

REVIEW ARTICLE

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Psychotherapy for PTSD – a scoping review of how change during treatment has been studied

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ABSTRACT

Background: Posttraumatic Stress Disorder (PTSD) treatment shows 40% of non-response rate despite the efficacy of evidence-based psychotherapies like Prolonged Exposure (PE), and Cognitive Processing Therapy (CPT). Understanding how PTSD symptoms change during treatment, and the mechanisms that precede, mediate, or moderate these changes, is essential for improving interventions.

Objective: This systematic scoping review mapped how changes in PTSD have been studied during psychotherapy between 2000 and 2023, focusing on (1) research objectives, (2) PTSD conceptualization, (3) covariates and mechanisms included, (4) repeated measurement timing and frequency, and (5) statistical modelling of change.

Methods: Following PRISMA guidelines, we searched scientific databases for English- and Spanish-language peer-reviewed studies. Eligible studies included adults diagnosed with PTSD, examined evidence-based psychotherapies, and incorporated at least three repeated in-treatment assessments. Excluded were pharmacological trials, case studies, and non-empirical articles. After a three-phase screening, 115 studies met inclusion criteria. Data were extracted on research objectives, measurements, demographics, and analytic methods, and summarized using descriptive statistics.

Results: Most studies were conducted in the United States (82%) involving veterans or active military (50%). PE (50%) and CPT (31%) dominated the treatment landscape. A total of 207 research objectives were identified, grouped into 16 categories. The most frequent were temporal precedence, time-stable predictors, and identification of change trajectories. PTSD and depression were the most frequently measured constructs (83%), typically assessed session-by-session with an average of nine repeated measurements, aligned with protocol duration. Multilevel regression modelling was the predominant analytic strategy (48%).

Conclusions: Future research should state causal aims openly and base measurement on theory and evidence rather than tradition. Exploratory studies are needed to build an accurate understanding of the timing of PTSD change. Crucially, no studies used ecological momentary assessment, and samples show limited generalizability. Finally, research efforts significantly increased since 2010, evidencing the importance of this type of research.

Psicoterapia para el TEPT: una revisión de alcance de cómo ha sido estudiado el cambio durante el tratamiento

Antecedentes: El tratamiento del Trastorno de Estrés Postraumático (TEPT) muestra que el 40% de los pacientes no responde, a pesar de la eficacia de las psicoterapias basadas en evidencia como la Exposición Prolongada (EP) y la Terapia de Procesamiento Cognitivo (TPC). Comprender cómo cambian los síntomas del TEPT durante la intervención y los mecanismos que preceden, median o moderan dichos cambios es esencial para mejorar el tratamiento.

Objetivo: Esta revisión sistemática de alcance mapeó cómo se han estudiado los cambios en el TEPT durante psicoterapia entre 2000 y 2023, centrándose en (1) objetivos de investigación, (2) conceptualización del TEPT, (3) covariables y mecanismos incluidos, (4) rango y frecuencia de mediciones repetidas, y (5) modelado estadístico del cambio.

Métodos: Siguiendo las directrices PRISMA, se buscó en bases de datos científicas relevantes artículos revisados por pares publicados en inglés o español. Se incluyeron estudios con adultos diagnosticados con TEPT que examinaban psicoterapias basadas en evidencia e incorporaban al menos tres medidas repetidas durante el tratamiento. Se excluyeron ensayos farmacológicos, estudios de caso y artículos no empíricos. Tras una fase de tamizaje

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HIGHLIGHTS

- Temporal precedence of PTSD and explanatory mechanisms, along with time-stable moderators of change, is the most frequent research question in PTSD treatment change research.
- Measurement of PTSD change during treatment seems to be based on practical issues (protocol length) rather than theory or empirical considerations.
- A clear conceptualization of change, along with adequate modelling, is necessary to answer the field's research questions.

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en tres etapas, 115 estudios cumplieron los criterios de inclusión. Se extrajeron datos sobre objetivos de investigación, mediciones, demográficos y métodos analíticos, y se resumieron mediante estadísticas descriptivas.

Resultados: La mayoría de los estudios realizados en Estados Unidos (82%), incluyendo a veteranos o militares activos (50%). La EP (50%) y la TPC (31%) dominaron el panorama terapéutico. Se identificaron 207 objetivos de investigación agrupados en 16 categorías amplias; los más frecuentes fueron precedencia temporal, predictores estables en el tiempo e identificación de trayectorias de cambio. El TEPT y la depresión fueron los constructos medidos con mayor frecuencia (83%), usualmente evaluados sesión a sesión con un promedio de nueve mediciones repetidas, alineadas con la duración de protocolos terapéuticos. Los modelos multilevel fueron la estrategia analítica predominante (48%).

Conclusiones: La investigación futura debe declarar abiertamente los objetivos causales y basar las mediciones en teoría y evidencia, no en tradición. Se requieren estudios exploratorios para construir una comprensión precisa de la temporalidad del cambio en el TEPT. Es crucial señalar que ningún estudio utilizó evaluación ecológica momentánea y que las muestras limitan la generalizabilidad. Finalmente, los esfuerzos investigativos aumentaron significativamente desde 2010, evidenciando la importancia de este tipo de investigación.

1. Introduction

Research on PTSD development and treatment has evolved as the scientific community has gained a better understanding of PTSD development, maintenance, and treatment over the years. Peleg and Shalev (2006) reviewed 25 years of longitudinal research from 1980 to 2005. Before the 2000s, studies mainly looked into risk factors and moderators for PTSD development, such as comorbidities, acute stress, and dissociation. In the 2000s, there was a shift towards examining trajectories of PTSD development and treatment response, identifying various clinical courses for PTSD, such as chronic PTSD, resilience, and remission (Berntsen et al., 2012; deRoos-Cassini et al., 2010; Solomon, 2006; Steinert et al., 2015).

Regarding remission rates, without treatment for PTSD, they range between 44% and 50% (Morina et al., 2014; Steinert et al., 2015). Remission following treatment remains stable after six to 12 months, with PTSD reduction showing small to moderate effect sizes for youth and moderate to large effect sizes for adults at follow-up (Gutermann et al., 2017; Kline et al., 2018; Weber et al., 2021). Long-term efficacy appears higher for trauma-focused and exposure-based treatments (Kline et al., 2018; Weber et al., 2021). While overall treatment effectiveness has been well established, a recent meta-analysis estimated the nonresponse rate for PTSD treatments to be 39% (Semmlinger et al., 2024), indicating a significant gap to meet the needs of patients.

The evident nonresponse to treatment has motivated research into trajectories of change during treatment, as well as moderators and mediators of treatment response. Early studies focused on how PTSD symptom clusters evolved in relation to the mechanisms targeted by interventions such as PE and CPT (Hackmann et al., 2004; Nishith et al., 2002; Taylor et al., 2003). Later research expanded to include symptom exacerbation

and sudden gains (Foa et al., 2002; Jun et al., 2013; Keller et al., 2014; Taylor et al., 2003), moderators such as comorbidities, trauma characteristics, cognitive mechanisms, and demographic variables (Gallagher & Resick, 2012; Luciano et al., 2022; Speckens et al., 2006; Szafranski et al., 2017), and mediation mechanisms such as negative cognition changes and habituation during exposure have also been explored (Ehlers & Clark, 2000; Foa et al., 2002; Gallagher & Resick, 2012; Hagenaars et al., 2010).

Furthermore, research on heterogeneous PTSD treatment responses using longitudinal latent class analysis has sought to explore and predict differences in treatment response (Galovski et al., 2016; Lin & Farber, 2021; Schmiede et al., 2018; J. A. Schumm et al., 2013). Another prolific area of research has focused on the psychological mechanisms that precede symptom change, such as the relationship between changes in trauma-related cognitions and subsequent changes in PTSD symptoms (Aderka et al., 2013; Gallagher & Resick, 2012; Hagenaars et al., 2010; Kleim et al., 2013). Collectively, these studies have contributed to a nuanced understanding of the patterns and mechanisms underlying change during treatment, employing diverse research questions, variables, designs, and methodologies. In the present study, we build on this body of work by examining how a range of research objectives (Table 2) – including direction, speed, and shape of change; temporal precedence; prediction of change; the impact of trajectories on treatment outcomes; sudden gains; and longitudinal latent classes, among others – have been addressed in terms of study design, measurement, and modelling approaches.

1.1. Current study objectives

The objective of the current systematic scoping review was to map research on PTSD change during

treatment conducted from 2000 to 2023; we sought to understand research practices rather than to provide an overview of effect sizes for treatment response or variable associations. Therefore, we sought to identify trends, limitations, and research gaps to inform future research directions. We investigated researchers' approaches regarding (1) research objectives, including temporal precedence, moderators of change, direction of change, sudden gains, among others (we identified 16 topics, Table 2). (2) PTSD conceptualization in terms of diagnosis, severity, or specific symptoms. (3) Biopsychosocial variables and comorbidities included as moderators or mediators of PTSD change. (4) We recorded repeated measurement choices regarding timing (frequency) and time frame (intended period of measurement, e.g. last week). Finally, (5) we identified the most frequently used modelling techniques to model change during treatment. By investigating these factors, we sought to, first, summarize how researchers in the field of psychotraumatology have approached the study of PTSD change during treatment, second, identify the gaps in our current understanding of treatment-induced change, third, provide a critical evaluation of implied assumptions guiding our field, and fourth, suggest avenues to move forward.

2. Methodology

2.1. Search strategy

Our systematic scoping review followed the PRISMA-ScR guideline (Preferred Reporting Items for Systematic Reviews and Meta-Analyses – Extension for Scoping Reviews). The review pre-registration is available in the supplemental materials. We searched English-language abstracts in the following databases: PubMed, PsycINFO, Embase, PTSDpubs, and Web of Science. We also conducted a search in the 'Portal Regional de la Biblioteca Virtual en Salud' (BVS) for abstracts of Spanish-language articles. We limited the search between January 2000 and December 2023. The search in these databases was conducted in a step-by-step process to identify studies focusing on evidence-based treatment for adults with PTSD that also included in-treatment repeated measurement. The search strings that were used to identify these studies across all databases are available in the supplemental materials. The results from the bibliographic search were processed using Rayyan (Ouzzani et al., 2016).

2.2. Inclusion criteria and selection of studies

Based on our objective of understanding research practices investigating change in PTSD symptomatology, the proposed inclusion criteria were: the study

had (a) a sample of adults (18 years or older), (b) participants diagnosed with PTSD or a probable diagnosis, (c) an objective focused on changes in PTSD during treatment, (d) at least one evidence-based intervention for PTSD (e.g. CPT, PE, EMDR), (e) use of a validated measure of PTSD, (f) only peer reviewed journal articles were considered, and (g) at least three assessments of PTSD or related measures (e.g. emotional distress) during treatment (i.e. baseline, at least one during treatment, and post-treatment); this criterion was included to increase the chances that studies focused on change during treatment. Additional exclusion criteria were: (a) case studies or pilots, (b) combined pharmacological treatment and psychotherapy without a psychotherapy-only arm, (c) studies not published in English or Spanish, (d) studies not focused specifically on PTSD, and (e) non-empirical studies. The full criteria are available in the supplementary materials.

The screening was conducted in two phases: title and abstract screening and full-text screening. The first phase was performed in two stages. Stage 1 focused on identifying PTSD treatment studies in the adult population, excluding case studies and publications that were not empirical studies. Stage 2 focused on identifying repeated measurements during treatment. Finally, phase 2 confirmed that at least one research objective focused on PTSD change during treatment, the number of measurements, type of treatment, measurements validity, and PTSD (probable) diagnosis. The full criteria screening is available in the supplementary materials. To conduct the screening process, six reviewers were trained on the selection criteria using a training set of 200 randomly selected abstracts. Two reviewers screened each article. Reviewers were not blinded to journal or author information, all discrepancies in the screening process were discussed and unified. A registry of decision inconsistencies is available in the supplementary materials.

2.3. Article categorization

Four researchers extracted data on the study structure, measurement, and demographics for further analysis. The study structure encompassed the extraction and categorization of objectives (hypothesis-based and exploratory), design (e.g. RCT), and treatments included. To categorize research objectives, we created predefined categories based on an initial set of 20 articles and iterated and refined them as needed. All the resulting categories are presented in Table 2. Measurement data extraction included: constructs measured repeatedly (e.g. PTSD, depression), measurement granularity (e.g. symptom severity, diagnosis), tool used, number of repeated measurements, and time resolution of measurements (e.g.

pre-mid-post, session-wise). Extraction of study characteristics included: comorbidities, type of trauma, study population (e.g. refugees), sample size, and country of the study. Additionally, the percentage of women, the mean age, and the majority ethnicity in the study were extracted. A full description of the data extraction and the final dataset are provided in the supplementary materials.

2.4. Data analysis

The extracted data were explored using descriptive statistics and graphical representations. For example, the frequency of type and classification of research objectives was calculated to build Table 2 as well as Figures 2 and 3. Multiple occurrences of research objectives, types of treatment, measurement characteristics (e.g. number of measurements, measurement used), and types of analysis could happen in a single study; therefore, all were recorded, which means that there are more research objectives ($n = 207$) than studies ($n = 115$). However, for variables such as date, country of the study, n of the study, gender, and ethnicity only one statistic was captured (e.g. the highest percentage reported by gender). These analyses were conducted using R (version 4.2.2., R Core Team, 2022). The code for data analysis is provided in the supplementary materials.

3. Results

3.1. Study selection

As shown in Figure 1, our initial search of bibliographic datasets yielded 23,452 registries: PubMed ($n = 5,462$), PsycINFO ($n = 6,651$), Embase ($n = 6,051$), PILOTS ($n = 3,188$), and Web of Science ($n = 2,100$). Bibliographic data were processed using Rayyan (Ouzzani et al., 2016). The combined dataset included 16,563 duplicated registries; after deduplication, the resulting dataset included 11,086 unique registries (a detailed explanation is presented in supplementary materials). We removed books, theses, and preprints using Rayyan filters, resulting in 9,742 registries to be screened. For phase one of screening, the stage 1 abstract screening resulted in 1,383 inclusions, and the stage 2 abstract screening yielded 297 inclusions. Full-text screening resulted in 115 articles for data extraction. No articles in Spanish were included since none met the inclusion criteria during abstract screening.

3.2. Study characteristics

Most studies were conducted in the United States ($n = 95$, 81.7%), followed by the Netherlands ($n = 8$, 7%) and Germany ($n = 5$, 4.3%). Ethnic representation

was primarily white ($n = 80$, 69.57%) and black ($n = 11$, 9.57%), with 19.13% studies that reported no ethnicity ($n = 22$). The mean age was 40 ($sd = 6.62$). The mean women percentage was 47.61% ($sd = 33$). As shown in Figures 2 and 3, most articles were published between 2011 and 2023. Most articles were secondary analysis of RCTs ($n = 37$, 32.17%) and RCTs ($n = 36$, 31.3%). As shown in Table 1, the most frequent treatments were PE ($n = 58$, 50.43%), CPT ($n = 36$, 31.30%), and EMDR ($n = 9$, 7.83%). Regarding the study population, most studies included veterans or active military personnel ($n = 58$, 50.43%), followed by general population ($n = 37$, 32.17%), and survivors of sexual or interpersonal violence ($n = 19$, 16.53%). The mean study sample size was 459 participants, with most studies having a sample size between 20 and 200 participants. A complete set of results is provided in the supplementary materials.

3.3. Research objectives

We identified 207 specific research objectives across 115 studies, including 16 general and 28 specific research objectives (Table 2). These objectives were classified into hypothesis-based ($n = 138$) and exploratory ($n = 69$), with 30 mixed objectives, 63 only hypothesis-based objectives, and 22 only exploratory objectives. The most common research objectives included: examination of temporal precedence ($n = 45$), time-stable predictors of speed of change ($n = 34$), change of association between variables across time ($n = 18$), identification of latent classes ($n = 17$), direction of change during treatment ($n = 14$), change of the dependent variable as a predictor of outcomes ($n = 14$), sudden gains ($n = 14$), and dropout ($n = 14$). This indicates that most studies presented a priori hypotheses in their research objectives and most studies examined mechanisms of change and their temporal precedence with PTSD, prediction of change by baseline variables, and descriptions of change over time.

3.3.1 Trajectories of change: direction, shape, and speed

The description of 'how' symptoms change was divided into three: (1) direction of change ($n = 14$), (2) shape of change ($n = 9$), and (3) speed of change ($n = 3$). Research on the direction of change focused on predicting whether a variable would increase, decrease, or remain stable during treatment; examining variables such as PTSD severity, PTSD clusters, and PTSD cognitions; a full list of variables is provided in the supplementary materials.

Studies on the symptoms' shape of change examined how the direction of change can vary at different points during treatment. Studies proposed questions

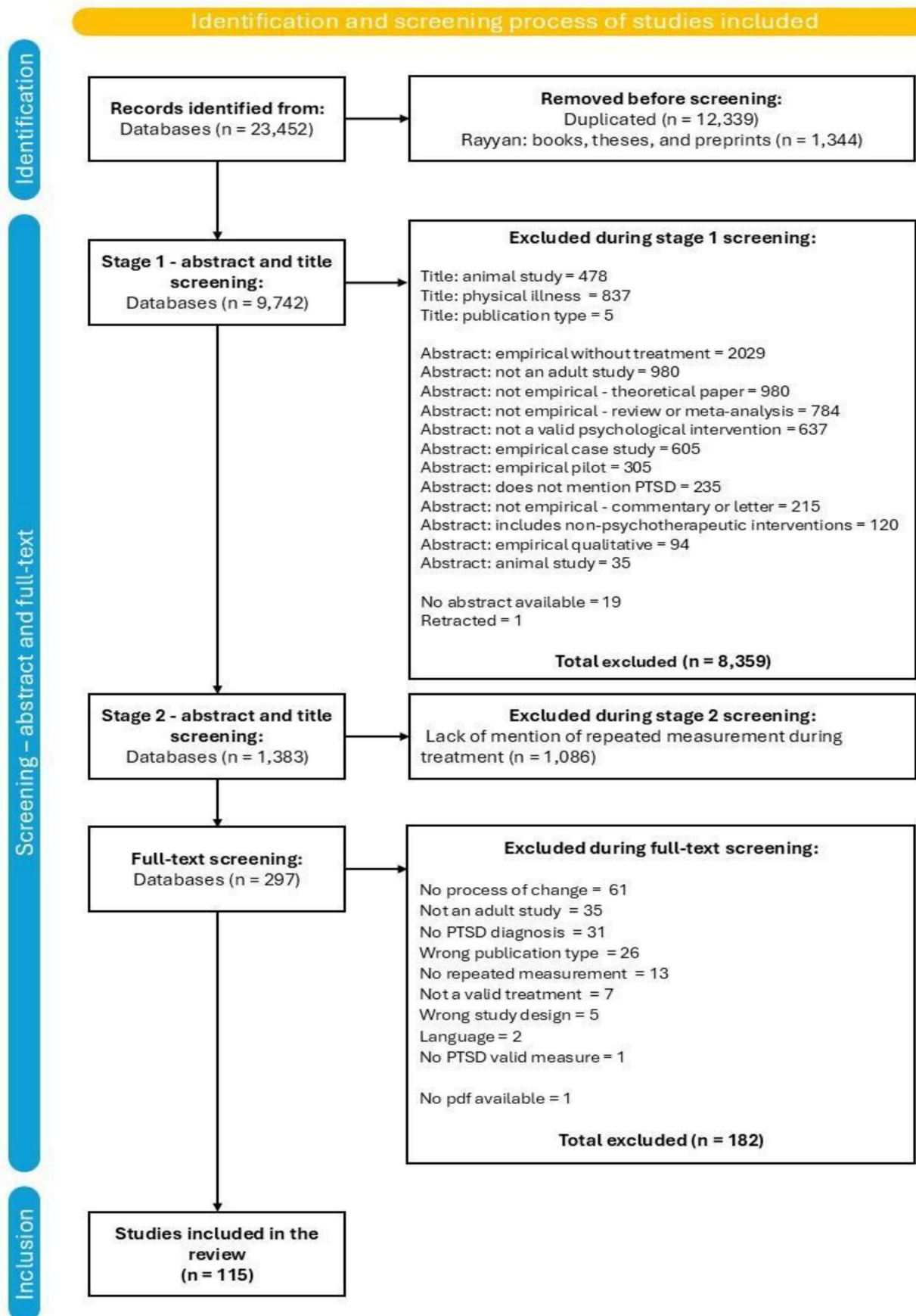


Figure 1. PRISMA scoping review flowchart.

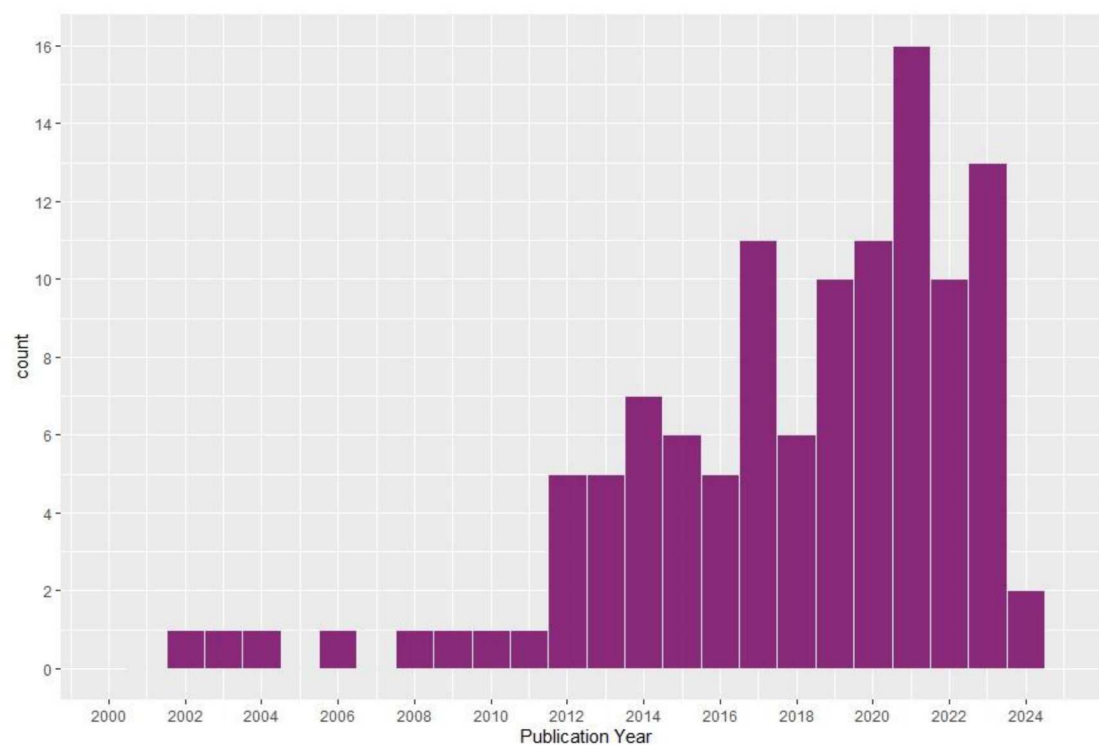


Figure 2. Frequency of studies published each year (2000–2023).

about linear trends, quadratic trends, and changes following the introduction of specific interventions or modules (Castillo et al., 2012; Macdonald et al., 2011; Thompson-Hollands et al., 2018). Regarding speed of change, it was the least researched, with only two articles by Holder et al. (2020a, 2020b) identifying the median effective dose of PE and CPT related to symptom reduction.

3.3.2 Change in the dependent variable predicts treatment outcomes

A set of 13 studies, which comprised 11 hypothesis-based and six exploratory questions, examined how different variables changed during treatment and their impact on outcomes. The variables studied included PTSD severity, subjective units of distress (SUDS), and depression, among others. A full list of

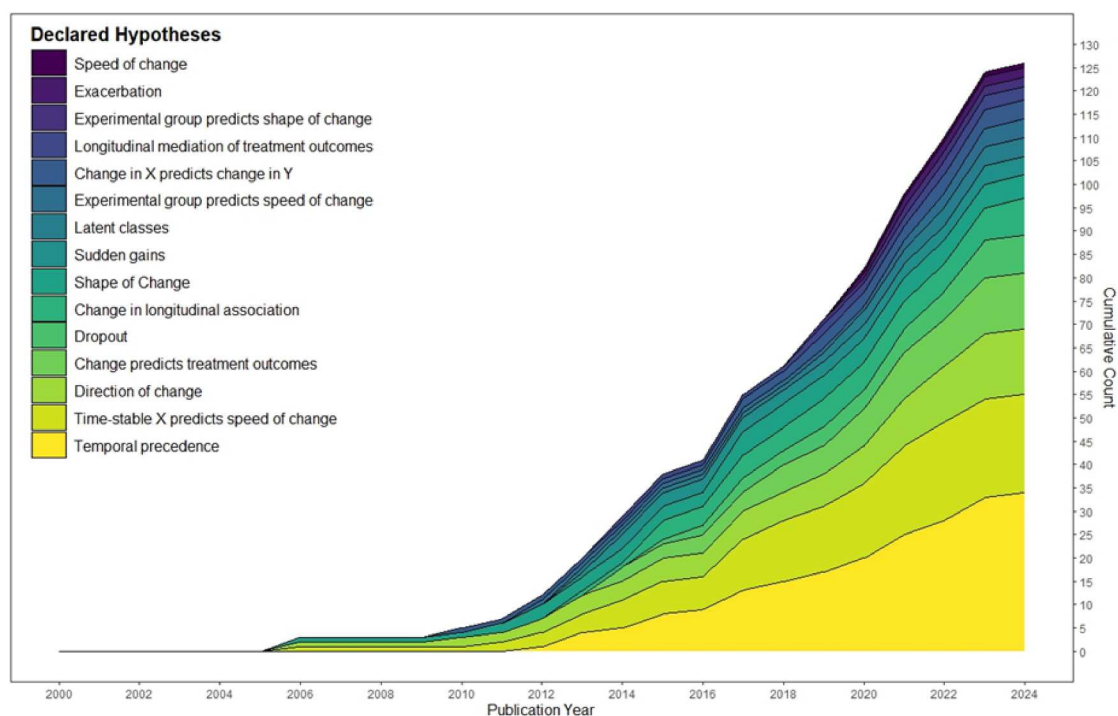


Figure 3. Cumulative count of hypothesis-based research objectives from 2000 to 2023.

Table 1. Treatment frequency.

Treatment	Frequency	Percentage
Prolonged Exposure (PE)	58	50.43
Cognitive Processing Therapy (CPT)	36	31.3
EMDR	9	7.83
Concurrent Treatment of PTSD and Substance Use Disorder (COPE)	9	7.83
Virtual Reality Exposure (VRE)	7	6.09
CBT for PTSD	4	3.48
Written Exposure Therapy (WET)	3	2.61
Cognitive Therapy for PTSD (CT)	3	2.61
Imagery Rescripting (ImRs)	3	2.61
Brief Eclectic Psychotherapy (BEP)	1	0.87

variables is provided in the supplementary materials. Most studies focused on how changes in distress influence treatment results, by exploring changes both within and between sessions and their association with PTSD outcomes.

3.3.3 A time-Stable variable predicts change in the dependent variable

We identified 22 studies examining stable predictors of change. Moderators of change included baseline PTSD, baseline anxiety, type of traumatic events, and demographic variables, among others. Studies using treatment as a moderator examined how treatment assignment differentially predicted change to support the theoretical underpinnings of each treatment. Finally, some studies used treatment response and non-response categories to explore change in distress. A full list of studied variables is provided in the supplementary materials.

3.3.4 Latent class analysis

Of the included studies, seven studies examined eight hypotheses and nine exploratory research questions on the identification, prediction, and impact of latent trajectories during treatment. These studies used a person-centered approach to identify subgroups of patients with differing treatment responses (Howard & Hoffman, 2018; Jung & Wickrama, 2008; Lin & Farber, 2021). Researchers typically employed growth mixture models (GMM) or latent growth class analysis (LGCA). Our results suggested that most studies focused on identifying trajectories of change for PTSD severity, with some examining depression and PTSD cognitions among other variables. A full list of studied variables is provided in the supplementary materials.

3.3.5 Temporal precedence

A total of 37 studies were categorized under temporal precedence, which generally investigated the interplay of PTSD cognition, depression symptoms, and distress habituation with PTSD symptoms, exploring mediation variables proposed by the cognitive model of PTSD (Ehlers & Clark, 2000) and the emotional processing model applied to PTSD (Foa et al., 2006). Furthermore, some studies also examined how the temporal associations between these variables change

over time (Mota et al., 2015), and how these changes are moderated by factors such as treatment and baseline symptomatology. A full list of temporal precedence studies, change-of-longitudinal association studies, and studied variables is provided in the supplementary materials.

3.3.6 Other research objectives

This section summarizes additional research objectives less frequently identified in the included studies, these include: sudden gains, symptom exacerbation, dropout, and network structures (Table 2). We found five studies investigating sudden gains, which refer to a significant and stable reduction in symptoms occurring rapidly during treatment, primarily discussed in the context of depression, but also identified in PTSD (Jun et al., 2013; Shalom & Aderka, 2020). These studies explored the prediction of sudden gains by social support and baseline symptoms, and how sudden gains predict treatment outcomes (e.g. Jun et al., 2013; Kuck et al., 2023).

Five studies explored symptom exacerbation, which is usually defined as a clinically significant increase in symptoms during treatment (Foa et al., 2002). This research focused on exposure-based treatments for PTSD (Foa et al., 2002; Taylor et al., 2003), PTSD comorbid with MDD (Walker et al., 2020), substance use disorders (Tripp et al., 2021), and psychosis (Burger et al., 2023). We identified 13 studies looking into treatment dropout and predictors of dropout, including baseline and time-varying predictors such as PTSD, depression, and anxiety sensitivity, among others (a full list of studied variables is provided in the supplementary materials). The focus on dropout prediction is especially relevant given the relatively high dropout rate (20%) from recommended treatments, which compromises treatment efficacy (Varker et al., 2021).

Regarding the least frequent research objectives (Table 2), two studies investigated PTSD symptoms through network analysis (Graziano et al., 2024; Hoffart et al., 2019). Longitudinal mediation was explored in relation to various factors like anger and guilt, sudden gains as mediators of PTSD reduction (Keller et al., 2014; Saraiya et al., 2023), and PTSD, depression, and interpersonal disconnection as mediators of treatment on suicidality (Brown, Zang, et al., 2019). Finally, a few studies examined how the change in SUDS, intrusion vividness (Norr et al., 2019), linguistic cohesiveness (Gandelman et al., 2022), and cortisol changes (Rauch et al., 2020) was associated with changes in PTSD symptoms, without implying temporal precedence.

3.4. Measurement

As shown in Table 3, PTSD ($n = 95$, 82.61%) and depression ($n = 95$, 82.61%) were the most frequently

Table 2. Research objectives, definitions, and frequency of exploratory and hypothesis based objectives.

Research Objectives	Description	# Hypothesis testing Objectives	# Exploratory Objectives	First Publication	Title of the First Publication
Temporal precedence	The article presents a research objective examining how the state of variable X at time t predicts the state of variable Y at $t + n$, and/or how the state of variable Y at time t predicts the state of variable X at time $t + n$. In other words, the research questions examine cross-lagged associations between two or more constructs, rather than autocorrelation across time points. For example, Schumm et al. (2015) hypothesize that <i>'change in dysfunctional posttraumatic cognitions will precede and be predictive of subsequent change in PTSD and depression symptoms during treatment.'</i>	34	10	2010	Cognitions in prolonged exposure therapy for posttraumatic stress disorder (Hagenaars et al., 2010)
A time-stable variable predicts change in the dependent variable	The article presents a research objective examining how a time-stable variable (e.g. a baseline clinical indicator, treatment group, or a group defined by a treatment variable such as homework completion) influences the speed* of change during treatment. For example, Speckens et al. (2006) hypothesize that <i>'The following factors will predict a smaller decrease in the frequency of intrusive memories after reliving: initial severity of PTSD symptoms, anxiety, depression, anger, dissociation, characteristics of intrusive memories and negative interpretation of PTSD symptoms.'</i>	19	15	2002	Pattern of change in prolonged exposure and cognitive-processing therapy for female rape victims with posttraumatic stress disorder (Nishith et al., 2002)
Direction of change	The article presents an explicit hypothesis on the direction of change of a variable during treatment. This research objective distinguishes itself from other research objectives, such as the speed or shape of change, as these studies do not make assumptions about these characteristics of change; instead, they focus on the direction of change of the variable, for example, whether PTSD decreases or increases during treatment. For example, Zoellner et al. (2023) hypothesize that <i>'If brief IE relies on extinction principles similar to longer exposure-based treatments, anticipatory anxiety, peak distress during IE, and end distress after IE should decrease from the first IE sessions to the last.'</i>	14	NA	2006	Changes in intrusive memories associated with imaginal reliving in posttraumatic stress disorder (Speckens et al., 2006)
Change in the dependent variable predicts treatment outcomes	The article presents a research objective examining how changes in a construct predict treatment outcomes. For example, Sack et al. (2008) mention that <i>'Thus, the current study was designed to investigate the question of whether psychophysiological changes during EMDR sessions are related to subjective and objective reduction of PTSD symptoms.'</i>	11	6	2008	Psychophysiological changes during EMDR and treatment outcome (Sack et al., 2008)
Change in the association between variables across time	The article presents a research objective that examines the change in the strength of association between variables over time during treatment. These objectives also include: time-stable variables predict changes in longitudinal associations (Hypothesized $N = 2$, Exploratory = 4) and experimental conditions predict changes in longitudinal associations (Hypothesized $N = 5$). For example, Mota et al. (2015) hypothesize that: <i>'... (1) Consistent with the study by Rauch and colleagues (2020), there will be a stronger, positive relationship between imagery vividness ratings and subjective units of distress (SUDS) during earlier imaginal exposure sessions than during later sessions.'</i>	8	5	2010	Cognitions in prolonged exposure therapy for posttraumatic stress disorder (Hagenaars et al., 2010)
Sudden gains	The article presents a research objective that examines the occurrence of sudden gains in symptoms during treatment. This category also includes: the prediction of sudden gains (Hypothesized $N = 4$, Exploratory = 2) and the prediction of treatment outcomes by sudden gains (Hypothesized $N = 4$, Exploratory = 1). For example, König et al. (2014) hypothesize that: <i>'The first is to add to the literature on sudden gains in PTSD treatment. We expect to find a rate and magnitude of sudden gains similar to those found in other PTSD treatment studies and ...'</i>	10	4	2013	Sudden gains in prolonged exposure and sertraline for chronic PTSD (Jun et al., 2013)

Dropout	The article presents a research objective that examines the prediction of participant dropout during treatment by using both time-stable variables (Hypothesized $N = 6$, Exploratory = 6) and time-varying variables (Hypothesized $N = 2$). For example, Szafranski et al. (2017) sought to '... validate findings from previous studies that a substantial proportion of participants who did not complete treatment (i.e. dropouts) would display significant reductions in alcohol use, PTSD, and depression.'	8	6	2015	Taking the pulse of prolonged exposure therapy: physiological reactivity to trauma imagery as an objective measure of treatment response (Wangelin & Tuerk, 2015)
Latent classes	The article presents a research objective that examines the identification of latent subgroups of trajectories of change during treatment by statistically analysing subclusters of trajectories, for example, using Growth Mixture Models (GMM). This category also includes the prediction of latent class membership (Hypothesized $N = 3$, Exploratory = 5), the prediction of treatment outcomes by class membership (Hypothesized $N = 2$), and the prediction of latent classes by experimental group assignment (Hypothesized $N = 2$). For example, Brown, Clapp, et al. (2019) first aim was to '... determine whether discrete classes of symptom change emerged within each condition. We used LPA to calculate discrete classes of symptom deviation from baseline over time. Based on prior research (Clapp et al., 2016), we hypothesized that S-PE and M-PE would each demonstrate three distinct classes, namely rapid responders, linear responders, and delayed responders.'	8	9	2013	Latent class differences explain variability in PTSD symptom changes during cognitive processing therapy for veterans (Schumm et al., 2013)
Shape of the change of the dependent variable	The article presents a research objective that examines the shape of change observed in a variable during treatment. For example, Hackmann et al. (2004) interestingly define it as 'Intrusive memories may disappear abruptly, or may fade out gradually. If they fade rather than disappear the sense of reliving, vividness or distress provoked may fade in unison, or some aspects may disappear abruptly or at different rates.'	4	4	2002	Pattern of change in prolonged exposure and cognitive-processing therapy for female rape victims with posttraumatic stress disorder (Nishith et al., 2002)
Time-stable variable moderates covariable effect on longitudinal change	The article explores how a time-stable variable moderates the effect of a covariate on the trajectory of change of a construct. A time-stable variable predicts the speed of change in the dependent variable', and the researchers are adding a moderator to that relationship. For example, Walter et al. (2020) secondary aim '... was to determine whether treatment condition would moderate any impact of depression symptom severity on change trajectories of self-reported symptom outcomes'.	NA	4	2016	Evaluating Potential Iatrogenic Suicide Risk in Trauma-Focused Group Cognitive Behavioral Therapy for the Treatment of PTSD in Active Duty Military Personnel (Bryan et al., 2016)
Experimental group predicts increased speed of change	The article presents an explicit hypothesis about how experimental interventions will influence the speed of change of a variable during treatment. For example, Nijdam et al. (2012) hypothesized that '... EMDR would lead to faster improvements in PTSD symptomatology than brief eclectic psychotherapy and that the improvements at the end would be equal.'	4	NA	2012	Brief eclectic psychotherapy vs eye movement desensitization and reprocessing therapy for post-traumatic stress disorder: Randomised controlled trial (Nijdam et al., 2012)
Exacerbation of symptoms	The article presents a research objective that examines symptom exacerbation during treatment. This category also includes prediction of exacerbation by experimental group assignment (Hypothesized $N = 2$) and prediction of treatment outcomes by exacerbation (Hypothesized $N = 2$). For example, Walker et al. (2020) propose that 'If potential clinical concerns are warranted, individuals in PE ought to experience a higher likelihood of symptom exacerbation than those receiving sertraline, those with symptom exacerbation should be more likely to dropout and be more symptomatic at post-treatment than those without an exacerbation ...'	5	5	2002	Comparative efficacy, speed, and adverse effects of three PTSD treatments: Exposure therapy, EMDR, and relaxation training (Foa et al., 2002)
Longitudinal Network Structure	The study seeks to identify the network structure of a set of variables during treatment. For example, Graziano et al. (2024) sought to '... to fill a gap in the literature by examining the baseline, midtreatment, and posttreatment PTSD symptom network of adults completing CPT.'	NA	2	2019	The temporal dynamics of symptoms during exposure therapies of PTSD: A network approach (Hoffart et al., 2019)

(Continued)

Table 2. Continued.

Research Objectives	Description	# Hypothesis testing Objectives	# Exploratory Objectives	First Publication	Title of the First Publication
Longitudinal mediation of treatment effects	The article examines how the change in a construct mediates the effect of a treatment on changes in an outcome variable. Compared to the hypotheses of 'temporal precedence', which are implicitly mediational, the objectives presented in this section are explicitly mediational between pre- and post-treatment levels of the dependent variable. For example, Saraiya et al. (2023) hypothesized that '... (3) <i>guilt and anger would mediate session-by-session reductions in PTSD symptoms.</i> '	3	1	2014	Depression sudden gains and transient depression spikes during treatment for PTSD (Keller et al., 2014)
Change in variable <i>X</i> predicts change in variable <i>Y</i>	The article examines how the change in a variable <i>X</i> predicts the change in a variable <i>Y</i> . These research objectives differ from 'temporal precedence' and 'Longitudinal mediation of treatment effects' because they do not investigate cross-lagged relationships and do not explicitly mention mediation processes in their objectives. For example, Rauch et al. (2020) in a secondary analysis examined '...the correlation between the slope of change in the biological variable and the slope of change in CAPS score'.	3	2	2019	Relationship between change in in-vivo exposure distress and PTSD symptoms during exposure therapy for active duty soldiers (Norr et al., 2019)
Speed of change	The article examines the speed of change in a variable during treatment. For example, Holder et al. (2020) hypothesized that '... eight sessions would represent a median effective dose of PE'.	1	1	2003	Comparative efficacy, speed, and adverse effects of three PTSD treatments: Exposure therapy, EMDR, and relaxation training (Taylor et al., 2003)

* Speed is defined as the rate of change of a variable, for example, in a regression analysis, when session number is regressed on PTSD severity, the resulting *Beta* for session is the average speed of change in each session-to-session interval.

Table 3. Granularity of repeated measurements.

Type of Measurement	Definition	Frequency	Percentage
Symptom Severity	The variable measured repeatedly is the overall score of a diagnosis severity tool, such as the PCL-5 or the BDI-II, without discriminating subscales.	91	79.13
Emotional Distress	Repeated measures of emotional distress during exposure, for example, SUDS or skin conductance.	24	20.87
Process-based measures	The variable measured repeatedly is a specific psychological process proposed as a mechanism of change in the article, for example, PTSD cognitions or shame.	19	16.52
Treatment variables	The variable measured repeatedly is treatment-related, such as therapeutic alliance or group cohesion in group treatment formats.	17	14.78
Symptom level measurement	The variable measured repeatedly is one or various specific symptoms of PTSD, for example, intrusions or the use of individual items from PTSD measurements.	10	8.70
Cluster-level measurement	The variable measured repeatedly is used as the scores of psychometrically relevant subscales of the tool, for example, hyperarousal for PTSD.	9	7.83
Brain-related measurements	The variable measured repeatedly is a measure of brain activity, for example, EEG.	1	0.87

constructs measured repeatedly, followed by emotional distress during exposure ($n = 27$, 23.48%), PTSD cognitions ($n = 11$, 9.57%), and substance use ($n = 11$, 9.57%). The most used tools for PTSD were the PTSD Checklist for DSM-5 (PCL-5; $n = 23$, 20%), PTSD Symptom Scale Self-Report (PSS-SR; $n = 17$, 14.78%), Clinician-Administered PTSD Scale (CAPS; $n = 12$, 10.43%), Posttraumatic Diagnostic Scale (PDS; $n = 11$, 9.57%), and PTSD Checklist for DSM-IV (PCL; $n = 10$, 8.7%); for depression, the tools were the Beck Depression Inventory-Second Edition (BDI-II; $n = 11$, 9.57%) and Beck Depression Inventory (BDI; $n = 11$, 9.57%); for PTSD cognitions, it was the Posttraumatic Cognitions Inventory (PTCI; $n = 14$, 12.17%), and for emotional distress, it was the use of SUDS ($n = 11$, 9.57%); a complete list of measurements can be found in supplemental materials.

In terms of measurement granularity (Table 4), repeated measures most often assessed symptom

Table 4. Resolution of repeated measurements frequency.

Type of Measurement	Definition	Frequency	Percentage
Session wise	The repeated measurement is conducted during the treatment session. Any regime is included, for example, every session, every two sessions, etc.	76	66.09
Treatment wise	The repeated measurements are conducted based on treatment modules or at the mid-point of treatment. For example, pre-, mid-, and post-measurement.	25	21.74
Weekly	The repeated measurements are conducted based on the week of treatment, not the session number. For example, in inpatient settings, measurement can be done independently of treatment sessions.	19	16.52
During session measurement	Measurements are taken repeatedly throughout the session. This category is mainly used for studies using SUDS.	9	7.83

severity, emotional distress, process-based measures, and treatment variables. In terms of measurement frequency, the mean repeated measurement frequency was 9 ($SD = 3.77$), with a range of 3–20 measurements. As shown in Figure 4, the most frequent number of measurements was 12, which coincided with the number of sessions commonly used in CPT and PE. Regarding the timing of measurements (Table 5), we found that the most common measurement scheme was session-wise, followed by treatment-wise (pre-, mid-, and post-treatment), weekly, and in-session measurement. These results suggest that decision-making regarding the number of measurements and timing is based on practical considerations, such as treatment duration and client contact opportunities.

3.5. Data analysis

An in-depth analysis of modelling techniques is outside the scope of this study. However, the most common type of analysis used was multilevel modelling ($n = 55$, 47.83%), which allows for modelling growth trajectories and cross-lagged relationships, essential for temporal precedence studies. Other notable techniques include survival analysis ($n = 6$, 5.22%), ANCOVA ($n = 4$, 3.48%), structural equation modelling (SEM) with cross-lagged associations ($n = 4$, 3.48%), latent growth curve models ($n = 4$, 3.48%), repeated measures ANOVA ($n = 4$, 3.48%), and t -tests ($n = 4$, 3.48%).

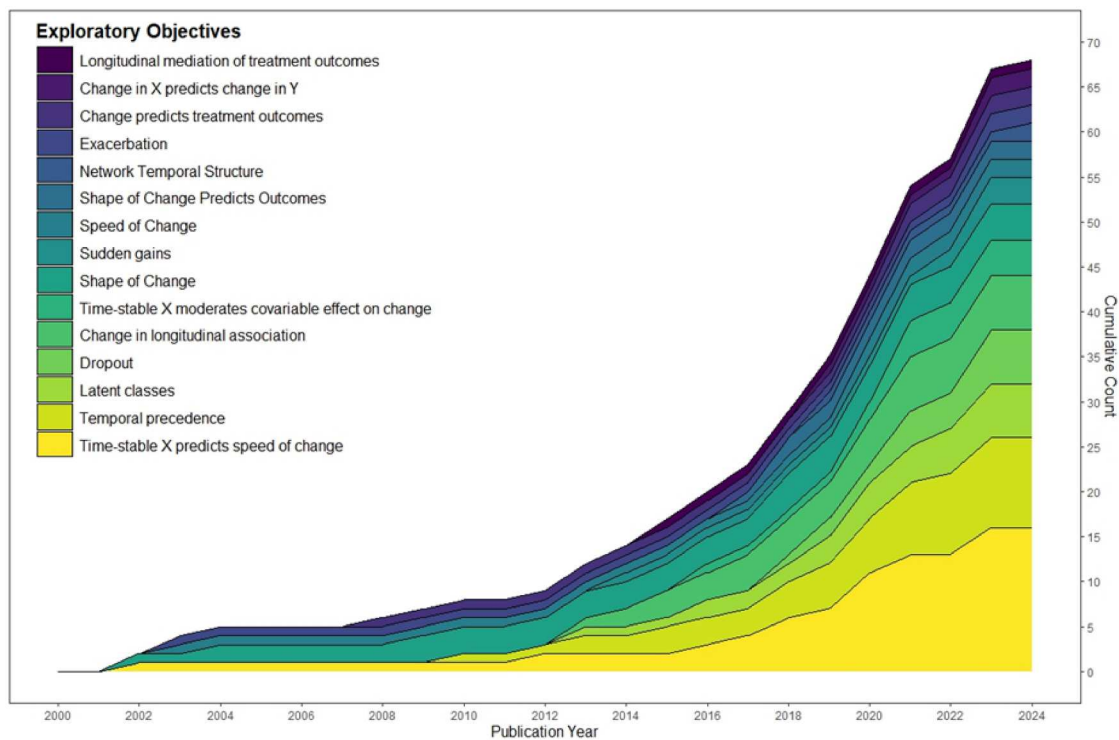


Figure 4. Cumulative count of exploratory-based research objectives from 2000 to 2023.

4. Discussion

This scoping review examined how researchers investigated symptom change in PTSD treatment over the past two decades, focusing on research objectives, measurement characteristics, PTSD conceptualization, and sample characteristics. Our results indicate that the most frequent hypothesis-based research objective was the identification of temporal precedence between constructs, while the main exploratory objective was the prediction of speed of change by time-stable variables (e.g. baseline PTSD). Most studies relied on repeatedly assessed PTSD symptom severity, followed by depression severity, and trauma-related cognitions. Most studies assessed these factors at session-based intervals, and nearly half employed multilevel modelling to analyse them. Based on these results, we discuss how different theoretical and methodological assumptions influence research trends, methodological limitations, and provide suggestions on how the field of psychotraumatology might best move forward.

4.1. Research objectives

Motivated by the high non-response rate to PTSD treatment, many studies focused on identifying mechanisms of change, treatment response moderators, and trends that could enhance PTSD treatment development. Each of these research objectives carries different implications regarding theory, measurement, and analysis, which we discuss below.

4.1.1 Direction, speed, and shape of change

The most straightforward question that can be asked about change is the direction of change, which asks whether symptoms or processes (e.g. intrusions, PTSD clusters, etc.) increase, decrease, or remain stable during treatment without addressing other features of change, such as the speed or shape of change (e.g. Hagenaars et al., 2010; Zoellner et al., 2023a). This fundamental question served as the basis for further research into the shape and speed of change.

Shape-of-change studies evaluate whether symptom trajectories are linear, quadratic, or otherwise. For example, Nishith et al. (2002) found that re-experiencing and arousal best fit a quadratic model in both PE and CPT, whereas avoidance followed a linear trajectory in CPT. While other studies found linear change or quadratic patterns in PE (Castillo et al., 2012; Junglen et al., 2017). We argue that careful interpretation is needed, for example, linear trends may indicate steady improvements (Sripada et al., 2020), whereas quadratic trends may reflect initial distress before improvement. Inconsistencies across studies may reflect differences in treatment type, sample characteristics, or measurement timing, underscoring the need for well-founded research examining these confounding variables to resolve heterogeneous results or provide evidence for differential responses.

Only two studies examined the speed of change, both archival studies with large sample sizes ($n > 20,000$) by Holder et al. (2020b, 2020a). These studies

showed median effective doses of four sessions for PE and eight for CPT, which calls into question the ongoing use of full-length protocols in research. This practice may be motivated by a preference to maintain comparability with other studies or by the need to include late responders in research samples, nevertheless, it may also reflect an uncritical reliance on methodological traditions. This is not to suggest that research using PE and CPT should limit treatment length to 4 or 8 sessions, but rather to explicitly reflect on how research questions relate to treatment length when designing study protocols. For example, studies predicting dropout during PTSD treatment have shown inconsistent results (Wright et al., 2024). One potential confounder is that participants might leave treatment early when they feel better (Szafranski et al., 2017). In other words, the concept of dropout is tied to treatment length and makes no distinction between leaving because of clinical improvement, lack of improvement, or symptom exacerbation. This highlights the importance of carefully considering how treatment length relates to our research questions.

Furthermore, early change patterns may influence the longitudinal trajectory or treatment outcomes. Holder et al. (2020b) found that 25% of patients in PE showed rapid improvement within three sessions. Sripada et al. (2020) reported that 40% of PE and CPT patients showed improvement before session eight, with only 10% improving after session eight; for this 10%, early improvements doubled the likelihood of later improvement. Other studies have noted how symptoms reduction (e.g. intrusions, Speckens et al., 2006), symptom exacerbation (Walker et al., 2020), and distress habituation (Bluett et al., 2014; Zoellner et al., 2023) predict treatment outcomes, underscoring the importance of identifying early change patterns. In conjunction, the literature suggests the presence of at least fast and slow responders (Brown et al., 2018; Galovski et al., 2016; Kovacevic et al., 2022; Schumm et al., 2013). Identifying these subgroups early could enable adaptive treatment strategies, such as augmentation or targeted skill training, thereby reducing unnecessary long-term treatment and costs.

4.1.2 Time-Stable moderators of treatment change

Time-stable predictors of treatment change were a main topic of research. Predictors included treatment type, specific comorbidities, baseline symptoms severity, specific psychological constructs (e.g. hope or posttraumatic cognitions), and responder status. Regarding treatment type, the central idea behind its role as a moderator is that its specific components may drive change in distinct ways (e.g. Brown, Clapp, et al., 2019; Pigeon et al., 2022). For example,

Walter et al. (2020) explored how PE and relaxation therapy influenced PTSD symptom reduction, and Badour et al. (2021) explored how COPE and prevention therapy influenced PTSD and substance use. Nevertheless, conclusions drawn from treatment comparisons are limited by the fixed and sequential implementation of treatment components. This limitation can be addressed by testing treatment components using Sequential Multiple Assignment Randomized Trials (SMART) designs, which are particularly well-suited to evaluate modular treatment effects as they incorporate decision points based on ongoing response tracking (Kidwell & Almirall, 2023). For example, Aderka et al. (2013) identified differential temporal precedence prediction of PTSD and depression when PE was implemented with and without cognitive restructuring.

Regarding other moderators of change, the question remains what to do with this information, since applying research insights in clinical settings can be vital. For example, following a SMART test of decision-making and intervention assignment based on baseline variables in experimental settings can adequately test the utility of moderator research. Nevertheless, reanalysing existing datasets is also an option. For example, non-linear growth modelling, testing for treatment component effects, testing for moderators' regions of influence (e.g. the Johnson-Neyman technique; Hayes & Little, 2022), and LGCA can provide decision-making points based on treatment effects. Combining these approaches with further treatment research will be valuable for implementation.

4.1.3 Identification of longitudinal latent classes

Latent class analysis is an exploratory approach that seeks to identify subgroups of individuals that share similarities. We highlight this approach for three main reasons. First, treatment change is not uniform; variable-centered studies showed diverse patterns of change (Brown, Clapp, et al., 2019; Macdonald et al., 2011). Second, identifying subgroups can potentially enhance clinical decision-making by informing patient trajectory-based care. Third, longitudinal latent classes can reveal qualitative differences among trajectories of change (Allan et al., 2020).

Kovacevic et al. (2022), in their study of veterans undergoing CPT, critique how longitudinal latent classes often yield fast responders, constant responders, and non-responders, reflecting severity differences indicating quantitative rather than qualitative differences. To be able to identify qualitative differences in latent trajectories, we consider three points: First, modelling non-linear trends is crucial for capturing qualitatively different latent classes (Liu, 2025), enabling us to identify rapid change, exacerbation, and linear trajectories; for example, Kovacevic

et al. (2022), found steady responders and partial responders, both starting with similar trajectories that diverge at week four of treatment. Second, moving beyond symptom severity to explore symptom clusters (e.g. PTSD hyperarousal) since focusing on symptom severity limits our ability to understand how dimensions of PTSD differentially respond to treatment (Nishith et al., 2002; Stevens et al., 2021). Three, using parallel process longitudinal growth class analysis (PP-LGCA) may be useful as it allows us to identify longitudinal latent classes based on the trajectories of two variables in parallel. For example, subgroups with the same PTSD trajectory, but different substance use trajectories have been observed (Allan et al., 2020). PP-LGCA could be used to identify processes that drive change differentially across patients, thereby informing decision-making that takes interindividual differences into account.

4.1.4 Temporal precedence of constructs

The first studies that introduced the concept of temporal precedence were Hageraars et al. (2010) and Zalta et al. (2014). Both explored whether negative PTSD cognitions temporally preceded the reduction in PTSD symptoms. Hageraars et al. (2010) sought to identify the mediating role of cognitions for treatment on the reduction in intrusions by examining patterns of temporal precedence; they presented open and clear causal determination aims consistent with Judd and Kenny's (1981) causal inference model (i.e. demonstrating association, temporal precedence, and ruling out alternative explanations). Hageraars et al. (2010) did not find the expected mediation effect of cognition. Zalta et al. (2014) responded to these findings by researching the role of negative cognitions on PTSD by implementing a Granger causality approach (i.e. identifying causality based on how well past values of a variable, X , predict future values of another variable, Y ; Shojaie & Fox, 2022). Zalta et al. (2014) did find cognition to predict PTSD in subsequent sessions. It is noteworthy that these studies mention their causal aims openly and clearly rather than focusing on their direct results. However, subsequent studies began to pose their research objectives by presenting them under the temporal precedence umbrella without explicitly addressing causality (e.g.: Aderka et al., 2013; Badour et al., 2021; Brown et al., 2018; Cooper et al., 2017; Kooistra et al., 2023; Schumm et al., 2023; Song et al., 2020). This practice risks confusion between temporal prediction and causal inference, and without explicit discussion of causal aims and research limitations on its establishment, progress in understanding PTSD treatment mechanisms remains limited.

Furthermore, these implicit causal aims are often presented in contexts meant to lend them causal weight, without addressing this explicitly. Some

examples of terminology that seem to communicate implicit causal aims found in this review are: 'temporal precedence' (e.g. Aderka et al., 2013; Badour et al., 2001; Kooistra et al., 2023), 'temporal relationship' (e.g. Aderka et al., 2013; Cooper et al., 2017), 'reciprocal relationship' (e.g. Johnson et al., 2021; Kooistra et al., 2023), 'precede and predict' (Schumm et al., 2023), or 'temporal dynamics' (Badour et al., 2001; Brown et al., 2018; Song et al., 2020), among others. Most of this research focuses on identifying treatment mechanisms of change that might mediate treatment effects, which necessarily invoke two causal claims: (1) treatment changes the mechanism, and (2) the mechanism changes PTSD symptoms.

We highlight these issues to pinpoint the need to address causal claims in clinical research. A first step is to clarify the motivation of research, whether it is (causal) explanation, prediction, or description. Temporal precedence research usually focuses on explanation. Hageraars et al. (2010) do this by explicitly stating their aim of finding a causal relationship. Zalta et al. (2014) explicitly introduce the concept of Granger causality. Baier et al. (2024) and Kleim et al. (2013) also mention causality upfront, opening the door for critical discussion, even if they do not follow current formal approaches to causal identification and estimation (Mulder et al., 2025; Waldorp et al., 2024).

While challenging, introducing causal inference into clinical psychological research is essential (Rohrer, 2024; Rohrer et al., 2022). A formal explanation of causal identification and estimation is beyond the scope of this review. However, existing literature bridges the gap between psychological research and causal inference. For example, entry-level introductions to causal inference exist (Rohrer, 2024), as do introductory texts focused on path analysis, mediation, and longitudinal data (Rohrer et al., 2022; Rohrer & Murayama, 2023). Additionally, developments in causal inference, such as directed acyclic graphs, can enhance our understanding of the roles of confounders, mediators, and moderators, and of how to address their effects in research with experimental and observational data (Rohrer, 2024; Waldorp et al., 2024). Furthermore, studies using longitudinal designs offer advantages such as the ability to control for stable confounders and to prevent reverse causality in cross-lagged relationships (Rohrer et al., 2022; Rohrer & Murayama, 2023). However, it is important to mention that no single study can definitely answer questions on causality; a diversity of approaches from experimental to clinical are necessary to answer these kinds of questions (Lorenzo-Luaces, 2023). Finally, a coherent theoretical framework is needed to guide research, conceptualize confounders, and propose expected temporal relationships (Borsboom et al., 2021; Eronen & Bringmann, 2021).

Other Longitudinal Research Objectives. Finally, we discuss sudden gains, exacerbation, dropout, and network studies within the context of change during treatment. Regarding sudden gains, we question how this concept aligns with other research questions in the field. Sudden gains are proposed as a proxy for non-linear change resulting from cognitive shifts during key therapy sessions (Jun et al., 2013). However, they face criticism for their tautological definition as predictors of treatment outcomes, as sudden gains themselves are indicators of symptom reduction, and for their inconsistent predictability from baseline characteristics (Kuck et al., 2023; Shalom & Aderka, 2020). If taken as a proxy for cognitive change, it might be preferable to measure those cognitive variables directly, and if taken as indicators of treatment response, non-linear and latent trajectory models should be able to capture sudden patterns of change. Similar to sudden gains, exacerbation studies identify clinically significant increases in symptoms, only in the opposite direction (Bischoff et al., 2020). As with sudden gains, it makes sense to include exacerbation within a general framework of change during treatment.

Finally, dropout is a significant concern in PTSD treatment, with around 20% of patients discontinuing treatment before completion (Wright et al., 2024). Factors affecting dropout appear inconsistent, reflecting diverse reasons individuals may leave treatment, such as early improvement (Szafranski et al., 2017), distress and avoidance (Eftekhari et al., 2020), or practical (Castro-Camacho et al., 2023). In other words, the same phenomena, patients leaving treatment early, can have different causes depending on the individual. Understanding these motivations is essential for analysing patterns of missing data and should be integrated into the study of change trajectories during treatment.

4.2. Measurement of PTSD and related processes

This section examines how PTSD is measured across studies and how these measurement choices influence research questions and the interpretation of clinical findings. We address two key aspects, measurement granularity and timing, which are conceptually and practically interdependent, but are discussed separately for clarity.

4.2.1 Measurement granularity

Repeated measures most frequently assessed symptom severity, followed by process-based measures (e.g. PTSD cognitions), treatment factors (e.g. therapeutic alliance), and emotional distress indicators (e.g. SUDs). Less common were symptom-level measures and brain-based measurements. Indicating a primary research focus on trajectories of symptom severity,

with temporal precedence adding measures of psychological processes. Although PTSD subscales are psychometrically consistent and robust phenomena, they were seldom used (Bovin et al., 2016). This results in a loss of crucial information, as they may show differential responses to treatment (Stevens et al., 2021) and may help provide evidence for specific theories (e.g. avoidance maintains reexperiencing and hyperarousal symptoms; Nishith et al., 2002). Additionally, PTSD subscale use can help solve measurement overlap issues, for example, PTSD negative cognitions overlap with the PTSD negative alterations in negative cognitions subscale (Bovin et al., 2016; Serier et al., 2023). Not addressing such overlap hinders support for specific theories. Still, severity scores remain valuable when the goal is to track overall PTSD change. Ultimately, aligning PTSD measurement with both theory and research objectives is essential for sound interpretation.

Finally, careful consideration of the definitions of process-based measures is also needed. For example, habituation is an indirect measure of emotional processing (Foa et al., 2006), nonetheless, current research shows mixed results regarding the relationship between habituation and treatment outcomes (Bryant et al., 2023). Sometimes, habituation is treated as a mechanism of change (Mota et al., 2015), redefined as extinction or inhibitory learning (Bryant et al., 2023), or as a proxy of emotional processing (Badour et al., 2021; Hoeboer et al., 2022). These definitions reflect competing frameworks, tested on the same data, illustrating a case of the ‘theory crisis’ in psychology (Eronen & Bringmann, 2021; Robinaugh et al., 2021). Where the usual solution is to address debates through more data collection and complex modelling, rather than advancing toward formal theories that are grounded in reliable phenomena, generating testable hypotheses, and being meaningfully refined, which offers better ground for scientific debate (Borsboom et al., 2021; Robinaugh et al., 2021).

4.2.2 Measurement timing

Our findings suggest that practical concerns rather than theoretical considerations often dictated the timing of measurements. Most assessment schemes were session-wise, preferred in outpatient settings, and pre-, mid-, and post-measurement. However, few authors explicitly justified their timing choices, a pattern consistent with other areas of clinical psychology research (Voelkle et al., 2018).

The average for repeated measurements was nine, and the mode was 12, consistent with the number of sessions for PE and CPT (8-12 sessions). This suggests that measurement choices mirror treatment protocols rather than theoretical or methodological guidance, limiting the study of change processes (Hamaker, 2025; Mulder et al., 2025; Voelkle et al., 2018). For instance, avoidance is a rapid response

to an intrusion that occurs at the minute- or hour-level; therefore, session-wise measurement intervals may miss this interplay. Furthermore, other important changes can occur in the time between sessions, and the use of diaries or EMA studies would provide the time resolution needed to observe them. However, our review indicates that research implementing intensive longitudinal data (ILD) (e.g. EMA) has not been conducted yet in PTSD treatment research. This gap may stem from a lack of theories detailing change patterns, leaving timing selection a matter of guesswork (Mulder et al., 2025). Thus, it is vital to specify the time scales of changes, potentially necessitating formal theory development (Bailey et al., 2024; Borsboom et al., 2021; Eronen & Bringmann, 2021; Hamaker, 2025; Robinaugh et al., 2021; Voelkle et al., 2018). This needs to be grounded in robust observations (Borsboom et al., 2021), where descriptive and exploratory research on processes of change using ILD can help us move forward, informing us about time scales at which specific processes unfold (Hamaker, 2025).

While ILD is valuable, reliability concerns, unintended effects, and construct-specific applicability questions remain. For instance, hyperarousal, often seen as stable, may not benefit from EMA measurement, whereas intrusions, as discrete events, may. For example, intrusion measurements via EMA and weekly assessments yielded similar results at the week-aggregate level for intrusions (Peters et al., 2024). This suggests convergence between the methods, although we argue that it does not imply equivalence. The choice of measurement strategy should be driven by theory and our research questions, with particular attention to the assumed time frame of change (Hamaker, 2025, 2026). For instance, in PTSD, hyperarousal and avoidance may therefore require distinct measurement regimens to capture change patterns and dependence relationships accurately.

Furthermore, the pitfalls of poor timing windows are substantial. Mulder et al. (2025) demonstrate that aggregating processes into larger units, for example, daily effects measured every two days, leads to underidentification of causal effects. Clinical science faces the dual challenge of building temporally explicit theories and designing studies to test them. Exploratory and descriptive studies can help identify temporal 'blind spots' and guide theory development, while also being supported by basic experimental research.

4.3. Data analysis considerations

This article highlights three key issues in longitudinal data analysis: (1) the need to distinguish between- and within-person variance; (2) the limitations of models assuming stationary characteristics (stable means,

variances, and temporal dependencies across time) when modelling time precedence during treatment; and (3) the necessity to clearly define 'change' in therapy before modelling it.

Nearly half of the studies in this review used multi-level modelling (MLM), specifically multilevel growth models (MGM) (Curran & Bauer, 2011). These models can estimate fixed effects (sample-level change) and random effects (individual intercepts and slopes) (Curran & Bauer, 2011; Voelkle et al., 2018). Crucially, MGMs can separate between- and within-person variance, enabling the modelling of psychological processes usually proposed at the within-individual level (Snippe et al., 2024). For example, the emotional processing model claims avoidance hinders fear-structure modification at the individual level (e.g. a patient avoids trauma-related stimuli, which hinders their emotional processing of fear and stimulus association; Foa et al., 2006), while between-person associations (e.g. individuals higher in avoidance also report more intrusions) can also be tested.

Nevertheless, when modelling temporal precedence, these models pose limitations due to their stationarity assumptions. For example, multilevel vector autoregressive models (mlVAR) and random-intercept cross-lagged panel models have a mean-stationarity assumption (Hamaker, 2026; Hamaker et al., 2015; Snippe et al., 2024). Therefore, these models represent fluctuations around an individual's mean, not changes in the mean over time (Snippe et al., 2024). These assumptions conflict with the temporal precedence research questions, which posit mean-level change questions. Using stationary models to answer such questions risks biased estimates and misleading conclusions. A solution would be to adopt models that explicitly incorporate mean change, such as latent change score models (LCSM) (Kleim et al., 2013; Voelkle et al., 2018), and change-point analysis (Ariens et al., 2020; Snippe et al., 2024). For example, Kleim et al. (2013) used LCSM to examine cognitive and PTSD symptom time precedence, while Snippe et al. (2024) applied change-point analysis to depression-related processes.

Finally, conceptual clarity about 'change' is important. Traditional diagnostic models define change as achieving a loss of diagnosis. However, it can also be defined as a clinically significant reduction in symptoms, as shifts in variability (e.g. too little or too much distress variability might be conceptualized as pathological), or as changes in inertia (e.g. how distress at one time point predicts later distress). Statistically, these correspond to changes in mean, variance, and autocorrelation, respectively (Kuppens & Verduyn, 2017). Explicitly linking research questions about change to the implemented analysis is essential for appropriate research designs, statistical modelling, and interpretations.

4.4. Considerations for diversity and generalizability

The reviewed literature exhibits significant restrictions in terms of geographical and demographic diversity. A predominance of studies conducted within the United States (81.7%) limits the relevance of these findings to global contexts. Only a small subset originated from countries such as the Netherlands, Germany, the United Kingdom, Japan, Norway, and Canada, underscoring the skewed geographic distribution. Ethnic representation was similarly limited; most samples consisted predominantly of white individuals (69.57%), with minimal inclusion of other racial or ethnic groups such as Black or non-western populations. Participant populations tended to be narrow, with veterans and military personnel comprising the majority of participants. Other groups, including survivors of sexual or interpersonal violence, civilians, and individuals with substance use disorders, were underrepresented, often in fewer than five studies.

This restricted sampling approach indicates that variations in PTSD trajectories and treatment responses across different cultural, trauma, and population subgroups remain largely unexplored. To address these limitations, future research should focus on implementing more diverse and transparent sampling strategies, emphasizing demographic and cultural diversity, and on standardized reporting of participant characteristics. Such measures are critical for enhancing the external validity of process-of-change research in PTSD treatment.

5. Non-systematic update for 2024 and 2025

To provide an update on our search cutoff of December 2023, we performed a systematic search of PTSDpubs using the original search string, which resulted in 363 abstracts. Based on our review results, we expect 4 new articles to be included (1% of the 363 new abstracts), but the publication rate also indicates that this number grows each year. A non-systematic search of abstracts resulted in three articles meeting our inclusion criteria: one examining the temporal relationship between positive affect and PTSD (Rosencrans et al., 2024) and two network analysis studies (Moshier et al., 2024; Zeifman et al., 2024). Notably, we looked into studies using ILD and identified a current narrative overview of how EMA measurement can be used for just-in-time interventions for PTSD (Pavlacic et al., 2025), but found no studies implementing ILD measurement during treatment.

6. Recommendations

The main objective of researching change in PTSD symptoms during treatment is to identify variables

and predictors that aid clinical decision-making and improve treatments. We recommend clearly stating causal aims in research questions, especially regarding the timing of mediators affecting PTSD symptoms during treatment, which will allow for better and more nuanced communication between researchers. Specifically, researchers should familiarize themselves with causal inference frameworks to better interpret results. Measurement timing and frequency during treatment should be guided by theory and empirical observations rather than tradition or practicalities alone; to do this, exploratory and observational studies are needed to understand patterns of PTSD change during treatment. Additionally, the literature lacks studies utilizing ILD during treatment. High-resolution studies are particularly needed in early treatment sessions. Furthermore, the use of psychometric subscales can help differentiate patterns of change during treatment. Finally, studying individual trajectories of change, particularly non-linear patterns, using person-centred approaches is an important yet underexplored area, where methods like multi-level modelling and longitudinal class analysis can be helpful, even when implementing and interpreting non-linear models can be challenging.

Despite the identified challenges and gaps, it is essential to note that the majority of the literature reviewed was published after 2015. This results highlight the relative youth of this area of research. It is encouraging to see how much the field of psychotraumatology has advanced when it comes to the understanding of treatment effects in PTSD, and it is exciting to see where the following avenues of research will take us.

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Author contributions

CRedit: **Nicolás García-Mejía:** Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Project administration, Resources, Software, Visualization, Writing – original draft, Writing – review & editing; **Anja F. Ernst:** Conceptualization, Methodology, Supervision, Writing – original draft, Writing – review & editing; **Miriam J.J. Lommen:** Conceptualization, Methodology, Supervision, Writing – original draft, Writing – review & editing; **Lea Seidel-Koulaxis:** Conceptualization, Data curation, Methodology, Resources, Writing – review & editing; **Julián**

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No potential conflict of interest was reported by the author(s).

Data availability

The study materials including data search process (search strings, datasets retrieved, and deduplication process), screening procedure (inclusion criteria, training materials, and conflicts), data categorization process (codebook and final dataset), data analysis R scripts, and a full set of results, can be found in the following link: supplementary materials.

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