**Insomnia and post-traumatic stress disorder: A meta-analysis on interrelated association (n=57,618) and prevalence (****n=****573,665)**

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**Abstract:**

Posttraumatic stress disorder (PTSD) is a common mental disorder, which is strongly associated with insomnia, yet their epidemiological overlap is poorly understood. To determine the convergent quantitative magnitude of their relationship, PubMed, EMBASE, Scopus, Web of Science, PubPsych, and PsycINFO were searched to identify studies that either reported the correlation or frequency of insomnia symptoms in PTSD and posttraumatic stress symptoms (PTSS), or both. Out of 3714 records, 75 studies met selection criteria and aggregate effect size (ES) estimates were generated for the correlations (K=44, comprising 57,618 subjects) and frequencies (K=33, comprising 573,665subjects with PTSD/PTSS) of insomnia symptoms in PTSD/PTSS. A medium-size significant correlation was found [ES: 0.52 (CI: 0.47-0.57)] with moderating effects of the COVID-19 pandemic and military service as causes of trauma. The prevalence of insomnia in PTSD/PTSS was 63% [CI: 45%-78%] and was moderated by the cause of trauma as well as the PTSD/PTSS assessment scale. The findings from this meta-analysis highlight the importance of screening and managing insomnia in PTSD patients.

**Keywords:** Posttraumatic stress disorder, PTSD, Posttraumatic stress symptoms, Insomnia, sleep disorder, Meta-analysis

**Abbreviations**

* ACC: Anterior Cingulate Cortex
* ACTH: adrenocorticotropic hormone
* AIS: Athens Insomnia Scale
* CAPS: Clinician-Administered PTSD Scale
* CBT: cognitive behavioral therapy
* CBT-I: cognitive behavioral therapy for insomnia
* CI: confidence interval
* CMA: comprehensive meta-analysis
* DSM-IV: Diagnostic and Statistical Manual of Mental Disorders, Fourth Edition
* DTS: Distress Tolerance Scale
* ES: effect size
* GPS: Global Psychotrauma Screen
* GSDS: General Sleep Disturbance Scale
* HPA: Hypothalamic-pituitary-adrenal
* IES: Impact of Event Scale
* IRT: Imagery Rehearsal Therapy
* ISI: insomnia severity index
* ISES: Iowa Sleep Experience Survey
* OSA: obstructive sleep apnea
* PCL: PTSD checklist for DSM-5
* PCL-M: PTSD checklist for DSM-5, military version
* PDS: Posttraumatic diagnostic scale
* PIRS: Pittsburgh Insomnia Rating Scale
* PRISMA: Preferred Reporting Items for Systematic Reviews and Meta-Analyses
* PSS: PTSD Symptom Scale
* PSS-SR: PTSD Symptom Scale-Self Report
* PTSD: posttraumatic stress disorder
* PTSS: posttraumatic stress symptoms
* REM: rapid eye movement
* SARS-CoV-2: Severe Acute Respiratory Syndrome Coronavirus COVID-19
* SDS: Sleep Disturbance Screening
* SN: Salience Network
* TAL: Thinking A Lot questionnaire
* TEC: Traumatic Experiences Checklist
* YSIS: Youth Self-Rating Insomnia Scale

1. **Introduction:**

Posttraumatic stress disorder (PTSD) is a common mental illness triggered by experiencing or witnessing traumatic events including threatened death, serious injury, sexual violence, or other threats (Bisson et al., 2015; Friedman et al., 2011; Kelly, 1981). Individuals with PTSD or posttraumatic stress symptoms (PTSS) manifest re-experiencing, avoidance, and hyperarousal and reactivity symptoms following exposure to a traumatic event (American Psychiatric Association, 2013; Cox et al., 2020). PTSD/PTSS refers to posttraumatic stress symptoms with or without meeting full diagnostic criteria in the present study. The lifetime prevalence of PTSD is about 8% worldwide (Kilpatrick et al., 2013; Lewis et al., 2019), which results in significant health care costs and a high burden on society (Walker et al., 2003). PTSD/PTSS is also accompanied by several medical and psychiatric conditions including metabolic or cardiovascular diseases, cognitive impairments, mood disorders, substance abuse, and sleep disturbances (Khazaie et al., 2013; Kilpatrick et al., 2003; Lamarche and De Koninck, 2007; Michopoulos et al., 2016; Vandrey et al., 2014).

Sleep disturbance is a prominent psychiatric feature of PTSD/PTSS (Germain, 2013; Koffel et al., 2016; Lamarche and De Koninck, 2007; Spoormaker, 2008), and contributes to maladaptive stress and emotional responses, which are considered modifiable risk factors in patients with PTSD (Germain, 2013). Although sleep abnormalities have been reported in PTSD patients using polysomnography (Zhang et al., 2019), other research suggests there is a discrepancy between subjective and objective measures of sleep (Ghadami et al., 2015). Previously, we have assessed the role of sleep parameters to differentiate PTSD patients from healthy individuals and observed that a combination of subjective and objective measurements improved classification accuracy between the two groups (Tahmasian et al., 2017). Further, prior work has demonstrated that treating sleep disturbance among at-risk individuals is a key target for the prevention and treatment of PTSD (Vandrey et al., 2014). Insomnia is among the most frequent sleep disturbances observed in PTSD (Germain, 2013; Khazaie et al., 2016; Lamarche and De Koninck, 2007). Despite considerable evidence demonstrating a relationship between insomnia and PTSD, there is substantial heterogeneity in the magnitude of the correlations reported (i.e., ranging from 0.12 - 0.84) between these conditions (Babson and Feldner, 2010; Ellison et al., 2019; Geng et al., 2019; Pillar et al., 2000). There is similar inconsistency in the reported frequency of insomnia in PTSD (i.e., ranging from 3-100%) (Maker et al., 2006; Mellman et al., 1995; Neylan et al., 1998). Hence, the inter-relationship between insomnia and PTSD/PTSS and the frequency of insomnia symptoms in patients with PTSD/PTSS show considerable variability.

In this comprehensive meta-analysis, we thus, pursued two main aims: i) to quantify the strength of the association between insomnia symptoms and PTSD/PTSS based on studies using correlational designs, and ii) to determine the frequency of insomnia symptoms in PTSD/PTSS based on studies that have reported frequency data. These two analyses using large-scale samples would enable us to shape a broader understanding of the distribution and linear relationship between these two continuous variables (i.e., insomnia and PTSD/PTSS symptoms). Therefore, we retrieved 75 existing publications investigating the relationship between insomnia and PTSD/PTSS for inclusion in quantitative meta-analytical analysis using various methodological designs to provide a comprehensive overview of the link between insomnia and PTSD/PTSS (Table S2 for MOOSE checklist).

1. **Method:**

This meta-analysis has been conducted according to the updated version of “Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA)” guidelines (Page et al., 2021), and was prospectively recorded at PsyArXiv preprints (<https://doi.org/10.31234/osf.io/7n84u>). Due to the growing number of new studies associated with trauma related to the emergence of the Severe Acute Respiratory Syndrome Coronavirus COVID-19 (SARS-CoV-2) pandemic, the literature contained within this analysis was updated to include reports that have been published since August 2019 until November 2021. Further, this study has been updated to follow recently published recommendations for systematic reviews and meta-analyses (Johnson and Hennessy, 2019).

**2.1. Eligibility criteria:**

In order to assess the eligibility of studies, we used “Participants, Interventions, Comparisons, Outcomes, Study Design (PICOS)” approach (Moher et al., 2009) to specify study charactristics. Thus, we have included studies that (a) were conducted with an adult population (age > 17 years), suffering from PTSD/PTSS with no prior comorbidity (e.g., substance abuse, depression or medical conditions including traumatic brain injury, pregnancy) at the time of sample retrieval; (b) reported the correlation between PTSD/PTSS and insomnia symptoms and/or the prevalence of insomnia in patients with PTSD/PTSS; (c) were observational (cross-sectional, case-control, or cohort studies) and interventional if they reported statistics at the baseline assessment, as we only used the baseline results in such cases; and (d) were published in the English language. Studies were excluded if they were review, meta-analysis, editorial letter, case report, or non-peer-reviewed publications.

**2.2. Information sources and search strategy:**

We searched six databases including PubMed, EMBASE, Scopus, Web of Science, PubPsych, and PsycINFO on November 2021 for studies published between 1990-2021 with no design restrictions. Our keywords for the search included the following string: "post-traumatic stress disorder" OR PTSD OR "Stress Disorders, Post-Traumatic") AND (Insomnia OR "Sleep Initiation and Maintenance Disorders" OR "Insomnia, Fatal Familial" OR "Asleep, Awakening" OR "Sleep Problems" OR "Sleep Disturbances".

**2.3. Selection process and methodological quality (risk of bias) assessment:**

After importing the data into the Endnote X8 reference manager program, manuscripts were screened in a two-step process. The titles and abstracts of identified studies were reviewed, and then full-text articles were checked based on our selection criteria. Papers retrieved from databases were examined by two authors (R.A. and S.R.). These authors completed the screening process (title and abstract assessments then full-text eligibility) independently (please see Table S1 for list of excluded studies with reason of exclusion).

After full-text investigation, two reviewers (M.O. and R.A.) used the “Joanna Briggs Institute (JBI) Critical Appraisal Checklist for Analytical Cross-Sectional Studies” (for correlational studies) and the “JBI Critical Appraisal Checklist for Studies Reporting Prevalence Data” (for frequency studies) to assess the studies for inclusion in the analyses (Moola et al., 2015). The JBI checklists are preferred tools to investigate the methodological quality and risk of bias in studies (Ma et al., 2020) which include several criteria, which were assessed for each study and rated as yes, no, unclear, or not applicable (Figure S1 and S2). The JBI checklists were used for all studies, including those with a longitudinal design when baseline or cross-sectional data were reported. In cases where the ratings of the two reviewers differed, the results of their reviews were discussed with the study team (N.J., F.E., R.A. and S.R.) to obtain a final decision regarding the inclusion of that particular study in the analysis. Furthermore, each study was assigned a score based on its quality assessment profile to be included in the univariate meta-regressions analysis.

**2.4. Data items and characterization of studies:**

The following data were retrieved from each study: name of first-author, year, country, study design, time period for longitudinal studies in weeks, demographic data, age, gender, total sample size, number of subjects with insomnia, number of subjects with PTSD/PTSS, cause of trauma, presence of trauma (current/history), reported statistics, PTSS assessment along with cut-off scores, insomnia assessment along with cut-off scores, and diagnostic approaches for PTSD and insomnia disorder.

If a publication did not report frequency data, the number of individuals with PTSD/PTSS and insomnia symptoms was divided by the total number of participants with PTSD/PTSS to calculate the frequency of insomnia in the sample. A similar strategy was applied to the papers that reported frequency data, but not the number of participants with PTSD/PTSS and/or insomnia. Specifically, frequency data were used to calculate the total number of PTSD/PTSS participants as well as the number of PTSD/PTSS participants with insomnia.

**2.6. Synthesis meta-analysis:**

For the quantitative synthesis, we collected data from 75 studies that met our criteria. The data collected from these studies included PTSD/PTSS and insomnia measures (frequencies and correlations), as well as relevant covariates that may serve as potential moderators. For the frequency analysis, we used the frequency data reported in the retrieved studies (i.e., prevalence of individuals with insomnia symptoms among the PTSD/PTSS population). For the correlation analysis, we used primary order correlation coefficients (i.e., Pearson correlation) between two continuous variables (i.e., PTSD/PTSS and insomnia symptoms) to maintain methodological and statistical homogeneity, rather than using a variety of correlation metrics, where a dichotomized variable was included. Moreover, correlations that were the result of network analysis, path analysis, structural equation modelling, multiple regressions, and logistic regression were omitted to keep our statistical approach homogeneous.

The comprehensive meta-analysis (CMA) software (Borenstein et al., 2005) was used for all analyses. This software was used to generate our aggregate measures of effect size (ES: frequency and correlation) and to determine the 95% confidence interval (95% CI). Alpha was set at P < 0.05 *a priori* and statistical heterogeneity was assessed via Q-statistics, I-squared and tau-squared values (Higgins et al., 2019). We examined the data for publication bias via statistical and graphical approaches (i.e., Begg and Mazumdar rank correlation, Egger’s regression tests, and funnel plot) (Begg and Mazumdar, 1994; Egger et al., 1997). Additionally, we used the Duval and Tweedie’s trim and fill approach (Duval and Tweedie, 2000) to locate outliers on either side of the aggregate means for both correlation and frequency analyses. Further, we used the classical fail-safe N (Rosenthal, 1979) to examine the robustness of our outcomes.

The distribution of data was examined using forest plots. Analyses of categorical and continuous data were completed as needed for the moderating variables included in our models. Univariate meta-regressions using method of moments were used for continuous data (e.g., mean age, percent female, year of publication, and quality assessment). When a study provided multiple correlation coefficients or frequencies, an aggregate for each metric was generated, allowing a particular study to contribute once to the overall effect-size estimate to minimize effect-size inflation.

**3. Results:**

**3.1. Study selection:**

We retrieved 6,739 results from several databases including PubMed (n = 1404), Embase (n = 854), Scopus (n = 1714), Web of Science (n = 1264), PubPsych (n = 466), and PsycINFO (n = 1037). After removing duplications, 3,714 abstracts were screened and out of them, a total of 599 articles were selected for a full-text review of eligibility criteria. Ultimately, seventy-five articles met our selection criteria and were included in final analyses. A diagram of the selection process and search strategy is illustrated in the PRISMA flow chart (Figure 1).

**------ Please Insert Figure 1 the Flow Diagram, about here------**

**3.2. Study characteristics:**

The studies included in the present analyses were completed in several countries including the USA (n = 44), Europe (n = 12), Asia (n = 11), Caucasus region (n = 1), Australia (n = 3), Canada (n = 3) and Africa (n = 1). Most studies (n = 66) had cross-sectional designs, while nine studies were longitudinal. The smallest (n = 20) and largest (n = 5,531,379) sample sizes included in our analyses came from studies completed in the USA.

**------ Please Insert Table 1 descriptive of included studies about here------**

**3.3. Results of syntheses:**

We performed two sets of analyses to estimate effect sizes based on the correlation and frequency data.

**3.3.1. Correlation results:** The aggregate correlation between PTSD/PTSS and insomnia symptoms showed a medium effect size, which was statistically significant, yet showed substantial heterogeneity [K = 44; r = 0.52; CI: 0.47-0.57; P-value = 0.0000; I2 = 98.07%; τ2 = 0.04]. The magnitude of the correlation, heterogeneity of the data, and p-values were consistent across moderating variables (e.g., military and COVID causes of trauma), where sufficient data was reported (See Table 2, bold rows).

Nearly half of the studies (23/44) that reported correlations between PTSD/PTSS and insomnia originated from the USA [K = 23; r = 0.51; CI: 0.42-0.60]. The remaining studies originated from other countries including Australia (k = 2), Canada (K = 3), China (K = 4), Germany (K = 2), Iran (K = 1), Israel (K = 1), Italy (K = 1), Spain (K = 2), South Korea (K = 1), Taiwan (K = 1), Netherlands (K = 1), and United Kingdom (K = 1). Thirty-eight of these 44 studies were cross-sectional [K = 38; r = 0.50; CI: 0.45-0.55] and six of the 44 studies used longitudinal designs (Table 2).

**------ Insert Table 2 outcome of the correlation analyses about here------**

More than half of the studies (32/44) reported current PTSD/PTSS [K = 32; r = 0.54; CI: 0.48-0.59] followed by 4/44 studies that reported the existence of PTSD/PTSS in the past. Eight out of 44 studies did not report the current or past status of PTSD/PTSS. The majority of the reported causes of trauma were related to military events (n = 10) and the COVID-19 pandemic (n = 9). Twenty-one studies used one of the versions of the PTSD Checklist (PCL) to assess PTSD/PTSS [K = 21; r = 0.60; CI: 0.53-0.66]. Other studies used PTSD/PTSS assessments that included the Clinician-Administered PTSD Scale (CAPS) (K = 2), Distress Tolerance Scale (DTS) (K = 1), Global Psychotrauma Screen (GPS) (K = 1), and versions of the Impact of Event Scale (IES) (K = 6), Posttraumatic Diagnostic Scale (PDS) (K = 2), Primary Care PTSD Screen (PC-PTSD) (K = 1), Primary Care PTSD Screen for DSM-5 (PC-PTSD-5) (K = 1), PTSD Symptom Scale (PSS) (K = 3), and Traumatic Experiences Checklist (TEC) (K = 1). Five studies did not report a specific scale for the assessment of PTSD/PTSS.

Most of the studies (40/44) did not report PTSD diagnostic criteria [K = 40; r = 0.54; CI: 0.49-0.59] and no specific diagnostic tool was consistently reported across studies. For insomnia assessment, most studies (29/44) used the Insomnia Severity Index (ISI), which is a self-administered structured questionnaire [K = 29; r = 0.52; CI: 0.46-0.58]. Two studies used a single-item measure with a dichotomous answer to assess insomnia. The other scales such as (Athens Insomnia Scale (AIS), General Sleep Disturbance Scale (GSDS), Insomnia Sleep Index (ISI\*), Iowa Sleep Experience Survey (ISES), Pittsburgh Insomnia Rating Scale (PIRS), Sleep Disturbance Screening (SDS), sleep disorder questionnaire based on Diagnostic and Statistical Manual of Mental Disorders, Fourth Edition (DSM-IV), subscale of military version of PCL (PCL-M) for insomnia and subscale of Thinking A Lot questionnaire (TAL) for insomnia, Youth Self-Rating Insomnia Scale (YSIS)) were used once across studies. Also, one of the studies did not report the scale used to assess insomnia. No diagnostic tool was explicitly used for the purpose of diagnosis.

**3.3.2. Frequency results:** 33 studies contained data related to the frequency of insomnia symptoms in individuals suffering from PTSD/PTSS, which resulted in an aggregated event rate (the proportion of individuals with PTSD/PTSS in whom the event of insomnia symptoms is observed) of 63% with substantial heterogeneity under random-effect model [K = 33; CI: 45%-78%; P-value = 0.1532; I2 = 99.88%; τ2 = 4.42]. All event rates were highly heterogeneous, with an I-square greater than 75%, when three or more studies were included in the analysis. Categorical analysis of countries showed consistent results for the USA, given the number of included published studies in this analysis [K = 21; event rate = 59%; CI: 35%-79%; P-value = 0.4840]. However, other countries did not show any consistent result. The studies included in the analysis were restricted to full-text papers [K = 31; event rate = 64%; CI: 46%-79%; P-value = 0.1327] and were cross-sectional in design [K = 30; event rate = 60%; CI: 41%-76%; P-value = 0.3017].

The event rate for studies with current PTSD/PTSS was 65% [K = 24; event rate = 65%; CI: 48%-79%; P-value = 0.0860] and 13/33 studies reported a military trauma, as the cause for PTSD/PTSS development [event rate = 53%; CI: 24%-79%; P-value = 0.8723], followed by 5/33 studies that reported multiple causes of PTSD/PTSS [event rate = 81%; CI: 53%-94%; P-value = 0.0342]. Furthermore, in other studies, work-related events (K = 2), car accidents (K = 1), COVID-19 pandemic (K = 3), illness (K = 1), displacement (K = 1), intimate partner violence (K = 1), natural disaster (K = 1), refugee (K = 1), and sexual or physical assault (K = 1) were reported as the causes of PTSD/PTSS, while three studies did not report any cause of trauma.

PCL [K = 11; event rate = 70%; CI: 57%-80%; P-value = 0.0041] and ISI [K = 8; event rate = 82%; CI: 69%-91%; P-value = 0.0001] were the most frequently used scales for the assessment of PTSD/PTSS and insomnia, respectively. Due to lack of information, no other diagnostic tool and scale for both insomnia and PTSD/PTSS were reported consistently across studies for frequency analysis.

**----Insert Table 3 outcome of the frequency analyses about here----**

**3.4. Reporting biases and sensitivity analysis:**

Publication bias analyses were conducted using the studies that reported frequency and correlation data. Using the correlational data, no sign of publication bias was detected based on the funnel plot (Figure 2), as there was no difference between the adjusted imputed and observed effect-size estimate (both empty and filled diamonds were at the same location). Similarly, the Begg and Mazumdar rank correlation without continuity analysis was non-significant (P-value = 0.59192). However, the Egger’s regression intercept analysis revealed a significant result (P-value = 0.03409) and Duval and Tweedie’s trim and fill, under fixed-effect model, suggests the possibility of 11 outliers to the left of the aggregate mean (observed value: 0.44903; adjusted value: 0.42342). However, this difference was too small to significantly influence the effect size. Nonetheless, examination of the artifact of bias via classical fail-safe N showed that given the observed Z-value of 94.08510, alpha 0.05 (2-tails), and number of observed studies, we would need an estimated 2303.3 missing studies for every observed correlational study for the effect to be nullified.

Using the frequency data, the funnel plot (Figure 3) shows the marked signs of significant variations across studies and possible outliers (the empty and filled circles were spaced distally from each other), and several adjusted filled circles are marked on the plot. Publication bias per the Begg and Mazumdar rank correlation without continuity and Egger’s regression intercept analyses were both significant, P-value = 0.01852 and P-value = 0.00163, respectively. Also, Duval and Tweedie’s trim and fill, under fixed-effect model, highlights 17 outliers on the left side of the aggregate mean (observed value: 0.09957; adjusted value: 0.08513). Given the high heterogeneity in frequency studies, it is important to consider the differences between fixed and random-effect models (Table 3). While random-effect model can be interpreted as the average effect, fixed-effect model addresses the best estimate of the effect (Higgins et al., 2019). In this heterogeneous setting, the observed differences between these two models are due to more relative weight to smaller studies in the random-effect model than the fixed-effect. Thus, the frequency reported maybe overestimating and need to be interpreted with caution. Based on examination of the artifact of bias via classical fail-safe N with current observed Z-value of -76.38132, alpha 0.05 (2-tails), and number of observed studies, we would need an estimated 1548.8 missing frequency studies for every observed study for the effect to be nullified.

As the I-squared is affected by the number of subjects but not the number of studies (Rücker et al., 2008), the heterogeneity could be due to clinical/symptom variability. Thus, the "one-study-removed" method was conducted as a sensitivity analysis to examine the effect of individual studies on the effect size estimate. Hermes and Rosenheck, 2014 was the only study emerging as significant in this analysis, with the largest sample size. However, with eliminating this study, as a potential contributing factor toward heterogeneity, no significant change occurred in the magnitude of I-squared.

**----Insert Figure 2 and 3 outcome of the correlation and frequency analyses about here----**

Univariate meta-regressions, using method of moment on continuous variables, were non-significant at alpha 0.05 for the year of publications (Slope = -0.0023, SE = 0.0084, df = 43), precent female (Slope = -0.0008, SE = 0.0010, df = 41), mean age (Slope = 0.0011, SE = 0.0060, df = 34), and quality assessment (Slope = -0.0019, SE = 0.0193, df = 43) for correlations; and year of publications (Slope = -0.0464, SE = 0.0525, df = 32), percent female (Slope = 0.0086, SE = 0.0117, df = 31), mean age (Slope = -0.2011, SE = 0.2838, df = 32), and quality assessment (Slope = -0.0152, SE = 0.0337, df = 24) for frequencies, respectively.

1. **Discussion:**

**4.1. Summary of main evidence:**

The objectives of this large-scale quantitative meta-analysis were to identify consistent findings regarding the associations between insomnia and PTSD/PTSS and prevalence of insomnia in patients with PTSD/PTSS. We included 75 studies with various designs and heterogeneous populations in the pooled analysis. Our finding suggests that there is a medium-size correlation of 0.52 between PTSD/PTSS and insomnia symptoms using 57,618 individuals. This relationship was moderated by the COVID-19 pandemic and military service as potential causes of trauma. We also observed that 63% of individuals with PTSD/PTSS experienced insomnia based on data from 573,665 participants. Publication bias analyses for the correlation data suggest there was no publication bias. Further, there was no difference between the observed and adjusted effect-size estimate. However, the frequency data showed significant variation across studies. Based on the available data, it is difficult to explain the sources of the observed heterogeneity across variables.

The relationship between insomnia and PTSD/PTSS has been well-documented before. For example, prior research has demonstrated that insomnia is a common manifestation of PTSD/PTSS that develops following a trauma. Further, insomnia symptoms prior to trauma exposure are a risk factor for the future development of PTSD (Short et al., 2020; Wang et al., 2019a; Bryant, 2003). Similarly, Gehrman and colleagues showed, in a group of 15,204 military participants, that pre-deployment insomnia was significantly correlated with new-onset PTSD, depression, and anxiety after deployment (Gehrman et al., 2013). Moreover, Wang and colleagues found that pre-deployment insomnia predicts post-deployment PTSD and suicidal ideation (Wang et al., 2019c). Taken together, the findings from the present meta-analysis support prior work that suggests there is a strong relationship between insomnia and PTSD (Germain, 2013; Richards et al., 2020).

There is considerable variability (range 3-100%) in the reported prevalence of insomnia in PTSD/PTSS in prior epidemiologic studies (Maker et al., 2006; Mellman et al., 1995; Neylan et al., 1998). In the present meta-analysis, we found the aggregated prevalence of insomnia in PTSD/PTSS was 63% with moderating effects of insomnia and PTSD/PTSS assessment scales, and multiple causes of trauma. The relatively high frequency of insomnia symptoms among PTSD/PTSS individuals should alert clinicians to the importance of screening these symptoms and the value of effective, early treatment of sleep disturbances (e.g., insomnia) in trauma-affected populations, particularly during and after the COVID-19 pandemic.

**4.2. The shared mechanism between insomnia and PTSD/PTSS:** The development and maintenance of trauma-induced insomnia are often attributed to a fear of sleeping and nightmares after a traumatic event (Inman et al., 1990; Werner et al., 2021). Werner and colleagues proposed that an increase in negative beliefs about safety, loss of control, and re-experiencing (e.g., nightmares) aspects of PTSD, induce fear of sleeping and lead to difficulty with sleep initiation. Additionally, avoidance, anxiety, and hyperarousal maintain insomnia symptoms in patients with PTSD (Werner et al., 2021). Several mechanisms for the underlying comorbidity between insomnia and PTSD have been suggested, including shared genetic factors, maladaptive function of the endocrine system, hyperarousal, emotion dysregulation, and aberrant neural circuits, which will be briefly described in the following sections.

**4.2.1.** **The role of genetic factors**: Results from a genome-wide association study (Ripke et al., 2013) of PTSD and sleep phenotypes using UK Biobank data have shown that both insomnia symptoms and sleep duration have a shared genetic etiology with PTSD (Lind et al., 2019). Cox and colleagues (2019) assessed the genetic contributions to the relation between insomnia and PTSS in 242 community-based twin pairs (157 Monozygotic, 85 dizygotic) with lifetime trauma exposure. They found significant associations between insomnia symptoms and intrusions/avoidance, in addition to genetic factors accounting for 36–44% of phenotypic variance (Cox et al., 2019). In addition, circadian rhythm disturbances are observed in both PTSD and insomnia and have been linked to clock genes - a component of circadian rhythm oscillating gene expression (Hastings, 1998). Mutations in circadian clock genes may modulate biological responses to stressful environmental events and serve as risk factors for various neuropsychiatric disorders, including PTSD (Landgraf et al., 2014). Such evidence indicates a potential reason why certain individuals exposed to trauma develop insomnia and PTSD/PTSS.

**4.2.2. The role of endocrine system**: Animal studies have shown that stress and fear conditioning lead to sleep disruption, insomnia symptoms, and REM fragmentation (Cano et al., 2008; Pace-Schott et al., 2015). Such sleep disturbances reactivate central stress systems including the sympathetic response and hypothalamic-pituitary-adrenal (HPA) axis. These neuroendocrine responses raise the arousal level, which increases sleep disturbance and stress reactivity (Pace-Schott et al., 2015). Further, conditioned fear appears to induce greater HPA axis activity, leading to an increase in hypothalamic corticotropin-releasing factor, cortisol, and sympathetic activity. This cascade of events decreases sleep quality and REM continuity, which leads to impaired fear extinction and extinction recall (i.e., the ability to learn and recall that stimuli that once signaled danger, do not signal danger anymore). Thus, insomnia disrupts sleep-dependent emotional processes and leads to a failure of extinction memory, which appears to maintain and perpetuate PTSD symptoms (Pace-Schott et al., 2015). Increased cortisol levels in PTSD patients are negatively associated with delta sleep, which is a marker for sleep homeostasis and the restorative function of sleep (Otte et al., 2005). Moreover, an increased adrenocorticotropic hormone (ACTH) response, which is common in PTSD, has been linked with a decrease in delta power sleep response (Inslicht et al., 2018). Together, these findings suggest that stress-related changes in HPA axis function may underlie the link between insomnia and PTSD.

**4.2.3. The role of arousal, fear conditioning, and emotion dysregulation:** Abnormal noradrenergic activity appears to account, in part, for the enhanced arousal, fear conditioning, and emotional reactivity observed in PTSD (Sherin and Nemeroff, 2011). These behavioral effects may be mediated by dysfunction of brain stem and subcortical structures (e.g., amygdala, locus coeruleus) in PTSD (Sherin and Nemeroff, 2011). High levels of noradrenergic activity appears to increase fear conditioning, arousal, startle responses, and sympathetic reactivity (e.g., higher heart rate, blood pressure, and respiration) to stress (Sherin and Nemeroff, 2011). Animal models of fear conditioning have found increased REM sleep latency, decreased REM sleep duration, and increased pontogeniculo-occipital waves, which is generally analogous to REM stage sleep in humans (Germain, 2013b; Germain et al., 2008; Jha et al., 2005). The effects of fear conditioning on sleep are mediated by amygdala projections to regions of the brainstem that support alerting processes and REM sleep generation, which enhances neuronal activity of the reticular activating system and other brain stem regions during sleep (Germain et al., 2008). On the other hand, the hyperarousal model of insomnia suggests that psychosocial stressors disrupt the normal relationship between arousal and sleep-inducing brain activity, which is a key feature of the pathophysiology of insomnia (Riemann et al., 2010). In fact, patients with insomnia often show abnormalities in brain areas associated with arousal. These abnormalities appear to destabilize the flip-flop switch that mediates sleep–wake regulation (Baglioni et al., 2010; Morin et al., 2015; Palmer and Alfano, 2017). Thus, greater sleep disturbance has been linked to greater arousal and enhanced fear conditioning in PTSD.

Insufficient emotion regulation and exaggerated emotional reactivity are important consequences associated with the vulnerabilities of sleep loss. Further, insomnia is an important predictor of PTSS (Short et al., 2014). PTSD patients with insomnia generally experience excessive worry, heightened arousal and anxiety levels, and dysfunctional coping and regulating strategies (Germain et al., 2008; Pace-Schott et al., 2015). Cognitive behavioral therapy (CBT) focused on cognitive emotion regulation strategies is an effective treatment for insomnia. Because emotion dysregulation is a key clinical feature of PTSD, targeting poor regulation strategies is crucial for PTSD treatment (Boden et al., 2013).

**4.2.4. The role of aberrant neural circuitry**: Prior quantitative neuroimaging meta-analyses suggest the anterior cingulate cortex (ACC), hippocampus, insula, and medial prefrontal cortex play an important role in PTSD (Kühn and Gallinat, 2013; Ramage et al., 2013; Wang et al., 2016). Further, neuroimaging studies have demonstrated structural and functional abnormalities within the amygdala, hippocampus, prefrontal cortex, and dorsal ACC, which appear to contribute to the sleep disturbances observed in PTSD (Germain et al., 2008; Pace-Schott et al., 2015; Shin et al., 2006). The amygdala is a key component of the neural circuit that processes fearful stimuli (Davis, 1992; Sabatinelli et al., 2005) and thus, plays an important role in the pathophysiology of PTSD (Shin et al., 2006). Moreover, the amygdala and hippocampus form an emotional memory circuit, which is impaired in PTSD and depression (Brohawn et al., 2010; Tahmasian et al., 2013). In particular, hyperactivation of the amygdala has been observed during the encoding of emotionally negative stimuli (Brohawn et al., 2010). Further, the intensity of amygdala activation was positively correlated with hippocampal activity and was linked with the severity of PTSD symptom expression (Brohawn et al., 2010). Other research has suggested that the enhanced activation of the amygdala and ACC, along with the deactivation of the hippocampus and ventromedial prefrontal cortex (vmPFC), during fear conditioning suggests PTSD is associated with hyperactivity of brain regions that support fear-related processes and hypoactivity within brain regions that support extinction-related functions (Pace-Schott et al., 2015).

The brain regions mentioned above, especially the ACC, insula, and amygdala, are hubs of the so-called salience network (Seeley, 2019). Recent evidence has revealed hypoconnectivity within the salience network in PTSD (Zhang, 2022). Although a prior activation likelihood neuroimaging meta-analysis suggests insomnia is associated with distributed brain abnormalities [Tahmasian, 2018), our previous systematic reviews suggest the salience network and related hubs (i.e., amygdala and ACC) play a crucial role in the pathophysiology of insomnia disorders (Khazaie, 2017). Beyond the salience network, there are also functional alterations within the default mode network that have also been observed in previous neuroimaging meta-analyses (Patel, 2012; Koch, 2016; Pankey, 2022), consistent with maladaptive internal thoughts, ruminations, and autobiographical memories. Interestingly, dysfunction of the salience and default mode networks is also considered a shared abnormality between insomnia and depression, which is the most common comorbidity in both insomnia and PTSD (Bagherzadeh-Azbari, 2019). Future neuroimaging studies may benefit from the use open-data sharing with a large-scale sample (e.g., UK-Biobank or through multi-center collaborations like the ENIGMA-Sleep working group) to improve the generalizability and reproducibility of individual neuroimaging studies (Tahmasian, 2021).

**4.3. Clinical relevance and therapeutic perspective**

Given the strong association between the two conditions, a behavioral and pharmacological intervention that improves insomnia symptoms in patients with PTSD has a crucial impact on patient's quality of life and disease-related costs (Brownlow et al., 2015; Nappi et al., 2012). Prior research has demonstrated a notable decrease in PTSD symptoms when insomnia was treated effectively (Galovski et al., 2016; Pruiksma et al., 2018). Thus, sleep disturbances (e.g., insomnia) require direct intervention in this context (Colvonen et al., 2018b). The initial objective of interventions (psychotherapy and pharmacotherapy) for sleep disturbance in PTSD patients is to effectively reduce nocturnal symptoms, which in turn improves the day-time wellbeing of patients (Weber and Wetter, 2021). Cognitive-behavioral therapy for insomnia (CBT-I) is the most frequently recommended approach for treating insomnia in PTSD (Benz et al., 2020; Colvonen et al., 2018b). In general, CBT decreases the intensity of chronic nightmares and negative emotions, improves mood, and reduces daytime impairments (Brownlow et al., 2015; Tomas, 2014). Alternatively, pharmacologic treatments should be considered as a second line for the treatment of sleep disturbances in PTSD. In particular, an alpha-adrenergic receptor antagonist (e.g., Prazosin) appears to be the most effective medication for such conditions (Khachatryan et al., 2016b). Overall, focusing on sleep treatment in patients with PTSD, as well as conducting more randomized controlled trials in this field is necessary to improve the management of symptoms and optimize the global health outcomes of PTSD patients (Brownlow et al., 2015; Nappi et al., 2012; Tomas, 2014).

**4.4. Strengths and limitations:**

To our knowledge, this is the first meta-analysis to investigate the frequency of insomnia in PTSD/PTSS, as well as the association between insomnia symptoms and PTSD/PTSS using a very large sample. Comprehensive records from six databases were reviewed using a systematic search strategy, which included studies from several countries. Additionally, the large sample size of our pooled estimates brings significant power to our reported frequency and correlation data. Moreover, we performed a careful meta-analysis following strict recommendations (Johnson and Hennessy, 2019) to assess the relationship between insomnia and PTSD/PTSS. However, our study has several potential limitations.

First, non-English language studies were excluded from this meta-analysis, which is a potential limitation of the present study. Hence, we suggest that future systematic reviews or meta-analyses consider including non-English language studies in their analyses. Secondly, although the lack of a nested analysis in this study can be seen as a limitation, our approach allowed us to obtain a larger sample size and increased the generalizability of the present findings. Thirdly, the majority of studies included in this meta-analysis were cross-sectional in design, and as a result, we were not able to determine a causal relationship between insomnia symptoms and PTSD/PTSS. Additionally, given that only a small number of studies had a case-control design, we were unable to calculate measures of association (relative risks, odds ratios, etc.) between insomnia symptoms and PTSD/PTSS.

Another limitation of the present study is that we did not examine the effect of medications that may have influenced the prevalence of insomnia in PTSD/PTSS. It is very likely that participants with PTSD/PTSS within the studies included in the present analyses were under polypharmacy or self-medication. Thus, the effect of medication may have induced insomnia-related symptoms. In turn, this medication-induced insomnia may have affected prevalence rates, as well as the magnitude of the correlation between insomnia and PTSD/PTSS in the present study. However, finding drug-naïve PTSD patients is rather difficult.

Finally, there were high levels of heterogeneity among the studies included in the present analyses, which should be considered as a limitation of our study. High heterogeneity is common in epidemiological studies, which can stem from a variety of sources (e.g., study design, risk of bias, and various clinical characteristics of the included samples) (Higgins, 2008; Higgins et al., 2003). Specifically in our study, there was inconsistency across studies regarding whether insomnia was defined based on self-report assessment or clinical diagnosis. Similarly, the assessment of PTSD/PTSS was not uniform across studies, and in some cases the authors did not provide sufficient detail regarding the assessment tools and diagnostic criteria to evaluate insomnia and PTSD/PTSS. In addition, many studies did not report the cause of trauma or the PTSD/PTSS status of participants. However, it is worth mentioning that the results of our multiple single-variable meta-regressions were non-significant across all variables and based on the fail-safe N analysis, it would take more than 1000 missing studies to overturn the observed outcome. Thus, future studies with different categorical and continuous variables [e.g., patient population (hospital vs general population), focus of studies (whether they have been looking specifically for sleep issues or they had other aims as primary motive) and variables for controlling for the effect of confounding variables in each study] are needed to examine the large heterogeneity and determine whether it should be considered a significant moderating factor.

1. **Conclusions:**

The findings of this quantitative meta-analysis, based on a large population, indicate there is a moderate link between insomnia and PTSD/PTSS (effect size 0.52), and demonstrate that insomnia is frequently found in those with PTSD/PTSS (63%). The present study sheds new light on the putative strength of the relationship between insomnia and PTSD as well as the frequency of insomnia in PTSD. These findings suggests that insomnia is a core feature of PTSD, which can be substantiated/validated by factor analysis of a large dataset. This study advances the field’s understanding of the link between insomnia and PTSD/PTSS and provides additional incentive for clinicians and health-related policy makers to consider the importance of screening and treating insomnia in patients with PTSD/PTSS. This work will hopefully stimulate more clinical trials focused on insomnia treatment to reduce the rate and burden of PTSD/PTSS. Future studies are needed to assess the potential mediators and moderators of the link between insomnia and PTSD/PTSS. In addition, studies are needed to identify the shared neurobiological mechanisms of insomnia and PTSD. Finally, additional work is needed to develop better pharmacological and non-pharmacological treatments for insomnia in PTSD patients.

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**Tables:**

**Table 1.** Descriptive information for the 75 included studies

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **No.** | **Author** | **Publication type** | **Country** | **Study design** | **Time period** | **Type of trauma** | **Presence of trauma** | **Reported statistics** | | **Gender**  **(% female)** | **Mean age** | **Age range** | **n Total** | **n Insomnia** | **n PTSD** | **PTSD scale** | **PTSD cut-off** | **PTSD diagnosis** | **Insomnia assessment** | **Insomnia cut-off** | **Insomnia diagnosis** |
| **Frequency** | **Correlation** |
| **1** | (Adriaenssens et al., 2012) | full paper | Netherlands | cross sectional | NR | work related | current | NR | 0.2 | 55.60 | 37.76 | NR | 248 | 17 | 21 | IES | 20 | NR | self-administered questionnaire | 4 | NR |
| **2** | (Angehrn et al., 2020) | full paper | Canada | cross sectional | NR | work related | current | NR | 0.58 | 32.50 | NR | >18 | 5146 | 2882 | NR | PCL-5 | 32 | NR | ISI | 10 | NR |
| **3** | (Babson et al., 2018) | full paper | USA | cross sectional | NR | military | NR | 75.83 | NR | 100.00 | 50.13 | NR | 6261 | 2967 | 1072 | NR | NR | ICD-9 | ISI | NR | NR |
| **4** | (Belleville et al., 2019) | full paper | Canada | cross sectional | NR | displacement | history | NR | 0.673 | 77.00 | 40.10 | NR | 379 | 274 | 237 | PCL-5 | 33 | NR | ISI | NR | NR |
| **5** | (Blanc et al., 2019) | abstract | USA | cross sectional | NR | natural disaster | current | NR | 0.76 | 47.90 | 30.70 | NR | 165 | 155 | 70 | NR | NR | NR | NR | NR | NR |
| **6** | (Blekas et al., 2020) | full paper | Greece | cross sectional | NR | COVID-19 | current | 73.30 | NR | 77.10 | 37.61 | >18 | 270 | 96 | 45 | PTSD-8 | 3 for each subscale | NR | AIS | 10 | NR |
| **7** | (Brownlow et al., 2017) | full paper | USA | cross sectional | NR | military | current and history | 69.70 | NR | 13.50 | 29.50 | 18-61 | 21449 | NR | 8558 | PCL-5 | NR | NR | BIQ | NR | NR |
| **8** | (Burns et al., 2019) | abstract | USA | cross sectional | NR | NR | NR | NR | 0.2 | 59.30 | 31.10 | NR | 58 | NR | 58 | CAPS-5 | NR | NR | ISI | NR | NR |
| **9** | (Coloma-Carmona and Carballo, 2021) **a** | full paper | Spain | cross sectional | NR | COVID-19 | current | NR | 0.47 | 71.2 | 36.98 | >17 | 468 | 275 | 159 | PC-PTSD-5 | 4 | NR | single-item measure | NR | NR |
|  | (Coloma-Carmona and Carballo, 2021) **b** | full paper | Spain | cross sectional | NR | COVID-19 | current | 73.00 | NR | 71.20 | 36.98 | >17 | 468 | 275 | 159 | PC-PTSD-5 | 3 | NR | single-item measure | NR | NR |
| **10** | (Colvonen et al., 2020) | full paper | USA | cross sectional | NR | military | current | 93.30 | NR | 17.20 | 34.80 | NR | 5552 | 3176 | 1262 | PCL-C | 44 | NR | ISI | 11 | NR |
| **11** | (Diaz et al., 2022) | full paper | USA | cross sectional | NR | COVID-19 | current | 84.71 | NR | 80.60 | NR | >18 | 813 | 592 | 471 | PC-PTSD-5 | 3 | NR | ISI | NR | NR |
| **12** | (Dimitrova et al., 2020) | full paper | UK | cross sectional | NR | NR | current | NR | 0.561 | NR | 42.77 | 18-65 | 49 | NR | 16 | TEC | NR | NR | ISES | NR | NR |
| **13** | (Don Richardson et al., 2018) | full paper | Canada | cross sectional | NR | military | history | NR | 0.546 | 9.00 | 44.60 | NR | 663 | 400 | 402 | PCL-M | 50 | NR | subscale of PCL-M | NR | NR |
| **14** | (Fekadu et al., 2019) | full paper | Ethiopia | longitudinal | 4 | car accident | current | 74.82 | NR | 35.80 | NR | NR | 299 | 157 | 139 | PCL-C | NR | NR | PROMIS-SD | NR | NR |
| **15** | (Gaffey et al., 2020) | full paper | USA | cross sectional | NR | military | current | 46.95 | NR | 51.80 | 43.80 | NR | 1109 | 373 | 360 | PCL-C | 45 | NR | ISI | 15 | NR |
| **16** | (Geng et al., 2021b) | full paper | China | cross sectional | NR | NR | NR | 59.43 | NR | 0.00 | 35.44 | 18-69 | 1491 | 391 | 106 | PCL-5 | NR | DSM-5 | self-administered questionnaire | NR | NR |
| **17** | (Geng et al., 2021a) | full paper | China | cross sectional | NR | multiple causes | history | 33.11 | NR | 66.90 | 38.12 | 18-82 | 7218 | 478 | 151 | PCL-5 | NR | NR | YSIS | 26 | NR |
| **18** | (Geng et al., 2021c) | full paper | China | cross sectional | NR | NR | history | NR | 0.32 | 67.3 | 38.09 | 18-81 | 7245 | 640 | NR | PCL-5 | NR | NR | YSIS | 26 | NR |
| **19** | (Green, 2003) | full paper | USA | cross sectional | NR | multiple causes | current | 95.00 | NR | 36.89 | 41.89 | NR | 103 | 98 | 103 | NR | NR | DSM-4 | NR | NR | DSM-4 |
| **20** | (Grossman et al., 2019) | full paper | Israel | cross sectional | NR | terrorism | current | NR | 0.21 | 100.00 | 24.41 | NR | 108 | NR | NR | NR | NR | ICD-11 | ISI | 10 | NR |
| **21** | (Gupta and Vujcic, 2020) | abstract | USA | cross sectional | NR | military | current | 3.82 | NR | 66.40 | 40.39 | NR | 3995 | 153 | 3995 | NR | NR | NR | NR | NR | NR |
| **22** | (Hall Brown et al., 2015) | full paper | USA | cross sectional | NR | multiple causes | history | 70.32 | NR | 57.10 | 22.00 | 18-35 | 465 | 260 | 155 | PCL-5 | 44 | NR | ISI | 11 | NR |
| **23** | (Han et al., 2018) | full paper | South Korea | cross sectional | NR | sexual assault | current | NR | 0.62 | 100.00 | 26.56 | NR | 43 | 23 | NR | PSS-SR | NR | NR | ISI | 15 | NR |
| **24** | (Hansen et al., 2018) | full paper | USA | cross sectional | NR | military | current | NR | 0.41 | 30.60 | 22.80 | 17-54 | 438 | 71 | 79 | PC-PTSD | 3 | NR | ISI | 15 | NR |
| **25** | (Heilemann et al., 2012) | full paper | USA | cross sectional | NR | NR | NR | NR | 0.38 | 100.00 | 28.00 | 21-40 | 312 | 112 | NR | IES-R | NR | NR | GSDS | 3 | NR |
| **26** | (Hermes and Rosenheck, 2014) | full paper | USA | cross sectional | NR | military | current | 8.38 | NR | 8.90 | 61.20 | NR | 5531379 | 190378 | 551441 | NR | NR | ICD-9 | NR | NR | ICD-9 |
| **27** | (Hinkson et al., 2021) | full paper | USA | cross sectional | NR | NR | NR | NR | 0.46 | 20.3 | 30.43 | 20-61 | 348 | 124 | 179 | PCL-5 | 33 | NR | ISI | 15 | NR |
| **28** | (Hinton et al., 2015) | full paper | USA | cross sectional | NR | refugee | current | NR | 0.84 | 60.50 | NR | NR | 200 | NR | 92 | PCL-5 | 34 | NR | subscale of TAL | NR | NR |
| **29** | (Hughes et al., 2013) | full paper | USA | cross sectional | NR | military | current | 100.00 | NR | 100.00 | 49.00 | NR | 107 | 107 | 55 | PCL-C | 33 | NR | ISI | NR | ICSD-R |
| **30** | (Kaczkurkin et al., 2021) | full paper | USA | longitudinal | 19 | NR | current | NR | 0.34 | 54.00 | 31.37 | NR | 326 | 278 | 44 | PDS-5 | NR | NR | ISI | NR | NR |
| **31** | (Kaup et al., 1994) | full paper | USA | cross sectional | NR | military | current | 80.00 | NR | 0.00 | 63.00 | 56-74 | 20 | 16 | 20 | NR | NR | DSM-3-R | NR | NR | DSM-3-R |
| **32** | (Killgore et al., 2021) | abstract | USA | longitudinal | 24 | COVID-19 | current | NR | 0.62 | 53.6 | NR | 18-84 | 6190 | NR | NR | PCL-5 | 38 | NR | ISI | 10 | NR |
| **33** | (Krakow et al., 2012) | full paper | USA | cross sectional | NR | NR | current | NR | 0.45 | NR | NR | >18 | 1078 | 259 | NR | PSS-SR | NR | NR | ISI | NR | NR |
| **34** | (Krakow et al., 2004) | full paper | USA | cross sectional | NR | natural disaster | current | NR | 0.53 | 64.10 | 51.50 | >18 | 78 | 77 | 75 | PDS-5 | 21 | NR | ISI | 10 | NR |
| **35** | (Lande, 2012) | full paper | USA | cross sectional | NR | military | current | NR | 0.388 | 46.00 | 31.00 | NR | 39 | NR | NR | PCL-M | NR | NR | PIRS | NR | NR |
| **36** | (Lee et al., 2016) | full paper | South Korea | cross sectional | NR | refugee | NR | 63.38 | NR | 72.88 | 38.22 | NR | 177 | 68 | 71 | IES-R | 25 | NR | NR | NR | ICD-10 |
| **37** | (Li et al., 2021) **a** | full paper | China | cross sectional | NR | COVID-19 | current | NR | 0.69 | 89.95 | 33.13 | >18 | 438 | 169 | 356 | IES-R | 26 | NR | self-administered questionnaire | NR | NR |
|  | (Li et al., 2021) **b** | full paper | China | cross sectional | NR | work related | current | NR | 0.69 | 93.14 | 33.64 | >18 | 452 | 143 | 166 | IES-R | 26 | NR | self-administered questionnaire | NR | NR |
| **38** | (Lies et al., 2018) | abstract | Australia | cross sectional | NR | refugee | NR | NR | 0.32 | 65.00 | 44.00 | NR | 55 | NR | NR | NR | NR | NR | ISI\* | NR | NR |
| **39** | (Lommen et al., 2016) | full paper | UK | longitudinal | 35 | multiple causes | current | 91.90 | NR | 60.00 | NR | 17-83 | 330 | NR | 246 | NR | NR | SCID | subscale of SCID | NR | NR |
| **40** | (Lu et al., 2021) | full paper | Taiwan | cross sectional | NR | COVID-19 | current | NR | 0.34 | 91.6 | 32.96 | NR | 500 | 223 | 77 | IES-6 | 1.75 | NR | ISI | 15 | NR |
| **41** | (Mahmoudi et al., 2021) | full paper | Iran | cross sectional | NR | COVID-19 | current | NR | 0.45 | 31.4 | 32.96 | NR | 844 | NR | NR | SF-PCL-5 | 28 | NR | ISI | NR | NR |
| **42** | (Maĭsuradze et al., 2010) | abstract | Georgia | cross sectional | NR | displacement | current | 100.00 | NR | NR | NR | NR | 45 | 23 | 19 | PDS-5 | NR | NR | NR | NR | NR |
| **43** | (Martindale et al., 2020) | full paper | USA | cross sectional | NR | military | current and history | 29.57 | NR | 12.63 | 41.63 | 23-71 | 293 | 66 | 115 | NR | NR | CAPS-5 | NR | NR | CPRS |
| **44** | (Martínez-Caballero et al., 2021) | full paper | Spain | cross sectional | NR | COVID-19 | current | NR | 0.72 | 46.4 | NR | >18 | 317 | NR | NR | DTS | 12 | NR | AIS-8 | NR | NR |
| **45** | (Mazzotta et al., 2021) | full paper | USA | cross sectional | NR | intimate partner violence | current | 63.46 | NR | 100.00 | 34.60 | 19-82 | 112 | 52 | 52 | PSS-SR | 46 | NR | ISI | 10 | NR |
| **46** | (McCallum et al., 2019) | full paper | Australia | cross sectional | NR | NR | current | 11.32 | NR | 81.00 | NR | >18 | 3620 | 3579 | 3620 | NR | NR | MINI | PROMIS-SD | NR | NR |
| **47** | (McLean et al., 2019) | full paper | USA | cross sectional | NR | military | current | NR | 0.369 | 12.02 | 32.73 | 18-56 | 366 | NR | NR | PSS-I | NR | NR | ISI | NR | NR |
| **48** | (Mei et al., 2021) | full paper | China | cross sectional | NR | COVID-19 | current | NR | 0.69 | 80.42 | 37.74 | 21-65 | 516 | NR | NR | PCL-C | 38 | NR | ISI | 15 | NR |
| **49** | (Milanak et al., 2019) | full paper | USA | cross sectional | NR | NR | current | 24.90 | NR | 52.00 | NR | >18 | 2647 | 513 | 277 | NR | NR | DSM-5 | NR | NR | DSM-5 |
| **50** | (Mysliwiec et al., 2013a) | full paper | USA | cross sectional | NR | military | current | 25.64 | NR | 2.70 | 33.60 | NR | 110 | 28 | 39 | PCL-M | 50 | NR | NR | NR | ICSD-2 |
| **51** | (Mysliwiec et al., 2013b) | full paper | USA | cross sectional | NR | military | current | 40.62 | NR | 6.80 | 35.50 | NR | 725 | 188 | 96 | NR | NR | EMR | NR | NR | ICSD-2 |
| **52** | (Nadorff et al., 2011) | full paper | USA | cross sectional | NR | NR | NR | NR | 0.53 | 77.35 | 19.40 | 18-29 | 583 | 76 | 70 | PCL-C | 50 | NR | ISI | 15 | NR |
| **53** | (O'Connor et al., 2017) | full paper | USA | cross sectional | NR | military | NR | NR | 0.3 | 1.90 | 48.00 | 23-71 | 134 | NR | NR | PCL-M | NR | NR | ISI | NR | NR |
| **54** | (Park et al., 2021) | full paper | USA | longitudinal | 52 | terrorism | history | NR | 0.73 | 40 | 35.80 | NR | 402 | NR | NR | PCL‐C | NR | NR | ISI | NR | NR |
| **55** | (Psarros et al., 2017) | full paper | Greece | cross sectional | NR | natural disaster | current | 79.10 | NR | 47.82 | 58.10 | NR | 92 | 58 | 43 | NR | NR | ICD-10 | AIS | 6 | NR |
| **56** | (Psarros et al., 2018) | full paper | Greece | cross sectional | NR | work related | current | 42.10 | NR | 0.00 | 40.00 | NR | 102 | 24 | 19 | NR | NR | ICD-10 | AIS | 6 | NR |
| **57** | (Quartana et al., 2015) | full paper | USA | cross sectional | NR | military | current | NR | 0.59 | 7.60 | NR | >18 | 587 | 91 | 65 | PCL-5 | 50 | NR | ISI | 15 | NR |
| **58** | (Rohr et al., 2021) | full paper | USA | cross sectional | NR | NR | current | NR | 0.12 | 47.4 | 35.24 | 18-89 | 2822 | NR | 327 | NR | NR | SCID-5-RV | SDS | NR | NR |
| **59** | (Rossi et al., 2021) | full paper | Italy | cross sectional | NR | COVID-19 | current | NR | 0.37 | 79.6 | NR | >18 | 18147 | NR | NR | GPS | NR | NR | ISI | 22 | NR |
| **60** | (Rugo et al., 2020) | full paper | USA | cross sectional | NR | military | current | NR | 0.535 | 13.14 | 27.53 | NR | 172 | NR | NR | PCL-5 | 33 | NR | ISI | NR | NR |
| **61** | (Saladin et al., 1995) | full paper | USA | cross sectional | NR | sexual/ physical assault | current and history | 46.40 | NR | 100.00 | NR | NR | 56 | 36 | 28 | NWS | NR | NR | subscale of NWS | NR | NR |
| **62** | (Shore et al., 2009) | full paper | USA | cross sectional | NR | military | current and history | 44.50 | NR | 0.00 | 47.00 | NR | 305 | 77 | 81 | M-PTSD | NR | CIDI | M-PTSD | NR | NR |
| **63** | (Short et al., 2018) | full paper | USA | cross sectional | NR | multiple causes | current | NR | 0.75 | 61.30 | 38.03 | 18-60 | 30 | NR | 30 | PCL-5 | 33 | SCID | ISI | 10 | NR |
| **64** | (Short et al., 2015) | full paper | USA | cross sectional | NR | NR | current | NR | 0.2 | 65.10 | 26.38 | NR | 255 | NR | 23 | NR | NR | DSM-4 | ISI | NR | NR |
| **65** | (Steele and Fogarty, 2017) | full paper | Australia | longitudinal | 18 | military | current | NR | 0.56 | 0.00 | NR | 19-52 | 212 | NR | NR | PCL-C | NR | NR | ISI | NR | NR |
| **66** | (Steudte-Schmiedgen et al., 2021) | full paper | Germany | cross sectional | NR | COVID-19 | current | NR | 0.36 | 74.5 | NR | >18 | 4724 | NR | NR | IES-6 | NR | NR | single-item measure | NR | NR |
| **67** | (Walsh et al., 2017) | abstract | USA | cross sectional | NR | interpersonal violence | NR | NR | 0.62 | 95.90 | 34.50 | NR | 797 | 616 | 671 | PCL-5 | NR | NR | ISI | NR | NR |
| **68** | (Wang et al., 2019b) | full paper | USA | cross sectional | NR | illness | current | 30.61 | NR | 50.00 | 56.80 | >18 | 112 | 59 | 49 | DSM-5 symptoms | NR | NR | CCRC patient assessment | NR | NR |
| **69** | (Waszczuk et al., 2019) | full paper | USA | cross sectional | NR | NR | current | NR | 0.61 | 11.00 | 55.22 | 32–82 | 452 | NR | NR | PCL-5 | NR | NR | ISI | NR | NR |
| **70** | (Werner et al., 2016) | full paper | USA | cross sectional | NR | interpersonal violence | NR | NR | 0.48 | 100.00 | 36.10 | 18-59 | 51 | NR | 51 | CAPS-5 | NR | NR | ISI | 15 | NR |
| **71** | (Williams et al., 2015) | full paper | USA | cross sectional | NR | military | current | 56.20 | NR | 8.50 | 35.10 | >18 | 130 | 73 | 130 | PCL-M | 50 | DSM-4 | NR | NR | NR |
| **72** | (Wright et al., 2011a) | full paper | Germany | longitudinal | 60 | military | current | NR | 0.65 | 2.00 | 26.00 | NR | 522 | NR | NR | PCL-5 | NR | NR | ISI | NR | NR |
| **73** | (Wright et al., 2011b) | full paper | Germany | longitudinal | 32 | military | current | NR | 0.77 | 4.00 | 25.00 | NR | 659 | NR | NR | PCL-5 | NR | NR | ISI | NR | NR |
| **74** | (Zayfert and DeViva, 2004) | full paper | USA | longitudinal | NR | multiple causes | current | 88.00 | NR | 89.00 | 37.20 | NR | 25 | 22 | 25 | NR | NR | CAPS | NR | NR | CAPS |
| **75** | (Zhang et al., 2020) | full paper | China | cross sectional | NR | work related | current | 95.52 | NR | 42.68 | NR | NR | 642 | 331 | 134 | PCL-C | 50 | NR | ISI | 8 | NR |

**Note:** AIS: Athens insomnia scale; BIQ: Brief Insomnia Questionnaire; CAPS-5: Clinician-Administered PTSD Scale for DSM-5; CCRC: Critical Care Recovery Center; CI: Confidence Interval; CIDI: Composite International Diagnostic Interview; DIS-Q: Dissociation Questionnaire; DSM: Diagnostic and Statistical Manual of Mental Disorders; DSM-5: Diagnostic and Statistical Manual of Mental Disorders, Fifth Edition; DSM-IV: Diagnostic and Statistical Manual of Mental Disorders, Fourth Edition; DTS: Distress Tolerance Scale; EMR: Electronic Medical Record; GPS: Global Psychotrauma Screen; GSDS: General Sleep Disturbance Scale; ICD: international classification of diseases; ICD-11: International Classification of Disease, Eleventh Revision; IES: The Impact of Event scale; IES-R: Impact of Event Scale-Revised; ICSD: International Classification of Sleep Disorders; ISES: Iowa Sleep Experience Survey; ISI: Insomnia Severity Index; ISI\*: Insomnia Sleep Index; MINI: Mini-International Neuropsychiatric Interview; M-PTSD: Mississippi Scale for Combat-Related PTSD; NR: Not reported; NWS: National Women's Study Posttraumatic Stress Disorder module; PCL: Posttraumatic Stress Disorder Checklist; PCL-5: PTSD Checklist for DSM-5; PCL-C: PTSD Checklist-Civilian Version; PCL-M: PTSD Checklist- Military version; PC-PTSD: Primary Care Screen for PTSD; PDS-5: Posttraumatic Diagnostic Scale for DSM-5; PIRS: Pittsburgh Insomnia Rating Scale, PROMIS-SD: Patient-Reported Outcomes Measurement Information System for Sleep Disturbance; PSS-I: PTSD Symptom Scale–Interview Version; PSS-SR: PTSD Symptom Scale-Self Report; PTSD-8: Posttraumatic Stress Disorder- 8 items; SCID-5: Structured Clinical Interview for DSM-5; SCID-IV: Structured Clinical Interview for DSM-4; SDS: Sleep Disturbance Screening; TAL: Thinking A Lot questionnaire; TEC: Traumatic Experiences Checklist; YSIS: Youth Self-Rating Insomnia Scale

**Table 2.** Correlation between PTSD/PTSS and Insomnia with related moderating categorical variables under random-effect model

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Variables** | **Sub-analysis** | **K** | **Model** | **Statistics for each study with CI** | | | | | **Heterogeneity** | | | |
| **r** | **Lower limit** | **Upper**  **limit** | **Z-Value** | **p-Value** | **Q-value** | **df (Q)** | **I2** | **τ²** |
| **Total** | **Sample size (n=57,618)** | **44** | **Fixed-effect** | **0.44** | **0.44** | **0.45** | **115.92** | **0.000** | **2230.88** | **43.00** | **98.07** | **0.04** |
| **Random-effect** | **0.52** | **0.47** | **0.57** | **17.29** | **0.0000** |
| **Country** | Australia | 2 |  | 0.47 | 0.21 | 0.66 | 3.40 | 0.0007 | 3.78 | 1.00 | 73.53 | 0.03 |
| Canada | 3 | 0.60 | 0.54 | 0.65 | 15.45 | 0.0000 | 10.42 | 2.00 | 80.81 | 0.00 |
| China | 4 | 0.62 | 0.35 | 0.79 | 4.05 | 0.0001 | 312.18 | 3.00 | 99.04 | 0.12 |
| Germany | 3 | 0.62 | 0.29 | 0.82 | 3.30 | 0.0010 | 286.90 | 2.00 | 99.30 | 0.14 |
| Iran | 1 | 0.45 | 0.39 | 0.50 | 14.06 | 0.0000 | 0.00 | 0.00 | 0.00 | 0.00 |
| Israel | 1 | 0.21 | 0.02 | 0.38 | 2.18 | 0.0289 | 0.00 | 0.00 | 0.00 | 0.00 |
| Italy | 1 | 0.37 | 0.36 | 0.38 | 52.32 | 0.0000 | 0.00 | 0.00 | 0.00 | 0.00 |
| Netherlands | 1 | 0.20 | 0.08 | 0.32 | 3.17 | 0.0015 | 0.00 | 0.00 | 0.00 | 0.00 |
| South Korea | 1 | 0.62 | 0.39 | 0.78 | 4.59 | 0.0000 | 0.00 | 0.00 | 0.00 | 0.00 |
| Spain | 2 | 0.61 | 0.31 | 0.80 | 3.56 | 0.0004 | 29.63 | 1.00 | 96.62 | 0.08 |
| Taiwan | 1 | 0.34 | 0.26 | 0.42 | 7.89 | 0.0000 | 0.00 | 0.00 | 0.00 | 0.00 |
| UK | 1 | 0.56 | 0.33 | 0.73 | 4.30 | 0.0000 | 0.00 | 0.00 | 0.00 | 0.00 |
| **USA** | **23** | **0.51** | **0.42** | **0.60** | **9.27** | **0.0000** | **1023.79** | **22.00** | **97.85** | **0.08** |
| **Study design** | **cross sectional** | **38** | **0.50** | **0.45** | **0.55** | **16.93** | **0.0000** | **1452.27** | **37.00** | **97.45** | **0.04** |
| longitudinal | 6 | 0.63 | 0.53 | 0.71 | 9.86 | 0.0000 | 118.13 | 5.00 | 95.77 | 0.03 |
| **Publication type** | abstract | 5 | 0.58 | 0.48 | 0.66 | 9.73 | 0.0000 | 34.96 | 4.00 | 88.56 | 0.02 |
| **full paper** | **39** | **0.52** | **0.47** | **0.57** | **16.88** | **0.0000** | **1714.87** | **38.00** | **97.78** | **0.04** |
| **Status of trauma** | **current** | **32** | **0.54** | **0.48** | **0.59** | **14.55** | **0.0000** | **1861.59** | **31.00** | **98.33** | **0.05** |
| history | 4 | 0.58 | 0.35 | 0.75 | 4.35 | 0.0000 | 240.34 | 3.00 | 98.75 | 0.09 |
| NR | 8 | 0.44 | 0.33 | 0.53 | 7.51 | 0.0000 | 49.37 | 7.00 | 85.82 | 0.02 |
| **Cause of trauma** | **COVID-19 pandemic** | **9** | **0.54** | **0.44** | **0.62** | **9.08** | **0.0000** | **766.67** | **8.00** | **98.96** | **0.04** |
| displacement | 1 | 0.67 | 0.61 | 0.72 | 15.83 | 0.0000 | 0.00 | 0.00 | 0.00 | 0.00 |
| interpersonal violence | 2 | 0.59 | 0.46 | 0.69 | 7.59 | 0.0000 | 1.85 | 1.00 | 45.87 | 0.01 |
| **military** | **10** | **0.53** | **0.43** | **0.63** | **8.28** | **0.0000** | **161.80** | **9.00** | **94.44** | **0.05** |
| multiple causes | 1 | 0.75 | 0.53 | 0.87 | 5.06 | 0.0000 | 0.00 | 0.00 | 0.00 | 0.00 |
| natural disaster | 2 | 0.67 | 0.38 | 0.83 | 3.95 | 0.0001 | 8.45 | 1.00 | 88.17 | 0.07 |
| NR | 11 | 0.39 | 0.29 | 0.48 | 7.37 | 0.0000 | 273.63 | 10.00 | 96.35 | 0.03 |
| refugee | 2 | 0.66 | -0.09 | 0.93 | 1.76 | 0.0778 | 32.55 | 1.00 | 96.93 | 0.38 |
| sexual assault | 1 | 0.62 | 0.39 | 0.78 | 4.59 | 0.0000 | 0.00 | 0.00 | 0.00 | 0.00 |
| terrorism | 2 | 0.52 | -0.12 | 0.86 | 1.61 | 0.1075 | 42.56 | 1.00 | 97.65 | 0.25 |
| work related | 3 | 0.52 | 0.30 | 0.69 | 4.31 | 0.0000 | 67.08 | 2.00 | 97.02 | 0.05 |
| **PTSD diagnostic tool** | DSM-4 | 1 | 0.20 | 0.08 | 0.32 | 3.22 | 0.0013 | 0.00 | 0.00 | 0.00 | 0.00 |
| ICD-11 | 1 | 0.21 | 0.02 | 0.38 | 2.18 | 0.0289 | 0.00 | 0.00 | 0.00 | 0.00 |
| NR | 40 | 0.54 | 0.49 | 0.59 | 18.41 | 0.0000 | 1802.96 | 39.00 | 97.84 | 0.04 |
| SCID | 1 | 0.75 | 0.53 | 0.87 | 5.06 | 0.0000 | 0.00 | 0.00 | 0.00 | 0.00 |
| SCID-5-RV | 1 | 0.12 | 0.08 | 0.16 | 6.40 | 0.0000 | 0.00 | 0.00 | 0.00 | 0.00 |
| **PTSD scale** | CAPS | 2 | 0.34 | 0.04 | 0.59 | 2.24 | 0.0250 | 2.63 | 1.00 | 61.96 | 0.03 |
| DTS | 1 | 0.72 | 0.66 | 0.77 | 16.08 | 0.0000 | 0.00 | 0.00 | 0.00 | 0.000 |
| GPS | 1 | 0.37 | 0.36 | 0.38 | 52.32 | 0.0000 | 0.00 | 0.00 | 0.00 | 0.00 |
| IES | 6 | 0.47 | 0.30 | 0.60 | 5.13 | 0.0000 | 183.50 | 5.00 | 97.28 | 0.06 |
| NR | 5 | 0.36 | 0.07 | 0.59 | 2.39 | 0.0170 | 119.22 | 4.00 | 96.64 | 0.11 |
| **PCL** | **21** | **0.60** | **0.53** | **0.66** | **14.24** | **0.0000** | **990.93** | **20.00** | **97.98** | **0.05** |
| PC-PTSD-5 | 1 | 0.47 | 0.40 | 0.54 | 11.00 | 0.0000 | 0.00 | 0.00 | 0.00 | 0.00 |
| PDS | 2 | 0.42 | 0.22 | 0.59 | 3.88 | 0.0001 | 3.39 | 1.00 | 70.51 | 0.03 |
| PC-PTSD | 1 | 0.41 | 0.33 | 0.49 | 9.09 | 0.0000 | 0.00 | 0.00 | 0.00 | 0.00 |
| PSS | 3 | 0.44 | 0.35 | 0.52 | 8.32 | 0.0000 | 5.31 | 2.00 | 62.32 | 0.01 |
| TEC | 1 | 0.56 | 0.33 | 0.73 | 4.30 | 0.0000 | 0.00 | 0.00 | 0.00 | 0.00 |
| **Insomnia assessment** | AIS | 1 | 0.72 | 0.66 | 0.77 | 16.08 | 0.0000 | 0.00 | 0.00 | 0.00 | 0.00 |
| GSDS | 1 | 0.38 | 0.28 | 0.47 | 7.03 | 0.0000 | 0.00 | 0.00 | 0.00 | 0.00 |
| ISI\* | 1 | 0.32 | 0.06 | 0.54 | 2.39 | 0.0168 | 0.00 | 0.00 | 0.00 | 0.00 |
| ISES | 1 | 0.56 | 0.33 | 0.73 | 4.30 | 0.0000 | 0.00 | 0.00 | 0.00 | 0.00 |
| **ISI** | **29** | **0.52** | **0.46** | **0.58** | **14.80** | **0.0000** | **1184.11** | **28.00** | **97.64** | **0.04** |
| NR | 1 | 0.76 | 0.69 | 0.82 | 12.68 | 0.0000 | 0.00 | 0.00 | 0.00 | 0.00 |
| PIRS | 1 | 0.39 | 0.08 | 0.63 | 2.46 | 0.0140 | 0.00 | 0.00 | 0.00 | 0.00 |
| SDS | 1 | 0.12 | 0.08 | 0.16 | 6.40 | 0.0000 | 0.00 | 0.00 | 0.00 | 0.00 |
| DSM-4 questionnaire | 1 | 0.20 | 0.08 | 0.32 | 3.17 | 0.0015 | 0.00 | 0.00 | 0.00 | 0.00 |
| self-administered questionnaire | 2 | 0.69 | 0.65 | 0.72 | 25.21 | 0.0000 | 0.00 | 1.00 | 0.00 | 0.00 |
| single-item measure | 2 | 0.41 | 0.30 | 0.51 | 6.59 | 0.0000 | 7.51 | 1.00 | 86.68 | 0.01 |
| TAL (subscale) | 1 | 0.84 | 0.79 | 0.88 | 17.14 | 0.0000 | 0.00 | 0.00 | 0.00 | 0.00 |
| PCL-M (subscale) | 1 | 0.55 | 0.49 | 0.60 | 15.74 | 0.0000 | 0.00 | 0.00 | 0.00 | 0.00 |
| YSIS | 1 | 0.32 | 0.30 | 0.34 | 28.22 | 0.0000 | 0.00 | 0.00 | 0.00 | 0.00 |

**Note:** AIS: Athens insomnia scale; CAPS: Clinician-Administered PTSD Scale for DSM-5; CI: Confidence Interval; df: Degree of Freedom; DSM-4: Diagnostic and Statistical Manual of Mental Disorders, Fourth Edition; DTS: Distress Tolerance Scale; GPS: Global Psychotrauma Screen; GSDS: General Sleep Disturbance Scale; ICD-11: International Classification of Disease, Eleventh Revision; IES: The Impact of Event scale; ISES: Iowa Sleep Experience Survey; ISI: Insomnia Severity Index; ISI\*: Insomnia Sleep Index; K: number of studies; NR: Not reported; PCL: posttraumatic stress disorder checklist; PCL-M: PTSD Checklist- Military version; PC-PTSD: Primary Care Screen for PTSD; PDS: Posttraumatic diagnostic scale for DSM-5; PIRS: Pittsburgh Insomnia Rating Scale; PSS: PTSD Symptom Scale–Interview Version; SCID: Structured Clinical Interview for DSM-4; SCID-5-RV: Structured Clinical Interview for DSM-5-, Revised Version; SDS: Sleep Disturbance Screening; TAL: Thinking A Lot questionnaire; TEC: Traumatic Experiences Checklist; YSIS: Youth Self-Rating Insomnia Scale

**Table 3.** Prevalence of insomnia in PTSD/PTSS with related moderating categorical variables under random-effect model

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Variables** | **Sub-analysis** | **K** | **Model** | **Statistics for each study with CI** | | | | | **Heterogeneity** | | | |
| **Event rate** | **Lower limit** | **Upper**  **limit** | **Z-Value** | **p-Value** | **Q-value** | **df (Q)** | **I2** | **τ²** |
| **Total** | **Sample size (n=573,665)** | **33** | **Fixed-effect** | **10%** | **10%** | **10%** | **-470.54** | **0.000** | **27347.53** | **32.00** | **99.88** | **4.42** |
| **Random-effect** | **63%** | **45%** | **78%** | **1.42** | **0.1559** |
| **Country** | Australia | 1 |  | 11% | 10% | 12% | -39.24 | 0.0000 | 0.00 | 0.00 | 0.00 | 0.00 |
| China | 3 | 70% | 32% | 92% | 1.05 | 0.2930 | 73.71 | 2.00 | 97.29 | 1.95 |
| Ethiopia | 1 | 75% | 67% | 81% | 5.57 | 0.0000 | 0.00 | 0.00 | 0.00 | 0.00 |
| Georgia | 1 | 98% | 70% | 100% | 2.56 | 0.0105 | 0.00 | 0.00 | 0.00 | 0.00 |
| Greece | 3 | 67% | 46% | 83% | 1.58 | 0.1145 | 8.17 | 2.00 | 75.52 | 0.46 |
| South Korea | 1 | 63% | 52% | 74% | 2.23 | 0.0260 | 0.00 | 0.00 | 0.00 | 0.00 |
| Spain | 1 | 73% | 66% | 79% | 5.56 | 0.0000 | 0.00 | 0.00 | 0.00 | 0.00 |
| UK | 1 | 92% | 88% | 95% | 10.39 | 0.0000 | 0.00 | 0.00 | 0.00 | 0.00 |
| USA | 21 | 59% | 35% | 79% | 0.70 | 0.4840 | 25593.46 | 20.00 | 99.92 | 4.96 |
| **Study design** | cross sectional | 30 | 60% | 41% | 76% | 1.03 | 0.3017 | 26623.39 | 29.00 | 99.89 | 4.36 |
| longitudinal | 3 | 86% | 69% | 94% | 3.46 | 0.0005 | 19.58 | 2.00 | 89.78 | 0.69 |
| **Publication type** | abstract | 2 | 52% | 0% | 100% | 0.02 | 0.9834 | 23.05 | 1.00 | 95.66 | 22.69 |
| full paper | 31 | 64% | 46% | 80% | 1.49 | 0.1327 | 27176.80 | 30.00 | 99.89 | 4.60 |
| **Status of trauma** | current | 24 | 65% | 47% | 80% | 1.66 | 0.0965 | 6704.70 | 23.00 | 99.66 | 2.62 |
| current and history | 4 | 48% | 26% | 71% | -0.18 | 0.8584 | 95.72 | 3.00 | 96.87 | 0.98 |
| history | 2 | 52% | 19% | 83% | 0.10 | 0.9191 | 40.32 | 1.00 | 97.52 | 1.73 |
| NR | 3 | 67% | 54% | 78% | 2.54 | 0.0110 | 17.08 | 2.00 | 88.29 | 0.25 |
| **Cause of trauma** | car accident | 1 | 75% | 67% | 81% | 5.57 | 0.0000 | 0.00 | 0.00 | 0.00 | 0.00 |
| COVID-19 pandemic | 3 | 78% | 67% | 86% | 4.50 | 0.0000 | 12.41 | 2.00 | 83.88 | 0.19 |
| displacement | 1 | 98% | 70% | 100% | 2.56 | 0.0105 | 0.00 | 0.00 | 0.00 | 0.00 |
| illness | 1 | 31% | 19% | 45% | -2.64 | 0.0083 | 0.00 | 0.00 | 0.00 | 0.00 |
| intimate partner violence | 1 | 63% | 50% | 75% | 1.92 | 0.0552 | 0.00 | 0.00 | 0.00 | 0.00 |
| military | 13 | 53% | 24% | 79% | 0.16 | 0.8723 | 23959.52 | 12.00 | 99.95 | 4.98 |
| **multiple causes** | **5** | **81%** | **53%** | **94%** | **2.12** | **0.0342** | **150.20** | **4.00** | **97.34** | **2.29** |
| natural disaster | 1 | 79% | 64% | 89% | 3.55 | 0.0004 | 0.00 | 0.00 | 0.00 | 0.00 |
| NR | 3 | 28% | 10% | 59% | -1.43 | 0.1518 | 170.98 | 2.00 | 98.83 | 1.26 |
| refugee | 1 | 63% | 52% | 74% | 2.23 | 0.0260 | 0.00 | 0.00 | 0.00 | 0.00 |
| sexual/ physical assault | 1 | 46% | 29% | 65% | -0.38 | 0.7057 | 0.00 | 0.00 | 0.00 | 0.00 |
| work related | 2 | 80% | 13% | 99% | 0.82 | 0.4150 | 29.24 | 1.00 | 96.58 | 5.51 |
| **PTSD diagnostic tool** | CAPS | 2 | 62% | 9% | 96% | 0.35 | 0.7247 | 19.46 | 1.00 | 94.86 | 3.88 |
| CIDI | 1 | 44% | 34% | 55% | -1.00 | 0.3183 | 0.00 | 0.00 | 0.00 | 0.00 |
| DSM | 5 | 67% | 41% | 85% | 1.29 | 0.1984 | 113.32 | 4.00 | 96.47 | 1.37 |
| EMR | 1 | 41% | 31% | 51% | -1.83 | 0.0678 | 0.00 | 0.00 | 0.00 | 0.00 |
| ICD | 4 | 48% | 7% | 92% | -0.05 | 0.9586 | 2560.30 | 3.00 | 99.88 | 6.17 |
| MINI | 1 | 11% | 10% | 12% | -39.24 | 0.0000 | 0.00 | 0.00 | 0.00 | 0.00 |
| NR | 18 | 67% | 47% | 82% | 1.71 | 0.0873 | 2997.19 | 17.00 | 99.43 | 2.89 |
| SCID | 1 | 92% | 88% | 95% | 10.39 | 0.0000 | 0.00 | 0.00 | 0.00 | 0.00 |
| **PTSD scale** | IES-R | 1 | 63% | 52% | 74% | 2.23 | 0.0260 | 0.00 | 0.00 | 0.00 | 0.00 |
| M-PTSD | 1 | 44% | 34% | 55% | -1.00 | 0.3183 | 0.00 | 0.00 | 0.00 | 0.00 |
| NR | 13 | 50% | 31% | 69% | 0.02 | 0.9848 | 0.00 | 0.00 | 99.67 | 2.14 |
| NWS | 1 | 46% | 29% | 65% | -0.38 | 0.7057 | 3585.86 | 12.00 | 0.00 | 0.00 |
| **PCL** | **11** | **70%** | **56%** | **81%** | **2.76** | **0.0058** | **0.00** | **0.00** | **98.34** | **0.81** |
| PC-PTSD-5 | 2 | 80% | 66% | 89% | 3.79 | 0.0002 | 603.52 | 10.00 | 90.69 | 0.23 |
| PDS-5 | 1 | 98% | 70% | 100% | 2.56 | 0.0105 | 10.74 | 1.00 | 0.00 | 0.00 |
| PSS-SR | 1 | 63% | 50% | 75% | 1.92 | 0.0552 | 0.00 | 0.00 | 0.00 | 0.00 |
| PTSD-8 | 1 | 73% | 59% | 84% | 3.00 | 0.0027 | 0.00 | 0.00 | 0.00 | 0.00 |
| DSM-5 symptoms | 1 | 31% | 19% | 45% | -2.64 | 0.0083 | 0.00 | 0.00 | 0.00 | 0.00 |
| **Insomnia assessment** | AIS | 3 | 67% | 46% | 83% | 1.58 | 0.1145 | 8.17 | 2.00 | 75.52 | 0.46 |
| BIQ | 1 | 70% | 69% | 71% | 35.42 | 0.0000 | 0.00 | 0.00 | 0.00 | 0.00 |
| CCRC patient assessment | 1 | 31% | 19% | 45% | -2.64 | 0.0083 | 0.00 | 0.00 | 0.00 | 0.00 |
| **ISI** | **8** | **82%** | **69%** | **91%** | **3.92** | **0.0001** | **432.11** | **7.00** | **98.38** | **1.02** |
| NR | 12 | 47% | 30% | 65% | -0.29 | 0.7707 | 965.46 | 11.00 | 98.86 | 1.53 |
| PROMIS-SD | 2 | 38% | 3% | 93% | -0.31 | 0.7555 | 241.91 | 1.00 | 99.59 | 4.93 |
| self-administered questionnaire | 1 | 59% | 50% | 68% | 1.93 | 0.0535 | 0.00 | 0.00 | 0.00 | 0.00 |
| single-item measure | 1 | 73% | 66% | 79% | 5.56 | 0.0000 | 0.00 | 0.00 | 0.00 | 0.00 |
| M-PTSD (subscale) | 1 | 44% | 34% | 55% | -1.00 | 0.3183 | 0.00 | 0.00 | 0.00 | 0.00 |
| NWS PTSD (subscale) | 1 | 46% | 29% | 65% | -0.38 | 0.7057 | 0.00 | 0.00 | 0.00 | 0.00 |
| SCID (subscale) | 1 | 92% | 88% | 95% | 10.39 | 0.0000 | 0.00 | 0.00 | 0.00 | 0.00 |
| YSIS | 1 | 33% | 26% | 41% | -4.07 | 0.0000 | 0.00 | 0.00 | 0.00 | 0.00 |

**Note:** AIS: Athens Insomnia Scale; BIQ: Brief Insomnia Questionnaire; CAPS: Clinician-Administered PTSD Scale for DSM-5; CCRC: Critical Care Recovery Center; CI: Confidence Interval; CIDI: Composite International Diagnostic Interview; df: Degree of Freedom; DSM: Diagnostic and Statistical Manual of Mental Disorders; EMR: Electronic Medical Record; ICD: International Classification of Disease; IES-R: The Impact of Event scale- Revised Version; ISI: Insomnia Severity Index; K: number of studies; MINI: Mini-International Neuropsychiatric Interview; M-PTSD: Mississippi Scale for Combat-Related PTSD; NR: Not reported; NWS: National Women's Study Posttraumatic Stress Disorder module; PCL: posttraumatic stress disorder checklist; PC-PTSD-5: Primary Care Screen for PTSD for DSM-5; PDS-5: Posttraumatic diagnostic scale for DSM-5; PROMIS-SD: Patient-Reported Outcomes Measurement Information System for Sleep Disturbance; PSS-SR: PTSD Symptom Scale-Self Report; PTSD-8: Posttraumatic Stress Disorder- 8 items; SCID: Structured Clinical Interview; YSIS: Youth Self-Rating Insomnia Scale

**Figure Captions:**

**Figure 1.** PRISMA flow diagram showing study selection and examination process

**Figure 2.** Funnel plot for the studies included in the overall aggregate for the **correlation** analysis. The plot suggests there is limited publication bias or significant outliers [empty Diamond and filled Diamond at the same location].

**Figure 3.** Funnel plot for the studies included in the overall aggregate for the **prevalence** estimate. The plot suggests there is possible publication bias and/or significant outliers [empty Diamond and filled Diamond are distant from each other]. Further, large variability around the mean was observed across studies