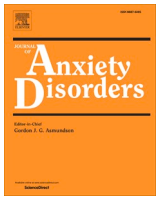
Journal of Anxiety Disorders 103 (2024) 102857

Contents lists available at ScienceDirect

Journal of Anxiety Disorders

journal homepage: www.elsevier.com/locate/janxdis



Review

Relationship between anxiety sensitivity and post-traumatic stress symptoms in trauma-exposed adults: A meta-analysis

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ARTICLE INFO

Keywords:
Post-traumatic stress disorder
Anxiety sensitivity
Meta-analysis

ABSTRACT

Given the high rate of trauma exposure among the general population, it is important to delineate the risk factors for post-traumatic stress disorder (PTSD). While historically implicated in panic disorder, anxiety sensitivity is increasingly found to play a role in PTSD. The present review investigated the size of the relationship between anxiety sensitivity and PTSD symptoms among trauma exposed adults. A systematic search on multiple electronic databases (PTSDpubs, CINAHL, MEDLINE and PsycINFO) generated a total of 1025 records, among which 52 (n = 15173) met study inclusion criteria and were included in our random effects meta-analysis. Our results indicated a medium effect size (r = .46, 95% CI =.41,.50) for the relationship between anxiety sensitivity and PTSD symptoms. There was significant between-study heterogeneity. Furthermore, sub-group analyses revealed that study design (cross-sectional vs. longitudinal) may significantly moderate the association between anxiety sensitivity and PTSD severity. No moderation effect was found for assessment of PTSD through interview versus questionnaire, interpersonal versus non-interpersonal trauma, or low versus high study quality. Such patterns of results are consistent with cognitive models of PTSD. Clinical implications, strengths and limitations of the review were discussed.

1. Introduction

The majority of the general adult population, i.e. around 60–90%, are exposed to some form of trauma in their lives (Benjet et al., 2016; Karatzias et al., 2019; Kilpatrick et al., 2013; Maercker et al., 2022). Within one month of trauma exposure, it is normal to reexperience images or thoughts related to the trauma, become avoidant of people and places and feel restless, irritable or anxious. These acute trauma reactions are known as symptoms of Acute Stress Disorder (ASD) and tend to diminish over time. However, for a sizeable proportion of trauma survivors, these ASD symptoms persist over one month, subsequently turning into Post-Traumatic Stress Disorder (PTSD). According to prevalence studies (e.g. Karatzias et al., 2019; Maercker et al., 2022), the lifetime prevalence of PTSD is around 6–10%. PTSD is associated with a range of physical health conditions (e.g. musculoskeletal pain, cardio-respiratory symptoms and gastrointestinal health), mental health comorbidities (e.g. depression, anxiety, substance abuse, dissociative disorders) as well as significant functional impairment and loss of quality of life (Bernhard et al., 2018; Galatzer-Levy et al., 2013; Simmons & Suárez, 2016). Following recurrent or prolonged traumatisation, one is at an increased risk of developing Complex PTSD (Brewin, 2020), a newly proposed diagnosis that encompasses symptoms of affect dysregulation, negative self-concept and relationship difficulties (World Health Organization, 2018). Given the extensive consequences of traumatic stress, it is crucial to identify the factors that predict PTSD to better prevent and address the condition.

1.1. Predictors of PTSD

Past studies have identified a range of factors that may increase the risk of developing PTSD. These risk factors can be broadly categorised into pre-trauma psychosocial factors, event-related factors and cognitive factors. Psychosocial factors include prior life events, socioeconomic status, intelligence, self-esteem, social support and female gender (Cox

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https://doi.org/10.1016/j.janxdis.2024.102857
Received 6 September 2023; Received in revised form 21 December 2023; Accepted 7 March 2024
Available online 9 March 2024

et al., 2008; Ostacoli et al., 2020; Ullman et al., 2007), whereas event-related factors include types of trauma (e.g. interpersonal versus non-interpersonal), presence of deaths, injury severity, levels of pain, peritraumatic dissociation and perceived fear responses (Cox et al., 2008; Heron-Delaney et al., 2013; Ozer et al., 2003; Vogt et al., 2007). While psychosocial factors and event-related factors may play a role in PTSD, they are mostly associated with small to medium effect sizes. Conversely, cognitive factors such as trauma appraisals, data-driven processing, nature of trauma memory, rumination and thought suppression (Brewin et al., 1996; Ehlers & Clark, 2000; Foa et al., 1989) were consistently found to predict PTSD with medium to large effect sizes (Ehlers et al., 2003; Gómez de La Cuesta et al., 2019; Kindt et al., 2008; Moulds et al., 2020). This suggests the relative importance of cognitive factors compared to other factors in the aetiology of PTSD.

1.2. Cognitive theories of PTSD

From a cognitive-behavioural perspective, psychological distress is caused and maintained by cognitive processes (Beck, 1972; Ellis, 1977). Whilst initially used to conceptualise depression, the cognitive model was later applied to various anxiety disorders including PTSD (Beck & Clark, 1997; Brewin et al., 1996; Ehlers & Clark, 2000; Foa & Rothbaum, 2001). According Ehlers and Clark (2000), one of the most widely researched cognitive models of PTSD, the persistence of PTSD symptoms can be attributed to a sense of current threat that arises during trauma processing. Two factors are put forward to be at play: First, autobiographical memory of the trauma tends to be disrupted. Hence, trauma memory may be experienced as threatening with its here-and-now quality and its nature of being fragmented, sensory-based and involuntarily triggered. Second, trauma and its sequela tend to be appraised in negative, catastrophic and overgeneralizing ways. For example, one may have beliefs such as "I attract disasters", "the world is a dangerous place" and "the next disaster will strike soon" in relation to their trauma; one may also endorse the beliefs "I am going crazy", "I am never going to recover" and "I have changed for the worst" in relation to one's reactions to trauma. These maladaptive beliefs consequently maintains one's sense of threat. Behaviourally, one may engage in strategies such as safety-seeking behaviours, cognitive avoidance, rumination and thought suppression in an attempt to reduce the threat.

1.3. Anxiety sensitivity and PTSD

A cognitive factor that may be conceptually associated with trauma appraisal is anxiety sensitivity. Anxiety sensitivity refers to the enduring fear of arousal-related sensations due to the belief that they have harmful consequences for the individual (Reiss, 1985). According to the Anxiety Sensitivity Index (ASI; Reiss et al., 1986), perceived consequences of anxiety can be classified into three dimensions, namely physical (e.g. "When I notice my heart beating rapidly, I worry that I might be having a heart attack"), cognitive (e.g. "When I cannot keep my mind on a task, I worry that I might be going crazy") and social (e.g. "Other people notice when I feel shaky") dimensions.

Anxiety sensitivity has been established as an important correlate of panic disorder (Donnell & McNally, 1990; Li & Zinbarg, 2007; McNally, 2002; Poletti et al., 2015). This is consistent with cognitive models of panic disorder (e.g. Clark, 1986) which considers catastrophic misinterpretations of anxiety-induced bodily symptoms as the core maintaining factor of the disorder. In recent decades, attention has been given to the role of anxiety sensitivity in other anxiety disorders (Asmundson & Stapleton, 2008; Marshall et al., 2010; Olatunji & Wolitzky-Taylor, 2009; Taylor, 2003). In particular, anxiety sensitivity is posited to be correlated with PTSD due to its conceptual overlap with trauma appraisals as well as the high comorbidity rate between PTSD and panic disorder (Leskin & Sheikh, 2002).

To date, a considerable number of independent studies have reported a significant association between anxiety sensitivity and PTSD symptoms (e.g. Amir et al., 2002; Wald & Taylor, 2007). Yet efforts to integrate existing findings remain insufficient. Whilst Olatunji and Wolitzky-Taylor (2009) and Naragon-Gainey (2010) both conducted a meta-analysis regarding anxiety sensitivity and various anxiety disorders, there are a number of reasons why an additional meta-analysis on the topic is warranted at this point. First, both Olatunji and Wolitzky-Taylor (2009) and Naragon-Gainey (2010) were conducted more than 10 years ago. The number of relevant studies were limited then; notably, only five studies were included in the PTSD section of Olatunji and Wolitzky-Taylor (2009). Given the growing literature around PTSD and anxiety sensitivity, a meta-analysis would help update and refine current understanding about their relationship. Second, Naragon-Gainey (2010) included studies that exclusively examined PTSD patients. Participants of such studies were likely to endorse high levels of PTSD symptoms. This made it difficult to determine the strength of association of anxiety sensitivity across a range of PTSD severity (e.g. for trauma-exposed individuals with lesser or no PTSD symptoms). Third, previous meta-analyses had not probed into the potential moderating effects of trauma types (interpersonal versus non-interpersonal), PTSD measures (questionnaires versus interviews) and study designs (cross-sectional versus longitudinal). Interpersonal trauma was associated with greater PTSD severity and complex PTSD symptoms (Chiu et al., 2023; Thomas et al., 2021), whereas the use of self-reported questionnaires could potentially produce more PTSD cases compared to structured diagnostic interviews (Stevens et al., 2013). Little is also known about the strength of association of anxiety sensitivity over time, as would be reflected by longitudinal studies. As such, a meta-analysis that included such moderator variables would provide a clearer picture of how and under what conditions anxiety sensitivity might influence PTSD.

1.4. Current review

The current review sought to conduct a comprehensive search and analysis of the existing studies on anxiety sensitivity and PTSD symptoms/diagnosis among trauma-exposed adults. To our knowledge, this constitutes the first meta-analysis in the area. Delineating the relationship between anxiety sensitivity and PTSD would help consolidate and expand current cognitive theories. It may also inform clinical management of PTSD.

2. Method

2.1. Protocol and registration

This review was registered with PROSPERO: International prospective register of systematic reviews (ID: CRD42022316095) on 16 March 2022. It was reported with reference to the Preferred Reporting Items for Systematic Review and Meta-Analyses (PRISMA) Statement (Moher et al., 2009).

2.2. Search strategy

A systematic search was conducted by the primary author (HC) to identify all studies on anxiety sensitivity and PTSD. Electronic databases included PTSDpubs, CINAHL, MEDLINE and PsycINFO. Search terms summarized two key domains: anxiety sensitivity and PTSD OR posttraumatic stress OR post traumatic stress OR posttraumatic stress (see Table S1), and were run by "Abstract and Title", keywords, and Medical Subject headings (MeSH). All searches were limited to human studies that were written in the English language and published from 1980 (when the Diagnostic and Statistical Manual of Mental Disorders first defined PTSD) to 25th July 2023.

2.3. Study selection

Subsequent to initial search and removal of duplicates, titles and abstracts were screened by one author (DL) against a set of pre-determined inclusion and exclusion criteria (see below). Among studies with relevant titles and abstracts, further full-text screening was conducted. A randomly selected 25% of the full-text articles were co-screened by the first author (HC) to ensure adherence to the inclusion and exclusion criteria.

Studies were included in the review if they 1) were academic journal articles, doctoral or master's theses/dissertations, 2) examined trauma-exposed individuals at or over the age of 18 (trauma exposure is defined in accordance with DSM-5 Criterion A; American Psychiatric Association, 2013), 3) adopted cross-sectional or prospective longitudinal designs, 4) assessed severity, symptoms or diagnosis of PTSD with a well-validated assessment measure and 5) contained either correlation statistics between anxiety sensitivity and PTSD or any relevant statistics that could be converted to correlation statistics (e.g. Cohen's d, odd ratios and eta squared).

Studies were excluded from the review if they 1) were reviews/meta-analyses, single case studies, qualitative studies, animal studies, book chapters or clinical trials/treatment studies (due to difficulty in determining the predictive power of anxiety sensitivity with no comparison to individuals with lesser or no symptoms of PTSD), 2) examined individuals under the age of 18, 3) used solely clinical or treatment-seeking samples of PTSD (due to difficulty in determining the predictive power of anxiety sensitivity with no comparison to individuals with lesser or no symptoms of PTSD), 4) used samples that were selected due to a mental health disorder (e.g. depression, anxiety) or neuro-developmental condition (e.g. traumatic brain injury, learning disability) and 5) did not include any correlation statistics between anxiety sensitivity and PTSD or any statistics that could be converted to such.

2.4. Data extraction

The following data were extracted from each study: 1) article details (e.g. title, authors, year of publication), 2) study design (i.e. cross-sectional vs. prospective longitudinal), 3) demographic information (e.g. sample population description, age, gender, ethnicity), 4) weeks since trauma exposure, 5) types of trauma (i.e. interpersonal vs. non-interpersonal), 6) country (i.e. high income country vs. middle to low income country), 7) nature of PTSD measure (interview-based vs. questionnaire) and 8) effect size and nature of effect size (e.g. raw correlation, Cohen's d, odd ratios).

Rules were set up to maintain consistency in the data extraction process. First, if PTSD was reported in both continuous measures (i.e. symptom severity) and dichotomous measures (i.e. diagnosis), effect sizes from continuous measures were prioritised since dichotomisation of data tend to underestimate effect size (Breh & Seidler, 2007). Additionally, for studies that presented multiple correlation statistics at different time points, the one derived at the earliest time point was selected for our main analysis; in other words, cross-sectional data were prioritised over longitudinal data.

2.5. Effect size calculation

Pearson's zero-order correlation coefficient (r) was used as the primary estimate of effect size due to its wide usage and easy interpretability. For studies that reported t-tests, ANOVAs or odds ratios, r was derived using standardised procedures for transforming effect sizes (Borenstein et al., 2021; Cohen, 1988; Rosnow & Rosenthal, 1996). In accordance with Cohen (1988), a correlation coefficient of 0.1, 0.3 and 0.5 represented small effect, medium effect and large effect respectively. If a study reported more than one effect sizes that fulfilled our aforementioned prioritisation criteria (i.e. derived from continuous measures and at the earliest time point) – for example, when more than one PTSD scales were used – r's were converted to Fisher's z to obtain a mean before being transformed back to r for analysis (Borenstein et al., 2021).

2.6. Quality assessment

In line with recommended practice, a risk of bias assessment was conducted for all included studies to account for differences in methodological quality (Higgins & Altman, 2008). A quality assessment tool was developed for this analysis with reference to existing checklists such as the Quality Appraisal Checklist for Studies Reporting Correlations and Associations (National Institute for Clinical Excellence (2012)) and the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) statement (Von Elm et al., 2007). The tool consisted of four items concerning 1) sample representativeness, 2) appropriate sampling and recruitment, 3) non-response bias and 4) reliability of anxiety sensitivity measures (see Table S2). Each item was rated on a "yes" (1) or "no" (0) scale, where a higher total score indicated a higher study quality / lower risk of bias.

To ensure process rigour, in addition to quality assessment by one author (AC) using the above framework, a randomly selected 25% of the included studies were co-rated by the main author (HC). Inter-rater reliability was recorded and disagreements in quality rating were resolved by discussion.

2.7. Meta-analytic method

A meta-analysis was conducted using the R "metafor" (version 2.0.0) package (Viechtbauer & Cheung, 2010) in R (version 4.1.2). Random effects models, which did not assume any common or fixed parameters across studies, were used to generalise findings beyond the included studies (Cuijpers, 2016; Hedges & Vevea, 1998). For meta-analysis of correlation coefficients, *metafor* undertook a Fisher transformation of these statistics before the meta-analysis; back-transformed results were reported here. Heterogeneity of effect sizes were assessed using the Q statistic (where variation between studies is implied if Q is significant, $p < .05$; Higgins & Thompson, 2002) and the I^2 statistic (where I^2 values of 25%, 50% and 75% represent small, moderate and large degree of heterogeneity respectively; Higgins et al., 2003). As recommended by IntHout et al. (2016), 95% prediction intervals were reported alongside 95% confidence intervals to provide better estimates of effect sizes based on study heterogeneity.

In addition to the main analysis, to investigate potential moderators of the relationship between anxiety sensitivity and PTSD severity/diagnosis, moderator analyses were conducted using random effects model (Field & Gillett, 2010). Meta-regression analyses were performed on the following variables: types of PTSD measure (i.e. interviews versus questionnaires), types of study (i.e. cross-sectional versus longitudinal), types of trauma (i.e. interpersonal versus non-interpersonal) and levels of study quality (i.e. high versus low, where high quality is operationalised as having a score of $\geq$3 in our risk of bias assessment, whilst low quality, a score of $\leq$2). A meta-regression analysis was also performed on study quality as a continuous measure (as per the original scale of 0 to 4).

3. Results

3.1. Search outcomes

The search identified 1025 references. Following the removal of duplicates, 469 records were screened based on titles and abstracts. This led to the removal of 382 entries that were considered not relevant. Full-text screening was subsequently conducted with the remaining 165 articles. Fifty-two studies met the inclusion criteria for this systematic review (see Fig. 1). Twenty-five percent of the full-text articles were co-screened with an interrater reliability of 94%.

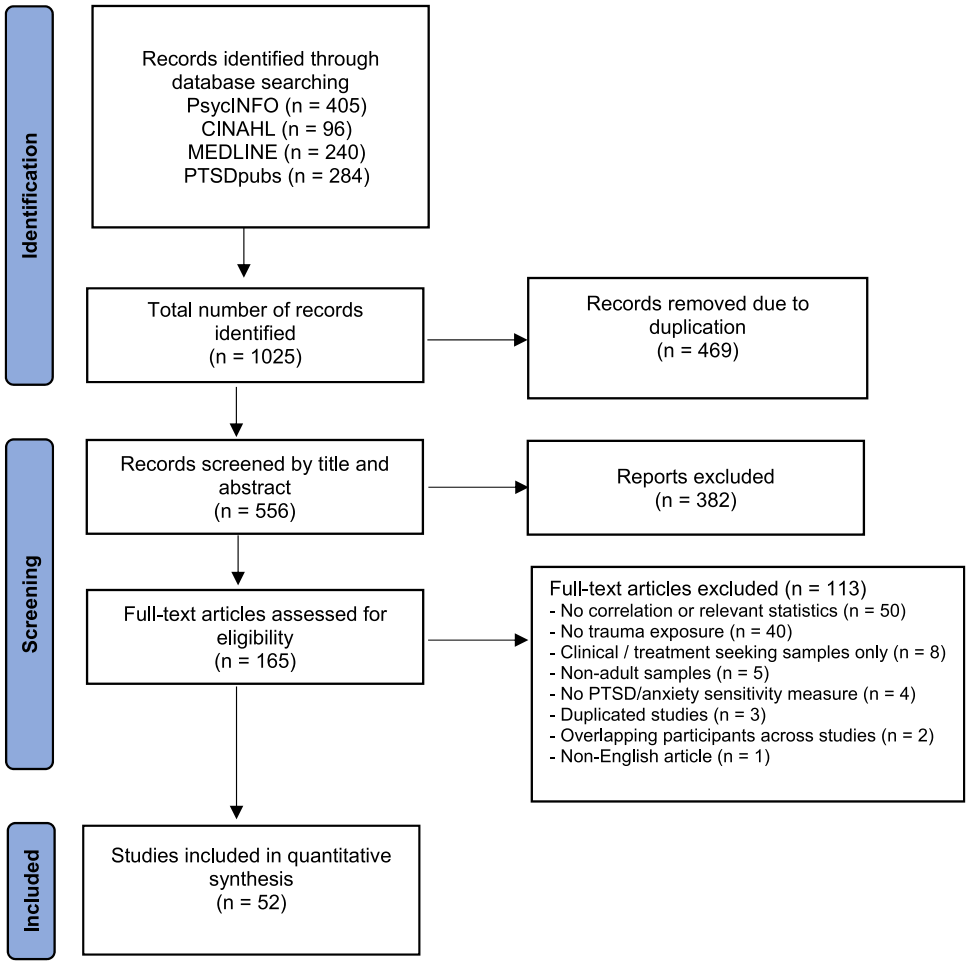

Fig. 1. PRISMA flow chart.

3.2. Study characteristics

Table 1 shows the characteristics of the 52 studies that were included in this review. The studies were published between 1998 and 2023 across the United States ($k = 39$), Canada ($k = 5$), the United Kingdom ($k = 2$), the Netherlands ($k = 2$), Australia ($k = 1$), Denmark ($k = 1$), Israel ($k = 1$) and Spain ($k = 1$). These studies comprised 15,453 adults in total. Participants' age ranged from 18 to 77. Approximately 54.48% were female ($n = 8418$). The sample exhibited substantial ethnic diversity, with participants from such ethnic groups as American Indian or Alaska Native, Asian, Black or African American, Native Hawaiian or Other Pacific Islander and White. Eight studies focused on interpersonal trauma (e.g., sexual assault), 10 focused on non-interpersonal trauma (e.g., motor vehicle accidents) and 34 focused on both types. Most studies took place after the acute stress period (i.e., four weeks after the trauma; $k = 45$), whereas seven studies were conducted within the acute stress period. The majority of the studies were cross-sectional in nature ($k = 45$) and the remaining were longitudinal ($k = 7$). All studies employed well-validated measures of PTSD and anxiety sensitivity.

3.3. Quality assessment

All 52 studies were evaluated using our quality assessment framework, where higher scores indicated higher study quality. Given a maximum score of 4, one study received a score of 0, four studies received a score of 1, 29 studies obtained a score of 2, 13 studies obtained a score of 3 and five studies achieved the maximum score of 4. Inter-rater reliability was computed for the ratings of 25% of all studies, yielding an agreement rate of 100%. Table S3 shows the rating details for each study.

3.4. Meta-analyses

A random-effects meta-analysis of 52 studies indicated a moderate effect size for the relationship between anxiety sensitivity and PTSD, $r = .46$, 95% CI = .41,.50. The 95% prediction interval was.15,.68. Estimates of heterogeneity suggested significant variance across the studies, $Q = 430.76$, $df = 51$, $p < .001$, $I^2 = 89.4\%$. A forest plot of all effect sizes and confidence intervals from each study is shown in Fig. 2.

A regression test for funnel plot asymmetry indicated no publication bias ($z = -.32$, $p = .75$). However, a trim-and-fill analysis estimated that there were potentially 11 missing studies ($SE = 4.76$) on the right side of the funnel plot. After adjusting for these potentially missing studies, the random-effects meta-analysis, which now includes a total of 63 studies, suggested an effect size of $r = .51$, 95% CI = .46,.55 (95% prediction interval is.13,.76). Estimates of heterogeneity remained high, with $Q = 804.81$, $df = 62$, $p < .001$, $I^2 = 93.1\%$. A funnel plot of standard errors by Fisher's Z for overall effect size is shown in Fig. 3.

3.5. Moderator and subgroup analyses

Results of moderator and subgroup analyses are displayed in Table 2. The size of relationship between anxiety sensitivity and PTSD was not moderated by type of PTSD measure used (interviews versus questionnaires), trauma type (non-interpersonal versus interpersonal) or study quality (high versus low). The same applied to study quality when

Table 1
Characteristics of studies included in the meta-analyses.

Article	Study design	Trauma event	Trauma type	Time since trauma	Sample size	Mean Age (SD)	Age range	Female (%)	Race / Ethnicity / Place of Birth	Country of study	PTSD measure	Measure type
Abrams (2008)	Cross-sectional	mixed	both	mixed	249	30.44 (11.24)	18-65	85	87% Ca, 5% first nations, 0.4% African, 0.2% Asian, 0.4% South Asian, 0.8% His, 3.2% Other	Canada	PCL-C	questionnaire
Albanese et al. (2018)	Cross-sectional	mixed	both	mixed	670	36.76 (13.04)	18-77	69.60	7.8% Ca, 6.3% African American, 2.8% Asian, 0.6% AIA, 0.1% HPI, and 2.4% Other	US	PCL-C	questionnaire
Amir et al. (2002)	Cross-sectional	mixed	both	mixed	36	37.33 (10.12)	NR	50	NR	US	PSS	interview
Arbona et al. (2022)	Cross-sectional	mixed	both	mixed	346	22.33 (4.44)	18-46	100	NR	US	PCL-5	questionnaire
Armstrong et al. (2021)	Cross-sectional	combat exposure	non-interpersonal	mixed	51	31.58 (7.63)	NR	5	74.5% White, 11.7% Black, 7.8% Latino, 1.9% Asian, 1.9% Multiracial, 2% Other	US	PCL (military)	questionnaire
Asmundson et al. (1998)	Cross-sectional	accidents, physical trauma	non-interpersonal	mixed	121	34 (12)	NR	38.60	NR	Canada	MPSS	questionnaire
Asmundson et al., 2008	Cross-sectional	mixed	non-interpersonal	mixed	138	39.8 (9.2)	NR	70.70	NR	Canada	PCL-C	questionnaire
Babson et al. (2012)	Cross-sectional	sexual assault, physical assault	interpersonal	mixed	46	27.54 (13.62)	NR	100	NR	US	CAPS	interview
Article	Study design	Trauma event	Trauma type	Time since trauma	Sample size	Mean Age (SD)	Age range	Female (%)	Race / Ethnicity / Place of Birth	Country of study	PTSD measure	Measure type
Badour et al. (2012)	Cross-sectional	sexual assault, physical assault	interpersonal	mixed	49	28.37 (13.86)	18-67	100	8.2% His, 87.8% Ca, 2.0% African American, 2.0% AIA, 6.1% Multi-racial, 2.0% Other	US	CAPS	interview
Bardeen & Fergus (2016)	Cross-sectional	mixed	both	mixed	903	36.06 (11.63)	19-65	67.60	83% White, 7% Black, 5% Asian, 1% AIA, 4% Other	US	PCL-5	questionnaire
Berenz et al. (2012)	Cross-sectional	mixed	both	mixed	88	22.9 (9.1)	18-62	63.60	6.5% Ca, 1.2% HL, 1.2% Asian, and 1.2% Biracial/Other	US	CAPS	interview
Bernstein et al. (2005)	Cross-sectional	mixed	both	mixed	254	20.8 (5.2)	NR	54	87% Ca, 6% African American, 3% Asian American, 1% His, 3% Other	US	PDS	questionnaire
Boelen (2019)	Longitudinal	mixed	both	mixed	193	21.3 (2.0)	NR	89.60	NR	Netherlands	PSS-SR	questionnaire
Brandt et al. (2015)	Cross-sectional	mixed	both	mixed	103	48.33 (9.34)	19-68	18.40	44.7% White/Ca, 28.2% Black, 17.5% His, 3.9% American, 3.9% Mixed, 1% French, and 1% West Indian	US	PDS	questionnaire
Cobb et al. (2017)	Cross-sectional	mixed	non-interpersonal	mixed	161	NR	19-25	19.87	18% HL, 72.7% Ca, 11.8% American, 9.9% African American, 5.6% Asian	US	PCL-short	questionnaire
Elwood (2008)	Longitudinal	sexual assault	interpersonal	mixed	89	20.69 (2.7)	NR	100	86.5% Ca	US	PPTS-R	questionnaire
Engelhard et al. (2001)	Cross-sectional	combat exposure	non-interpersonal	mixed	30	53.00 (3.04)	NR	0	NR	US	PSS-SR	questionnaire
Article	Study design	Trauma event	Trauma type	Time since trauma	Sample size	Mean Age (SD)	Age range	Female (%)	Race / Ethnicity / Place of Birth	Country of study	PTSD measure	Measure type
Engelhard et al. (2011)	Longitudinal	war exposure	non-interpersonal	6 months after deployment	138	24 (4.9)	NR	0	NR	Netherlands	PSS	questionnaire

(*continued on next page*)

Table 1 (*continued*)

Article	Study design	Trauma event	Trauma type	Time since trauma	Sample size	Mean Age (SD)	Age range	Female (%)	Race / Ethnicity / Place of Birth	Country of study	PTSD measure	Measure type
Feldner et al. (2006)	Cross-sectional	mixed	both	mixed	61	21.15 (5.16)	NR	62.30	88% White, 5% African American, 3% Asian American, 1% Other	US	PDS	questionnaire
Feldner et al. (2008)	Cross-sectional	mixed	both	mixed	78	24.38 (10.51)	18-61	75.60	96.7% Ca	US	PDS	questionnaire
Fetzner et al. (2012)	Cross-sectional	mixed	both	mixed	311	30.2 (10.9)	NR	72	88% Ca	Canada	PCL-C	questionnaire
Haas et al. (2019)	Cross-sectional	mixed	both	mixed	122	22.98 (5.84)	18-42	77.70	100% Black	US	PCL-C	questionnaire
Hansen et al. (2014)	Longitudinal	bank robbery	non-interpersonal	10 days, 6 months	450	42.26 (12.54)	19-65	60.90	NR	Denmark	HTQ	questionnaire
Hashoul-Andary et al. (2016)	Cross-sectional	forest fire	non-interpersonal	< 1 month	151	27.73 (10.03)	NR	76.80	84.8% Israel, 7.9% Former Soviet Union, 2.6% North America, 1.3% Eastern Europe, 1.3% Asia, 0.7% Central and South America, and 1.3% no country of origin	Israel	PDS	questionnaire
Hiller et al. (2016)	Cross-sectional	MVA	non-interpersonal	< 1 month	88	NR	NR	89.50	37.5% Ca, 62.1% minority	UK	PDS	questionnaire
Horswill et al. (2021)	Cross-sectional	mixed	both	mixed	500	NR	NR	20	88.6% White, 6.4% first nations, 0.2% Black, 0.2% Asian, 4.2% Other	Canada	PCL-5	questionnaire
Article	Study design	Trauma event	Trauma type	Time since trauma	Sample size	Mean Age (SD)	Age range	Female (%)	Race / Ethnicity / Place of Birth	Country of study	PTSD measure	Measure type
Lang et al. (2002)	Cross-sectional	IPV	interpersonal	mixed	42	32.8 (10.3)	18-57	100	56% Ca, 15% African-American, 15% His, 14% Other	US	CAPS	interview
Lebeaut et al. (2020)	Cross-sectional	mixed	both	mixed	652	38.7 (8.57)	NR	6.70	77.8% White, 25.9% HL, 10.9% Black/African American, 7.7% Others, 1.8% AIA, 1.7% Asian, 0.2% HPI	US	PCL-5	questionnaire
Lehman & Cheung (2002)	Cross-sectional	mixed	both	mixed	59	49 (36–64)	NR	1.70	59.2% White, 20% Black, 15% His, 2.5% Asian, 0.8% American	US	PCL	questionnaire
Marshall et al. (2010)	Longitudinal	mixed	both	9 days, 6 months	677	33.31 (11.72)	36-64	Approx. 75%	48.7% His, 25.3% non-His Ca, 19.9% African American, 6.1% Other	US	PCL	questionnaire
McGrew et al. (2023)	Cross-sectional	assault	interpersonal	mixed	288	23.3 (5.4)	NR	100	84.1% US/territories, 15.9% outside US	US	PCL-5	questionnaire
Medina et al. (2011)	Cross-sectional	mixed	both	mixed	114	22.31 (8.89)	NR	50.80	89.5% White/non-His	US	PDS	questionnaire
Nillni et al. (2014)	Cross-sectional	mixed	both	mixed	63	21 (6.1)	18-46	100	93.7% Ca, 1.6% Asian, 1.6% HL, 1.6% Biracial	US	CAPS	interview
Nixon et al., 2003	Cross-sectional	non-sexual assault, MVA	both	< 1 month	30	28.2 (9.32)	NR	50	NR	Australia	ASDI	interview
Article	Study design	Trauma event	Trauma type	Time since trauma	Sample size	Mean Age (SD)	Age range	Female (%)	Race / Ethnicity / Place of Birth	Country of study	PTSD measure	Measure type
Oglesby et al. (2016)	Cross-sectional	campus shooting	non-interpersonal	mixed	50	18.22 (0.58)	17-20	78	82% Ca, 8% African American, 2% Asian, 8% NR	US	PCL-C	questionnaire
Paltell et al. (2019)	Cross-sectional	mixed	both	mixed	836	36.24 (8.65)	NR	5.40	75.4% White, 12.8% Black/African American, 1.4% Asian, 0.2% HPI, 1.7% AIA, 8.5% Other	US	PCL-5	questionnaire
Paulus et al. (2018)	Cross-sectional	mixed	both	mixed	787	38.6 (8.6)	NR	0	75.7% White, 25.8% HL, 12.1% Black/African American, 8.8% Other, 1.7% Asian, 0.1% HPI, 1.7% AIA	US	PCL-5	questionnaire
Ranney et al. (2020)	Cross-sectional	mixed	both	mixed	836	38 (9)	NR	6.1	75.4% White, 25.7% HL, 12.8% Black/African American, 1.4%	US	PCL-5	questionnaire

(*continued on next page*)

Table 1 (*continued*)

Article	Study design	Trauma event	Trauma type	Time since trauma	Sample size	Mean Age (SD)	Age range	Female (%)	Race / Ethnicity / Place of Birth	Country of study	PTSD measure	Measure type
									Asian, 0.2% HPI, 1.7% AIA. 8.5% Other			
Raudales et al. (2021)	Cross-sectional	sexual assault	interpersonal	mixed	500	34.54 (10.52)	18-76	45.6	79% White, 12.2% African American/Black, 6.6% Asian, 1.4% AIA, 0.4% HPI, 0.6% NR	US	PCL-5	questionnaire
Ruiz-Párraga & López-Martínez (2014)	Cross-sectional	mixed	both	mixed	229	45.5 (11.9)	32-60	71.2	NR	Spain	DTS	questionnaire
Short et al. (2020)	Longitudinal	sexual assault	interpersonal	6 week	48	27.89 (10.57)	18-60	100	58.3% White, 18.8% AIA, 6.3% Asian, 14.6% Black/African American, 22.9% Other	US	PCL-5	questionnaire
Article	Study design	Trauma event	Trauma type	Time since trauma	Sample size	Mean Age (SD)	Age range	Female (%)	Race / Ethnicity / Place of Birth	Country of study	PTSD measure	Measure type
Stanley et al. (2017)	Cross-sectional	mixed	both	mixed	254	37.66 (9.40)	19-58	100	93.3% White/Ca, 2.4% Black/African American, 1.2% HL, 0.4% API, 0.8% AIA, and 2.0% Other	US	PCL-5	questionnaire
Stephenson et al. (2009)	Cross-sectional	campus shooting	Interpersonal	< 1 month	1045	NR	NR	100	91% non-His, 68% White, 20% Black/ African American	US	DEQ	questionnaire
Testa (2008)	Cross-sectional	mixed	both	mixed	135	19.12 (2.32)	17-35	78	NR	US	PDS-R	questionnaire
Viana et al. (2017)	Cross-sectional	mixed	both	mixed	183	37.7 (10.7)	NR	88.5	56.3% Mexican/Mexican American, 29.0% Central American, 5.5% South American, 4.4% American/Born in America, 2.2% Cuban, 2.7% Other	US	PDS	questionnaire
Vujanovic et al. (2013)	Cross-sectional	mixed	both	mixed	190	25.3 (11.4)	18-62	52.6	93.0% White/Ca, 1.6% Black/African-American, 1.6% HL, 1.1% Asian, 1.1% biracial, 1.6% Other	US	PDS	questionnaire
Wild et al. (2016)	Longitudinal	mixed	both	every 4 months for 2 years	453	30.31 (7.69)	NR	41.7	89.2% Ca, 2.4% Black, 0.7% Indian/ Pakistani/Bangladeshi, 7.5% Other, 0.2% NR	UK	SCID	interview
Zahradnik et al. (2009)	Cross-sectional	mixed	both	< 1 month	677	33.3 (11.7)	NR	22	48.7% His, 25.3% Black, 19.9% Ca, 6.1% API or American Indian	US	PCL	questionnaire
Zoellner et al. (2009)	Cross-sectional	mixed	both	mixed	105	31.58 (12.02)	NR	100	NR	US	PDS	questionnaire
Article	Study design	Trauma event	Trauma type	Time since trauma	Sample size	Mean Age (SD)	Age range	Female (%)	Race / Ethnicity / Place of Birth	Country of study	PTSD measure	Measure type
Zvielli et al. (2012)	Cross-sectional	mixed	both	mixed	103	23.68 (9.55)	18-62	64.1	91.3% White/Ca, 1.9% Asian, 1.9% HL, 1% Biracial, 2.9% NR	US	CAPS	interview
Zvolensky et al. (2018)	Cross-sectional	mixed	both	mixed	1377	21.01 (2.5)	18-29	76.7	NR	US	PDS	questionnaire
Zvolensky et al. (2020)	Cross-sectional	mixed	both	mixed	294	37.79 (10.85)	18-63	71.4	73.1% White/Ca, 9.5% HL, 6.5% Black/ African American, 3.4% Multiracial, 2.7% API, 2% AIA, 2.8% Other	US	PDS	questionnaire

Notes: AIA = American Indian/Alaskan Native, ASDI = Acute Stress Disorder Interview, CAPS = Clinician-Administered PTSD Scale, DEQ = Distressing Events Questionnaire, DTS = Davidson Trauma Scale, HTQ = Harvard Trauma Questionnaire, His = Hispanic, HPI = Native Hawaiian/ Pacific Islander, IPV = intimate partner violence, MPSS = Modified PTSD Symptom Scale, MVA = motor vehicle accidents, NG = not given, NR = not reported, PCL = Posttraumatic Stress Disorder Checklist, PCL-5 = Posttraumatic Stress Disorder Checklist for DSM-5, PCL-C = Posttraumatic Stress Disorder Checklist - Civilian, PDS = Posttraumatic Diagnostic Scale, PPTS-R = Purdue PTSD Scale-Revised, PSS = PTSD Symptom Scale, PSS-SR = Posttraumatic Symptom Scale Self Report Version, SCID = Structured Clinical Interview for the Diagnostic and Statistical Manual of Mental Disorders, fourth edition.

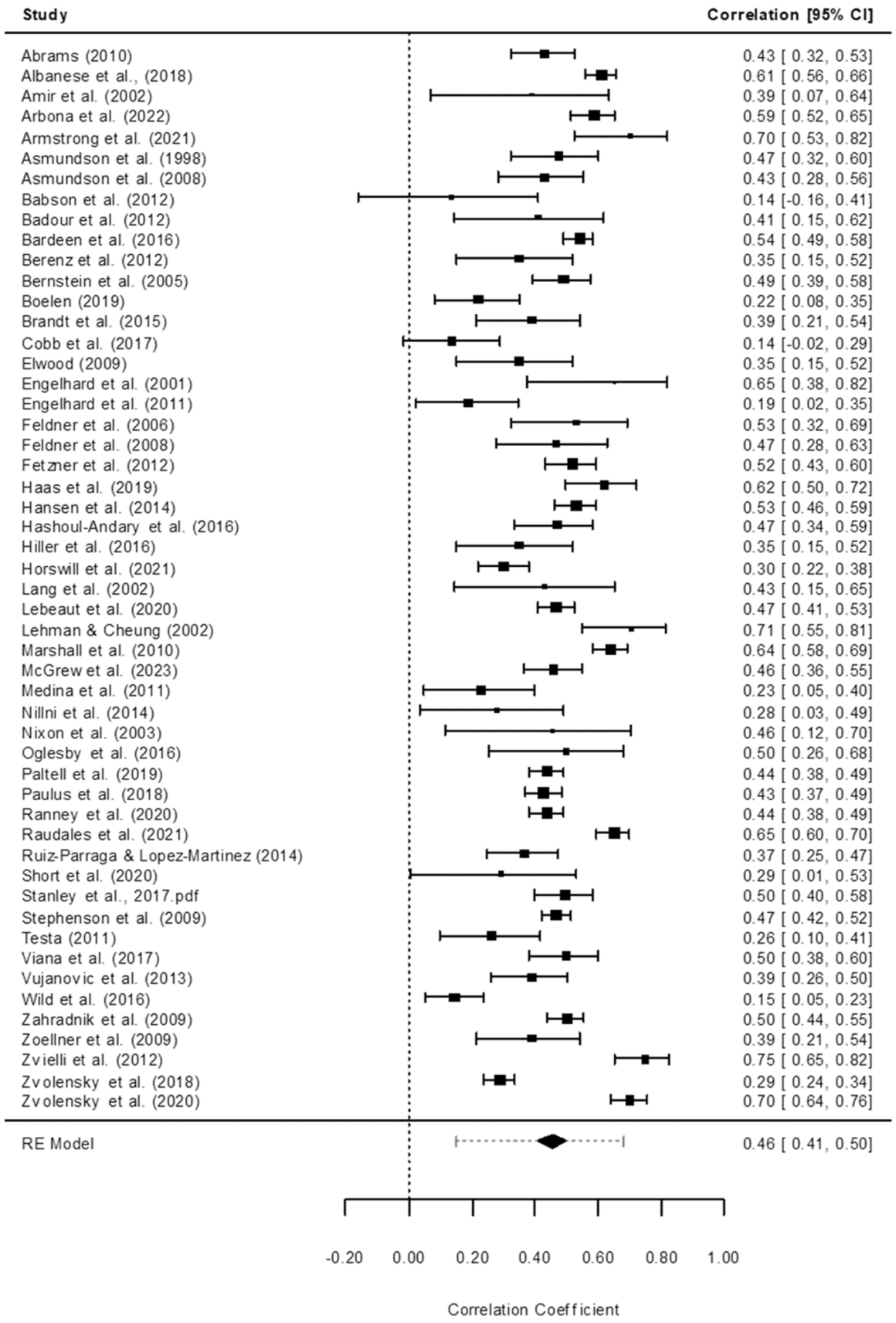

Fig. 2. Forest plot. **Note**: A random-effects meta-analysis of 52 studies indicated a moderate effect size for the relationship between anxiety sensitivity and PTSD, $r = .46$, 95% CI = .41,.50. The 95% prediction interval was.15,.68. Estimates of heterogeneity suggested significant variance across the studies, $Q = 430.76$, $df = 51$, $p < .001$, $I^2 = 89.41\%$.

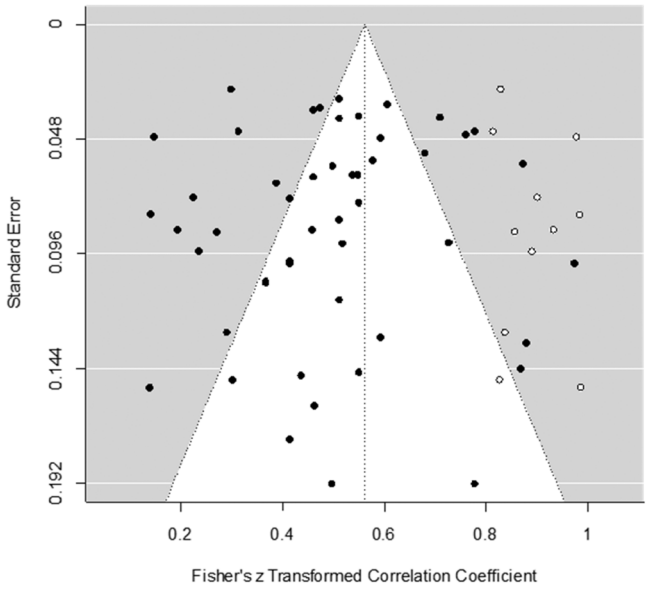

Fig. 3. Funnel plot. **Note**: A regression test for funnel plot asymmetry indicated no publication bias ($z = -.32$, $p = .75$). The trim-and-fill analysis estimated that there were potentially 11 missing studies ($SE = 4.76$) on the right side of the funnel plot. After adjusting for these potentially missing studies, the random-effects meta-analysis, which now includes a total of 63 studies, suggested an effect size of $r = .51$, 95% CI = .46,.55. The 95% prediction interval is.13,.76. Estimates of heterogeneity remained high, with $Q = 804.81$, $df = 62$, $p < .001$, $I^2 = 93.07\%$.

entered as a continuous measure (see Fig. S1 for moderation plot). Where data allowed, a sensitivity analysis was conducted on those studies in which participants with a PTSD diagnosis (based on a structured interview) were compared to trauma-exposed participants without a PTSD diagnosis (k = 5, n = 540). A large effect size was found, Hedges' g = .61, 95% CI = .27,.94. No sign of heterogeneity was indicated, Q = 6.09, df = 4, p = .19, I^2 = 36.9% (see Fig. S2).

Study design was a moderator of this relationship, with cross-sectional studies yielding a stronger relationship (r = .47) than longitudinal studies (r = .34). While each subgroup yielded statistically significant effect sizes, heterogeneity remained pronounced; nevertheless, in most instances the prediction interval did not cross the line of no effect.

We could not undertake our planned moderator analysis on country (i.e. high income versus low and mid income country) as the included studies were overwhelmingly from high income countries (50 of 52).

4. Discussion

This review examined the strength of the relationship between anxiety sensitivity and PTSD symptoms/diagnosis among trauma-exposed adults. Our findings indicated a positive relationship between anxiety sensitivity and PTSD, measured in terms of both PTSD severity levels (i.e. questionnaires), and when comparing adults with a PTSD diagnosis (based on a structured interviews) with trauma-exposed adults without a PTSD diagnosis. Based on the data of 52 empirical studies published between 1998 and 2023 (n = 15173), a medium effect size (r = .46) was detected. While there was significant between-study heterogeneity, prediction intervals suggested that the effect was robust.

This pooled effect size is comparable to the findings of previous meta-analyses (e.g. Olatunji and Wolitzky-Taylor, 2009; Naragon-Gainey, 2010), though slightly weaker than that found by Gómez de La Cuesta et al. (2019) which meta-analysed the relationship between PTSD and various trauma appraisals. In any case, the association between anxiety sensitivity and PTSD appeared to be significantly stronger than that between PTSD and psychosocial factors / event-related factors (Brewin et al., 2000; Ozer et al., 2003). With reference to our moderator analyses, the relationship between anxiety sensitivity and PTSD was unaffected by PTSD measures (interviews versus questionnaires), trauma types (interpersonal versus non-interpersonal) and study quality (high versus low). Whilst the effect size was weaker in longitudinal studies than in cross-sectional studies, the difference was not substantial (i.e. a medium effect size was found in both subgroups). This suggests that anxiety sensitivity has a longitudinal as well as a cross-sectional relationship with PTSD.

The current findings are consistent with cognitive models of PTSD. According to Ehlers and Clark (2000)'s model, PTSD could be conceptualised as a sense of current threat maintained by maladaptive appraisals of trauma and its sequelae. Elevated anxiety sensitivity may constitute a vulnerability factor that intensifies maladaptive trauma appraisals, in particular those related to anxiety sensations. By way of illustration, people with high anxiety sensitivity may interpret their own reactions to trauma (e.g. pounding heart, racing thoughts) in catastrophic ways (e.g. "I am having a heart attack", "I am going crazy"). This may amplify their anxiety levels, create a sense of ongoing threat and consequently increase the risk of developing PTSD.

Moreover, anxiety sensitivity could influence PTSD through the increased use of maladaptive cognitive and behavioural strategies. Due to their aversion to anxiety and arousal-related sensations, individuals with elevated anxiety sensitivity may be more likely to engage in cognitive avoidance, selective attention to threat cues and safety-seeking behaviours (Wilson & Hayward, 2006). Whilst these strategies may reduce anxiety in the short term, they tend to prevent changes in trauma appraisals and trauma memory, thereby maintaining PTSD symptoms in the long term (Ehlers & Clark, 2000; Beck & Haigh, 2014;

Table 2
Moderator and subgroup analysis.

Moderator/subgroup	k	N	Pooled effect size (r)	95% CI	95% PI	Q	I^2 (%)	Moderation effect
Overall	52	15453	.46	.41,.50	.15,.68	430.76***	89.4	
PTSD measure								p = .22
Interview	9	910	.39	.22,.53	-09,.72	60.27***	81.7	
Questionnaire	43	14342	.47	.42,.51	.19,.67	341.06***	89.0	
Study design								p = .04
Cross-sectional	45	13405	.47	.43,.51	.20,.68	306.60***	87.5	
Longitudinal	7	1768	.34	.18,.48	-.09,.67	103.05***	91.2	
Trauma type								p = .70
Non-interpersonal	10	1378	.44	.33,.54	.08,.70	45.90***	81.5	
Interpersonal	8	2107	.44	.32,.54	.12,.67	41.67***	84.1	
Study quality (BD)								p = .50
Low	34	8576	.47	.42,.51	.20,.67	245.01***	85.0	
High	18	6676	.44	.35,.52	.05,.71	176.06***	93.7	
Study quality (CD)								p = .52

Notes: BD = Binary data, CD = Continuous data (0-4), CI = Confidence interval, PI = Prediction interval, * ** = p < .001.

Dunmore et al., 1999; Paunovic, 1998).

It is also possible for anxiety sensitivity to influence PTSD indirectly through panic attacks. Research has found that both peritraumatic and posttraumatic panic attacks were predictive of PTSD (Boscarino & Adams, 2009; Nixon & Bryant, 2003). As mentioned above, anxiety sensitivity is a strong predictor of panic disorder (Donnell & McNally, 1990; Li & Zinbarg, 2007; McNally, 2002; Poletti et al., 2015). Hence, it may be that anxiety sensitivity predisposes one to experiencing panic attacks during and after a traumatic event, which in turn increases one's susceptibility to PTSD.

That said, in light of the predominantly correlational nature of our findings, causality between anxiety sensitivity and PTSD remains unclear. Rather than anxiety sensitivity being a pre-trauma vulnerability factor for PTSD, it is plausible that experiences of trauma contribute to both elevated anxiety sensitivity and PTSD (Taylor, 2003). In other words, a particular stressor might have induced not only PTSD symptoms, but also a propensity to fear all stimuli associated with the stressor (including anxiety-related body sensations) through the process of associative learning (Bouton et al., 2018). The latter may result in an inflation of anxiety sensitivity, which may then go on to reinforce PTSD through the aforementioned cognitive mechanisms. Nevertheless, the present review did find robust evidence of a longitudinal effect of anxiety sensitivity on PTSD.

4.1. Clinical implications

Given the positive association between anxiety sensitivity and PTSD, anxiety sensitivity level could help inform the screening of at-risk individuals. Tools such as the ASI-3 – the most recent version of the ASI – could be used to assess those with trauma exposure. This is irrespective of whether the trauma is interpersonal or non-interpersonal in nature, as trauma types was not found to influence the size of the anxiety sensitivity-PTSD relationship. For those assessed to have high risks of developing PTSD, brief intervention around anxiety sensitivity, such as psychoeducation on anxiety and its functions, might be a useful preventative measure. For example, Vujanovic et al. (2012) tested the effectiveness of single-session anxiety sensitivity reduction program which involved four components: 1) psychoeducation on PTSD and panic disorder symptoms, 2) cognitive and acceptance-based techniques, 3) interoceptive exposure and 4) ongoing use and review of situational exposure. This was then found to prospectively reduce trauma symptom development among trauma-exposed adults.

Further, for those diagnosed with PTSD, anxiety sensitivity could similarly serve as a target for treatment given its malleability (Keough & Schmidt, 2012; Schmidt et al., 2014). Specifically, intervention may incorporate interoceptive exposure, mindful awareness of bodily sensations and behavioural experiments around the effects of anxiety, all of which are shown to address elevated anxiety sensitivity (Keough & Schmidt, 2012; Schmidt et al., 2014). Given the trait-like nature of anxiety sensitivity, this mechanism may be an important pre-trauma vulnerability factor that could be addressed in groups who have high exposure to trauma (e.g. first responders, armed service personnel).

4.2. Strengths, limitations and future research directions

The present review is strengthened by the inclusion of a large number of studies (k = 52), homogeneity of anxiety sensitivity measure (i.e. ASI-3) and preregistration of protocol which helped reduce bias and increase transparency (Stewart et al., 2012). Alongside cross-sectional studies, longitudinal studies were included in our review. This provided valuable insights around directionality (i.e. anxiety sensitivity is likely to have an impact on PTSD). Furthermore, race/ethnicity was sufficiently diverse in our samples with a range of American Indian or Alaska Native, Asian, Black or African American and Hispanic or Latino individuals. This increased the generalisability of our findings to various cultural contexts.

The review is however not without flaws. First, most of the included studies were conducted in high income countries. It remained unclear to what extent the present findings could be generalised to developing countries where trauma exposure is potentially higher. Second, the majority of studies examined PTSD in the context of single traumatic events. It was not certain whether anxiety sensitivity is equally correlated with PTSD among individuals with complex trauma such as child abuse. Third, as most of our moderator analysis findings were insignificant, we were unable to identify mechanisms through which anxiety sensitivity might affect PTSD.

To fill the above knowledge gaps, future studies could examine the relationship between PTSD and anxiety sensitivity in the context of developing countries where both the quantity and types of trauma may be different. For example, warfare and political violence tend to be a more common source of trauma in Third World countries (Hoppen et al., 2021; Masinda & Muhesi, 2004), and populations such as refugees are currently understudied. Research could also be conducted on individuals with complex trauma history such as abuse and maltreatment. Moreover, more longitudinal studies could be carried out to better elucidate the role of anxiety sensitivity in PTSD over time and the factors that might account for this. Such attempts may help create a more nuanced understanding of when and under what circumstances anxiety sensitivity might have an impact on PTSD and correspondingly constitute an effective intervention target.

4.3. Conclusion

The current review indicated a medium effect size for the relationship between anxiety sensitivity and PTSD symptoms among trauma-exposed adults. This corroborated cognitive models of PTSD and has significant clinical implications in terms of the assessment, prevention and treatment of the condition.

CRediT authorship contribution statement

Richard Meiser-Stedman: Conceptualization, Formal analysis, Investigation, Methodology, Supervision, Writing – review & editing. **Angel Hiu Tung Chan:** Data curation, Project administration. **Debbie Chi Wing Low:** Data curation, Project administration. **Henry Tak Shing Chiu:** Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Project administration, Writing – original draft, Writing – review & editing, Resources, Visualization.

Declaration of Competing Interest

None

Appendix A. Supporting information

Supplementary data associated with this article can be found in the online version at doi:10.1016/j.janxdis.2024.102857.

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