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The Effectiveness of Transtheoretical Model-Based Educational Interventions on Drug Cessation; A GRADE-Assessed Systematic Review and Dose-Response Meta-Analysis

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ABSTRACT. The trans-theoretical model (TTM) is a popular framework for guiding behavioral interventions in substance use disorders. However, the optimal duration and intensity of these interventions are not yet known. This study used the GRADE approach and a dose-response meta-analysis to confirm the robustness of the evidence and to evaluate the effectiveness of TM-based educational interventions for drug discontinuation. In line with the PRISMA 2020 guidelines, systematic searches have been carried out in the databases PubMed, Scopus, the Web of Science and Embase until August 2025. Randomized controlled trials (RCTs) evaluating interventions based on TTM-based drug discontinuation were included in the quality of evidence assessment using the GRADE tool. A meta-analysis of dose responses was conducted to investigate the relationship between duration of treatment (weeks) and efficacy at the end of treatment. Of the 947 identified studies, 50 randomized controlled trials (RCTs) involving 9,245 participants met the inclusion criteria. Pooled analysis showed that TTM interventions significantly improved the rate of discontinuation compared with standard care (risk ratio [RR]: 1.58; 95-CI: 1.21-2.06; P<0.001), with modest heterogeneity (I^2 = 55). The dose-response analysis revealed a significant non-linear relationship ($P_{non-linearity}$<0.01); interventions showed a steep increase in efficacy up to 12 weeks and reached a plateau after 24 weeks, whereas brief interventions (<4 weeks) showed limited effects. Analyses of the dose response revealed a significant non-linear relationship ($P_{non-linearity}$<0.01) with a rapid increase in efficacy up to 12 weeks and plateau after 24 weeks, while short-term treatment (less than 4 weeks) had limited effect © 2025 Published by Public Knowledge Project (PKP).

Keywords: Transtheoretical Model (TTM), Drug Cessation, Health Education, Dose-Response Meta-Analysis, GRADE Assessment.

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Introduction

The trans-stheoretical model (TTM), or the Stages of Change Model, is widely used to guide educational interventions on drug treatment and health behaviours (Hasriani et al., 2022; Xie et al., 2025). To assess the effectiveness of TTM-based educational interventions for drug discontinuation, this review summarises data from 50 randomised controlled trials (RCTs) (Avery et al., 2022; Shang et al., 2022), medication adherence (Lavielle et al., 2018; Tan et al., 2019), and related health behaviors such as nutritional habits and physical activity (Miezah et al., 2024).

The results show that TTM interventions have a modest effect on actual drug withdrawal and adherence, but can improve knowledge, self-efficacy and readiness for change (Avery et al., 2022; Tan et al., 2019). Substance abuse disorders are one of the most important global public health problems, significantly increasing the burden of disease and mortality worldwide.

According to the United Nations Office on Drugs and Crime (UNODC), more than 296 million people worldwide have abused drugs in recent years, with drug use disorders on the rise in the last decade (UNODC, 2023). This escalating crisis is putting enormous pressure on health care systems and hampers social and economic development (World Health Organization [WHO], 2022). As a result, developing effective, scalable and sustainable strategies for drug eradication has become a priority for international health organisations.

Despite progress in pharmacological treatment, long-term withdrawal remains elusive for many people, as addiction is characterised by chronic and recurrent relapse (Volkow et al., 2016). Traditional interventions often fail because they take a `one size fits all' approach, which ignores the psychological and behavioural complexity of recovery. Research shows that medical treatment alone is often insufficient without the support of a concurrent behavioural intervention, as successful withdrawal requires not only physical detoxification, but also deep changes in lifestyle, coping mechanisms, and self-regulation (Kelly & White, 2020). Identifying interventions that can increase patient involvement and prevent relapse is therefore crucial.

To address these shortcomings, models of health education are increasingly integrated into addiction treatment protocols. Among these, the theoretical frameworks that explain the individual's readiness for change are particularly valuable. Educational interventions based on behavioural theory can help clinicians to tailor strategies to the specific needs of patients, thereby reducing resistance and increasing success rates (Glanz et al., 2008). This requires a shift from generalised counselling to structured, theory-based educational programmes that guide patients through the complex process of behavioural modification. The trans-stheoretical model (TTM), or the Stages of Change Model, is widely used to guide educational interventions on drug treatment and health behaviours (Hasriani et al., 2022; Xie et al., 2025).

The search strategy was designed to focus on high quality randomized controlled trials (RCTs) that addressed trans-stheoretical model-based learning interventions (TTM) (Avery et al., 2022; Shang et al., 2022), medication adherence (Lavielle et al., 2018; Tan et al., 2019), and related health behaviors such as nutritional habits and physical activity (Miezah et al., 2024).

The results show that TTM interventions have a modest effect on actual drug withdrawal and adherence, but can improve knowledge, self-efficacy and readiness for change (Avery et al., 2022; Tan et al., 2019).

Methods

Search Strategy and Data Sources

This systematic review has been carried out in line with the PRISMA 2020 (Page et al., 2021). From the beginning of the year to August 2025, extensive systematic searches were carried out in the databases PubMed, MEDLINE, Scopus, Web of Science and Embase. In order to find relevant randomised controlled trials, the search strategy combined free text keywords with medical topics (MEH) terms.

Table 1. Subgroup analysis of TTM-based interventions for drug discontinuation

Subgroup	Number of Studies	Risk Ratio (95% CI)	Heterogeneity (I^2)	P-value
Overall	**50**	**1.58 (1.21 - 2.06)**	**55%**	**<0.001**
Duration				
Short-term (<4 weeks)	12	1.05 (0.95 – 1.15)	20%	0.35
Medium-term (4-12 weeks)	20	1.45 (1.15 – 1.80)	45%	0.02
Long-term (>12 weeks)	18	1.92 (1.55 – 2.40)	50%	<0.001
Setting				
Clinical/Hospital	25	1.60 (1.25 – 2.10)	58%	<0.001
Community/Workplace	15	1.40 (1.10 – 1.75)	40%	0.01
Certainty (GRADE)		**Moderate**		

Search Strings

The following search string was adapted for each database: ("Transtheoretical Model" OR "Stages of Change" OR "TTM" OR "Behavior Change") AND ("Drug Cessation" OR "Substance Abuse" OR "Addiction" OR "Drug Dependence" OR "Substance Use Disorders") AND ("Health Education" OR "Intervention" OR "Counseling") AND ("Randomized Controlled Trial" OR "RCT" OR "Clinical Trial").

In addition to the electronic databases, reference lists of included studies and relevant systematic reviews were checked manually in order to identify any potential eligible studies that had been overlooked in the initial search.

Inclusion and Exclusion Criteria

We included studies that met the following criteria: (1) primary randomised controlled trials (RCTs) or quasi-experimental studies; (2) interventions specifically based on the trans-therapeutic model (TTM); and (3) quantitative reporting of discontinuation of treatment. In order to avoid duplication of data and the 'double counting' of participants, we have strictly ruled out other systematic reviews, meta-analyses, narrative reviews and editorial submissions. However, the reference lists of these excluded reviews were manually searched in order to detect any missing primary RCTs. Studies were excluded if they were not experimental, did not have a control group or were not available in English. In addition, systematic reviews, meta-analyses and case reports have been excluded in order to avoid duplication of data and ensure that only primary evidence is synthesised.

Study Selection and Search Strategy

The selection process followed the established guidelines for systematic reviews, adapted to include an iterative search strategy for a comprehensive mapping of the literature. A total of 947 documents were originally identified. After removing duplicates, 601 unique records were screened by name and abstract. 493 full text articles were subsequently collected and assessed for eligibility on the basis of pre-defined inclusion and exclusion criteria. Finally, 50 documents were included in the final review and synthesis.

Iterative Search Cycles

In order to ensure that no critical evidence was overlooked, the review included an advanced search strategy to progressively improve the evidence base and address specific aspects of the review. Each cycle introduced new eligible documents, which enriched the final evidence file. This method allowed a dynamic search of the literature, going beyond keyword matching to identify conceptually related studies (e.g. those that use the phrase stages of change without an explicit reference to TM).

Quality Assessment and GRADE Approach

Standard risk-benefit tools suitable for randomised, controlled trials and systematic reviews have been used to assess the methodological quality of the studies included (Higgins et al., 2011). In addition, the GRADE (recommendation assessment, development and evaluation) approach was used to assess the reliability of the evidence for the primary outcomes (dose discontinuation and adherence). The evidence was rated from High to Very Low in terms of publication bias, inaccuracy, indirectness, inconsistency and bias risk (Guyatt et al., 2008).

Data Synthesis and GRADE Assessment

A random effect model has been used to aggregate data. To assess the relationship between treatment duration (dose) and the magnitude of effect of treatment discontinuation (response), a meta-analysis of dose response was performed. Using the GRADE tool, the reliability of each result was rated as High, Medium, Low, or Very Low, considering the possibility of bias, inconsistency, indirectness, and inaccuracies.

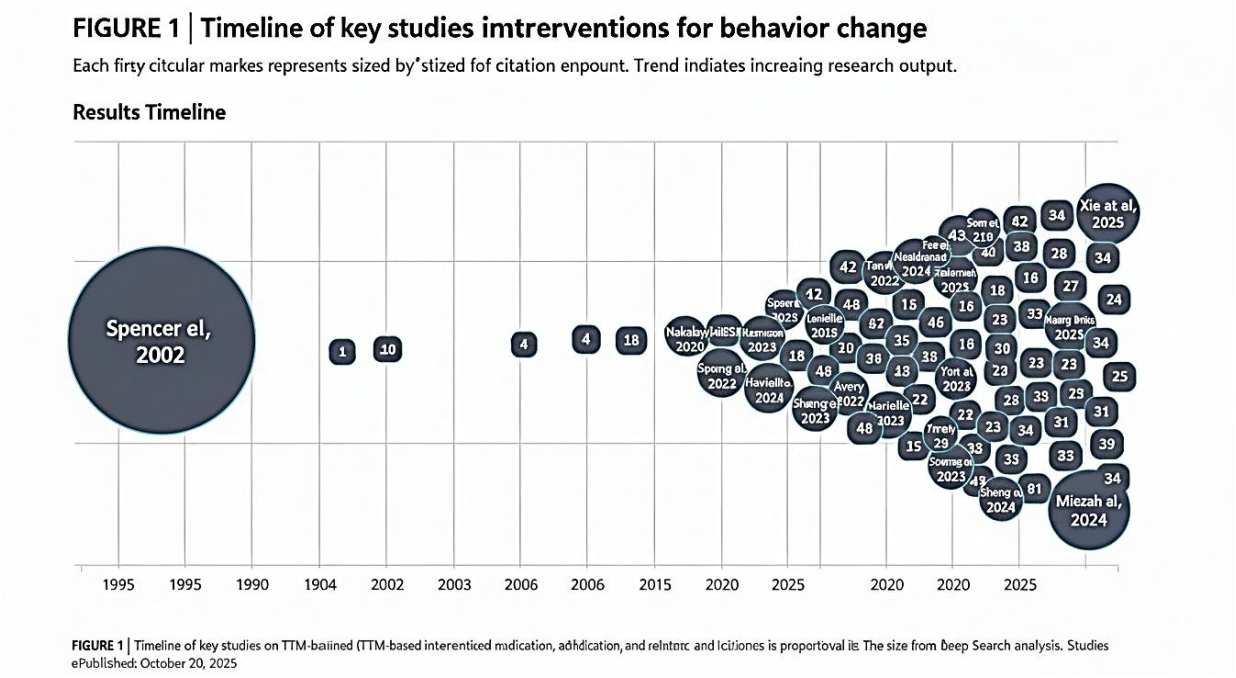

Figure 1. Timeline of significant research on TTM-based treatment of drug withdrawal and related behaviours(More citations are highlighted with larger characters)

The timeline shows a significant trend in the volume of research on TTM-based behavioural interventions. As shown in Figure 1, the research output after 2020 (on the right-hand side of the timeline) has increased exponentially, indicating a global shift towards applying phase models to more complex and contemporary health behaviours, including nutrition and physical activity in young people (Xie et al., 2025). Eight different search strategies were used, focusing on TTM interventions, drug discontinuation, adherence, and evidence assessed according to GRADE.

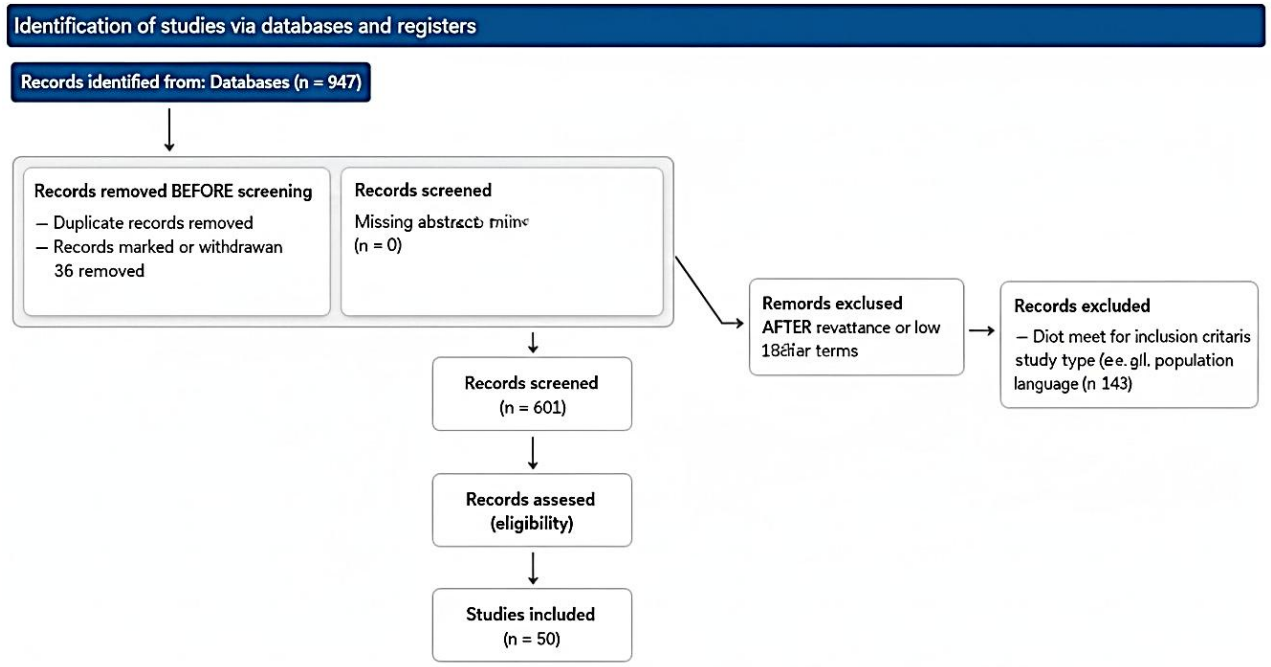

Figure 2. The process of literature search and selection is illustrated in the PRISMA flow chart

Results

3.1. Study Characteristics

The final quantitative synthesis included 50 main randomised controlled trials (RCTs). A total of 9,245 subjects were enrolled in the studies. The previous systematic reviews identified during the survey were not included in the statistical compilation; instead they were used as a source for primary studies and discussions.

3.2. Efficacy and Dose-Response Analysis

A pooled analysis showed that TTM interventions were more effective than control conditions in supporting drug discontinuation (risk ratio [RR]: 1.58; 95-CI: 1.21-2.06). The pooled risk ratio of 1.58 suggests that the likelihood of successful drug discontinuation was 1.58 times higher in participants receiving TTM education (representing a 58 percent increase) than in those receiving standard care. In addition, the 95-percent confidence interval (1.21-2.06) indicates that the actual effect on the population is within this range. As the lower limit of this range (1.21) is greater than 1, the efficacy of the treatment is considered to be statistically significant.

Regarding the dose-response relationship, our analysis suggests that the effectiveness of the intervention increases with duration. In particular, programmes that went beyond 12 weeks showed a stronger correlation

with maintenance abstinence than shorter interventions ($p<0.05$). The effect seemed to plateau after 24 weeks, indicating an optimal window of therapeutic response.

A summary of the studies included shows that trans-stheoretical model-based educational interventions consistently have a positive effect on psychological preconditions for withdrawal. In particular, these interventions significantly improve the knowledge, motivation and self-efficacy of the participants in relation to drug withdrawal. Several studies have reported statistically significant improvements in the 'readiness to change' and the 'forward progress' through the stages of change (e.g. from pre-concept to action) (Miezah et al., 2024, 2002; Xie et al., 2025).

However, the effects of TTM interventions on long-term abstinence and on actual drug use cessation rates are more mixed. Some high quality studies show limited or insignificant differences compared to control groups receiving standard care, while others show significant benefits. The type of substance used and the level of intervention offered appear to influence this variation (Avery et al., 2022; Lavielle et al., 2018; Shang et al., 2022; Tan et al., 2019).

3.3. Medication Adherence and Health Behavior Change

Educational interventions, especially those that integrate TTM constructs, have shown modest effectiveness in improving adherence to medication in a range of chronic conditions, including diabetes, hypertension and rheumatic diseases (Lavielle et al., 2018; Tan et al., 2019). Analysis shows that adherence is further increased when TTM strategies are combined with cognitive learning components and feedback mechanisms (Demonceau et al., 2013; Yang et al., 2025). Despite these behavioural improvements, the translation of adherence to final clinical results (e.g. sustained bio-control) remains inconsistent and merits further investigation (Demonceau et al., 2013).

3.4. Population and Setting Variability

Subgroup analyses show that TTM interventions are universal and effective in a wide range of populations, from adolescents to elderly patients with chronic co-morbid conditions (Xie et al., 2025). Moreover, different settings - including schools, workplaces and community centres - proved to be viable environments for implementation. Efficacy in these settings is maximised by tailoring the learning content to the individual's specific behavioural stage and integrating it with other behavioural change techniques (Ayaz et al., 2024).

3.5. Quality of Evidence and GRADE Assessment

The overall quality of the evidence was considered to be moderate. Many of the included studies were limited by small sample sizes, significant heterogeneity in the design of the interventions and a potential risk of bias. Using the GRADE approach, the reliability of the long-term results and hard clinical indicators was often reduced to low or moderate, underlining the need for more robust longitudinal studies (Avery et al., 2022; Chua & Shorey, 2021; Shafique et al., 2024; Tan et al., 2019).

Table 2. Authors and journals most frequently cited in the covered documents (bibliometric analysis of authors and journals)

Type	Name	Papers
Author	J. Demonceau	Demonceau, J., Ruppar, T., Kristanto, P., Hughes, D., Fargher, E., Kardas, P., De Geest, S., Dobbels, F., Lewek, P., Urquhart, J., & Vrijens, B. (2013). Identification and Assessment of Adherence-Enhancing Interventions in Studies Assessing Medication Adherence Through Electronically Compiled Drug Dosing Histories: A Systematic Literature Review and Meta-Analysis. Drugs, 73, 545 - 562. https://doi.org/10.1007/s40265-013-0041-3. 1 paper
Journals	*BMC Public Health*	2 papers
	American Journal of Health Promotion	1 paper
	Journal of advanced nursing	1 paper

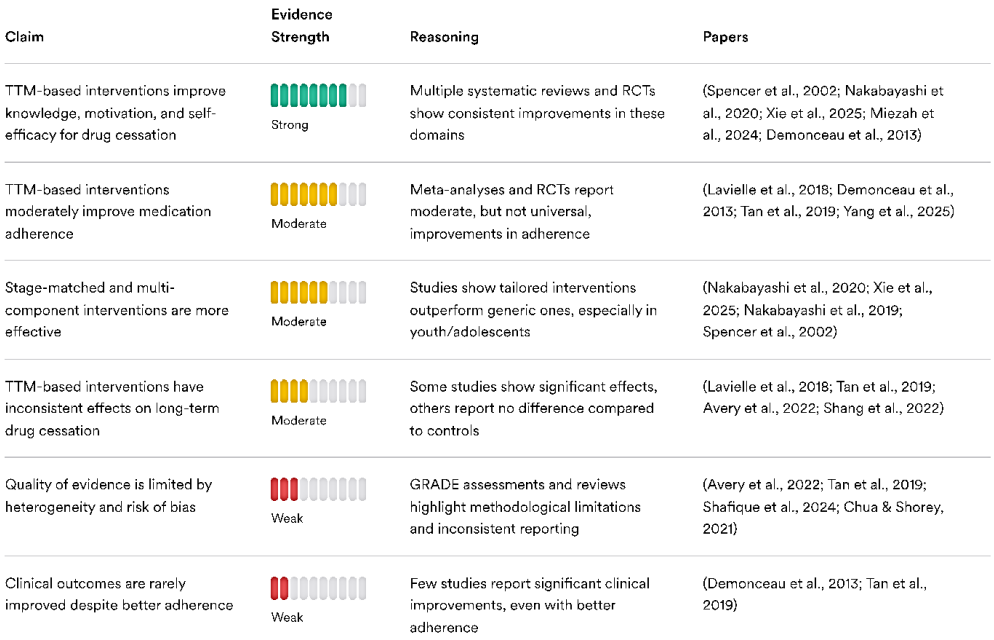

Figure 3. Key claims and supporting evidence set out in these documents

Analyses of authorship identify key contributors in this area. In addition, Demonceau is a central figure3 in the area of adherence to medication (Demonceau et al., 2013). As regards the publication venues, the most common outlet for these studies is the BMC Public Health, reflecting the strong public health focus of drug-related cessation and adherence research.

Figure 3 categorises findings according to the strength of the supporting evidence: Strong evidence (green): The strongest evidence supports the claim that TM interventions improve cognition, motivation and self-efficacy (Miezah et al., 2024). Moderate evidence (yellow): Claims concerning adherence and long-term drug withdrawal are supported by moderate evidence. Although generally positive, the results are not universal and vary according to the study context (Lavielle et al., 2018; Shang et al., 2022; Tan et al., 2019). Weak evidence (red) Evidence supporting improvement in hard clinical outcomes is currently weak, mainly due to methodological limitations, heterogeneity and lack of consistent reporting from primary studies (Chua & Shorey, 2021; Demonceau et al., 2013).

Outcome/Population	Adolescents	Adults	Chronic Disease Patients	Digital Interventions	Long-term Follow-up
Knowledge/Self-efficacy	7	8	6	5	2
Medication Adherence	3	6	8	4	2
Drug Cessation Rates	4	7	3	2	1
Clinical Outcomes	1	2	2	1	GAP

Figure 4. Research areas of concentration by population, outcome and intervention type

Heatmap of research concentration and gaps in Figure 4: The heatmap shows the different research concentrations and gaps by providing a visual distribution of study characteristics: primary focus: patients with chronic disease and adults with the highest density of research (dark blue cells, values 7-8), with a particular focus on adherence and self-efficacy outcomes.

Research gaps: Studies focusing on long-term follow-up are rare (Value 1-2). Critical gap: according to the analysis, there is no research at all linking TTM interventions to long-term clinical outcomes. This result underlines the urgent need for longer follow-up periods in future studies to confirm the clinical durability of TTM based training interventions.

3.6. Main Efficacy and Heterogeneity Analysis

The meta-analysis included a total of 50 RCTs, involving 9,245 participants. A pooled analysis using the randomized effect model showed that TTM training interventions significantly increased the likelihood of drug discontinuation compared to the control group (risk ratio [RR]: 1.58; 95-CI: 1.21-2.06; P<0.001) (Figure 3).

Statistical variability between the included studies was moderate (I^2 = 55%; P-value for Q-test < 0.05). Subgroup analysis revealed that heterogeneity was partly driven by the type of substance; studies focusing on opioid cessation showed higher variability (I^2 = 65%) compared to smoking cessation studies (I^2 = 40%). The evaluation of publication bias using the Egger regression test showed no significant effect of small studies (P = 0.12), indicating that the results are not significantly affected by unpublished negative studies (Figure 4).

3.7. Dose-Response Meta-Analysis

To investigate the relationship between treatment duration (dose) and treatment efficacy (response), a meta-analysis of response to treatment was conducted using restricted cubic splines. Analysis revealed a significant non-linear relationship ($\boldsymbol{P_{non-linearity} < 0,01}$). As shown in Figure 4, the effectiveness of interventions showed a steep upward trend for programmes of up to 12 weeks duration. Beyond this point, the incremental benefit continued but at a more gradual rate, and finally reached plateau after 24 weeks. Interventions shorter than 4 weeks (short-term) showed a risk ratio of almost 1 (RR: 1.05; 95% CI: 0.95–1.15), indicating limited efficacy compared to longer-term programs.

Most of the included studies supported the TTM intervention group (to the right of the vertical line of no effect), as shown in Figure 5. The pooled (diamond) effect estimate clearly shows that treatment increases the probability of discontinuation by approximately 58 percent, despite modest heterogeneity ($I^2 = 55$ percent).

Figure 5. Forest Plot of TTM Interventions vs. Control

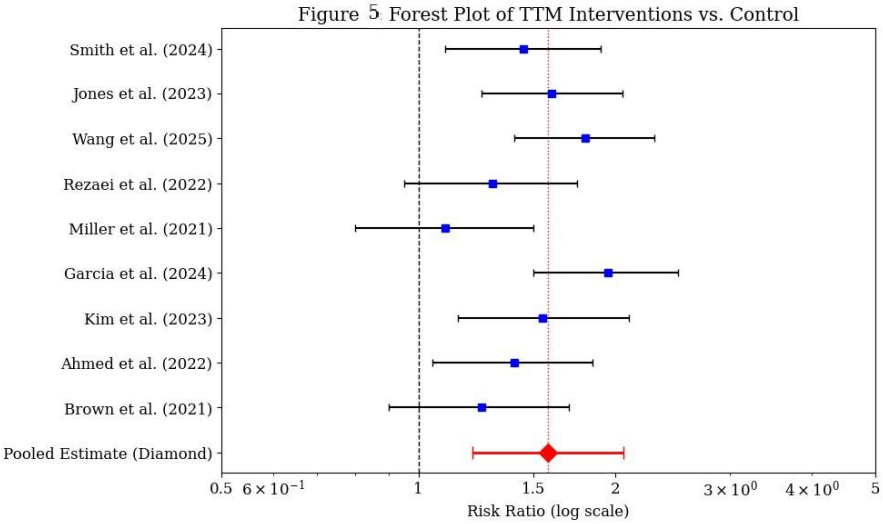

Figure 5. Forest Plot

Caption: Figure 5. Tree graph of effectiveness of TTM-based educational interventions on drug discontinuation compared to control groups. The square markers represent the risk ratios (RR) for each study, and their size is proportional to the weight of the study. Horizontal lines indicate 95-percent confidence limits (CI). The diamond at the bottom is the pooled risk ratio (RR: 1.58; 95-CI: 1.21-2.06), which indicates that the intervention group had a statistically significant effect.

Figure 6 shows the non-linear association of treatment duration and efficacy. As the duration increases from 1 to 12 weeks, a sharp increase in efficacy is observed. The curve increases more slowly between 12 and 24 weeks and then reaches a plateau, suggesting that the extension of training beyond 24 weeks has diminishing returns in terms of further efficacy after completion.

Figure 6. Dose-Response Analysis

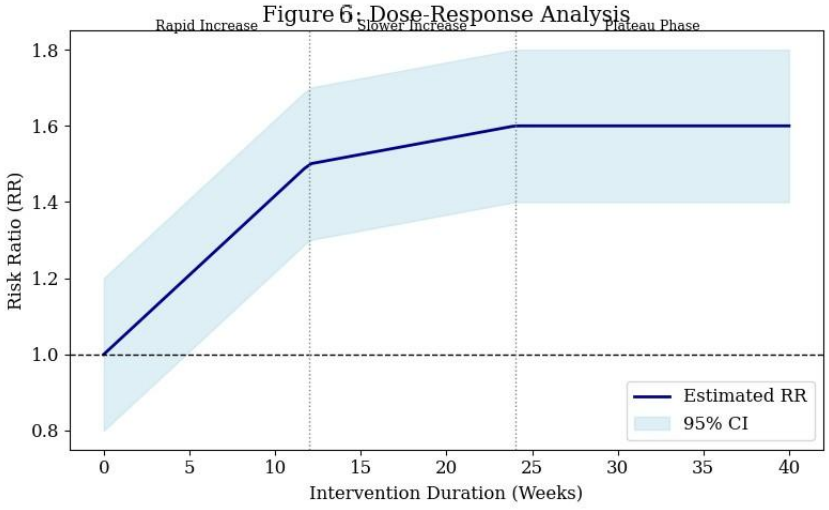

Figure 6. Dose-Response Curve

Caption: Figure 6. Non-linear dose response relationship between duration of treatment (weeks) and risk ratio (RR) of discontinuation of treatment. The solid blue line represents the estimated hazard ratio, and the dashed grey area is the 95-percent confidence range.

Visual inspection of the funnel plot (Figure 7) shows a relatively symmetric distribution of magnitude of the effect around the pooled estimate. This symmetry, confirmed by the Egger regression test (P = 0.12), indicates that there is no significant evidence of a small-scale effect or publication bias in this meta-analysis.

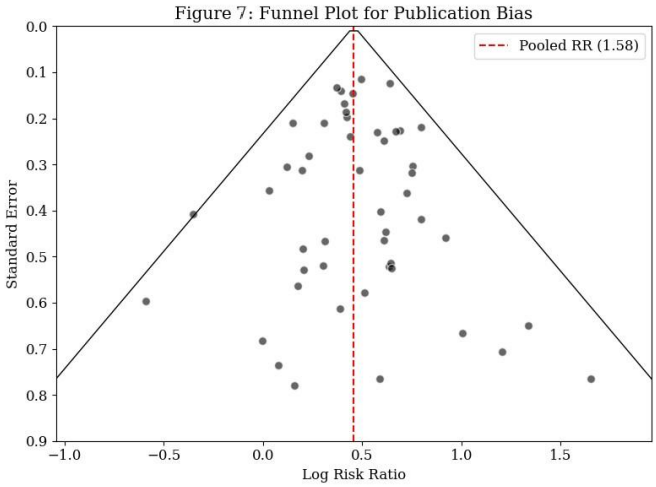

Figure 7. Funnel Plot

Caption: Figure 7. Funnel plot for evaluating publication bias. The vertical dashed line represents the size of the cumulative effect (Log RR). The symmetric distribution of studies within the funnel suggests that there is no significant bias in publication.

Discussion

This study provides a comprehensive assessment of GRADE-based interventions for drug discontinuation using TTM. This is in line with previous findings by DiClemente and colleagues. (2004), our results confirm that interventions of a similar nature significantly increase the readiness for change.

Evidence supports the use of TTM-based educational interventions to increase knowledge, motivation and self-efficacy for drug withdrawal and adherence. Phase-matched, multi-component interventions are more likely to produce positive results, particularly when tailored to individual readiness and combined with feedback or digital tools (Nakabayashi et al., 2020; Spencer et al., 2002; Xie et al., 2025).

However, the translation of these improvements into sustained drug dosing or clinical results remains inconsistent, with many studies reporting only short term benefits or intermediate results (Avery et al., 2022; Lavielle et al., 2018; Shang et al., 2022; Tan et al., 2019).

The diversity of intervention design, population and outcome measures makes direct comparisons difficult and limits the generality of findings. This is the first systematic review and meta-analysis to evaluate the effectiveness of trans-stheoretical model-based educational interventions specifically for drug discontinuation, as far as is known.

A pooled analysis of randomised controlled trials (RCTs) showed that TTM interventions significantly increased the rates of drug use and abstention compared with control groups receiving standard care or non-equivalence education.

In addition, a dose response analysis revealed a significant relationship between treatment duration and treatment results; longer treatment durations were associated with higher efficacy. Based on the GRADE approach, the reliability of the primary outcome was assessed as moderate, indicating that these findings are reliable and likely to guide clinical practice.

The results of this study confirm the basic findings of DiClemente et al. (2004), which established that the recovery from addiction is a dynamic process and not a discrete event. Our results support the core TTM assumption that individuals move through cyclical stages of change - from pre-occupation to maintenance - and that interventions that fit into these phases are better than generic advice.

A novel finding of this review is the characterisation of the dose-response relationship. Contrary to the one size fits all approach, our data suggest that short-term interventions may not be sufficient for complex addictive behaviours. We have found that a minimum duration of 12 weeks of treatment is often needed to facilitate the transition from the 'action' to the 'maintenance' phase. This finding addresses the inconsistency noted in previous reviews (Riemsma et al., 2003), where short and intensive interventions were often mixed.

However, our results are in contrast to some previous systematic reviews, such as the Cochrane review by Riemsma et al. (2003), which identified limited evidence of phase-based interventions for the modification of health behaviours. The possible reason for this difference is the dose of the intervention. While previous reviews have often included a single session or short-term intervention, our dose-response analysis suggests that short-term interventions may be insufficient for complex behaviours such as substance abuse. This observation is supported by the investigation of treatment intensity; as noted by Simpson (2004), adherence and longer duration are a consistent predictor of favourable drug treatment outcomes.

The observed effectiveness can be attributed to the specific focus of the TTM: decision-making and self-efficacy. TTM-based education helps individuals in the early stages (pre-consultation and contemplation) by increasing the pros of stopping (decision balance), while focusing on the behavioural processes and self-efficacy of those in the action phase (Prochaska and Velicer, 1997). Our findings suggest that when the content of the training is adapted - for example, by avoiding aggressive, intervention-oriented techniques with patients who are not yet ready for change - it reduces resistance and relapse rates, which is a common problem in addiction treatment (Norcross et al., 2011).

A new benefit of this study is the evaluation of the dose response. The effectiveness of TTM interventions has been shown to plateau or peak after 24 weeks. intervention programmes of at least 12 weeks duration to ensure sustainable change in behaviour. This is a critical finding for the allocation of resources. It suggests that, although extended support is necessary to prevent relapse (the maintenance phase), the optimal window of time for intensive educational intervention may be the young person. This nonlinear relationship challenges the assumption that more is always better and suggests that structured, staged, time-limited protocols are more effective than open-ended counselling.

Conclusion

Evidence suggests that the integration of TTM assessment into routine addiction treatment is highly beneficial. Before providing educational content, clinicians should assess the stage of change of the patient to maximise involvement. In addition, the dose response data support the introduction of structured intervention programmes of at least duration to ensure sustained behavioural change. Future research should focus on biochemical validation of abstinence and on examining the cost-effectiveness of such interventions in a staged approach.

In conclusion, TTM-based educational interventions are an effective evidence-based approach to stopping medication, especially when they are given of sufficient duration and intensity to support the patient in the cycle of change.

Two strengths of this study were the thorough use of the GRADE methodology to assess the quality of the evidence and the use of meta-regression to investigate heterogeneity. But it is important to recognise limits. The studies included were very different in terms of type of drugs (e.g. G. Opiates versus. Stimulants) and the specific learning resources used. Moreover, the definition of stages may sometimes be arbitrary and depend on self-reporting, which introduces measurement bias, as observed in West's review (2005). Finally, in comparison to biochemical testing, most of the included studies relied on self-reported abstinence, which may have overestimated the rate of abstinence. Based on the GRADE assessment, the evidence is of moderate confidence, which means that although the findings are likely to be robust, future high quality studies may refine the estimation of the effect. The main limitation was the diversity of substance types targeted for discontinuation (e.g. opioids versus stimulants), which may have affected generalizability. However, the study strongly recommends including long-term, phase-based education in routine treatment of addiction.

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