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Insomnia severity index: a psychometric investigation among Saudi nurses

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Abstract

Background Insomnia is the most prevalent sleep disorder, but it is widely untreated and under-diagnosed in Saudi Arabia. Moreover, no tool to screen insomnia has been validated in the Saudi population in general or nurses in particular. This study, therefore, assessed the psychometric validity of the Insomnia Severity Index (ISI) in Saudi nurses.

Methods A cross-sectional study with purposive sampling was performed with nurses ($n = 134$, age = 21–48 years) from Al Majmaah, Saudi Arabia. Both conventional and online survey methods using the ISI, a brief measure of metacognition, and a socio-demographics questionnaire were employed.

Results No ceiling or floor effects were found in the ISI total score (8.84 ± 5.07) or the factor scores, but the floor effect was found in the item scores. A two-factor model showed the best fit (Pclose .97, comparative fit index [CFI] 1.00, root mean square error of approximation [RMSEA] 0.00, non-significant χ^2test, χ^2/df 0.904). This model showed favorable configural, metric, scalar, and partial strict invariance across gender groups (CFI > .95, RMSEA < .05, χ^2/df < 3, non-significant $\Delta\chi^2$, ΔCFI ≤ .01). The internal consistency was adequate (Cronbach's alpha = 0.75, 0.78 for the two factors of the ISI). The lack of correlations between the ISI scores and the scores of the brief measure of the metacognition favored its divergent validity.

Conclusion The ISI showed adequate psychometric validity for screening insomnia among Saudi nurses.

Keywords Insomnia · Factor analysis · Measurement invariance · Validity · Sleep disorder · Primary care

Abbreviations

ISI	insomnia severity index
CFA	confirmatory factor analysis
KMO	Kaiser-Meyer-Olkin test of sampling adequacy
CFI	comparative fit index
GFI	goodness of fit index
RMR	root mean square residual
RMSEA	root mean square error of approximation

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Background

Insomnia is the most common and persistent sleep disorder among adults [1]. Evidence indicates an undeniable increment in insomnia prevalence in all those countries where the trend has been investigated in recent decades [2–4]. For example, in the past 10 years, sleep-onset insomnia increased from 13.1 to 15.2%, and the prevalence of insomnia based on the *Diagnostic and Statistical Manual of Mental Disorders-IV* classification rose from 14.8 to 18.8% among Norwegian adults [2]. The prevalence of insomnia among American adults increased from 17.5% in 2002 to 19.2% in 2012 (p trend < .001) [4].

The pathophysiology of insomnia depends on the convergence of factors that may predispose, precipitate, and perpetuate the disorder. There is some degree of non-consensus about the classification of insomnia in three systems (*DSM-V*, *ICSD-3*, and *ICD-10*). However, in all three systems, problems of sleep onset and maintenance and daytime distress and impairment are common [5]. Insomnia is often associated with both short- and long-term psycho-physiological health conditions, such as stress, behavioral issues, fatigue, diminished motivation, and self-esteem. Furthermore, poor cognitive health factors, such as decreased memory, attention, and concentration, may deteriorate overall health and decrease occupational productivity [6]. In the long run, chronic insomnia may lead to mental health issues, including anxiety and depression [6]. It may also be associated with disturbances that involve nearly all or many of the body's physiological systems [6–8]. The economic costs of insomnia management and treatment are estimated to exceed US$100 billion annually [1]. It, therefore, is important to focus on cost effectiveness, practical feasibility, and the overall target to mitigate the health consequences of insomnia.

Insomnia is a prevalent sleep disorder among health providers, including physicians and nurses [5]. Sleep disorders, including insomnia, reduce cognition [9] and psychomotor abilities [10], which increase the perception and the incidence of medical errors by nurses and physicians [5, 11]. Insomnia is a common sleep disorder in the Saudi population but is significantly untreated and under-diagnosed [12]. In Saudi Arabia's referral-based health care system which starts with primary health care centers, a lack of knowledge and training about sleep disorders among primary care physicians often delays treatment and referral of sleep disorders [9]. It, therefore, is imperative to develop insomnia diagnosis and management strategies for primary care. In this context, a rigorously validated tool could advance screening of insomnia at the level of primary care physicians.

The Insomnia Severity Index (ISI) is a brief, easily administered, and widely used questionnaire tool to screen insomnia [13–15]. Recent findings have suggested that the ISI has advantages over other tools because it uses both *ICD-10* and *DSM-5* criteria to assess insomnia [16]. Psychometric validation of the ISI has been conducted among various populations from the Americas, Europe, Africa, and Asia [13, 14, 17–19]. However, the psychometric validity of the ISI has not been investigated among Saudis nor has the index been characterized among nursing professionals. The present study, therefore, was planned to investigate the psychometric properties of the ISI in a population of Saudi nurses.

Methods

Participants

The study participants were nurses from the city of Al Majmaah, Riyadh Region, Saudi Arabia (n = 134, age = 21–48 years). Healthy adult nurses with active registration with the Saudi Commission for Health Specialists were included in the study. Those on neuro-psychotic medication based on self-reports were excluded.

Procedure

In this cross-sectional study, purposive sampling was used to recruit nurses through an online and a paper-based self-administered survey questionnaire package. Nurses working in hospitals and health care facilities in Al Majmaah, Saudi Arabia, were contacted to request their participation using Survey Monkey links and conventional paper-based methods according to their preferences. Majmaah is a fast-growing city with one hospital and seven primary healthcare centers, where more than 500 nurses work. The majority are expatriates, along with 219 Saudi nurses (the source population). Of the 150 Saudi nurses contacted, 134 participated in the study with a response rate of 89.33%. The survey package is composed of the ISI, a brief measure of metacognition, and a semi-structured socio-demographics survey [14, 20]. The potential participants were informed about the voluntary nature of participation, exclusion criteria, absence of health risks, and right to withdraw at any stage. Written informed consent was obtained from the participating nurses after a detailed explanation of the study aims and procedures. The Institutional Review Board (IRB log number: 18-257E), Ministry of Health, Saudi Arabia, approved the study. The norms of Helsinki declaration (2002) and institutional guidelines were followed.

Measures

Insomnia severity index

The ISI is a questionnaire for screening insomnia developed at Centre d'EÂtude des Troubles du Sommeil, Université Laval, Canada. The tool's seven items broadly assess sleep problems and the associated satisfaction, stress, effects on quality of life, and interference in daily life. The items appraise sleep problems and associated symptoms for about 2 weeks before test administration. Each item is scored from 0 to 4 to rate the increasing severity of sleep problems and the associated diurnal symptoms. According to the original scoring guidelines assuming the unidimensionality of the scale, all the individual item scores are added to obtain a total score within the range of 0–28. The application of the scale ranges from routine screening to efficacy assessment of treatments in clinical interventions [14]. The ISI has been found to have adequate internal consistency, reliability, and factorial, convergent, and concurrent validity among American and European populations [14, 17, 19, 21–25].

A brief measure of metacognition

Klusmann et al. [20] developed a brief, self-reported tool of nine items to assess two important aspects of metacognition: meta-memory (five items) and meta-concentration. The items are scored as poor (1), fair (2), average (3), good (4), and very good (5). The scores for the individual items are added to determine scores for meta-memory and meta-concentration, with ranges of 5–25 and 4–20, respectively. The total score for the tool is obtained by adding the scores for meta-memory and meta-concentration, within the range of 9–45. Lower scores represent poor levels of metacognition and its two measured aspects [20]. The measure has been found to have favorable score distribution, item discrimination, reliability, factorial validity, and incremental validity in a German elderly population [20].

Socio-demographics questionnaire

The semi-structured questionnaire for socio-demographic information had 15 items: three open-ended and 12 closed-ended. Information was collected on the participants' age, gender, marital status, self-reported physical activity, clinical duty schedules, hours of daily clinical duty, and habitual use of tea, coffee, cigarettes, and shisha/hookah use.

Statistical analysis

The statistical analysis was performed using SPSS 23.0. Mean ± SD, percentages, and ranges were used to summarize the participants' characteristics. The preliminary item analysis consisted of Cronbach's alpha if item deleted, item–factor correlation, mean ± SD, skewness, kurtosis, and percentage distribution across item scores. No multivariate outliers were found based on the criteria of the Mahalanobis distance (X^2 (df = 7) = 29.88, $p < .0001$) [26]. There were no major kurtosis issues because the absolute values of the Z score for all the ISI item scores were less than 3.29 (Table 1). Similarly, there were no major distribution issues as assessed by the Z score of the skewness (the absolute value was less than 3.29), but for ISI item 3 (Table 1). The scores of all the ISI items were retained without transformation [27].

The factorability and suitability of the ISI scores for factor analysis were determined by communality, determinant, inter-item correlations, the diagonal element of the anti-image correlation matrix, Bartlett's test of sphericity, and the Kaiser–Meyer–Olkin Test of sampling adequacy (KMO). Next, confirmatory factor analysis (CFA) was performed using maximum likelihood extraction for standardized estimates of factor loadings and bootstrapping to manage the skewness issue and multivariate non-normality. CFA evaluated six ISI models: model A: one factor [19]; model B: two factors [18]; model C: two factors [13, 21, 22]; model D: two factors [23, 28]; model E: three factors [18]; and model F: three factors [14, 17, 24, 25] (Fig. 1). Multiple fit indices from different categories were used, as suggested in the literature [26, 29, 30]: the comparative fit index (CFI), root mean square error of approximation (RMSEA), p of close fit

(Pclose), root mean square residual (RMR), goodness of fit index (GFI), and χ^2 test [26].

Model fit was assumed when the CFI and GFI had values greater than 0.95, the χ^2 test was non-significant, the χ^2/df was less than 3, the RMSEA was less than or equal to 0.08, and the RMR was less than or equal to 0.05 [31]. Multi-group CFA across genders was performed to assess configural, metric, scalar, and strict measurement invariance. Cronbach's

Table 1 Descriptive statistics of the Insomnia Severity Index among Saudi nursing professionals

Items of the ISI	Cronbach's alpha if item deleted		Item–factor/corrected item–factor correlation		Mean ± SD	Skewness		Kurtosis		Percentage distribution across item scores					
	1-F	2-F	1-F	2-F		Statistic (SE)	z	Statistic (SE)	z	0	1	2	3	4	Missing value
ISI-1	.61		.84*/.63*		1.10 ± 0.99	0.66 (.21)	3.15	− 0.13 (.42)	− 0.32	32.1	36.6	22.4	7.5	1.5	0.0
ISI-2	.61		.83*/.64*		1.10 ± 0.92	0.55 (.21)	2.65	− 0.18 (.42)	− 0.43	28.4	41.0	23.1	6.7	0.7	0.0
ISI-3	.78		.78*/.48*		1.16 ± 1.01	0.77 (.21)	3.66	0.26 (.42)	0.63	28.4	39.6	22.4	6.7	3.0	0.0
ISI-4		.75		.74*/.54*	1.64 ± 1.09	0.12 (.21)	0.58	− 0.63 (.42)	− 1.53	17.9	25.4	35.8	16.4	4.5	0.0
ISI-5		.72		.80*/.59*	1.31 ± 1.02	0.45 (.21)	2.17	− 0.55 (.42)	− 1.31	23.1	38.8	23.1	13.4	1.5	0.0
ISI-6		.69		.79*/.65*	1.22 ± 0.93	0.35 (.21)	1.69	− 0.44 (.42)	− 1.07	24.6	38.1	29.1	7.5	0.7	0.0
ISI-7		.73		.78*/.56*	1.30 ± 1.09	0.62 (.21)	2.95	− 0.42 (.42)	− 1.02	25.4	38.8	17.9	14.2	3.0	0.7
F1					3.37 ± 2.39	0.58 (.21)	2.75	0.30 (.42)	0.73						
F2					5.47 ± 3.21	0.37 (.21)	1.76	− 0.37 (.42)	− 0.89						

F1, F2 ISI factors, *SD* standard deviation, *SE* standard error; * $p < .0$

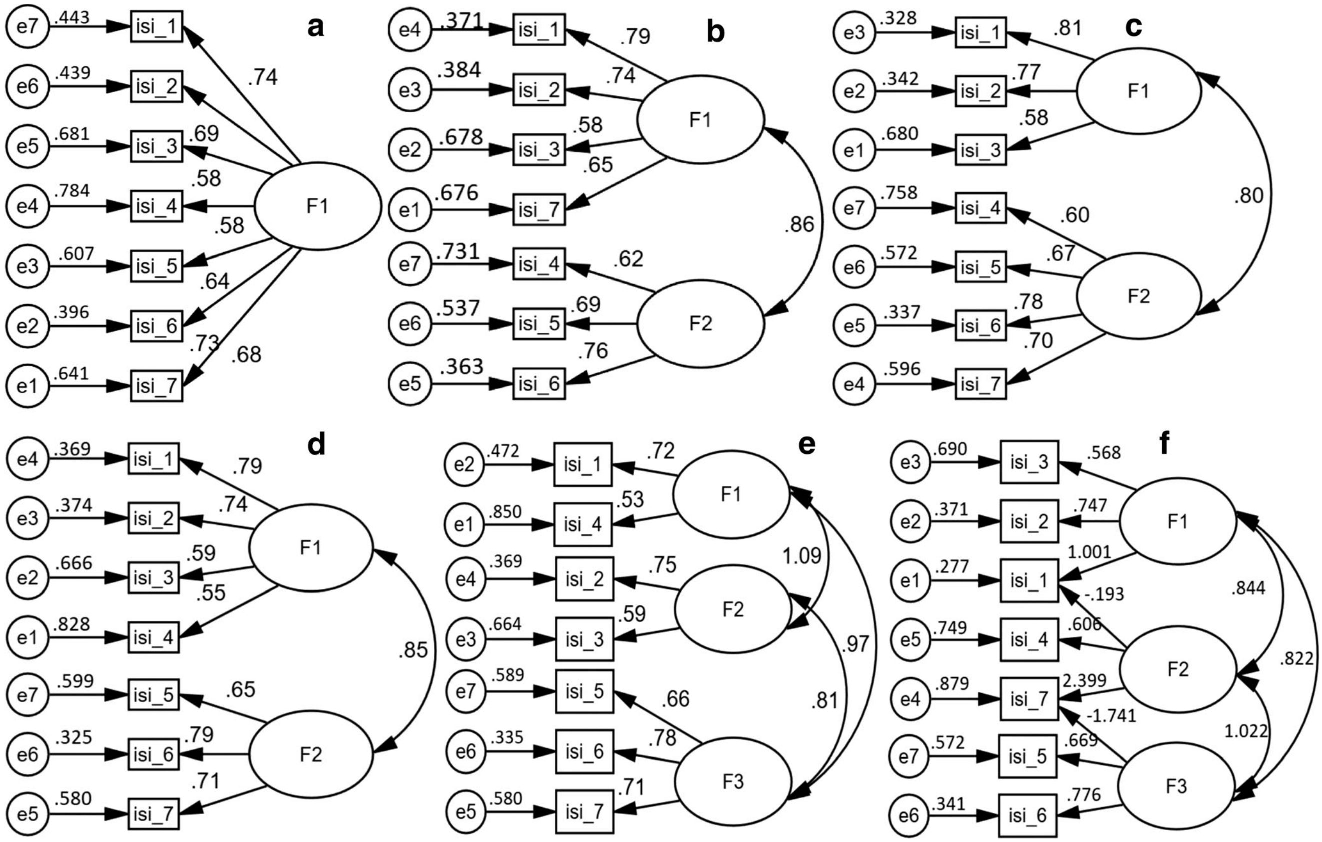

Fig. 1 Confirmatory factor analysis models of the Insomnia Severity Index among Saudi nursing professionals. **a** One-factor model (Gerber et al [19]). **b** Two-factor model (Chahoud et al [18]). **c** Two-factor model (Manzar et al [13]; Chung et al [21]; Moscou-Jackson et al [22]). **d** Two-factor model (Yu [28]; Savard et al [23]). **e** Three-factor model (Chahoud et al [18]). **f** Three-factor model (Bastien et al [14]; Chen et al [24]; Castronova et al [17], Fernandez-Mendoza [25]). ISI_1–7: ISI items. F1–3: ISI factors. All the coefficients are standardized. Ovals represent latent variables, rectangles represent measured variables, circles represent error terms, single-headed arrows between ovals and rectangles represent factor loadings, single-headed arrows between circles and rectangles represent error terms. Amos did not display the standardized values of the models' uniqueness, so the models were manually edited to display numerical values taken from the Amos text output (estimates → scalars → variances). Amos did not display the standardized loadings of model f with cross-loading, so model f was manually edited to display numerical values taken from the Amos text output (estimates → scalars → standardized regression weights)

alpha and item–factor Spearman's correlations were used to determine internal consistency. Divergent validity was assessed by Spearman's correlations.

Results

Participants' characteristics

Most of the participants (65.7%) were female nurses, and the mean age of the participants was 30.68 ± 5.88 years (Table 2). The majority of the participating nurses were married (61.2%) and reported working the morning shift (66.4%) (Table 2). About half of the nurses worked for 8 h of daily clinical duty and reported no sports activities (Table 2). The majority of the participants were habitual consumers of tea (54.5%) and coffee (70.9%) (Table 2). Habitual smokers included users of cigarettes (8.2%) and water pipes (3.7%) (Table 2). The mean of the ISI total score was 8.84 ± 5.07, with a range of 0–26. The prevalence of moderate-severe insomnia was 15.67% in the study population.

Preliminary item analysis

Table 1 describes the preliminary item analysis. The missing values for the study dataset were completely random as determined by Little's Missing Completely At Random (MCAR) test results (χ^2 (df = 123) = 146.414, $p < 0.074$), with only one missing value in the ISI scores (ISI item 7;Table 1). The missing value for the ISI scores was imputed by the expected maximization method because it was the preferred approach after taking into account the sample size, distribution characteristics, and proportion of the missing data [32]. There were no skewness or kurtosis issues in the distribution characteristics of the two ISI factor scores because the absolute value of the Z score for skewness and kurtosis was less than 3.29

Table 2 Participants' characteristics

Characteristics	Mean ± SD/number (percentage)
Age (year)	30.68 ± 5.88
Gender	
Male	46 (34.3)
Female	88 (65.7)
Marital status	
Single/never married	45 (33.6)
Married	82 (61.2)
Divorced	7 (5.2)
Clinical duty schedules	
Morning shift	89 (66.4)
Afternoon shift	24 (17.9)
Night shift	21 (15.7)
Hours of daily clinical duty	
Less than 8 h	9 (6.7)
8 h	66 (49.3)
More than 8 h	47 (35.1)
Unreported	12 (9.0)
Self-reported sports activity	
No	67 (50.0)
Yes	66 (49.3)
Unreported	1 (0.7)
ISI total score	8.84 ± 5.07 (0–26)
Metacognition#	29.74 ± 7.26
Habitual use	
Tea	
No	61 (45.5)
Yes	73 (54.5)
Coffee	
No	39 (29.1)
Yes	95 (70.9)
Cigarettes	
No	123 (91.8)
Yes	11 (8.2)
Shisha/hookah	
No	129 (96.3)
Yes	5 (3.7)

SD, standard deviation; *ISI*, Insomnia Severity Index

Based on the brief measure of metacognition

(Table 1). There was no ceiling effect for the ISI total score, factor-1, and factor-2 because only 0.7%, 0.7%, and 0.0% of the participants, respectively, reported the highest scores. Similarly, there was no floor effect for the ISI total score, factor-1, and factor-2 because only 3.0%, 14.2%, and 5.2% of the participants, respectively, reported the lowest scores. Among the ISI item scores, none had a ceiling effect, but all seven items showed the floor effect because more than 15% of the participating nurses reported the lowest score of zero (Table 1) [33, 34].

Factor analysis

Measures assessing the adequacy, suitability, and factorability of the ISI scores

The ISI score correlation matrix was statistically different from the singular matrix based on significant results for Bartlett's test of sphericity [35]. The conditions for multicollinearity and the absence of singularity were satisfied, as evidenced by the determinant value greater than 0.00001 [35]. The communality for all the ISI item scores was more than 0.4, indicating that the optimum level of variance was accounted by common factors; therefore, all seven ISI item scores were used in factor analysis [36]. The common variance of the ISI item scores was meritorious because the KMO was more than 0.8, indicating sample adequacy for factor analysis [35]. Furthermore, the factorability of the ISI item score correlation matrix was indicated by the fact that all the inter-item ISI score correlations were more than 0.3 (Table 3) [27].

Confirmatory factor analysis

A two-factor model (model C) showed the best fit with the highest value for Pclose, a perfect CFI (1.00), a GFI more than 0.95, a non-significant χ^2 test, the least χ^2/df value, the least RMSEA value (0.00(0.00–.08)), and a RMR less than 0.05 (Table 4) [31]. Model A did not have adequate fit, as shown by a significant χ^2 test, very low Pclose value, and RMSEA more than 0.08 (Table 4).

Model C: Measurement invariance across gender groups

When model C was assessed across gender groups without any constraints, it showed a non-significant χ^2 test,

Table 3 Inter-item correlation matrix of Insomnia Severity Index scores among Saudi nursing professionals

	ISI-1	ISI-2	ISI-3	ISI-4	ISI-5	ISI-6	ISI-7
ISI-1		.63*	.44*	.36*	.44*	.46*	.47*
ISI-2			.46*	.32*	.40*	.44*	.43*
ISI-3				.36*	.40*	.41*	.36*
ISI-4					.51*	.43*	.41*
ISI-5						.56*	.47*
ISI-6							.61*
ISI-7							

* $p < 0.01$

χ^2/df < 1, CFI > .95, and RMSEA < .05, indicating configural invariance in the model (Table 5) [37]. Weak/metric invariance across gender groups in model C was indicated by a non-significant chi-square difference test and ΔCFI < .01 (Table 5) when compared with the fully unconstrained model. A non-significant chi-square difference test and ΔCFI < .01 (Table 5) between models constrained for loadings and models constrained for intercepts indicated strong/scalar invariance in model C [37]. Strict invariance in model C was not found. However, evidence for partial strict invariance was found in a non-significant chi-square difference test and ΔCFI < .01 (Table 5) between model constrained for variances (some variances freed) and model constrained for intercepts [37].

Internal consistency, internal homogeneity, and item discrimination

Cronbach's alpha values for ISI factor-1 and factor-2 were 0.75 and 0.77, respectively. The item–factor (r = .74–.84, p < .01) and corrected item–factor (r = .74–.84, p < .01) correlations for the ISI scores were moderate to strong (Table 1). Cronbach's alpha if item deleted values ranged from .61 to .78 (Table 1).

Divergent construct validity

The ISI and the metacognition scores had some weak negative correlations (Table 6).

Discussion

To the best of our knowledge, this is the first study to assess the psychometric validity of an insomnia screening instrument among the Saudi population in general and Saudi nurses in particular. The original English version of the ISI showed favorable psychometric characteristics among Saudi nursing professionals, as evidenced by the item analysis, internal consistency and homogeneity, factorial and divergent validity, and measurement invariance of the validated model across gender groups.

Preliminary item analysis

The non-significant value for Little's MCAR test in this study dataset and the very low proportion of missing values for the ISI scores indirectly support the psychometric considerations because managing non-random and higher proportions of missing data may pose challenging requirements for validity [38]. The responsiveness and discriminative validity of the highest and lowest scores are implied because the variance in the ISI total and factor scores is accounted for, even at these extreme values [33, 39]. Similarly, generalizations for acceptable responsiveness and discriminative validity at the highest scores of the ISI items scores are suggested by the absence of the ceiling effect for all seven items [13, 33]. These findings are similar to those reported when administering the ISI to Ethiopian adults who use substances [13]. There were some concerns regarding the floor effect for the ISI item scores, but this may be explained by the non-clinical nature of the study population (nursing professionals).

Confirmatory factor analysis

The factorial validity of the ISI is a debated question, with as many as six factor models reported in previous studies: two three-factor models, three two-factor models, and one one-factor model (Fig. 1) [13, 14, 17–19, 21–25]. The methodological differences and discrepancies in studies investigating the ISI's factorial validity might be responsible for non-consensus. Briefly put, the differences and discrepancies are on many levels (i.e., non-reporting of measures testing the

Table 4 Fit statistics of the Insomnia Severity Index models among Saudi nursing professionals

Models	Pclose	CFI	RMR	GFI	RMSEA	χ^2	df	p	χ^2/df
A	.067	.949	.049	.936	.092 (.045–.138)	29.722	14	.008	2.123
B	.208	.970	.046	.955	.073 (.000–.124)	22.293	13	.051	1.715
C	.796	1.000	.036	.975	.000 (.000–.079)	11.753	13	.548	.904
D	.257	.974	.052	.956	.068 (.000–.120)	21.065	13	.072	1.620
E	.260	.977	.045	.963	.069 (.000–.125)	17.989	11	.082	1.635
F	.559	.995	.033	.979	.035 (.000–.107)	10.430	9	.317	1.159

A: one-factor (Gerber et al. 2016), B: two-factor model (Chahoud et al. 2017), C: two-factor model (Manzar et al. 2018; Chung et al. 2011; Moscou-Jackson et al. 2016), D: two-factor model (Yu 2010; Savard et al. 2005), E: three-factor model (Chahoud et al. 2017), and F: three-factor model (Bastien et al. 2001; Chen et al. 2015; Castronova et al. 2016; Fernandez-Mendoza 2012). Pclose: p of close fit. *CFI*, comparative fit index. *GFI*, goodness of fit index. *RMR*, root mean square residual. *RMSEA*, root mean square error of approximation

Table 5 Measurement invariance in the two-factor model of the Insomnia Severity Index in Saudi nursing professionals across gender groups

	X^2	df	p value	X^2/df	CFI	RMSEA	X^2 difference test statistics			ΔCFI
							ΔX^2	Δdf	p value	
Two-factor model of the ISI										
Configural invariance	24.590	26	.542	.946	1.000	.000 (.000–.064)				
Weak/metric invariance—equal loadings	29.684	31	.534	.958	1.000	.000 (.000–.061)	5.093	5	.405	.000
Strong/scalar invariance—equal intercepts	34.375	38	.638	.905	1.000	.000 (.000–.052)	4.692	7	.698	.000
Strict invariance—equal factor variances	54.657	48	.236	1.139	.979	.032 (.000–.068)	20.282	10	.027	− .021
Partial strict invariance—equal factor variances	46.554	46	.449	1.012	.998	.010 (.000–.059)	12.179	8	.143	− .002

suitability of data for factor analysis, EFA and its details, CFA and its details, application/non-application of measurement invariance and its detail) [13, 14, 17–19, 21–25]. CFA, therefore, was performed to evaluate all these models in the study sample of Saudi nurses. One of the two-factor models, model C, had the best fit [13, 21, 22]. A similar model was found to have the best fit in studies on Ethiopian adults with substance use problems [13], American adults with sickle cell disease [22], and Chinese adolescents [21]. Models B, D, E, and F had almost comparable fit indices values as model C in the study population [31], but these models had discriminative validity issues and multicollinearity problems in the factor scores because the inter-factor correlations were more than 0.85 [31]. Model F had an additional issue of cross-loading, which may indicate a flaw in the factor structure [36]. The one-factor model had a poor fit in the study, although Gerber et al. [19] reported it was valid in a German population.

Model C: measurement invariance among gender groups

The validity of model C, a two-factor model, was favored by the results for measurement invariance (i.e., configural, metric, scalar, and partial strict invariance among male and female Saudi nurses). This is the first report on the measurement invariance of a two-factor model of the ISI across gender in any population. Previous studies have reported measurement invariance for one- and three-factor models of the ISI [19, 24]. Gerber et al. [19] found evidence for measurement invariance in a one-factor model of the German version of the ISI. Chen et al. [24] found that a three-factor model of the Chinese version of the ISI had longitudinal measurement invariance (configural, weak, partial strong, and partial strict) among those with insomnia in Taiwan. Multi-group CFA also showed that a three-factor ISI model had configural, weak, and strong invariance across cultures (i.e., Chinese and Canadian populations) [24].

Internal consistency, internal homogeneity, and item discrimination

The two factors in model C of the ISI had adequate internal consistency in the study population [40]. The two-factor structure of the ISI found valid for this population of Saudi nurses has been shown to be valid in other populations [13, 21, 22]. Moscou-Jackson et al. [22] reported slightly higher Cronbach's alpha values (0.85, 0.87) in American adults with sickle cell disease, while Manzar et al. [13] reported slightly lower values (0.68, 0.78) in Ethiopian substance-using adults. However, Chung et al. [21] developed a two-factor structure similar to model C for Chinese adults but reported Cronbach's alpha for a unidimensional ISI scale.

All the item–factor and the corrected item–factor correlations for factor-1 and factor-2 were more than 0.3, implying that the items measured the same construct and had adequate item discrimination [35]. The multidimensionality of the ISI has been documented, but previous studies reported item-total correlations rather than item–factor or corrected item–factor correlations [13, 14, 28]. Cronbach's alpha if item deleted

Table 6 Discriminant or divergent validity: correlation of Insomnia Severity Index scores and the brief measure of metacognition among Saudi nursing professionals

ISI scores	Metacognition
ISI-1	− .12
ISI-2	− .14
ISI-3	− .23**
ISI-4	− .03
ISI-5	.04
ISI-6	− .19*
ISI-7	− .18*
Factor-1	− .19*
Factor-2	− .11
ISI total score	− .15

* $p < .05$, ** $p < .01$

suggested that minor improvement (.029) in the consistency of factor-1 was possible if item 3 was deleted. However, it was retained because the resulting change was marginal and would lead to a simultaneous loss of important information about the participants' sleep. Similarly, some earlier studies ignored potential minor improvements in Cronbach's alpha at the expense of item deletion because the ISI is an established, widely used insomnia screening tool [13, 14, 28]; however, doing so may not be indisputably advisable during the development stage of a new tool. All the inter-item correlations were higher than the critical limit value of 0.2 [19], supporting the homogeneity of the ISI item scores among the Saudi nurses. Some previous studies reported that most inter-item correlations were greater than 0.2, but some had lower values, and some correlations were insignificant [13, 19]. It, therefore, is possible to argue that the ISI scores for this study population have relatively better homogeneity.

Divergent construct validity

Metacognitive abilities are related to the characteristic mental activity of insomnia and insomnia disorder [41, 42]. The severity of insomnia might be related to changes in cognitive activity in the resting state [43]. Similarly, the development of sleep-related arousal in insomnia is possibly mediated by metacognitive processes [44]. Similar metacognitive issues may be involved in sleep-related arousal and sleep reactivity among those with insomnia [42, 43]. These evidences of the relationship reinforce the implicit association between metacognition and insomnia. Nevertheless, insomnia and metacognition represent two different, non-overlapping constructs [41, 42, 44]. A non-significant and a weak negative correlation of Saudi nurses' ISI and metacognition scores, therefore, arguably provide evidence for the divergent validity of the ISI.

Conclusion

In brief, the evidence from the item analysis, factorial investigations, adequate internal consistency, internal homogeneity, and adequate divergent validity demonstrates the psychometric validation of the ISI for Saudi nursing practitioners.

Limitations

Due to the study's modest sample size, the findings may need further validation with a more representative sample to support a wider application in the general Saudi population. Not using sleep apnea as an exclusion criterion was a limitation and requires further examination. Future studies should investigate the ISI's concurrent validity, convergent validity, and test–retest reliability for nurses. However, the study results suggest that application of the ISI at the primary health centers may serve as a first step to combat the under-treatment and under-diagnosis of insomnia in Saudi Arabia due to primary care physicians' lack of knowledge about sleep disorders.

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Authors' Contributions MDM and AA: concept development and study design, data acquisition, and critical revision of the manuscript

MDM: data analysis and interpretation and manuscript preparation.

All the authors read and approved the final version of the manuscript.

Availability of data, material, and methods All the data files analyzed in this study are available from the corresponding author on reasonable request.

Compliance with ethical standards

Ethical approval and consent to participate The study was approved by the Institutional Review Board (IRB log number: 18-257E) of the Saudi Ministry of Health, and all the participants provided written informed consent. All the authors approved the final draft.

Consent to publish The participants provided written informed consent for publication, although no personal or identifiable information has been published.

Competing interests The authors declare that they have no competing interests.

References

1. Wickwire EM, Shaya FT, Scharf SM (2015) University of Maryland School of Pharmacy University of Maryland School of Medicine. Sleep Med Rev 30:72–82. https://doi.org/10.1016/j.smrv.2015.11.004
2. Pallesen S, Sivertsen B, Hilde I, Bjorvatn B (2014) A 10-year trend of insomnia prevalence in the adult Norwegian population. 15:173–179. https://doi.org/10.1016/j.sleep.2013.10.009
3. Kronholm E, Partonen T, Härmä M, Hublin C, Lallukka T, Peltonen M, Laatikainen T (2016) Prevalence of insomnia-related symptoms continues to increase in the Finnish working-age population. J Sleep Res 25:454–457. https://doi.org/10.1111/jsr.12398
4. Ford ES, Cunningham TJ, Giles WH, Croft JB (2015) Trends in insomnia and excessive daytime sleepiness among US adults from 2002 to 2012. Sleep Med 16:372–378. https://doi.org/10.1016/j.sleep.2014.12.008
5. Schmidt RE, Cullati S, Mostofsky E, Haller G (2015) Healthcare-related regret among nurses and physicians is associated with self-

rated insomnia severity : a cross-sectional study. PLoS One 10(10): e0139770. 1–12. https://doi.org/10.1371/journal.pone.0139770
6. Thomas F, Hopkins RO, Handrahan DL, Walker J, Carpenter J (2006) Sleep and cognitive performance of flight nurses after 12-hour evening versus 18-hour shifts. Air Med J 25:216–225. https://doi.org/10.1016/j.amj.2006.06.005
7. Johnson AL, Brown K, Weaver MT (2010) Sleep deprivation and psychomotor performance among night-shift nurses. AAOHN J 58: 147–154. https://doi.org/10.3928/08910162-20100316-02
8. Arimura M, Imai M, Okawa M et al (2010) Sleep, mental health status, and medical errors among hospital nurses in Japan. Ind Health 48:811–817. https://doi.org/10.2486/indhealth.MS1093
9. Almeneessier AS, Alamri BN, Alzahrani FR et al (2018) Insomnia in primary care settings : still overlooked and undertreated ? J Clin Sleep Med 13(8):937–939. https://doi.org/10.4103/JNSM.JNSM
10. Morin CM, Jarrin DC (2013) Epidemiology of insomnia: prevalence, course, risk factors, and public health burden. Sleep Med Clin 8:281–297. https://doi.org/10.1016/j.jsmc.2013.05.002
11. Manzar MD, Ejaz Hussain M (2012) Sleep-immune system interaction: advantages and challenges of human sleep loss model. Front Neurol 3:16–18. https://doi.org/10.3389/fneur.2012.00002
12. Manzar MD, Zannat W, Hussain ME (2015) Sleep and physiological systems: a functional perspective. Biol Rhythm Res 46:195–206. https://doi.org/10.1080/09291016.2014.966504
13. Manzar MD, Salahuddin M, Khan TA, Shah SA, Alamri M, Pandi-Perumal SR, Bahammam AS (2018) Psychometric properties of the Insomnia Severity Index in Ethiopian adults with substance use problems. J Ethn Subst Abus 0:1–15. https://doi.org/10.1080/15332640.2018.1494658
14. Bastien CH, Vallières A, Morin CM (2001) Validation of the insomnia severity index as an outcome measure for insomnia research. Sleep Med 2:297–307. https://doi.org/10.1016/S1389-9457(00)00065-4
15. Morin CM, Belleville G, Bélanger L, Ivers H (2001) The insomnia severity index : psychometric indicators to detect insomnia cases and evaluate treatment response. Sleep 18–20 34:601–608. https://doi.org/10.1093/sleep/34.5.601
16. Seng L, Seow E, Abdin E et al (2018) Identifying the best sleep measure to screen clinical insomnia in a psychiatric population. Sleep Med 41:86–93. https://doi.org/10.1016/j.sleep.2017.09.015
17. Castronovo V, Galbiati A, Marelli S, et al (2016) Validation study of the Italian version of the Insomnia Severity Index (ISI). https://doi.org/10.1007/s10072-016-2620-z
18. Chahoud M, Chahine R, Salameh P, Sauleau EA (2017) Reliability, factor analysis and internal consistency calculation of the Insomnia Severity Index (ISI) in French and in English among Lebanese adolescents. eNeurologicalSci 7:9–14. https://doi.org/10.1016/j.ensci.2017.03.003
19. Gerber M, Lang C, Lemola S, Colledge F, Kalak N, Holsboer-Trachsler E, Pühse U, Brand S (2016) Validation of the German version of the insomnia severity index in adolescents, young adults and adult workers: results from three cross-sectional studies. BMC Psychiatry 16:1–14. https://doi.org/10.1186/s12888-016-0876-8
20. Klusmann V, Eversa A, Schwarzer R, Heuser I (2011) A brief questionnaire on metacognition: psychometric properties. Aging Ment Health 15:1052–1062. https://doi.org/10.1080/13607863.2011.583624
21. Chung K, Kan KK, Yeung W (2011) Assessing insomnia in adolescents : comparison of Insomnia Severity Index , Athens Insomnia Scale and Sleep Quality Index. Sleep Med 12:463–470. https://doi.org/10.1016/j.sleep.2010.09.019
22. Moscou- Jackson G, Allen J, Smith MT, HaywoodCarlton J (2016) Psychometric validation of the insomnia severity index in adults with sickle cell disease. J Heal Care Poor Underserved 27:209–218. https://doi.org/10.1353/hpu.2016.0010.Psychometric
23. Savard M-H, Savard J, Sébastien Simardand HI (2005) Empirical validation of the insomnia. Psychooncology 14:429–441. https://doi.org/10.1002/pon.860
24. Chen PY, Yang CM, Morin CM (2015) Validating the cross-cultural factor structure and invariance property of the Insomnia Severity Index: evidence based on ordinal EFA and CFA. Sleep Med 16: 598–603. https://doi.org/10.1016/j.sleep.2014.11.016
25. Fernandez-Mendoza J, Rodriguez-Muñoz A, Vela-Bueno A, Olavarrieta-Bernardino S, Calhoun SL, Bixler EO, Vgontzas AN (2012) The Spanish version of the Insomnia Severity Index: a confirmatory factor analysis. Sleep Med 13:207–210. https://doi.org/10.1016/j.sleep.2011.06.019
26. Jaccard J, Wan CK (1996) LISREL approaches to interaction effects in multiple regression. SAGE Publications, Thousand Oaks, California
27. Tabachnick BG, Fidell LS (2013) Using multivariate statistics. Pearson Education, MA:Allyn & Bacon, Boston
28. Yu DSF (2010) Insomnia Severity Index: psychometric properties with Chinese community-dwelling older people. J Adv Nurs 66: 2350–2359. https://doi.org/10.1111/j.1365-2648.2010.05394.x
29. Manzar MD, Zannat W, Moiz JA, Spence DW, Pandi-Perumal SR, Bahammam AS, Hussain ME (2016) Factor scoring models of the Pittsburgh Sleep Quality Index: a comparative confirmatory factor analysis. Biol Rhythm Res 47:851–864. https://doi.org/10.1080/09291016.2016.1202375
30. Manzar MD, Zannat W, Hussain ME, Pandi-Perumal SR, Bahammam AS, Barakat D, Ojike NI, Olaish A, Spence DW (2016) Dimensionality of the Pittsburgh Sleep Quality Index in the young collegiate adults. Springerplus 0–5 5:1550. https://doi.org/10.1186/s40064-016-3234-x
31. Manzar MD, Bahammam AS, Hameed UA et al (2018) Dimensionality of the Pittsburgh Sleep Quality Index: a systematic review. Health Qual Life Outcomes 16:89 9–11. https://doi.org/10.1186/s12955-018-0915-x
32. Gold MS, Bentler PM (2009) Structural equation modeling : a treatments of missing data : a Monte Carlo comparison of RBHDI , iterative stochastic regression imputation, and expectation-maximization. *Struct Equ Model* 7:319–355. https://doi.org/10.1207/S15328007SEM0703_1
33. Lim CR, Harris K, Dawson J, Beard DJ, Fitzpatrick R, Price AJ (2015) Floor and ceiling effects in the OHS: an analysis of the NHS PROMs data set. BMJ Open 5:e007765. https://doi.org/10.1136/bmjopen-2015-007765
34. Salahuddin M, Maru TT, Kumalo A, Pandi-Perumal SR, Bahammam AS, Manzar MD (2017) Validation of the Pittsburgh sleep quality index in community dwelling Ethiopian adults. Health Qual Life Outcomes 15:58. https://doi.org/10.1186/s12955-017-0637-5
35. Field A (2013) Discovering statistics using IBM SPSS statistics, 4th edn. SAGE Publications Ltd, London
36. Costello AB, Osborne JW (2005) Best practices in exploratory factor analysis. Four Recommendations for Getting the Most From Your Analysis 10:1–9 https://pareonline.net/getvn.asp?v=10&n=7
37. Cheung GW, Rensvold RB (2002) Evaluating goodness-of- fit indexes for testing measurement invariance. Struct Equ Model A Multidiscip J 9:233–255. https://doi.org/10.1207/S15328007SEM0902
38. Stockdale M, Royal K (2016) Missing data as a validity threat for medical and healthcare education research: problems and solutions. Int J Health 2:67–72. https://doi.org/10.5430/ijh.v2n2p67
39. Manzar MD, Salahuddin M, Maru TT, Alghadir A, Anwer S, Bahammam AS, Pandi-Perumal SR (2018) Validation of the adapted Leeds sleep evaluation questionnaire in Ethiopian university students. Health Qual Life Outcomes 16:1–8. https://doi.org/10.1186/s12955-018-0876-0

40. George D, Mallery P (2003) SPSS for Windows step by step: answers to selected exercises. A Simple Guid Ref 63
41. Palagini L, Piarulli A, Lai E, Cheli E, Espie C, Gemignani A (2013) Metacognition selectively defines primary insomnia. Sleep Med 14: e228. https://doi.org/10.1016/j.sleep.2013.11.549
42. Palagini L, Piarulli A, Menicucci D, Cheli E, Lai E, Bergamasco M, Mauri M, Kyle SD, Espie CA, Gemignani A (2014) Metacognitive beliefs relate specifically to sleep quality in primary insomnia: a pilot study. Sleep Med 15:918–922. https://doi.org/10.1016/j.sleep.2014.03.017
43. Palagini L, Cellini N, Mauri M, Mazzei I, Simpraga S, dell'Osso L, Linkenkaer-Hansen K, Riemann D (2016) Multiple phenotypes of resting-state cognition are altered in insomnia disorder. SLEH. 2: 239–245. https://doi.org/10.1016/j.sleh.2016.05.003
44. Palagini L, Ong JC, Riemann D (2017) The mediating role of sleep-related metacognitive processes in trait and pre-sleep state hyperarousal in insomnia disorder. J Psychosom Res 99:59–65. https://doi.org/10.1016/j.jpsychores.2017.03.001