389 was predicted mainly by BMI, snoring, and daytime
390 sleepiness [19]. Our sample had a low mean BMI, which
391 may explain the more modest reflux association.

392 Nocturnal gastrointestinal waking showed a pattern: every
393 participant who woke weekly from a gastrointestinal
394 symptom was a poor sleeper. This complete separation
395 is a known statistical feature of rare, strongly predictive
396 events, properly handled by penalized regression rather
397 than standard logistic models [20]. Beyond the statistics,
398 the finding fits current thinking on circadian gut-brain
399 signaling. A recent review describes how melatonin,
400 produced in far greater quantities by the gut than the

pineal gland, helps regulate colonic motility across the
sleep-wake cycle, and how disruption of this rhythm
is common in disorders of gut-brain interaction [21].
Nonetheless, this discovery is derived from merely 10
participants and must be regarded with caution.

Almost no participant met full Rome IV criteria, despite
a clear symptom-sleep link below that threshold. This is
not unusual. The Rome Foundation's own global study,
across 33 countries, found that Rome IV criteria identify
far fewer IBS cases than the older Rome III criteria,
even in the same respondents [22]. A systematic review
of Saudi population studies reported wide swings in
prevalence by definition and setting, from single digits
up to 40% [23]. A Saudi university sample using the
full Rome IV battery similarly found that psychological
factors carried as much weight as gastrointestinal ones in
shaping who met criteria [24]. Our low criterion-based
prevalence, alongside a much higher rate using symptom
criteria alone, points to under-recognized symptom onset
rather than a truly low burden.

Psychological distress did not explain the symptom-sleep
link in our data. A Taiwanese comparison of functional
constipation and constipation-predominant IBS found
sleep quality independently predicted the first condition,
while depression predicted the second [25]; our sample,
dominated by mild symptoms, may sit closer to the first
pattern. The poor internal consistency of our full PHQ-
4 score is also worth noting. Translated PHQ-4 versions
elsewhere usually report good reliability, around 0.78-0.84
[26]; our much lower figure suggests one item performed
poorly here, rather than a true absence of distress.

Table 5. Nocturnal gastrointestinal symptoms (Model D), psychological distress as a mediator, late-evening eating, and sensitivity analyses.

Analysis	Estimate	95% CI	p	Test/comparison
Panel A. Model D — nocturnal gastrointestinal symptoms (confirmatory)				
Pre-specified definition (woken $\geq 1\text{-}2 \times$ /week, $n = 10$), Firth-penalized OR	29.18	(2.84-4006.32)	0.002	Firth; penalized LR $\chi^2(1) = 9.45$
Broader definition (woken at any frequency, $n = 22$), Firth-penalized OR	14.33	(4.08-65.00)	<0.001	Firth; penalized LR $\chi^2(1) = 18.43$
Broader definition, crude OR (maximum likelihood)	29.83	(8.59-103.61)	<0.001	Binary logistic
Broader definition, adjusted OR (Model D)	17.44	(4.11-74.02)	<0.001	Model D
GSRS total (per SD) within Model D	1.55	(1.11-2.17)	0.010	Model D
Improvement in model fit, Model D versus Model A	$\chi^2(1) = 19.26$	—	<0.001	Likelihood-ratio test
Poor sleep among those woken $\geq 1\text{-}2 \times$ /week	10/10 (100%)	—	<0.001	Fisher's exact test
Panel B. Psychological distress as confounder and mediator (exploratory)				
GSRS total (per SD), model without PHQ-4	1.95	(1.50-2.54)	<0.001	Binary logistic
GSRS total (per SD), model with PHQ-4	1.84	(1.35-2.50)	<0.001	Model A
Change in OR on adding PHQ-4	5.92%	—	—	Confounding assessment
PHQ-4 total (per point) $\rightarrow$ poor sleep, adjusted OR	1.10	(0.85-1.42)	0.462	Model A
Path a: GSRS total (per SD) $\rightarrow$ PHQ-4 total	$B = 0.627$	—	<0.001	Linear regression
Path b: PHQ-4 total $\rightarrow$ poor sleep (GSRS controlled)	$B = 0.095$	—	0.462	Binary logistic
Indirect (mediated) effect, log-odds scale	$B = 0.060$	(-0.098 to 0.227)	—	5,000 bootstrap resamples
Proportion of total effect mediated	8.90%	—	—	$B(\text{indirect})/B(\text{total})$
Panel C. Additional exposures and sensitivity analyses (adjusted OR per SD of GSRS total unless stated)				
Late-evening eating $\geq 3 \times$ /week, adjusted OR	1.97	(0.55-7.05)	0.299	—
Symptom-based FD, adjusted OR	8.12	(2.31-28.48)	0.001	—
Primary (Model A)	1.84	(1.35-2.50)	<0.001	$n = 414$, 87 events
Unadjusted (crude)	2.01	(1.55-2.60)	<0.001	$n = 416$, 88 events
Age- and sex-adjusted only	2.01	(1.55-2.60)	<0.001	$n = 416$, 88 events
Fully adjusted (11 covariates)	1.84	(1.33-2.55)	<0.001	$n = 414$, 87 events
Uncorrected clock times	1.72	(1.20-2.45)	0.003	$n = 353$, 76 events
Poor sleep defined without component 4	1.84	(1.37-2.46)	<0.001	$n = 414$, 133 events
Excluding GSRS straight-liners ($n = 25$)	1.79	(1.29-2.48)	<0.001	$n = 389$, 85 events
Excluding organic GI disease ($n = 5$)	1.78	(1.30-2.44)	<0.001	$n = 409$, 82 events
Excluding acid-reducing or hypnotic medication ($n = 8$)	2.13	(1.52-2.97)	<0.001	$n = 406$, 81 events
Excluding diagnosed sleep apnea ($n = 2$)	1.89	(1.38-2.58)	<0.001	$n = 412$, 86 events
GAD-2 in place of PHQ-4 total	1.90	(1.45-2.50)	<0.001	$n = 414$, 87 events
PHQ-4 excluding item (d)	1.93	(1.47-2.54)	<0.001	$n = 414$, 87 events
No distress covariate	1.95	(1.50-2.54)	<0.001	$n = 414$, 87 events

All adjusted models control for age, sex, BMI, current smoking, and PHQ-4 total score unless stated otherwise. Panel C entries are adjusted ORs per 1 SD of GSRS total score for poor sleep quality.

Panel A. The pre-specified nocturnal variable is completely separated from the outcome — all 10 respondents woken at least once or twice weekly were poor sleepers — so no maximum-likelihood estimate exists for it. It is therefore estimated by Firth penalized logistic regression with profile-likelihood confidence limits. The upper confidence limit is uninformative by construction, and the broader definition should be used when a magnitude is required.

Panel B. Mediation inferred from cross-sectional data assumes a temporal ordering this design cannot verify.

Panel C. “Uncorrected clock times” repeats the primary model with bed and wake times coded exactly as entered. The row “poor sleep defined without component 4” removes that component from the outcome entirely (six components, score > 4).

“GSRS straight-liners” are the 25 respondents who gave the identical response to all 15 GSRS items.

LR = likelihood ratio.

Strengths and Limitations

This study has strengths, including validated instruments, a pre-specified analysis plan, and rigorous handling of a statistically difficult subgroup. It also has limits. Recruitment relied on social media, a method known to skew samples toward younger, more educated adults and to introduce self-selection bias that cannot be fully corrected afterward [27]. Convenience sampling might restrict the capacity to generalize findings to the broader Jazan population. Data collection fell outside Ramadan, so sleep-timing findings may not generalize to that

month, when bedtime and wake time in this country shift markedly [28]. The cross-sectional design cannot establish which condition came first, and all measures were self-reported.

These findings still carry a practical message. A randomized trial of brief insomnia therapy in college students with IBS reduced not only insomnia severity but also gastrointestinal symptom severity and nocturnal symptoms [29]. Screening for sleep quality in gastroenterology clinics, and for gastrointestinal symptoms in sleep clinics, may catch problems earlier.

454 Future work should follow participants over time, add an
 455 objective sleep measure such as actigraphy, and recruit
 456 through clinics and households, not social media alone.

457 Conclusion

458 This study found that poor sleep quality and
 459 gastrointestinal symptoms are meaningfully linked
 460 among adults in the Jazan region, one in five of whom
 461 slept poorly. Higher gastrointestinal symptom scores,
 462 especially abdominal pain, were independently associated
 463 with higher odds of poor sleep, and this held across 12
 464 sensitivity checks. Nocturnal gastrointestinal waking
 465 showed the strongest link of all, present in every affected
 466 participant. Nonetheless, this discovery is derived from
 467 merely 10 participants and must be regarded with caution.
 468 Psychological distress, measured by the PHQ-4, did not
 469 explain this relationship. Formal Rome IV diagnoses
 470 were rare, but sub-threshold symptoms still carried real
 471 weight for sleep. These results extend evidence from
 472 Asia, Europe, and North America to an Arab population
 473 for the first time. Clinicians treating either gastrointestinal
 474 or sleep complaints in this region should ask about the
 475 other. Longitudinal studies with objective sleep measures
 476 are needed to confirm which condition drives the other.

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 479 contribution.

480 List of Abbreviations

481 BMI	Body mass index
482 CI	Confidence interval
483 FD	Functional dyspepsia
484 GI	Gastrointestinal
485 GSRS	Gastrointestinal Symptom Rating Scale
486 IBS	Irritable bowel syndrome
487 LR	Likelihood ratio
488 OR	Odds ratio
489 PHQ-4	Patient Health Questionnaire-4
490 PSQI	Pittsburgh Sleep Quality Index

491 Conflict of interest

492 The authors declare no conflict of interest.

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495 Consent to participate

496 Written informed consent was obtained from all the
 497 participants.

498 Consent for publication

499 Informed consent was obtained from all subjects involved in
 500 the study.

501 Ethical approval

502 Ethical approval was obtained from the Jazan University
 503 Research Ethics Committee (HAPO-10-Z-001; reference
 504 number REC-46/07/1340) on 09 January 2025. Participation
 505 was voluntary, and electronic informed consent was
 506 obtained from all participants before completing the survey.
 507 No personal identifiers were collected, and all data were
 508 stored anonymously to ensure participant confidentiality
 509 and privacy.

Data availability

All the data are available in the current manuscript.

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Supplementary content (If any) is available online.

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