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Attrition Rates in Mindfulness-Based Interventions for Chronic Pain: A Meta-Analysis with Meta-Regression

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Abstract

Objective: Mindfulness-based interventions (MBIs) show promise in managing chronic pain but often require substantial time commitments, leading to high attrition and concerns about acceptability. This meta-analysis evaluated attrition rates in MBIs for chronic pain and examined moderators contributing to participant withdrawal.

Methods: Following PRISMA guidelines, **we searched relevant databases for studies of MBIs for pain. Eligible studies included randomised controlled trials, controlled trials, and quasi-experimental designs that reported attrition data for adults (≥18 years) with chronic pain lasting over 3 months. Data extraction covered attrition metrics, program characteristics, and participant demographics. Statistical analyses included random-effects meta-analyses of proportions, sensitivity analyses, meta-regression, and publication bias assessments.**

Results: **Forty-four studies (45 intervention conditions) were included.** The pooled attrition rate was 30.1% (95% CI: 24.5% to 37.3%) with substantial heterogeneity (I^2 = 89.0%). **Attrition increased with** stricter completion thresholds **(minimum sessions required for programme completion status)** ($p < 0.001$, $R^2 = 28.1\%$): **18.0% (≥3–4 sessions), 31.6% (≥5–6 sessions), and 49.7% (>6 sessions)**. Online delivery showed higher

attrition (51.0%) **than** in-person delivery (25.6%, $p = 0.002$, $R^2 = 17.1\%$). Individually delivered MBIs **were also associated with higher attrition than** group formats ($\beta = 0.216$, $p = 0.039$, $R^2 = 5.5\%$). **Publication bias analyses suggested minor influence on the pooled effect, which remained robust after adjustment.**

Discussion: Attrition rates for MBIs in chronic pain vary widely. Higher attrition is associated with stricter completion criteria, online delivery, and individual formats. These findings highlight the need to optimise MBI programme structure for management of pain.

Keywords: Mindfulness, Pain, Attrition

1. Introduction

Mindfulness-based interventions (MBIs) are often recommended in the psychological treatment of chronic pain, with empirical evidence supporting their efficacy in reducing pain-related discomfort and functional impairment.[1-3] However, the implementation of MBIs places practical demands on participants, which are often compounded by the challenges of managing chronic pain.[4,5] Indeed, a significant barrier to undertaking MBIs is the time commitment and sustained effort required to learn and integrate mindfulness practices effectively.[6] While the benefits of mindfulness may not be solely dependent on the amount of time spent practicing, MBIs often require participants to engage in sustained and structured mindfulness training to achieve meaningful outcomes, particularly during the early stages of the learning process.[6-8]

The considerable time investment associated with mindfulness training is demonstrated in the program structure of traditional MBIs such as Mindfulness-Based Stress Reduction (MBSR) and Mindfulness-Based Cognitive Therapy (MBCT). Both MBSR and MBCT typically involve weekly 2.5-hour training sessions over eight weeks, alongside daily 45-minute practice sessions for at least six days per week, and these programs often conclude with a full-day retreat.[9,10] Beyond the initial intensive training period, continued time investment in maintaining a consistent practice regimen is also necessary to help preserve and deepen mindfulness skills.[7] Kabat-Zinn, the founder of MBSR, emphasised that mindfulness should be cultivated as a lifelong practice rather than approached as a finite eight-week course.[11] This perspective frames mindfulness training as a long-term lifestyle integration—a skill to be learned, refined, and mastered over time—rather than a single-dose intervention for symptom relief.[12]

Furthermore, the structured design of traditional MBIs, which are taught in a sequence of components that each build on the components taught in the earlier weeks, highlights the importance of program attendance and completion to fully develop the foundational skills of mindfulness.[13] Partial program completion may not provide sufficient exposure to these core practices, potentially limiting the effectiveness of the intervention. Despite this, program attrition across studies examining MBIs across diverse participant populations and pain conditions varies widely, with rates ranging from 27% to 80%.[14-17] This variability suggests that there may be potential barriers to program completion which could impede participants' ability to fully engage with and benefit from the MBIs.

Previous research on treatment and clinical trial attrition suggests that variability in program completion is likely influenced by multiple factors, including program design features (e.g., session length and frequency), delivery methods (e.g., online vs. in-person), methodological differences (e.g., inconsistent definitions of completion and attrition rates), and participant-specific factors (e.g., demographic differences or pre-treatment expectations).[18-21] However, for MBIs targeting chronic pain, the specific reasons underlying attrition rates and their variability across studies remain unexplored, as no research has systematically investigated attrition patterns in this context.

Attrition in psychological and clinical trials has important implications for how results are interpreted and applied. When individuals who discontinue an intervention differ in systematic ways from those who remain, treatment effects can become biased, as outcomes may be estimated from a select subgroup rather than the intended sample.[22,23] For example, findings may generalise only to those participants who were more motivated or able to complete the program, rather than to the broader population for whom the intervention is intended. [22,23] Reduced sample sizes also weaken statistical power and precision, making it harder to determine whether observed effects are

reliable.[23] Attrition also has important implications for the interpretation of intervention efficacy. If analyses rely only on completers without an intention-to-treat analysis, results may overestimate efficacy because those who remain engaged are often those more likely to respond.[24,25] Conversely, when intention-to-treat approaches are applied but attrition is substantial, the estimated efficacy may appear lower than what might be achievable in a program designed to improve retention.[24,25] Moreover, non-completers may in some cases experience a deterioration in symptoms that is unmeasured if post-intervention data are not collected, inflating impressions of efficacy.[24,26] Taken together, participant attrition can stem from varied methodological, program-specific, and participant factors, and its influence must be considered when interpreting intervention outcomes.

Given the important role of program attendance for skill acquisition in MBIs, particularly during the early stages of participation,[6] understanding the factors contributing to attrition is fundamental to improving the efficacy of MBIs. This insight can inform refinements to program design and implementation to better retain participants, enable identification of participant characteristics and circumstances that influence program completion, and provide insights into the barriers and facilitators of participation in mindfulness practices in the context of chronic pain management. The present review and meta-analysis therefore aim to systematically evaluate attrition rates in MBIs for chronic pain and explore the moderating factors that influence retention, with the ultimate goal of enhancing therapeutic outcomes and ensuring interventions better meet participant needs and expectations.

2. Materials and Methods

2.1. Protocol and Registration

The protocol for this systematic review and meta-analysis was registered with PROSPERO (CRD42024507477). The systematic review was conducted following the guidelines of the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA, see Supplementary Table S1, Supplemental Digital Content 1, http://links.lww.com/CJP/B264).[27]

2.2. Search Strategy

The development of the electronic search strategy was conducted in collaboration with the review team. Searches were carried out using the Ovid platform, which included access to databases such as MEDLINE, MEDLINE(R), Epub Ahead of Print, In-Process & Other Non-Indexed Citations, Daily and Versions(R), EBM Reviews - Cochrane Central Register of Controlled Trials, APA PsycInfo, and Ovid Embase.

A set of keywords that aligned with the aims of this review was employed across these databases (e.g., mindfulness, chronic pain). The search terms were tailored to each database to accommodate their unique indexing requirements, with no restrictions on publication date or language. An updated search was conducted prior to the final analysis to include recent studies. A detailed record of the search strategy with a complete list of search terms can be found in Supplementary Material: Search Strategy, Supplemental Digital Content 2, http://links.lww.com/CJP/B265.

Two reviewers, MYW and MPP, were provided training prior to conducting the literature screening. This training encompassed the study's aims, variables, outcomes, and inclusion/exclusion criteria, along with specific search techniques. Training concluded with a pilot review of randomly selected abstracts to ensure inter-rater consistency and reliability in the screening process. The review process was structured in two phases: an initial phase where studies were chosen based on the relevance of their titles and abstracts, and a second

phase involving detailed full-text reviews. Any discrepancies in study selection were discussed and resolved with the assistance of two additional independent reviewers, NWB and BMF, to achieve a consensus.

2.3. Selection Criteria

The present review sought to examine attrition rates in MBIs for chronic pain management. Studies were included if they met the following *a priori* criteria: (1) the nature of chronic pain was clearly defined, specifically noting that the condition persisted for more than three months, as per the definition provided by the International Association for the Study of Pain (IASP);[28] (2) the study implemented MBIs with detailed intervention protocols; (3) the article was published in a peer-reviewed journal and written in English; (4) valid pain measurement tools were included; and (5) participants consisted of an adult population aged 18 years or older. All intervention modalities (e.g., in-person, telehealth, group, or individual) were considered eligible, and no restrictions were placed on the type of pain condition. **Eligible study designs comprised randomised controlled trials (RCTs), controlled trials (CTs), and quasi-experimental studies.** For studies meeting inclusion criteria but lacking complete attrition data, corresponding authors were contacted to obtain additional information.

Studies were excluded if: (1) they only consisted of purely theoretical content or were commentaries without empirical data, (2) they presented a single case report, (3) they involved participants with prior mindfulness experience, (4) they included interventions that combined mindfulness with other therapeutic approaches (e.g., art therapy, motivational interviewing), (5) they had programs lasting less than two weeks as these were deemed insufficient for evaluating program effectiveness and attrition patterns, (6) they were secondary analysis of previous published studies already included in this review, and (7) they

did not present complete data sufficient to enable our analyses, and the corresponding author did not respond to data requests prior to a specified deadline.

2.4. Outcome Measures

The primary outcomes of interest covered three key domains: attrition metrics, program characteristics, and participant demographics. Attrition metrics included the number of participants who: (1) initiated the program (defined as attending at least one session), (2) discontinued after attending at least one session, thus not completing the program as designed (e.g., all eight sessions), and (3) attended all sessions of the program. Program characteristics included the mode of the MBI delivery (e.g., in-person, virtual, telephone, hybrid), program duration and frequency, session length, instructor qualifications and experience, total program duration in minutes, and unique protocol characteristics. Additionally, comprehensive demographic information was collected, including participants' age, gender, race, and pain classification. These variables were selected to provide a thorough understanding of both program implementation factors, as well as participant characteristics that might influence program participation and attrition rates.

2.5. Risk of Bias Assessment

Risk of bias was assessed using a two-step approach, which has been previously applied in similar systematic reviews of pain and mindfulness research[29,30] to assess risk of bias across varied study designs, including randomised, cohort, and cross-sectional studies. First, methodological quality was evaluated with an adapted version of the Lievense checklist.[30] This tool consists of 15 items that assess internal validity and can be applied to cohort, cross-sectional, or case-control studies. Each item was scored 1 (criterion met) or 0 (criterion not met), and the total score was used as an indicator of study quality. The results from the Lievense checklist were then assessed using an

adapted Cochrane collaboration for cohort studies.[31] This version included four items for cross-sectional studies and five items for cohort studies. Each item was rated low, moderate, or high using the Lievense scores as a guide. For example, the Cochrane domain "Can we be confident in the assessment of exposure?" was mapped to Lievense items 5, 6, and 7 (e.g., Item 5: Exposure [Mindfulness Intervention] assessment blinded). If all three of these items were rated as criterion met, the Cochrane domain was classified as "low risk." However, if any of these items were rated as criterion not met, the corresponding Cochrane domain was rated as moderate or high risk depending on the number and severity of the unmet criteria. Overall study risk was then classified according to pre-specified rules: low (all items on the adapted Cochrane criteria scored as low), low-moderate (one item moderate), moderate (two items moderate), or high (>2 items moderate or any item high). This method requires all items to be scored low for a study to be classified as low risk (see Supplementary Tables S2, Supplemental Digital Content 3, http://links.lww.com/CJP/B266 and S3, Supplemental Digital Content 4, http://links.lww.com/CJP/B267 for a copy of the adapted tools).

To improve consistency, two reviewers (MYW, MPP) first carried out a calibration exercise on a small number of studies and created a brief implementation guide outlining how to apply each item. All studies were then independently assessed by each reviewer, with disagreements resolved through discussion until consensus was reached. This approach aligns with recommendations for the revised Cochrane risk-of-bias tool for RCTs (RoB 2), where review-specific guidance and calibration have been shown to improve reliability and efficiency.[32,33]

2.6. Statistical Analyses

All statistical analyses were conducted using R version 4.4.2 and the R packages metafor and meta. Given our smaller study pool and observed proportions deviating from 0.5,

we implemented the Freeman-Tukey double arcsine transformation[34,35] to address distribution skewness and achieve more consistent variance. This transformation has demonstrated superior performance compared to alternatives such as logit transformation in simulation studies.[36,37] Back-transformation was based on Miller's equation which facilitated interpretation following significance testing.[34,38] **The analysis employed pooled proportions (attrition rates), transformed using the Freeman-Tukey double arcsine transformation, with weighted means using inverse-variance weights, estimated through restricted maximum likelihood (REML) in random-effects models. This approach was justified by heterogeneity indicators from the I^2 statistic, interpreted using standard thresholds of 25%, 50%, and 75% to represent low, moderate, and high heterogeneity respectively.[39,40] While Cochran's Q was calculated, interpretation focused on I^2 given that *Q* can be influenced by the number of studies included in the meta-analysis, often lacking power when few studies are included and becoming overly sensitive as study numbers increase.[41]** The random-effects model was selected for its capacity to account for both within- and between-study variances, which is particularly appropriate given our diverse study methodologies and populations.[42]

2.6.1. Sensitivity analysis (outliers)

A sensitivity analysis was conducted to address between-study heterogeneity and evaluate potentially influential outliers.[43] A combination of diagnostic tools and statistical tests were utilised. First, a Baujat plot was used to visually inspect each study's contribution to heterogeneity (as measured by Cochran's *Q* test) and its influence on the pooled effect size. This was followed by formal diagnostics, including case deletion methods (e.g., DFFITS and Cook's distance) and leave-one-out analyses, to evaluate the impact of individual studies on the overall summary effect and heterogeneity. We also screened externally studentised

residuals (ESR), using absolute z-scores greater than 2 to identify potential outliers. Rather than automatically excluding identified outliers, we examined the characteristics of studies identified as outliers using the absolute z-scores to understand their influence on the results and potential moderating effects. Outlying studies were retained if they were methodologically sound and were deemed to reflect real-world variability, but excluded if they were deemed to be methodologically flawed or to compromise overall result validity.[42] Detailed findings are reported in the results section.

2.6.2 Moderator analysis

A stepwise approach was implemented to investigate moderator effects on attrition rates in mindfulness-based interventions for chronic pain. The analysis proceeded in two phases. Initially, individual meta-regressions were conducted to assess each moderator's independent contribution to explaining heterogeneity in attrition rates across studies. Subsequently, theoretically related moderators demonstrating statistical significance were integrated into a comprehensive mixed-effects meta-regression model to evaluate their relative contributions while controlling for potential confounding effects. Moderators included demographic variables such as gender, age, and race, as well intervention specific variables such as intervention type, delivery format, program and session length, and trainer qualification. The hierarchical analysis approach enabled a nuanced understanding of both independent and interactive moderator effects on participant retention. For a detailed description and guide of the methods described here please see the paper by Wang.[42]

2.7. Publication Bias

Publication bias represents a significant threat to the validity of meta-analyses, as studies with statistically significant or larger effect sizes are more likely to be published, while smaller studies with non-significant results are often excluded. This selective reporting

can lead to an overestimation of the true effect.[44] **In assessing the publication bias of studies, we primarily relied on visual inspection of funnel plot asymmetry to assess the risk of publication bias or small-study effects. While we also applied Egger's regression and the trim-and-fill method, these results are presented as exploratory, since statistical tests can be underpowered or yield inflated false positives in the presence of substantial heterogeneity, even with larger study numbers.[45,46]**

3. Results

3.1. Study Selection

A total of 4270 studies remained after duplicates were removed. Title and abstract screening resulted in the exclusion of 3,951 studies that did not meet inclusion criteria. Full text screening further excluded 264 studies. There were 26 studies that contained missing or incomplete data, and corresponding authors were contacted via email for supplementary information. Of these, nine authors responded to our request; however, only two of the studies were suitable for inclusion based on our study aims. Finally, 44 studies, comprising 45 conditions, met our inclusion criteria and were included in the subsequent analyses. Figure 1 presents a flow diagram of the study selection process.

2. Description of Selected Studies

The characteristics of the selected studies are presented in Table 1. As one study featured multiple conditions/arms (comparing MBSR with MBCT) each condition was included as a separate entity to ensure comprehensive evaluation of each intervention approach. Chronic pain conditions across the studies were systematically categorised based on diagnostic similarities, with conditions such as low back pain and back pain consolidated under the broader classification of musculoskeletal pain. The selected studies represented a

variety of chronic pain conditions, including musculoskeletal disorders, headaches/migraines, and fibromyalgia, with sixteen studies specifically examining mixed pain conditions.

Across studies, MBSR was the predominant mindfulness-based approach adopted for chronic pain intervention, typically adhering to standard protocols involving in-person, group-based delivery over an eight-week duration.[47] While some programs included the traditional one-day retreat component, others omitted this element. The most notable variation between MBSR studies appeared in session duration, which ranged from 1.5 to 2.5 hours. Several studies implemented modified versions of MBSR, including brief interventions, extended programs, or adaptations for online or web-based administration.

MBCT was the second most common intervention and followed a similar program structure to MBSR protocols. Other interventions comprised author-developed protocols that followed Kabat-Zinn's definition of mindfulness as "paying attention in a particular way: on purpose, in the present moment, and nonjudgmentally".[48] Program facilitation was primarily conducted by psychologists and accredited MBSR instructors.

A significant methodological variation was found in the reporting of attrition data across studies. The definition of program completion varied substantially, with some studies classifying participants as completers after attending four sessions (out of the total number of sessions provided by the course which was typically eight) and considering those attending only 1-3 sessions as those have dropped out of the program, with anyone completing 4 or more sessions considered as program completers. Other studies employed more stringent criteria, requiring attendance of at least six sessions or completion of the entire program to qualify as program completers. This heterogeneity in attrition definition was considered a potential moderator (referred to as completion threshold for the remainder of this paper) in explaining variability in attrition rate across studies.

A total of 44 studies were assessed for risk of bias. Of these, 25 studies were rated as having a moderate risk of bias with the most common issues identified as a lack of participant or assessor blinding, small sample sizes, reliance on self-reported pain or function outcomes, and incomplete follow-up. Nineteen studies were rated as low-moderate risk, typically well-conducted randomised trials in which only a single domain was rated moderate, most often participant blinding or reliance on self-report while all other domains were low. No studies were rated as low risk of bias, as all studies had at least one domain on the adapted Cochrane criteria that failed to meet low-risk standards. No studies were rated as high risk of bias according to the Lievense + adapted Cochrane criteria; even early pilot or single-arm studies generally showed overlapping moderate risk features rather than a single critical high-risk flaw. A meta-regression comparing the studies that were rated as moderate risk of bias with those rated as low–moderate risk showed no significant difference in attrition rates ($QM(1) = 0.01$, $p = .93$). For a comprehensive description of the selected studies, including a full list of the included studies with corresponding author and year of publication, detailed methodological specifications, participant characteristics, and intervention protocols, please refer to the Supplementary Table S4, Supplemental Digital Content 5, http://links.lww.com/CJP/B268.

3.3. Overall Attrition Analysis

The meta-analysis, using a random-effects model to account for heterogeneity, revealed a pooled attrition rate of 30.1% (95% CI: 24.5% to 37.3%) across all included studies. Individual study attrition rates ranged from 2.2% to 72.9%. The Q statistic was significant ($Q(44) = 400.510$, $p < 0.0001$, $k = 45$), and the I^2 value was 89.0%, indicating significant heterogeneity across the selected studies.

A sensitivity analysis was conducted to identify potential influential studies or outliers. One study was identified as an influential outlier.[49] However, with this study removed, the pooled attrition rate changed to a negligible extent: 29.6% (95% CI: 23.7% to 35.9%) across the remaining studies. The *Q* statistic remained significant ($Q(44) = 376.677$, $p < 0.0001$, $k = 44$), and the I^2 value was 88.5%. As the methods used in the outlier study were deemed methodologically sound, and the *Q* statistic and I^2 value remained significant and high respectively, the study was retained in further analyses. The persistent significant *Q* statistic and high I^2 value after outlier removal suggest that the observed variability in attrition rates was unlikely to be due to random sampling error alone or influenced by a single outlier. Instead, this variability may reflect differences in population or intervention characteristics, warranting further analysis to examine potential moderators contributing to the considerable variation in attrition rates.

3.4. Moderator Analysis

Meta-regression analyses revealed no significant associations (all $p > .05$) between attrition rates and gender, age, race, intervention type, program length, session length trainer qualification, participation reward, or chronic pain condition type (see Table 2 for detailed statistics).

3.4.1. Completion threshold and attrition analysis

A mixed-effects meta-regression was performed to evaluate the influence of completion threshold on attrition rate. The moderator was found to be statistically significant ($QM(1) = 13.064$, $p < 0.001$). The estimated effect size for the moderator was 0.162 (95% CI: 0.074 to 0.250), explaining 28.1% ($R^2 = 28.1\%$) of the heterogeneity in attrition rates. Figure 2 presents a forest plot of the relationship between completion thresholds and attrition rates. As shown in Figure 2, attrition rates increased progressively with higher completion thresholds. The pooled attrition rate of studies with low completer threshold (participants

recognised as completers after completing more than 3-4 sessions) was 18.0% (95% CI: 10.00% to 27.5%), while the rate for the moderate completer threshold (studies that required participants to complete 5-6 sessions) was 31.6% (95% CI: 24.1% to 39.7%). The higher completer threshold, representing participant withdrawal more than 6 sessions, showed the highest attrition at 49.7% (95% CI: 35.2% to 64.3%).

3.4.2. Delivery method and attrition analysis

A mixed-effects meta-regression model was conducted to evaluate the influence of delivery method on attrition rates. Delivery method was found to significantly explain some of the variability in attrition rates across studies ($QM(1) = 9.516$, $p = 0.002$). The in-person delivery method was associated with lower attrition rates (pooled proportion = 25.6%, 95% CI [19.5%, 32.2%]) compared to other delivery methods (e.g., online/mobile or mixed), which had significantly higher attrition rates (pooled proportion = 51.0%, 95% CI [36.2%, 65.6%]). The results indicate that delivery method explains a small but significant portion of the heterogeneity in effect sizes ($R^2 = 17.1\%$). However, as only a small number of included studies (7 studies in total) used the online/mobile or mixed methods, these results should be interpreted with caution. Figure 3 presents a forest plot summarising the pooled attrition rates across different delivery methods.

3.4.3. Therapy format and attrition analysis

A mixed-effects meta-regression model was conducted to examine the impact of therapy format (group or individual) on attrition rates across studies. Therapy format was found to significantly explain 5.5% ($R^2 = 5.5\%$) of the variability in attrition rates across studies ($QM(1) = 4.271$, $p = 0.039$). The results indicated that interventions delivered

individually, as opposed to group settings, were associated with significantly higher attrition rates (β = 0.216, p = 0.039, 95% C.I. [0.011, 0.420]). This suggests that group formats may be more effective in retaining participants compared to individual delivery formats. Figure 4 presents a forest plot of attrition rates by therapy format (group vs. individual).

3.4.4. Interaction effects between completion threshold and treatment characteristics

While individual meta-regression analyses identified significant moderators (e.g., completion threshold, delivery method, therapy format), a large proportion of heterogeneity remained unaccounted for. Given the varying definitions of completion thresholds across studies, we conducted a mixed-effects meta-regression model (k = 45) to examine potential interactions between completion threshold and other variables. This analysis investigated whether the relationship between completion threshold and attrition rates was moderated by other key variables, particularly delivery method and therapy format, which had shown significant influence on attrition rates.

The mixed-effects meta-regression revealed no significant interactions between completion threshold and either therapy format (β = -0.112, p = 0.533) or delivery method (β = -0.117, p = 0.418). This indicates that the relationship between completion threshold and attrition rates remain consistent regardless of delivery method and therapy format. While the main effect of completion threshold remained a significant predictor of attrition rates, substantial residual heterogeneity persisted (I^2 = 84.71%, $Q(38)$ = 228.724, p < .0001), with the model accounting for 34.2% of the variance (R^2 = 34.2%).

3.5. Publication bias

Visual inspection of the funnel plot (Supplementary Figure S1, Supplemental Digital Content 6, http://links.lww.com/CJP/B269) indicated asymmetry, with a greater concentration of observed studies on the left-hand side (lower attrition) and fewer studies on the right (higher attrition). This pattern raises the possibility that studies reporting higher attrition rates may be under-represented in the published literature. A supplementary analysis using Egger's regression test did not indicate significant asymmetry (p = 0.311). Trim-and-fill analysis estimated six potentially missing studies on the right side of the plot, consistent with an underrepresentation of studies reporting higher attrition rates. After trim-and-fill adjustment, the pooled attrition estimate remained at a comparable level to the non-adjusted results (estimate = 0.639, 95% CI [0.565, 0.712], $p < 0.0001$), suggesting that the finding of substantial attrition across studies is unlikely to be explained by reporting bias. Heterogeneity remained high (I^2 = 91.7%, Q = 550.38, $p < 0.0001$), indicating substantial between-study variability and justifying moderator analyses.

4. Discussion

This meta-analysis aimed to systematically evaluate attrition rates in MBIs for chronic pain and to explore moderators influencing attrition rates. We found an overall attrition rate of approximately 30% across MBIs for chronic pain, with higher rates associated with stricter completion thresholds, online delivery, and formats that provided the MBI to a single individual per session. This overall attrition rate aligns with findings from efficacy-related meta-analyses which aligns with findings from efficacy-related meta-analyses, such as that by Marikar Bawa and colleagues,[50] who reported attrition rates in MBIs for chronic pain ranging from 2% to 50% (median 20%). The meta-analysis conducted by Marikar Bawa and colleagues specifically focused on MBSR and MBCT programs lasting a minimum of six weeks.[50] Our meta-analysis included a broader range of

mindfulness interventions which provided a wider spectrum of attrition rates. This expanded scope enabled a more comprehensive examination of attrition patterns across diverse intervention types and protocol designs specifically targeting chronic pain.

When compared with other meta-analyses across various pain treatment modalities, our findings are broadly consistent. For instance, Oosterhaven and colleagues reported attrition rates ranging from 10% to 51% in different pain management programs,[51] while Veehof and colleagues found attrition rates between 26.7% and 67.3% across treatments with mindfulness elements—including Acceptance and Commitment Therapy (ACT), MBSR, and MBCT—without finding significant differences between modalities.[53] **More broadly, our findings are comparable to attrition rates observed in other behavioural and health intervention domains. Exercise interventions typically report attrition rates of 18 to 34%, with outlier attrition rates of up to 58%,[53] while app-based chronic disease programs show pooled attrition rates of around 43%,[54] and longitudinal primary care studies using electronic health record data indicate that roughly one-third of patients are lost to follow-up within three years.[55]**

Taken together, these comparisons suggest that attrition in MBIs for chronic pain falls within the range commonly observed across behavioural and health interventions. Within our own analysis, several methodological features appeared to contribute to this variability. Moderator analysis in this study revealed progressively higher attrition rates with increased completion thresholds, particularly in studies requiring participants to have completed 6 to 8 sessions (non-consecutive) to be considered to have completed the program. Variation in delivery method (online versus in-person) and delivery format (individual versus group) explained some heterogeneity in effect sizes, with both online delivery and individual formats showing higher attrition rates compared to in-person and group sessions.

4.1. Higher Attrition Rates with Higher Completion Thresholds

An analysis of attrition rates across different completion thresholds revealed that programs requiring attendance at six or more sessions had higher attrition rates. On average, only around 50% of participants attended six or more sessions (non-consecutive). This highlights a significant challenge in retaining participants in MBIs, as half of the participants struggle to meet attendance requirements of programs with higher session counts.

The higher attrition rates observed at higher completion thresholds may stem from several practical and physical challenges, including the severity of disability-related difficulties, logistical constraints, and fatigue, all of which can hinder sustained participation. For example, poor attendance among individuals with chronic pain in MBIs has been linked to difficulties in performing specific mindfulness techniques.[56,57] Techniques such as prolonged body scans—which require participants to remain still and focus on various body parts for extended periods—can exacerbate pain-related discomfort and limit the number of sessions participants are able to attend.[56,57] Additional factors impacting attendance include individual characteristics such as baseline pain severity, fatigue, and pain in areas that make prolonged sitting difficult, all of which can significantly reduce participation over time, especially in programs with longer session durations.[56,58] However, it is worth noting that no significant differences were found between pain types in our analysis, suggesting that pain types may not directly influence attendance in mindfulness practices. Furthermore, logistical challenges such as transportation difficulties and scheduling conflicts may become more pronounced as programs progress, further increasing the likelihood of missed sessions.[58,59]

In addition to practical and physical limitations, psychological factors may also play an important role in attrition rates. Research has consistently demonstrated a complex relationship between participant expectations and program retention in MBIs for chronic pain, with unmet expectations of pain relief being a significant contributor to attrition.[51,60]

Participants who enter MBIs expecting mindfulness training to eliminate or significantly reduce pain intensity often discontinue participation when they realise that the program's focus is instead on pain acceptance and management.[57] To mitigate the impact of these unmet expectations, programs could prioritise clear communication about the objectives of MBIs early in the process. Explicitly explaining, either before enrolment or during the first session, that the program emphasises pain acceptance and coping strategies rather than pain elimination may help align participant expectations with program goals. While this approach may reduce initial enrolment, it could lead to fewer participant withdrawals and better outcomes overall, as participants would be better prepared for the nature of the intervention.

Despite these challenges, it remains unclear whether attending fewer than six sessions necessarily limits clinical benefit. Findings from studies with less intensive formats,[14,61] which required only four sessions rather than the standard eight sessions (with the same frequency of 1 session per week) still reported significant improvements in pain and coping outcomes. Although current evidence is too limited to establish a reliable dose-response relationship between the number of mindfulness practice sessions and improved pain management outcomes, these findings may suggest that attrition at higher completion thresholds may overstate disengagement if clinically meaningful effects can be achieved at lower levels of attendance. Future studies should examine the relationship between number of sessions attended and clinical outcomes to clarify the minimum "dose" of mindfulness training required to confer benefit, and whether more sessions provide more substantial benefits.

4.2. The Role of Session Format and Group Dynamics in Participant Retention

Across the selected studies, programs delivered on an individual basis were associated with higher attrition rates compared to group-based interventions. This finding aligns with evidence from studies examining factors that influence participant experiences in MBIs,

which highlight that participants value the group format for fostering a sense of community and shared understanding.[56,57] This group setting helped reduce feelings of isolation often experienced by individuals with chronic pain, as mutual validation of experiences creates a supportive environment.[56,57] Additionally, group dynamics provide motivational benefits, as peer support and accountability encourage regular attendance and sustained engagement.[58] The collective learning environment further enhances participation by allowing individuals to observe and adopt others' coping strategies, share mindfulness practice adaptations, and engage in collaborative problem-solving.[57] These interconnected mechanisms—social support, shared learning, and collective experience—not only improve participation but also address cost-efficacy concerns, as group formats are generally more cost-effective than individual sessions.[57,62]

These group-based advantages may also explain the observed differences in retention rates between in-person and online interventions. In general, online programs for pain management have been consistently associated with higher attrition rates compared to in-person programs.[63,64] This disparity may stem from the reduced interpersonal connection in virtual settings, which can diminish the sense of community and engagement. Additionally, online interventions may face challenges such as compromised information delivery, fewer opportunities to clarify program guidelines, and lower accountability.58,65 However, it is important to recognise that while group sessions may benefit some participants, the availability of diverse program formats—ranging from intensive in-person retreats to short, accessible sessions on mobile devices—offers flexibility and broadens accessibility. Online MBIs have been shown to improve well-being in certain populations, particularly when tailored to meet individual needs.[64,66,67] Offering a range of delivery methods ensures that MBIs can cater to a wider variety of participant preferences, logistical constraints, and psychological needs, thereby enhancing their accessibility and impact. However, clinicians

and researchers should be aware that online delivery methods are associated with higher rates of attrition.

4.3. Inconsistency in Attrition Reporting

A central theme emerging from this review is the inconsistency with which attrition is defined and reported across studies of MBIs for chronic pain. Some studies classified participants as completers after attending only four sessions, whereas others required attendance at six or more sessions, or completion of the full program. In addition, several studies defined attrition solely in terms of non-completion of follow-up outcome assessments, rather than withdrawal during the intervention itself. These divergent approaches to defining dropout and completion create substantial challenges for interpretation, as they obscure the extent to which participants are engaging with the core components of the intervention.

The lack of standardisation in reporting also limits cross-study comparability and hampers meta-analytic synthesis. Without consistent reporting of how many sessions participants actually attend, and reporting of their reasons for discontinuing, it is difficult to determine whether attrition reflects difficulties with the intervention, barriers external to the program, or a combination of both. This absence of detail further restricts the ability to explore dose-response relationships, and makes it difficult to establish what level of participation is sufficient to confer clinical benefit. Addressing these inconsistencies will require the adoption of standardised definitions of attrition and completion, coupled with more transparent reporting of attendance patterns and reasons for dropout. Such practices would strengthen the interpretability of individual studies, enhance the comparability of findings across trials, and ultimately support the

development of more robust evidence on the feasibility and effectiveness of MBIs for chronic pain.

4.4. Methodological Limitations and Field-Wide Considerations in Mindfulness-Based Intervention Research

4.4.1. Lack of homework tracking

A notable limitation in the selected studies is the lack of systematic tracking and analysis of homework adherence, with only 3 out of the 42 studies reporting on homework adherence and completion rates. This issue is not unique to this meta-analysis but reflects a broader trend across the field, with multiple meta-analyses across the field reporting similar gaps in homework adherence data.[64,66,68,69] Informal at-home practise is an important component of mindfulness training for chronic pain, as it helps consolidate learning and enhance skill acquisition.[10] The lack of homework adherence data undermines our understanding of the dose-response relationship in mindfulness interventions. Without knowing how much participants actually practice, it is difficult to establish evidence-based guidelines for home practice or to identify the barriers that hinder consistent engagement with the recommended practice amounts. This limitation impacts our ability to optimise interventions and develop targeted strategies to support participant with home practice, potentially compromising the overall effectiveness of MBIs for chronic pain management.

4.4.2 Research-Related Barriers and Methodological Limitations

Additionally, the attrition rates reported in these studies may not accurately reflect real-world attrition rates due to research-specific confounding factors. For example, the burden imposed by research-related activities—such as pre- and post-intervention interviews and comprehensive questionnaire batteries—may independently influence attrition rates. These components, which are absent in standard clinical implementations of MBIs, make it

challenging to isolate intervention-specific factors contribution to program, attrition from those related to research demands. Furthermore, research eligibility may exclude individuals who cannot attend sessions, lack interest, or have conflicting commitments. This pre-screening may limit the generalisability of our findings to broader populations, as it creates a sample that may not fully represent the diversity of individuals who could benefit from MBIs in real-world settings. Another element that may distort attrition is the use of study-specific incentives or additional supports (e.g., travel reimbursement, frequent contact from research staff). These features, which are often not available in clinical settings, may temporarily enhance retention during studies, leading to attrition estimates that may not reflect the processes of real-world program delivery. Taken together, these factors highlight how research contexts introduce both upward and downward pressures on attrition that may not reflect usual clinical implementation.

Furthermore, trainer qualifications were examined as a potential moderator, the analysis was limited to broad categories (psychologist versus trained MBSR instructor) that may not capture important nuances in instructor experience and expertise or the influence of trainer qualifications other than psychologist or trained MBSR instructor on participant retention. However, the effect of trainer qualifications on attrition rates approached our significance threshold ($p = 0.057$), revealing a non-significant trend where programs taught by trained MBSR/MBCT instructors were associated with lower attrition rates. Although the effect of trainer qualifications appears to be small based on these results, a future meta-analysis with a larger sample size may demonstrate a significant effect. Moreover, analyses that incorporate both trainer experience and qualifications may reveal stronger associations, highlighting the importance of considering this factor in future research as a potential determinant of participant attrition rates. A similar near-significant effect was observed for session length, where shorter sessions showed a non-significant trend towards lower attrition

rates (p = 0.080). Larger meta-analyses again may confirm this association in future. Nevertheless, even if shorter sessions are shown to reduce attrition, researchers and clinicians must carefully balance this finding against the potential reduction in program efficacy associated with shorter session durations.

Other programme design variables may also create barriers. For example, session frequency and programme intensity may influence whether participants can sustain attendance. In this case, we speculate that weekly sessions may be more feasible for participants in terms of reducing logistical and physical burden and therefore may support greater retention compared to more intensive schedules requiring multiple sessions per week. However, since all MBIs included in our meta-analysis provided one session per week, we were unable to test this suggestion. Similarly, the length of follow-up periods may affect reported attrition, as longer programmes provide more opportunities for dropout. Differences in intervention format, such as inclusion of retreats or extended homework requirements, may place additional demands on participants and thereby increase discontinuation. Unfortunately, data on these factors were inconsistently reported across studies, preventing formal analysis in the present review. Nonetheless, future research should systematically capture and report these variables, as they may shape both engagement and retention in MBIs and have important implications for programme design.

Several potential factors contributing to heterogeneity in attrition rates between studies couldn't be analysed due to insufficient data.[70] These include participant-related factors such as pain severity, concurrent health conditions, wait-time before commencing the program, work/family commitments, education, and socioeconomic barriers. Future research should systematically document these variables to better understand their impact on participant retention in MBIs for chronic pain.

4.4.5. Study Quality and Bias Considerations

The risk of bias profile of the included studies demonstrated methodological concerns that limit the certainty of interpretation. All of the included studies were classified either as low-to-moderate, or moderate risk, typically due to weaknesses across multiple domains such as incomplete blinding, small samples, reliance on self-reported outcomes, or limited reporting of follow-up and attrition. It is important to note however that blinding is difficult to achieve in mindfulness studies even when active comparators are used.[71]

While we did not observe differences in attrition patterns between studies rated as moderate risk and low-moderate risk, it is still possible that the heterogeneity and variation in risk of bias of study designs could still influence reported effects of MBIs on pain, function, and related efficacy outcomes rather than reflecting intervention efficacy alone.[26,72] For example, reliance on unblinded self-reported pain and disability measures may have increased the potential for expectation or reporting bias, while small samples and incomplete follow-up may have inflated or obscured true effects.[72,73] The absence of any study meeting low-risk criteria suggests that the evidence base is best regarded as moderate in certainty.[26,73] It should also be noted that our risk of bias assessment applied strict criteria, which may have led to more conservative ratings than in other reviews.

Taken together, these limitations mean that both attrition estimates, and intervention effects should be interpreted with caution. Studies with larger samples, standardised and blinded outcome assessment, and clearer reporting of participant sign up, attendance, drop-out rates, and follow-up measures are required to provide more reliable evidence on both the efficacy and the acceptability of MBIs for chronic pain.

4.4. Future Directions and Conclusion

This study investigated attrition rates and moderators of attrition in MBIs for chronic pain. Our findings identified higher attrition rates reported in studies that required participants to have attended a higher number of sessions before considering them to be program completers. Significant differences in attrition rates were also observed across delivery methods, with online and individually delivered program formats associated with higher attrition compared to in-person group sessions. Future studies should prioritise the standardised reporting of attrition rates and adherence metrics, including session attendance (specifying the number of individuals who attend each session of the program), reasons for discontinuation, and emphasise systematic tracking of homework adherence. This would enhance comparability between studies and provide insights into factors affecting attrition or conversely, retention. Moreover, future studies should integrate with real-world implementation to better understand program feasibility, adherence, and effectiveness across various clinical settings. Together, this work may assist in developing adaptive program structures that accommodate disability-related challenges while maintaining therapeutic integrity. Thereby, enhancing the accessibility and appeal of MBIs for chronic pain management across diverse populations.

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Table 1. Characteristics of Selected Studies

	N of Conditions (%)
Total	45
Pain Condition	
Chronic musculoskeletal pain	14 (31.1%)
Fibromyalgia	8 (17.8%)
Headache/Migraine	5 (11.1%)
Mixed - all related to chronic pain	16 (35.6%)
Other	2 (4.4%)
Intervention Type	
MBSR	28 (62.2%)
MBCT	5 (11.1%)
Other	12 (26.7%)
Delivery Mode	
In-person	37 (82.2%)
Telehealth	2 (4.4%)
In-person/Telehealth	1 (2.2%)
Web/Mobile	5 (11.1%)
Therapy Format	
Group	45 (88.9%)
Individual	5 (11.1%)

Program Duration	
3-4 weeks	4 (8.9%)
5-6 weeks	4 (8.9%)
8 weeks	35 (77.8%)
>8 weeks	2 (4.4%)
Trainer Qualification	
Psychologist (clinical, health)	13 (28.9%)
Trained MBSR instructor	24 (53.3%)
N/A	8 (17.8%)
Session Length	
Self-pace online	4 (8.9%)
1-hr	2 (4.4%)
1.5-hrs	7 (15.6%)
2-hrs	17 (37.8%)
2.5-hrs	12 (26.7%)
3-hrs	2 (4.4%)
Completion Threshold	
3-4 sessions	14 (31.1%)
5-6 sessions	24 (53.3%)
>6 sessions	7 (15.6%)
Homework	
Assigned	41 (91.1%)

Tracked homework completion	3 (6.67%)
Reward	
Yes	16 (35.6%)
No	29 (64.4%)

Note: MBSR-Mindfulness based stress reduction; MBCT-Mindfulness-based cognitive therapy; MBPM-Mindfulness-based pain management program; Completion Threshold-Program completion criteria used in each study (e.g., number of sessions attended to qualify as a completer); Reward-Whether participants were offered a reward for participation; N of Conditions-Number of unique experimental conditions across all included studies.

Table 2. Meta-Regression Analysis of Moderators on Attrition Rates in Mindfulness-Based Interventions for Chronic Pain

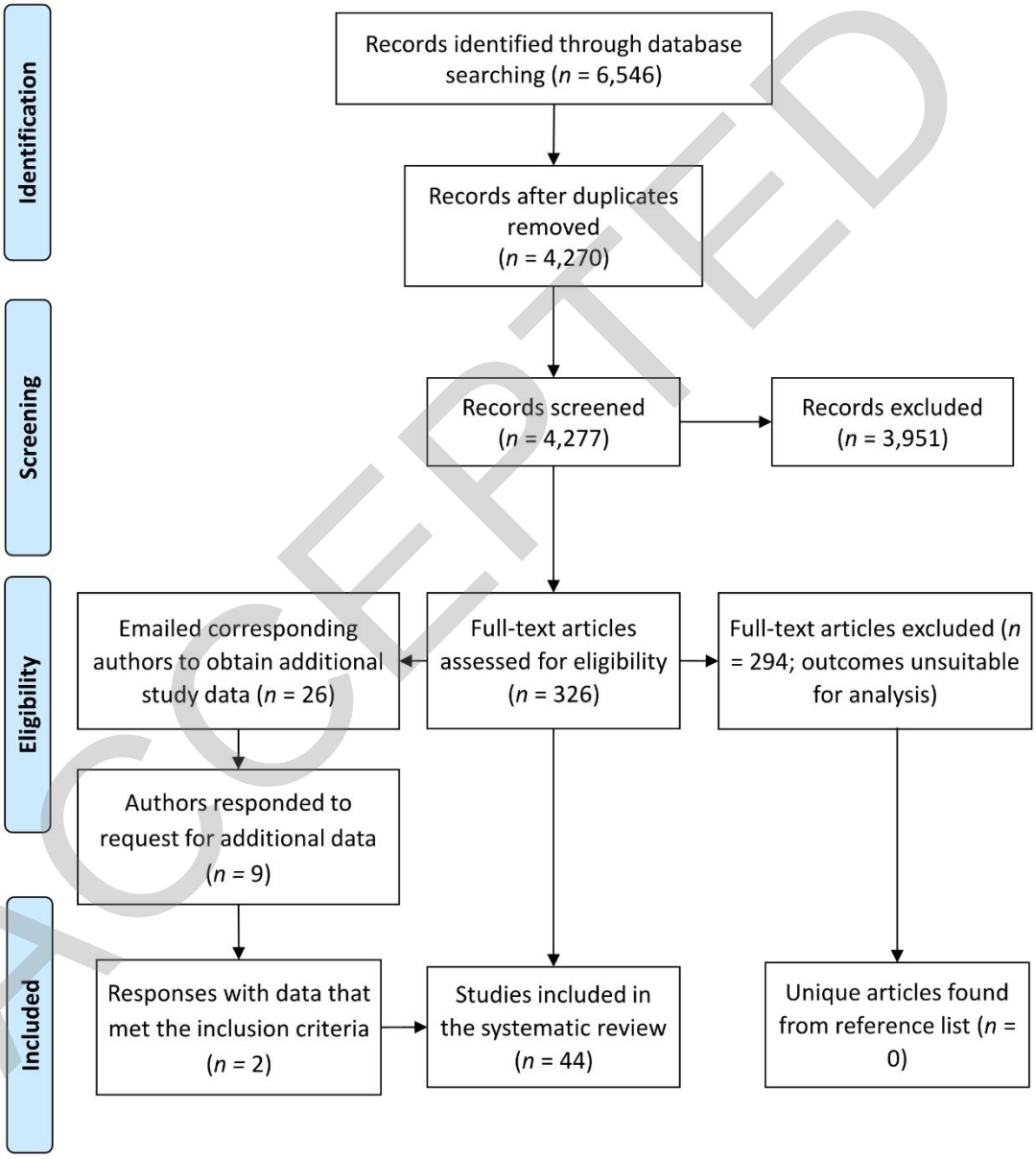
	Q statistic
Intervention Characteristics	
Completion Threshold	$QM(1) = 13.064$, $p < 0.001$*
Pain Condition	$QM(1) = 0.124$, $p = 0.724$
Intervention Type	$QM(1) = 0.204$, $p = 0.652$
Delivery Method	$QM(1) = 9.516$, $p = 0.002$*
Therapy Format	$QM(1) = 4.271$, $p < 0.039$*
Program Duration (in weeks)	$QM(1) = 2.109$, $p = 0.146$
Trainer Qualification	$QM(1) = 3.627$, $p = 0.057$
Session Length (in minutes)	$QM(1) = 3.065$, $p = 0.080$
Total Program Time in Minutes (without homework)	$QM(1) = 1.790$, $p = 0.182$
Reward	$QM(1) = 1.535$, $p = 0.215$
Participant Demographics	
% Female (N = 42)	$QM(1) = 0.103$, $p = 0.748$
M age (N = 42)	$QM(1) = 0.0002$, $p = 0.989$
% Caucasian (N = 30)	$QM(1) = 0.358$, $p = 0.550$

Note: Completion Threshold- program completion criteria used in each study (e.g., number of sessions attended to qualify as a completer). % of Females-percentage of female participants in the condition; % of Caucasian-participants identifying as

Caucasian in the condition; *M*-Mean; Reward-whether participants were offered a reward for participation; Significant Q statistics are highlighted with *.

Figure 1

Flow Diagram of the Study Selection Process



Note: *n*-number of articles.

Figure 2

Forest Plot of Attrition Rates by Completion Threshold with Pooled Proportions and 95% Confidence Intervals

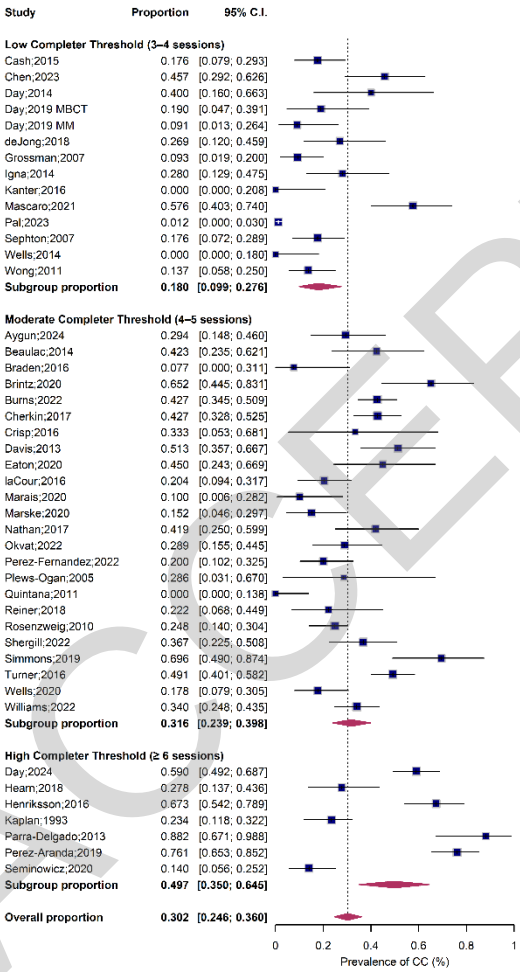


Figure 3

Forest Plot of Attrition Rates by Delivery Method (In-Person vs Other) with Pooled Proportions and 95% Confidence Intervals

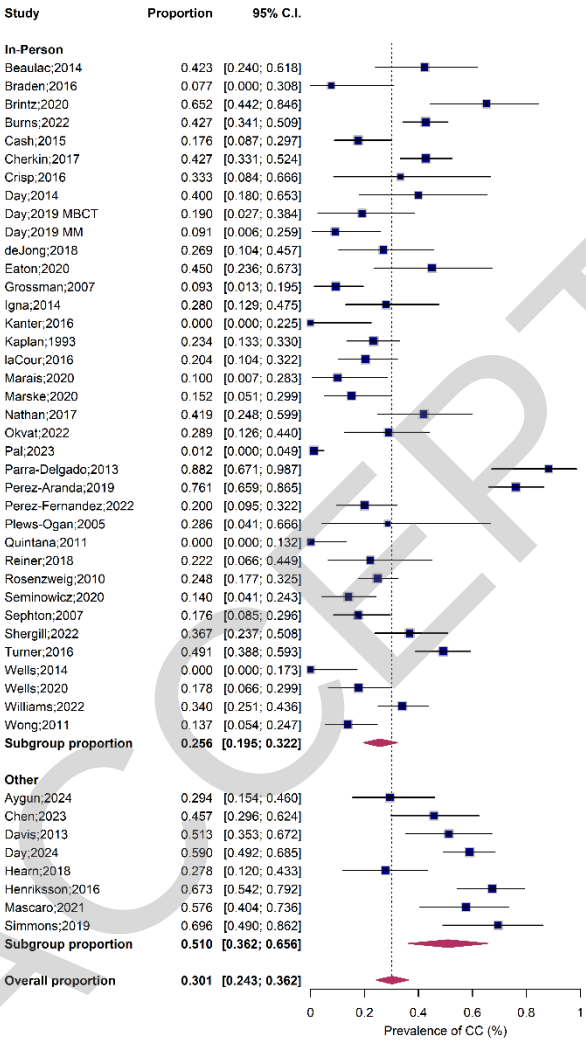


Figure 4

Forest Plot of Attrition Rates by Therapy Format (Group vs. Individual) with Pooled Proportions and 95% Confidence Intervals