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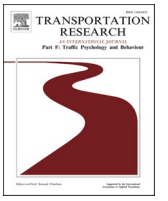

The mindful driver: A systematic review of mindfulness and safe driving behavior

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ABSTRACT

Mindfulness, characterized by present-moment awareness and nonreactive attentional control, has increasingly been examined as a psychological factor associated with safer driving behavior. This is important because motor vehicle crashes remain a significant public health and transportation safety concern, with distracted and aggressive driving linked to attentional lapses, mind-wandering, and failures of emotional regulation. This PRISMA-compliant systematic review synthesizes evidence on the relationship between mindfulness, mind-wandering, and driving behavior. A comprehensive database search identified 37 eligible studies published between 2011 and 2024, including cross-sectional, cohort, case-control, and randomized controlled trial designs. Across studies, higher levels of mindfulness were generally associated with safer driving outcomes, particularly fewer attentional lapses, lower distracted driving, and fewer self-reported violations, although findings varied by study design, measurement approach, and driving outcome. Intervention studies generally demonstrated improvements in driving performance, although increases in self-reported mindfulness were less consistently observed. Findings are consistent with attentional control, emotion regulation, and reduced mind-wandering as candidate psychological mechanisms through which mindfulness may be associated with safer driving behavior. Methodological limitations, including heavy reliance on trait mindfulness measures and self-reported driving outcomes, are discussed. Future research should prioritize state-based and driving-specific mindfulness measures alongside objective assessments to advance theory and experimental research in traffic psychology.

1. Background

Motor vehicle crashes are a significant global health concern. Each year, it has been estimated that 1.19 million people die in traffic crashes worldwide, while another 20–50 million suffer nonfatal injuries, often incurring disabilities (WHO, 2023). Motor vehicle crashes are the leading cause of death worldwide for people aged between 5 and 29 and the 12th leading cause of death for all ages (WHO, 2023). Distracted and aggressive driving are two of the primary causes of road injuries and fatalities. In 2022, distracted drivers

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killed 3308 people in the United States, injuring a further 289,310 (NHTSA, 2024).

Distracted driving is defined as a driver's inattention to the task of operating a motor vehicle. It includes visual distractions, taking eyes off the road; manual distractions, involving hands in an activity other than driving; and mind-wandering, when the driver's cognitive attention drifts from awareness of and attention to driving (Berthié et al., 2015). Mind wandering and mindfulness are generally considered inversely related constructs, with higher levels of mindfulness associated with lower levels of task-unrelated thought (Traficante et al., 2025). Inattention and mind-wandering while driving delay hazard awareness and impair reaction time when responding to unexpected situations. Distractions may include cell phone use, eating, adjusting vehicle controls, daydreaming, and talking to passengers (NHTSA, 2024). Distracted driving is typically measured through self-report instruments with commonly applied measures, including the Attention Related Driving Errors Scale (Castro et al., 2024) and the Driver Behavior Questionnaire (DBQ) (af Wåhlberg & Dorn, 2012; Ozkan et al., 2006). Distracted driving has also been investigated using simulated driving experiences to track cognitive attention, driving behavior (Balconi et al., 2019; Chahine et al., 2022; Valero-Mora et al., 2015), and real-time observations (Hasan et al., 2022; Prat et al., 2015; Unit, J.H.I.I.R., 2024). Interventions addressing distracted driving have included traffic safety campaigns, educational programs, and in-vehicle monitoring and warning systems (Unit, J.H.I.I.R., 2024).

Aggressive driving is when a person drives a vehicle in a way that may endanger lives or property. This can involve anger, attempts to gain an advantage over other drivers, and inappropriate speed (Deffenbacher et al., 2016; Kirley et al., 2023a). Aggressive driving has been measured using self-report measures such as the Driving Anger Scale (Deffenbacher et al., 2016), but has also been investigated in driving simulated experiences. Aggressive driving has layers of intentionality and severity. It can include swearing or gesticulating at another driver and physical acts like speeding or cutting too closely in front of another vehicle, to the extreme of intentionally harming a person or property. An aggressive driver's behavior can generate anger toward the aggressive driver, instigating retaliatory behavior (Stephens et al., 2018; Stephens et al., 2020; Stephens & Groeger, 2011). Addressing issues related to aggressive driving is complex and requires a multidisciplinary focus (Baltruschat et al., 2021; Kirley et al., 2023a). The propensity toward aggressive driving may be mitigated by enhancing a person's ability to self-regulate emotions and behaviors, thereby reducing the impulse to engage in retaliatory driving and helping maintain a calm, focused demeanor while driving (Deffenbacher et al., 2016; Kirley et al., 2023a).

Interventions to reduce distracted and aggressive driving have traditionally involved enacting laws such as speed limits, banning hand-held cell phone use, and requiring distracted driving licensing for young drivers. They have also involved environmental changes such as building road rumble strips to increase attention and decrease mind-wandering driving errors and safety campaigns (Kirley et al., 2023b; Stephens & Groeger, 2011).

Over the past decade, there has been increasing interest in the relationship between distracted and aggressive driving and the potential for mindfulness to reduce those behaviors (Baltruschat et al., 2021; Koppel et al., 2019; Murphy & Matvienko-Sikar, 2019). Distracted and aggressive driving both result in a person's inattention to the driving task, although the degree to which emotional processes contribute differs between them. Distracted driving is characterized by a lack of awareness and attention to driving because of innocuous distracting behaviors and stimuli. Aggressive driving is more strongly associated with difficulties in emotional regulation that lead to behaviors that pose risks to both the driver and others on the road (Ehsani et al., 2024a).

Mindfulness, commonly defined as moment-to-moment non-judgmental attentiveness and awareness (Kabat-Zinn, 2005; Stephens & Groeger, 2009), involves observing external stimuli (sounds and sights) and internal experiences (Berthié et al., 2015) without letting them dominate reactions. In the context of driving safety, mindfulness has been theorized to enhance self-regulation and present-moment awareness, potentially reducing distractedness and emotionally triggered aggressive driving behaviors (Ehsani et al., 2024a; Stephens & Groeger, 2009).

Research suggests an association between higher levels of mindfulness and lower levels of distracted and aggressive driving through emotional self-regulation, increasing attention to and awareness of what is happening in the present moment, and improving one's ability to observe situations nonjudgmentally (Crane et al., 2017; Murphy & Matvienko-Sikar, 2019; Stephens et al., 2020). Drivers with higher levels of mindfulness may notice when their emotions are sparked and can self-regulate subsequent emotions and behaviors, bringing their attention back to the driving task and reducing the likelihood of behaving aggressively (Koppel et al., 2018a). Unlike other safe driving interventions, mindfulness interventions offer broader benefits, having previously been linked to the prevention of substance misuse and mental health issues while supporting chronic pain management and stress reduction (Crane et al., 2017).

Mindfulness can be described as a trait as well as a state of being. Trait mindfulness is a long-term characteristic of a person's personality (Kabat-Zinn, 2005). State mindfulness is a temporary condition that is partially dependent on a person's level of trait mindfulness but can change immediately following a brief mindfulness practice. While trait mindfulness can change over time, it is a slow process and requires time spent engaged in mindfulness practices. State mindfulness is a measure of mindfulness in a given moment (Mrazek et al., 2013). In the context of driving, state mindfulness may be important to determine whether a person's level of mindfulness during an act of driving is associated with safe driving.

Mindfulness training and practice help develop calmness and clarity amid stressors (De Paz et al., 2014; Kabat-Zinn, 2005), facilitating emotional and behavioral self-regulation (De Paz et al., 2014; Kabat-Zinn, 2005), improving attention, reducing distraction (Luberto et al., 2018; Schöne et al., 2018). Mindfulness training has increased both trait and state mindfulness, resulting in temporary and sustained non-distraction (Mrazek et al., n.d.; Mrazek et al., 2013). There is a wide variety of mindfulness interventions. Many include guided meditation and breathing exercises to foster sensory awareness (Zhang et al., 2021). Practices range from short, one-time stand-alone experiences (Mahmood et al., 2016) to practice over a lifetime (Crane et al., 2017; Ludwig & Kabat-Zinn, 2008). Mindfulness-based interventions that strengthen emotional awareness and regulatory control may help drivers maintain focus while managing cognitive and emotional disruptions (Ehsani et al., 2024a; Stephens & Groeger, 2009).

One mechanism through which mindfulness may influence driving behavior is by reducing mind wandering (Feruglio et al., 2021; Koppel et al., 2018a). Although mind wandering and mindfulness are not strict opposites, they are generally considered inversely related constructs, with higher levels of mindfulness associated with lower levels of task-unrelated thought (Somaraju et al., 2024). This relationship is particularly relevant in driving contexts, where mind wandering has been linked to reduced situational awareness, delayed hazard perception, and impaired driving performance. Consistent with this relationship, previous mindfulness-meditation studies have reported reductions in mind wandering following mindfulness practice interventions, including interventions lasting as little as two weeks (Drews et al., 2009; Feruglio et al., 2021).

A systematic review exploring the relationship between mindfulness and improving road safety was completed in 2018 (Koppel et al., 2019), concluding that mindfulness can potentially reduce road trauma. This review identified articles studying the relationship between a person's level of mindfulness and their driving behavior, but few focused on the effects of a specific mindfulness intervention (Koppel et al., 2019). Since then, interest in mindfulness as a behavioral self-regulation strategy has grown substantially (Bockmann & Yu, n.d.), alongside an expanding body of literature investigating the effects of mindfulness-based interventions on driving behavior and related safety outcomes (Ehsani et al., 2024a). Despite this growing evidence base, current understanding of how mindfulness interventions influence driving behavior remains fragmented.

Recent research has increasingly distinguished between different dimensions of mindfulness, particularly trait and state mindfulness, and examined how these may be differentially influenced by mindfulness interventions (Firth et al., n.d.). These distinctions were not clearly addressed in the 2018 review (Koppel et al., 2019) despite their potential importance for understanding the mechanisms through which mindfulness may influence driving behavior and related safety outcomes.

At the same time, relatively little attention has been paid to the measurement tools used to assess mindfulness across studies. This represents an important methodological gap, as variation in measurement approaches may affect the interpretation, comparability, and broader application of findings.

Accordingly, this systematic review aimed to synthesize evidence relating to the effects of mindfulness on driving behavior, with particular attention to: (1) the effects of mindfulness-based interventions, (2) differences between trait and state mindfulness in relation to driving outcomes, and (3) the measurement tools used to assess mindfulness across studies.

1.1. Theory

This review is grounded in three complementary theoretical models from traffic psychology, mindfulness science, and cognitive psychology that together account for the proposed relationship between mindfulness, mind-wandering, and safe driving behavior.

Garland et al.'s (2009) (Garland et al., n.d.) mindfulness coping model proposes that mindfulness facilitates positive cognitive reappraisal of negative events by broadening attention and preventing cognitive narrowing. Applied to driving, this mechanism predicts that more mindful drivers will respond to frustration-inducing situations such as congestion or provocation by other road users with reduced anger and more adaptive behavioral responses, thereby decreasing aggressive and retaliatory driving.

The decoupling hypothesis (Smallwood & Schooler, 2006) proposes that mind-wandering, task-unrelated thought, represents a decoupling of cognitive processing from the immediate perceptual environment. This decoupling reduces awareness of external stimuli and delays responses to environmental demands. In driving, it predicts slower hazard perception, reduced headway maintenance, and impaired vehicle control during mind-wandering episodes. Given that mindfulness is generally considered to be inversely related to mind-wandering (Mrazek et al., n.d.; Brandmeyer & Delorme, 2021), higher trait and state mindfulness are expected to be associated with reduced attentional decoupling and, consequently, with fewer driving errors, lapses, and crashes.

Reason's (1990) skill-rule-knowledge framework (Reason et al., 1990) widely applied in traffic psychology, distinguishes between skill-based failures, automatic behaviors that break down due to inattention rule-based failures involving deliberate violations of established rules, and knowledge-based failures arising in novel situations requiring analytical reasoning. This framework predicts that attentional mechanisms, and therefore mindfulness, should be most strongly associated with unintentional skill-based failures such as driving errors and attentional lapses, and less strongly associated with deliberate rule violations or aggressive behavior.

Together, these three frameworks identify three distinct but related pathways through which mindfulness may influence driving safety. (See Fig. 1) First, mindfulness is expected to enhance attentional engagement with the primary driving task, thereby reducing susceptibility to both internal distractions, such as rumination, and external distractions such as mobile phone use. Second, mindfulness is inversely related to mind-wandering, a cognitive state repeatedly shown to impair hazard perception, reaction time, and vehicle control. Third, mindfulness supports emotion regulation by reducing reactivity to stressors such as congestion or provocation, which may in turn reduce aggressive and retaliatory driving behaviors.

Consistent with contemporary traffic psychology research, mindfulness is conceptualized in this review as dispositional factors, including both a trait-like individual difference and a state-based construct that fluctuates over time and context. Given the dynamic nature of driving as a task, mindfulness is theoretically well aligned with models that emphasize real-time psychological mechanisms of attentional control, emotion regulation, and cognitive control. This theoretical framework positions mindfulness as a proximal psychological factor that may mediate or moderate established predictors of driving safety outcomes, including driving errors, attention lapses, distraction, driving violations, stress, and emotional dysregulation, and it informed study selection, outcome categorization, and interpretation throughout this review.

The theoretical framework outlined in Fig. 1 guided the analytical approach used in this review. Specifically, the review examined whether the included studies provided evidence for three proposed pathways linking mindfulness and driving safety: attentional engagement with the driving task, reduced mind-wandering, and improved emotion regulation. These pathways were used to organize interpretation of the findings and to identify conceptual and methodological gaps in the literature, particularly the limited use of state-

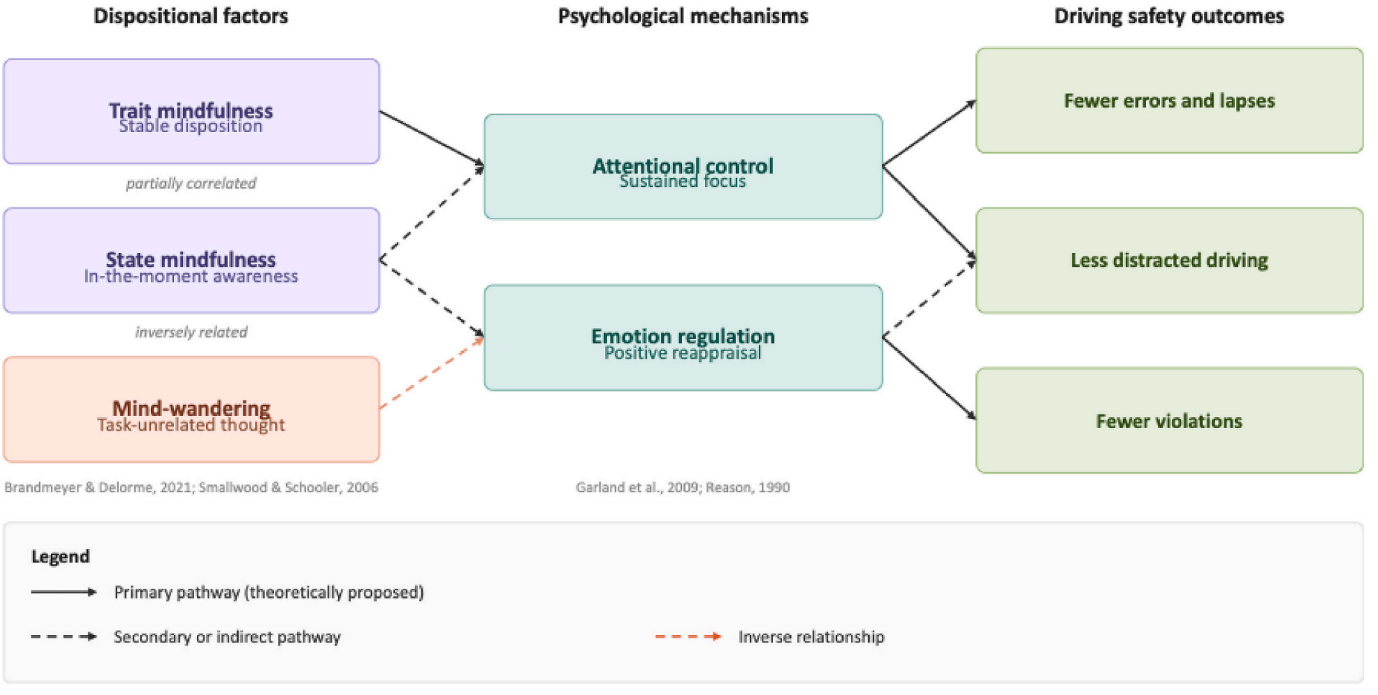

Fig. 1. Proposed theoretical pathway from mindfulness and mind-wandering to driving safety outcomes.

based and driving-specific mindfulness measures.

To translate this theoretical framework into a reviewable question, the research question was structured using a modified PICO framework that accommodated both intervention and observational study designs:

- Population (P): Licensed drivers aged 18 years and older
- Intervention/Exposure (I/E): Mindfulness, operationalized either as mindfulness-based interventions or as naturally occurring levels of state and trait mindfulness or mind-wandering
- Comparator (C): Where applicable, comparison groups included non-intervention controls, lower levels of mindfulness, or higher levels of mind-wandering
- Outcome (O): Driving behavior, including aggression, speeding, traffic offenses, crash involvement, distracted driving, driving errors, and related safety outcomes

Research question: How are mindfulness and mind-wandering associated with safe driving behavior, and what evidence exists that mindfulness-based interventions improve driving-related safety outcomes?

This review addressed three sub-questions:

1. What evidence exists that mindfulness-based interventions improve driving behavior or driving-related safety outcomes?
2. How are trait mindfulness, state mindfulness, and mind-wandering associated with driving behavior?
3. What instruments have been used to measure mindfulness and mind-wandering in driving-safety research, and what measurement gaps remain?

2. Methods

In performing the review, we adhered to the guidelines set forth by the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA). Before initiating the process, a protocol was registered in the PROSPERO register (# 2023 CRD42023411991). While the main focus for the review was on literature exploring the relationship between mindfulness and driving behavior, studies exploring mind-wandering (Mrazek et al., n.d.) were also considered relevant as there is an inverse correlation between the two concepts, i.e., higher levels of mindfulness are generally associated with lower levels of mind-wandering (Brandmeyer & Delorme, 2021).

2.1. Eligibility criteria

To be included in the review, studies must be written in English and include a measure of mindfulness or mind wandering. They also had to assess at least one aspect of driving behavior, which could encompass various behaviors such as driver aggression, speeding, traffic offenses, involvement in crashes, distracted driving, and other related behaviors. No restrictions were placed on the type of motorized vehicle included in the studies as long as drivers were licensed and over 18. Studies were excluded if they were conference abstracts or papers, qualitative articles, or reviews synthesizing the results of previous work.

2.2. Sources and search strategy

To identify relevant studies, a comprehensive search was conducted using the Web of Science, Scopus, MEDLINE, PsycINFO, and CINAHL databases (See Appendix B for full search strings).

The search was completed on April 10, 2023, and a second search was conducted in November 2024 to ensure that the most recent literature was included. The following search terms and synonyms were used: (mindful OR mindfulness) AND (driving, OR driver OR traffic OR road). No restrictions were placed on the publication date or language at the search stage; the English-language requirement was applied at the eligibility stage rather than the search stage. The retrieved papers were imported into Covidence (Veritas Health Innovation, Melbourne, Australia), a web-based collaboration software platform that streamlines the production of systematic reviews. Duplicates were removed within the Covidence software package.

2.3. Data collection process and items

2.3.1. Title and abstract review

Once imported into Covidence, two researchers independently reviewed articles at the title and abstract levels. Studies were rejected if they did not meet the inclusion criteria. The researchers compared the independent title and abstract review results, and any differences were discussed. A third researcher was available to resolve disagreements if consensus could not be reached, but this was not necessary.

2.3.2. Full-text evaluation

Two researchers read the full text of articles that remained after reviewing the titles and abstracts. Once again, each researcher independently assessed each article against the inclusion and exclusion criteria before discussing the results with the second researcher and resolving potential discrepancies.

2.3.3. Data extraction

One researcher systematically extracted data, while a second researcher independently extracted data from a random selection of the articles (38% of the sample) to verify consistency and ensure inter-rater reliability. The comprehensive data extracted included the following key details: Author(s) and year of publication, Study design, Sample size, Demographic and geographic information, including age, sex distribution of participants, and country, Mindfulness intervention details (if applicable, Mindfulness outcome measures: scales or instruments used to assess mindfulness levels, Driving behavior measures used to evaluate driving performance, Study results: primary findings, statistical significance, and effect sizes where available.

2.3.4. Data synthesis

Because of substantial heterogeneity across study designs, mindfulness measures, driving outcomes, and reporting practices, this

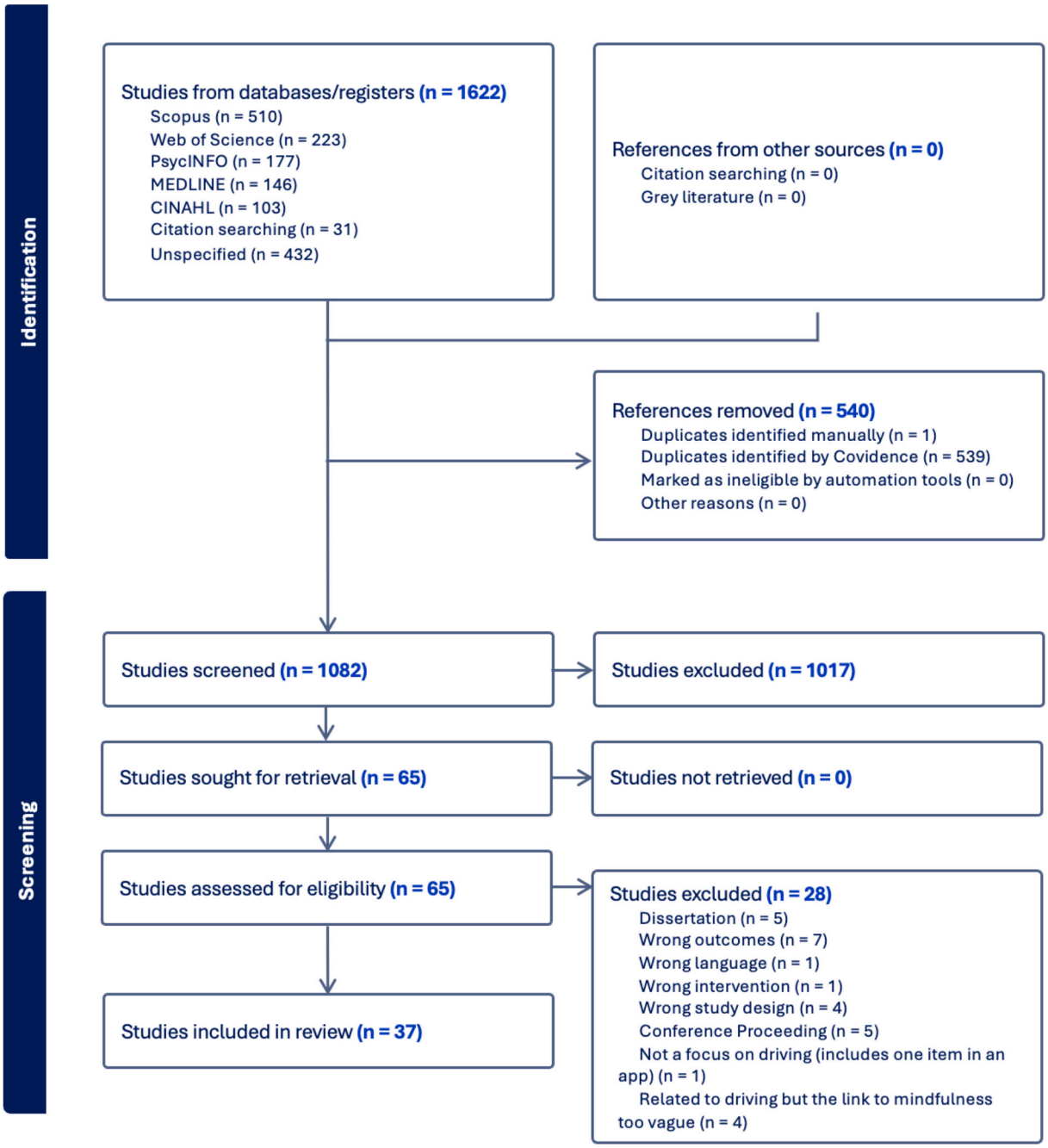

Fig. 2. Prisma Flow Chart.

review used a theory-driven qualitative synthesis rather than a meta-analysis. Studies were first classified according to design, including cross-sectional, case-control, cohort, and randomized controlled trial designs. They were then grouped according to whether they examined associations between naturally occurring levels of mindfulness or mind-wandering and driving behavior, or whether they evaluated the effects of mindfulness-based interventions on driving outcomes.

Driving outcomes were categorized into behavioral domains, including distracted driving, aggressive driving, driving errors, traffic violations, and crash involvement. Mindfulness-related constructs were similarly classified as trait mindfulness, state mindfulness, or mind-wandering. This approach allowed the findings to be interpreted in relation to the theoretical mechanisms identified above. It also illuminated the measurement and design limitations that precluded quantitative synthesis: the use of incompatible outcome metrics across studies, including self-reported texting frequency, Driver Behavior Questionnaire subscale scores, simulator-based lateral control measures, crash-responsibility odds ratios, and reaction times.

Effect sizes and statistical indicators were extracted as reported by study authors where available. Because the included studies used heterogeneous designs, mindfulness measures, driving outcomes, and statistical reporting practices, results were not converted to a common effect-size metric or pooled meta-analytically. Where standardized effect sizes were not reported, available statistical indicators, including correlations, regression coefficients, odds ratios, test statistics, confidence intervals, *p*-values, model accuracy, or predicted probabilities, were summarized descriptively.

2.4. Study risk of bias assessment

The quality of articles included in the final review was assessed using the Johanna Briggs Institute (JBI) critical appraisal tools (JBI Critical Appraisal Tools, 2020). These tools are designed to engage researchers in rigorous processes to evaluate the quality of research articles, and different tools are available for assessing specific study designs. At least two researchers reviewed each article to evaluate the risk of bias and research quality across the studies included in this review.

3. Results

Fig. 2 presents the PRISMA flowchart displaying the number of articles identified during the different review phases. The initial database search identified 1190 articles, while the follow-up search in 2024 identified an additional 432 articles. Researchers agreed to exclude 1082 articles based on a review of titles and abstracts, while 28 were excluded during the full-text review. (see Fig. 2).

3.1. Article summary

The final selection of 37 articles included 28 cross-sectional studies, four case-controlled studies, two cohort studies, and three randomized controlled trials published 2011–2024. Tables 1A and 1B in Appendix A summarize the general characteristics of the studies. Sample sizes ranged from 16 to 1686 participants. The ages of the study subjects were not reported in all articles. The average number of female participants (52%) was slightly higher than that of male participants (48%), with less than 1% identifying as 'other.' Most studies were conducted in the United States ($n = 10$) and Australia ($n = 6$). The remaining studies were conducted in Spain ($n = 4$), France, Canada, Lebanon ($n = 3$ each), Italy, and Ireland ($n = 2$ each), followed by Indonesia, China, Israel, and New Zealand ($n = 1$ each). Six studies utilized mindfulness interventions, while the remaining 31 assessed the association between levels of mindfulness and driving behavior without a specific intervention. Table 2, in Appendix A, shows the mindfulness measures used in the studies.

3.2. Risk of Bias and quality assessments

Quality assessments for each JBI criterion were made using the relevant tool for each study design (JBI Critical Appraisal Tools, 2020). Researchers' consensus ratings are in Appendix C, Risk of Bias Table. Quality assessment was conducted independently by two reviewers for 25 of the included studies prior to consensus discussion, with discrepancies resolved through discussion. For the remaining studies, the team jointly completed assessment. Inter-rater reliability was calculated as percentage agreement across all JBI checklist items for independently rated studies. Overall pre-consensus agreement was 82.6% (176/213 items; 6/25 studies showed perfect item-level agreement). Agreement by study design was: RCT 91.7%, cohort studies 90.9%, cross-sectional studies 81.3%, and case-control studies 80.0%. All discrepancies were resolved through discussion and consensus.

In two randomized control trials, participants, intervention providers, and assessors were not blind to their treatment assignment (Balconi et al., 2019; Rohl et al., 2016). However, due to the nature of the treatments, meeting the standards for blind treatment assignment would have been challenging. Only one of the four case-control studies precisely described whether the control groups were comparable at baseline (Galéra et al., 2012), and none described whether they were appropriately matched. Twenty-three of the cross-sectional studies met nearly all the JBI criteria. The most common criteria that were unclear or did not meet the JBI assessment standard were stating strategies for dealing with confounding factors.

3.3. Measures of mindfulness

Several measures of mindfulness and mind-wandering were identified across the included studies, with three instruments used most frequently. (Appendix A, Table 2) The Mindfulness Awareness and Attention Scale (MAAS) ($n = 24$) was the most applied measure. Four studies used the Cognitive Affective Mindfulness Scale (CAMS) or the Five Factor Mindfulness Questionnaire (FFMQ). Additional

measures of mindfulness included the Daydreaming Frequency Scale ($n = 1$), Attention-related Cognitive Errors Scale (ARCES) ($n = 1$), the Freiberg Mindfulness Inventory (Concentration Scale) ($n = 2$), Mind Wandering tests ($n = 3$), and several other individually developed measures. Some studies utilized more than one method to measure levels of mindfulness.

3.4. Measures of safe driving behavior

Most studies measured driving behavior using self-reported data ($n = 30$). Data collection included the Robertson and Drummer crash responsibility instrument, self-reports of motor vehicle crashes, the Driving Health Inventory, and the Attention-related Driving Errors Scale (ARDES). In 11 studies, driving behavior was measured in a driving simulator, and 7 of those used self-report measures alongside simulator data. Simulator studies measured driving errors by assessing participants' ability to stay in driving lines (Valero-Mora et al., 2015; Valero-Mora et al., 2021), respond to hazards appropriately, maintain a safe space (Yanko & Spalek, 2014), and use caution at yellow lights (Chahine et al., 2022). One study used an active box placed in participants' cars to measure driving behavior in real-time (Balconi et al., 2019). One observed cell phone touches per minute while driving (Kita & Luria, 2020a; Kita & Luria, 2020b).

3.5. Results of studies

3.5.1. Intervention studies

Impact of Interventions on Safe Driving and Mindfulness:

Five of the six studies investigating the relative effects of mindfulness interventions on safe driving reported a significant positive impact on experiment group driving behavior. These included higher levels of attention (Albert et al., 2023; Kass et al., 2011) and lower numbers of driving violations (Balconi et al., 2019; Baltruschat et al., 2021; Rohl et al., 2016) than control groups. However, only two studies showed significant increases in mindfulness scores, one using the MAAS State Scale (Albert et al., 2023) and the other using the MAAS Trait Scale (Trub & Starks, 2017). The other four studies found no differences in mindfulness levels between the experiment and control groups after the intervention.

The articles reviewed used a wide variety of mindfulness interventions. Positive, safe driving effects were reported after participants used a mindfulness reminder sticker on their windshields, reducing texting and social media use while driving. However, there was no significant difference in pre- and post-mindfulness scores using the CAMS-R Scale (JBI Critical Appraisal Tools, 2020). A 21-day neurofeedback intervention improved driving behavior and reduced traffic violations (Balconi et al., 2019). The experiment groups had significant positive differences in the non-reactivity mindfulness facet score on the FFMQ scale but no differences in the other four factors: describing, observing with attention, non-judging experiences, and acting with awareness. Following a 5-week mindfulness training program held 3 h a week, the experiment group's driving performance in risky situations improved, resulting in fewer crashes (Baltruschat et al., 2021). However, no significant difference was found in emotional regulations using the Difficulties of Emotions Regulations Scale and the Cognitive Emotional Regulation Questionnaire. The three-week use of the Mindful Messaging smartphone application showed positive, non-significant changes in reducing texting while driving (Trub & Starks, 2017). Partial positive effects were seen after a semester-long college Buddhist mindfulness course, with self-reported situational awareness during a driving simulation and fewer traffic violations than in the control group ($p = .07$) (Kass et al., 2011). The mindfulness course resulted in significantly higher scores on the Concentration Scale but not on the Mindfulness Questionnaire. In Albert et al. (Albert et al., 2023), experiment participants participated in 4–6 15-min online mindfulness training sessions. Before and after their interventions, the control and experiment groups engaged in a simulated driving session. The experiment group had significantly fewer mind-wandering episodes while driving and higher state mindfulness scores immediately following the practice and second simulated driving experience.

3.5.2. Non-intervention studies

Thirty-one studies did not include an intervention but focused on associations between driving behavior and mindfulness levels. Twenty-eight of these studies found positive relationships between mindfulness levels and safe driving. Many examined more than one aspect of safe driving. Thirteen studies explored connections between distracted driving and levels of mindfulness. Of those, seven specifically looked at texting while driving. Eight studied driving errors such as lane changing and stopping distance, and six studies investigated aggressive driving, including speeding. Five investigated connections between mindfulness and the number of crashes a driver was involved in or responsible for. Three looked at driving infractions, not including crashes.

Of the studies that did not find significant relationships between levels of mindfulness and driving behavior, 2 studied aggressive driving (Herrero-Fernández et al., 2022; Valero-Mora et al., 2015), and one studied distracted driving with smartphone use (Kita & Luria, 2020a). Herrero found that mindfulness, measured using the MAAS, was not significantly correlated with driving aggression ($p = .08$). Valero-Mora et al. (2015) (Valero-Mora et al., 2015) used a driving simulator to measure aggressive driving, specifically speeding, and also measured mindfulness with the MAAS. While a significant relationship was not found in this study, a follow-up study (Valero-Mora et al., 2021) did identify a significant relationship between lateral control while driving, driving within parallel lines, and levels of mindfulness. Kita and Luria (2020) (Kita & Luria, 2020a) compared smartphone screen touches while driving with mindfulness levels using CAMS and found no significant relationship. Among studies reporting correlation coefficients, most fell in the small-to-medium range ($r = 0.15–0.44$), consistent with a modest but consistent association; studies by Koppel et al. (2022) (Koppel et al., 2022) and Murphy and Matvienko-Sikar (2019) (Murphy & Matvienko-Sikar, 2019) reported effects at the upper end of this range, particularly for attentional lapses and errors.

3.6. Trait versus state mindfulness

Most studies used MAAS, CAMS, and/or FFMQ scales to measure trait mindfulness. Three studies explored whether state mindfulness or mind-wandering were associated with safe driving (Albert et al., 2023; Burdett et al., 2016; Gil-Jardiné et al., 2017). Gil-Jardiné (2017) (Gil-Jardiné et al., 2017) studied whether higher levels of trait and state mind wandering were associated with being in a motor vehicle crash. To measure state mind wandering, participants were asked whether their attention to driving was distracted by thoughts unrelated to driving. Researchers developed a custom trait mind-wandering scale to measure trait mind-wandering (Burdett et al., 2016). They found that both trait and state mind wandering were associated with being responsible for a motor vehicle crash. Burdett et al. (2016) (Burdett et al., 2016) also studied state mind-wandering, trait mindfulness, and associations with safe driving. State mind-wandering was measured by asking participants about their attentional state while driving in various situations. Trait mindfulness was measured using MAAS to determine general levels of mindfulness and its relationship with safe driving. They found that drivers under age 21 have lower trait mindfulness and higher levels of lapses in driving attention. The study results explicitly described the relationship between safe driving and state levels of mind-wandering related to mindfulness, namely being relaxed and anxious. Finally, Albert et al. (2023) (Albert et al., 2023) used the State Mindfulness Scale (SMS) (Tanay & Bernstein, 2013) to see whether a mindfulness training intervention improved state mindfulness and thereby improved driving. They found that SMS mind scores improved significantly following the training and subsequent improvement in driving safety in the follow-up simulated driving experience.

4. Discussion

In scholarly literature, mindfulness interventions have been associated with improvements in attention, awareness, and emotional self-regulation (Baltruschat et al., 2021; Koppel et al., 2019; Murphy & Matvienko-Sikar, 2019). In traffic safety, mindfulness has been identified as a potential mediator of distracted and aggressive driving (Feldman et al., 2011a; Feldman et al., 2011b; Koppel et al., 2018a; Koppel et al., 2018b). Taken together, findings across the 37 included studies suggest a generally positive but heterogeneous pattern of association between mindfulness, mind-wandering, and safer driving behavior.

Among the non-intervention studies, 28 of 31 found significant associations between higher mindfulness and at least one driving safety outcome, with effect sizes predominantly in the small-to-medium range. These findings should be interpreted as a convergent body of associational evidence rather than as a pooled estimate of effect, given heterogeneity across study designs, mindfulness instruments, driving outcome measures, and populations. The strongest associations were observed for attentional outcomes, including lapses, errors, and mind-wandering during driving, whereas associations with deliberate violations and aggressive behaviors were generally weaker or more conditional.

This review includes 29 articles not included in a previous review (Koppel et al., 2019). This review advances the field in three ways. First, it tests the existing evidence base directly against theory, evaluating the degree to which findings from included studies are consistent with three established psychological frameworks (Section 4.1). Second, it systematically documents the specific mindfulness measure used in each included study, an aspect of study design not cataloged in the prior review, which surfaces a measurement gap with direct implications for future research design (Section 4.2). Third, by including studies of mind-wandering alongside studies of mindfulness explicitly, it offers a more complete picture of the attentional continuum underlying safe driving behavior than either construct considered in isolation. However, the cross-sectional designs that dominate this literature cannot determine whether mindfulness improves driving or whether safer drivers are simply more mindful. Longitudinal and intervention designs are needed to clarify the direction of this relationship. The sections that follow examine how well the existing evidence base maps onto theory (Section 4.1), how it compares with and extends the most recent prior systematic review (Section 4.2), and what its methodological patterns suggest for future measurement (Section 4.3).

4.1. Comparison of theory and findings

The three theoretical frameworks outlined in 1.1 each find empirical support in the reviewed literature, though the strength of evidence varies across mechanisms and outcome types.

Support for Garland et al.'s (2009) (Garland et al., n.d.) mindfulness coping model which predicts that mindfulness reduces aggressive responding to aversive driving situations through positive reappraisal is provided most directly by Qu et al. (2024 (Qu et al., 2024)), who found that mindfulness was associated with lower driving anger and anger rumination, which in turn predicted lower aggressive driving expression. Feldman et al. (2011) (Feldman et al., 2011b) further demonstrated that mindfulness was associated with reduced texting while driving partly through emotion-regulation motives, suggesting that the same regulatory pathway extends beyond aggression to a broader range of emotionally mediated driving behaviors. Both studies are consistent with the theoretical prediction that mindfulness may help interrupt the escalation from emotional arousal to unsafe behavioral response.

Evidence consistent with the decoupling hypothesis (Smallwood & Schooler, 2006) is strongest in the simulator and intervention studies. Yanko and Spalek (2014) (Yanko & Spalek, 2014) demonstrated directly that mind-wandering episodes during simulator driving were associated with significantly slower braking reaction times, higher speeds, and shorter headway distances — precisely the performance costs the decoupling hypothesis predicts. Tinella et al. (2022) (Tinella et al., 2022) extended this finding to real-world driving behavior, showing that mind-wandering tendency mediated the association between neuroticism and aberrant driving across two national samples, indicating that the attentional decoupling mechanism operates independently of personality differences. Burdett et al. (2016) (Valero-Mora et al., 2021) and Gil-Jardiné et al. (2017) (Gil-Jardiné et al., 2017) further demonstrated that both

trait and state mind-wandering were associated with driving lapses and crash responsibility, respectively, providing ecologically valid support for the decoupling account.

Reason's (1990) (Reason et al., 1990) skill-rule-knowledge framework is consistent with the overall pattern of effect sizes observed across the included studies. Associations between mindfulness and attention lapses, errors, and mind-wandering during driving were consistently larger than associations with deliberate violations and aggressive behaviors. This gradient is precisely what the framework predicts: mindfulness should be most protective against unintentional skill-based failures driven by inattention, and less directly relevant to deliberate rule-breaking. The large SEM path coefficients for lapses ($\beta = -0.58$) and errors ($\beta = -0.46$) reported by Koppel et al. (2018) (Koppel et al., 2018a), compared with the smaller coefficients for violations across multiple studies, illustrate this predicted pattern clearly.

These findings should also be interpreted in light of individual differences in how drivers respond to distraction. Although attentional control provides a plausible pathway linking mindfulness with safer driving behavior, distraction may not produce the same behavioral response across all drivers. Recent simulator-based research on mobile-phone distraction at roundabouts found heterogeneous gap-selection patterns, with some distracted drivers selecting smaller or larger gaps and with driving experience influencing these choices (Hutchins et al., 2025). This suggests that mindfulness may matter not only because it reduces attentional lapses, but also because it may support more adaptive behavioral responses when cognitive demand increases, such as more conservative gap acceptance, increased headway, or reduced speed. Future studies should examine whether mindfulness moderates driver responses to distraction and whether more mindful drivers are more likely to compensate safely under increased cognitive load.

Taken together, the theoretical frameworks are mutually reinforcing rather than competing. Attentional control, mind-wandering reduction, and emotion regulation represent three distinct but interacting mechanisms through which mindfulness may be associated with safer driving, each most relevant to a different category of unsafe behavior. Associations appear strongest for attentional lapses and errors, the skill-based failures predicted by Reason's framework and consistent with the decoupling hypothesis, with a somewhat weaker and more conditional influence on deliberate violations and aggressive behavior, consistent with Garland's coping model predicting effects only when emotional regulation is engaged.

Fig. 3 provides a visual counterpart to the pattern described above, mapping the relative strength of each route directly onto the proposed theoretical structure. The diagram makes visible what the effect sizes alone do not: that the attentional control pathway is the dominant route through which mindfulness relates to safer driving, while the emotion regulation pathway, though theoretically grounded in Garland et al.'s (2009) (Garland et al., n.d.) coping model, carries comparatively thinner empirical support across the included studies. This asymmetry suggests that future intervention research may see more immediate returns from targeting attentional mechanisms specifically, rather than treating mindfulness training as a uniform intervention across both pathways.

4.2. *Comparison with previous systematic review*

The present review builds directly on the work of Koppel et al. (2019) (Kirley et al., 2023a), who conducted an earlier systematic review of mindfulness and road safety, identifying 17 articles published between 2011 and 2017. That review concluded that mindfulness showed promise for reducing road trauma but identified few studies focused on the effects of specific mindfulness interventions and did not systematically document how mindfulness was measured across studies. The present review extends that evidence base substantially, identifying 29 additional articles not included in Koppel et al., with 27 of these published after 2017. Of

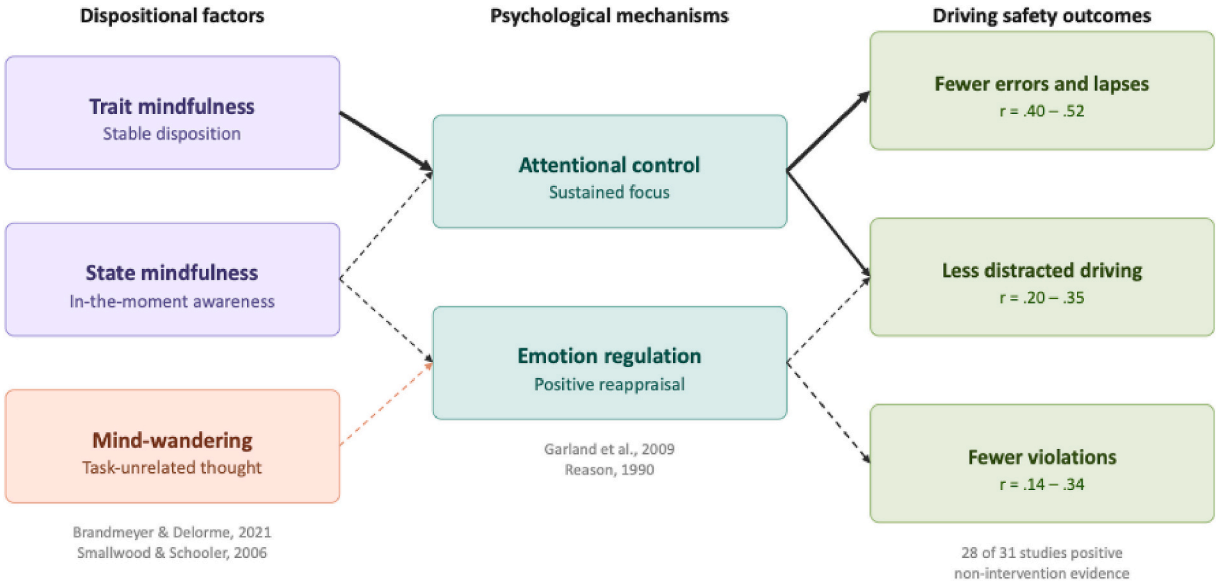

Fig. 3. Empirical support for the proposed pathway, based on findings from the present review.

the eight studies shared between the two reviews (Burdett et al., 2016; Feldman et al., 2011b; Galéra et al., 2012; Gil-Jardiné et al., 2017; Kass et al., 2011; Panek et al., 2015; Terry & Terry, 2015a; Yanko & Spalek, 2014) findings are broadly consistent, suggesting the association between mindfulness and safer driving behavior has replicated across independent samples and research groups over time.

The expansion of the evidence base since 2019 has been accompanied by greater methodological diversity, including a growing number of intervention studies. The present review identified six studies utilizing mindfulness interventions, compared with one in Koppel et al. Five of these six reported improvements in safe driving behavior in the intervention group relative to control, representing a more developed if still methodologically heterogeneous intervention literature than was available at the time of the previous review. These intervention findings are broadly consistent with the theoretical mechanisms outlined in Section 4.1: improvements were most reliably observed for attentional outcomes, such as mind-wandering, situational awareness, and driving errors, while effects on deliberate violations and aggressive behavior were less consistent, a pattern aligned with Reason's skill-rule-knowledge framework and the decoupling hypothesis.

However, a striking and theoretically important pattern emerged from the intervention studies: five of the six reported improvements in driving behavior despite only two finding significant increases in mindfulness scores one using the State MAAS (Albert et al., 2023) and one using the Trait MAAS (Trub & Starks, 2017). This disconnect between behavioral change and measured mindfulness change warrants careful consideration. Several explanations are plausible. Mindfulness-based interventions may produce improvements in driving behavior through pathways that are not captured by general self-report mindfulness scales, for example, through stress reduction, relaxation, or physiological arousal regulation, mechanisms that could improve attentional performance without producing detectable shifts on instruments like the MAAS. Alternatively, behavioral improvements may precede measurable changes in self-reported mindfulness, consistent with a skill-acquisition trajectory in which performance changes before stable trait-level shifts are consolidated. A third possibility is that the general mindfulness scales in common use are simply not sensitive enough to detect the specific attentional and regulatory changes that are most relevant to driving. To better understand these relationships, future studies should utilize multiple validated mindfulness scales assessing different aspects of the construct, incorporate physiological indicators such as heart rate variability or neural activity, and include active control groups designed to isolate the mindfulness component from non-specific intervention effects.

This measurement sensitivity issue points to a broader gap that is evident across the full body of reviewed literature, not only the intervention studies. The most widely used instrument across all 37 studies was the MAAS, employed in 24 studies. The MAAS is a unidimensional measure of present-moment attentional awareness and was not developed for driving contexts. As a single-factor scale, it cannot distinguish between the specific facets of mindfulness — such as non-reactivity, acting with awareness, or non-judging of inner experience — that theory and emerging evidence suggest are most proximally relevant to driving safety. By contrast, the four studies using the multidimensional FFMQ identified facet-specific associations: non-reactivity was associated with reduced driving violations in Balconi et al. (2019) (Valero-Mora et al., 2015); acting with awareness and non-judging of inner experience were associated with fewer cell phone near-accidents in Terry and Terry (2015) (Terry & Terry, 2015a); and acting with awareness was the single strongest predictor of texting while driving in Panek et al. (2015) (Kita & Luria, 2020a). Taken together, these facet-level findings suggest that the relationship between mindfulness and driving safety is not uniform across the construct, and that unidimensional instruments may underestimate or misrepresent the specific psychological processes involved.

None of the mindfulness measures used across the 37 included studies were designed to assess mindfulness in the context of driving specifically. This represents a meaningful methodological constraint, as general trait measures may not capture the moment-to-moment attentional regulation, delayed hazard awareness, impaired reaction time, and emotional reactivity that are most directly relevant to safe driving behavior. Future research should prioritize driving-specific measures of mindful attention regulation, such as the Driver Attention Regulation Scale (DARS) (Love et al., 2024), which may be more sensitive to the attentional processes linking mindfulness to driving outcomes. The choice of mindfulness measure should also be theoretically guided by the specific driving behaviors under investigation and the nature of the intervention being tested, rather than defaulting to the MAAS on the basis of its widespread use.

4.3. Measuring trait and state mindfulness

The measurement limitations identified above extend beyond instrument choice to a more fundamental issue: the almost exclusive focus in the reviewed literature on trait mindfulness, at the expense of state-based assessment. State mindfulness was evaluated in only 3 studies identified in the present review. This finding contrasts with a recommendation by Valero-Mora et al. (2021) (Valero-Mora et al., 2021), who suggest that driving studies use measures of state mindfulness specifically. Given that driving behavior is influenced by moment-to-moment attention, awareness, and emotional regulation, measures of state mindfulness may be more appropriate in assessing how mindfulness fluctuates in real-time or following a short mindfulness intervention. Of the three studies measuring state mindfulness in this review, one observed an improvement in driving behavior following a mindfulness intervention (Albert et al., 2023); one demonstrated that involvement in crashes correlated with lower levels of mindfulness (Gil-Jardiné et al., 2017), and one did not report results of state mindfulness (Burdett et al., 2016). Results highlight an imbalance in scholarly literature, with a focus on trait mindfulness. To gain a more precise understanding of how mindfulness influences driving behavior, we recommend that future research incorporate measures of state mindfulness. Other possible mindfulness measures include psychophysiological measures of attention through heart rate and arousal through skin conductance and facial electromyography (Bolls et al., 2019; Howell et al., 2019).

Thirty articles in this review used self-report measures of safe driving, with seven utilizing objective measures, including driving simulators and observation tools. Some argue that self-report measures of driving behavior present a false assessment of actual

behavior due to response bias, such as social desirability effects (Bailey & Wundersitz, 2019; Sullman & Taylor, 2010), and recall bias (Kamaluddin et al., 2018). Kaye et al. (2018) suggest that for some behaviors (e.g., driving in stressful situations), there is a linkage between subjective and objective measures, while for others (sleepiness and vigilance), there are differences. A mixed-methods approach, combining self-reports with objective data, would enhance the reliability and validity of findings and provide a more comprehensive understanding of the relationship between mindfulness and driving behavior.

4.4. Practical implications

The findings of this review have several practical implications for traffic safety practitioners, driver educators, and policymakers. Across the reviewed studies, some authors have suggested that mindfulness exercises could be incorporated into driver education and rehabilitation programs (Karras et al., 2024; Sabek et al., 2024). Among the intervention studies, Baltruschat et al. (2021) (Baltruschat et al., 2021) demonstrated that a five-week mindfulness-based program significantly reduced dangerous driving and crash frequency among repeat traffic offenders — a high-risk group of particular relevance to road safety agencies. Importantly, Albert et al. (2023) (Albert et al., 2023) demonstrated that brief online mindfulness training, delivered in as few as four to six fifteen-minute sessions, improved state mindfulness and reduced mind-wandering during simulated driving, suggesting that scalable, low-cost digital delivery is feasible for driver education programs. For targeted interventions, Kita and Luria (2020) (Kita & Luria, 2020b) identified male drivers as a priority group for mindfulness-based approaches to reduce smartphone use while driving, while Karras et al. (2024) [(Karras et al., 2024) specifically recommend mindfulness exercises as a component of driver rehabilitation curricula for offenders. Policymakers and road safety agencies may wish to consider mindfulness-based approaches as a complement to existing countermeasures, particularly for attentional distraction and anger management, though broader adoption should await more rigorous randomized controlled trial evidence establishing efficacy under real-world driving conditions.

5. Limitations and strengths

This review should not be considered an exhaustive list of all mindfulness and driving behavior studies. We limited our search to English-language publications and did not include gray literature, which may have led to the omission of valuable studies. Additionally, divergent study designs made it difficult to draw quantitative conclusions from the studies included in this review. The studies also used various driving behaviors and mindfulness measures, and the variability in the measurement tools for mindfulness levels and driving behavior made it difficult to compare results. The wide variety of geographic and demographic study populations also limited the generalizability of study findings. Many studies did not consistently report standardized effect sizes, limiting formal quantitative synthesis and comparisons across studies. Finally, the predominance of cross-sectional designs also limits causal interpretation and prevents conclusions about whether mindfulness contributes to safer driving or whether safer drivers report higher mindfulness.

This review also has several notable strengths. It is, to our knowledge, the most comprehensive synthesis to date of the relationship between mindfulness and driving behavior, more than doubling the number of articles identified in the most recent prior systematic review. The dual-reviewer process used for title and abstract screening, full-text review, and risk-of-bias assessment, together with the documented inter-rater reliability calculations, supports the methodological rigor of study selection and quality appraisal. The review is also the first in this literature to systematically catalog the specific mindfulness measurement instrument used in each included study, surfacing a measurement gap that has direct implications for future research design. Finally, by considering studies of mind-wandering alongside studies of mindfulness explicitly, the review offers a more complete account of the attentional continuum underlying safe driving behavior than prior reviews focused on mindfulness alone.

6. Conclusions

This review provides evidence that mindfulness is generally, though not uniformly, associated with safer driving behavior, and that attentional control, emotion regulation, and reduced mind-wandering represent theoretically plausible psychological pathways connecting these constructs, though the predominantly cross-sectional evidence base does not permit causal conclusions. While evidence from intervention studies remains limited and methodologically heterogeneous, findings are consistent with the value of further experimental work examining mindfulness-based approaches within controlled driving contexts. Advancing the field will require greater conceptual precision in mindfulness measurement and increased use of state-based and driving-specific instruments aligned with psychological theory.

Further research is needed to examine whether short interventions primarily influence state mindfulness, whether longer trainings affect trait mindfulness, and how changes in each construct relate to measurable improvements in driving behavior.

CRediT authorship contribution statement

Marcia Howell: Writing – review & editing, Writing – original draft, Software, Resources, Project administration, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Petra Wagman:** Writing – review & editing, Supervision, Methodology, Formal analysis, Conceptualization. **Viveca Larsson:** Writing – review & editing, Supervision, Methodology, Formal analysis, Conceptualization. **Nerrolyn Ramstrand:** Writing – review & editing, Writing – original draft, Supervision, Software, Resources, Methodology, Investigation, Formal analysis, Data curation, Conceptualization.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Declaration of AI-assisted language editing

During the preparation of this work, the authors used ChatGPT and Claude AI to improve language and readability. After using this tool, the authors reviewed and edited the content as needed and took full responsibility for the publication's content.

Appendix A. Appendix

Table 1A
Intervention Studies: Mindfulness and Safe Driving ($n = 6$). *Impact key: Positive = mindfulness associated with safer driving outcomes | Mixed = partial or inconsistent effects | Negative = no significant association found.*

Citation	Study Design	N	Population / Country	Mindfulness Measure	Intervention Description	Driving Outcome	Driving Measure Method	Impact	Effect Size	Key Finding
Albert et al. (2023) (Albert et al., 2023)	RCT	26	Ages 21–25, Canada	MAAS (Trait & State)	4–6 sessions × 15 min online mindfulness training	Mind wandering; driving performance	Self-report; Driving simulator	Positive	State mindfulness (SMS-Mind): d = 1.01 (large). Mind wandering reduction OR = 0.35 (MT vs. PMR, $p = .01$). No significant effect sizes for driving behavior outcomes; power insufficient in this pilot ($N = 26$).	Significantly fewer self-observed mind-wandering episodes during simulator driving; state mindfulness scores increased over control group. Driving behavior analysis was exploratory.
Balconi et al. (2019) (Balconi et al., 2019)	RCT	50	Licensed drivers, no psychiatric history, Italy	Five Facet Mindfulness Questionnaire (FFMQ)	21-day neurofeedback protocol	Attention; driving violations; aggressive violations	Self-report (DBQ); Active in-vehicle box	Positive	DBQ violations decreased in the experimental group from pre- to post-intervention, $t(28) = 2.136$, $p = .042$; aggressive violations also decreased, $t(28) = 2.525$, $p = .018$. Active Box overall driving performance improved from pre- to post-intervention, $t(28) = -3.728$, $p = .005$. No standardized effect size reported.	DBQ violations and aggressive violations significantly decreased in experimental group. Non-reactivity facet of FFMQ improved significantly.
Baltruschat et al. (2021) (Baltruschat et al., 2021)	Case-control	89	Repeat traffic offenders vs. non-offenders, Spain	Difficulties Emotion Regulation Scale; Cognitive Emotion	5-week MBI (3 h./week)	Risky driving; crash frequency	Self-report; Driving simulator	Mixed	Driving performance $F(2,84) = 3.919$, $p = .024$, $\eta^2 = 0.085$ (small–medium). Accidents RR = 6.37	Trained group performed better in risky driving scenarios and had fewer simulated

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Table 1A (*continued*)

Citation	Study Design	N	Population / Country	Mindfulness Measure	Intervention Description	Driving Outcome	Driving Measure Method	Impact	Effect Size	Key Finding
				Regulation Questionnaire					(R-M vs. R repeat offenders, $p < .05$). No significant effect for emotion regulation outcomes.	crashes. No significant change in emotion regulation scores.
Kass et al. (2011) (Kass et al., 2011)	Case-control	16	College students, mean age 24.9, USA	Mindfulness questionnaire (45-item); Concentration Scale	Semester-long Buddhist mindfulness course	Situational awareness; driving performance	Driving simulator; SAGAT	Mixed	Mindfulness training group scored significantly higher on situation awareness than the control group, M = 6.00 vs. 4.43, t(12) = 2.98, $p <$ .01. Mindfulness was strongly correlated with situation awareness, $r = 0.80$, $p <$ .01, and with fewer pedestrian collisions, $r = -0.61$, $p < .05$. Stop sign/traffic light violations were lower in the mindfulness group but did not reach statistical significance, M = 0.29 vs. 1.00, t(12) = 1.99, $p = .07$. No standardized between-group effect size reported.	Mindfulness group scored significantly higher on situational awareness ($p <$ .01); no significant difference in stop sign/traffic light violations ($p =$ .07)
Rohl et al. (2016) (Rohl et al., 2016)	RCT	NR	Medical students, USA	Cognitive & Affective Mindfulness Scale (CAMS-R)	Mindfulness reminder sticker on windshield	Texting while driving	Self-report	Mixed	. In the sticker group, self-reported sending texts, reading texts, and using social media while driving decreased significantly from pre- to post-survey, while control-group changes were not significant. Baseline mindfulness was not significantly correlated with texting-related outcomes in either group. No standardized effect size reported	The windshield sticker intervention significantly reduced self-reported sending texts, reading texts, and social media use while driving in the sticker group, while the control group showed no statistically significant pre–post changes. Mindfulness scores showed no significant correlation with texting-while-driving modalities.
Trub & Starks (2017) (Trub & Starks, 2017)	Cohort	29	Young adults with prior risky smartphone behavior, USA	MAAS; Difficulties in Emotional Regulation Scale	3-week Mindful Messaging smartphone app	Texting while driving	Self-report	Mixed	Mindfulness increased significantly from baseline to follow-up, MAAS dz. = 0.45, $p =$ .03. Texting while driving showed a small, non-significant reduction, dz. = 0.21, $p = .26$. No control group; pre–post design only.	Non-significant trend toward reduced texting while driving. Trait mindfulness (MAAS) increased significantly in the intervention group.

Abbreviations: RCT = Randomized Controlled Trial; MAAS = Mindful Attention Awareness Scale; FFMQ = Five Facet Mindfulness Questionnaire; CAMS = Cognitive & Affective Mindfulness Scale; DBQ = Driver Behavior Questionnaire; SAGAT = Situation Awareness Global Assessment Technique; NR = Not Reported; MBI = Mindfulness-Based Intervention.

Table 1B
Non-Intervention Studies: Mindfulness, Mind-Wandering, and Safe Driving ($n = 31$). Impact key: Positive = mindfulness associated with safer driving outcomes | Mixed = partial or inconsistent effects | Negative = no significant association found.

Citation	Study Design	N	Country	Mindfulness Measure	Driving Outcome Category	Driving Measure Method	Impact	Effect Size	Key Finding
Bolla et al. (2023) (Bolla et al., 2023)	Cross-sectional	396	Indonesia	MAAS	Driving performance (crashes, speeding, braking)	Driving simulator	Positive	Mindfulness predicted riding performance β = 0.119. Poorer riding performance predicted accident probability OR = 11.55 ($p < .001$). Model $R^2 = 0.280$.	Mindfulness significantly positively correlated with riding performance.
Burdett et al. (2016) (Burdett et al., 2016)	Cross-sectional	502	New Zealand	MAAS; Cognitive Failures Questionnaire	Mind wandering; driving lapses	Self-report	Positive	MAAS–mind wandering $r = -0.46$ ($p < .01$, medium). Regression $R^2 = 0.524$; MAAS β = −0.269 (strongest predictor). Road familiarity effect on mind wandering $\eta^2p = 0.718$ (large) and age (β = −0.210) contributing most strongly.	Lower trait mindfulness and higher mind wandering associated with greater lapses of attention and violations; strongest in drivers under 25.
Chahine et al. (2022) (Chahine et al., 2022)	Cross-sectional	102	Lebanon	MAAS	Intersection decision-making	Self-report; Driving simulator	Positive	Among the safest-driver cluster, participants who stopped at the training intersection had higher mindfulness scores than those who passed, M = 4.36 vs. 3.98, $t = -2.04$, $p = .046$. A decision-tree model using mindfulness and speed predicted the go/no-go decision at Intersection 1 with 98% accuracy, sensitivity, and specificity. No standardized effect size reported.	Higher mindfulness associated with safer stopping decisions at yellow traffic lights.
Cimino et al. (2022) (Cimino et al., 2022)	Cross-sectional	NR	Italy	MAAS	Multiple motor vehicle crashes in adolescents	Crash records	Positive	MAAS lower in multiple-crash group $\eta^2 = 68.65$ (large). Mindfulness not retained as independent predictor in regression ($R^2 = 0.82$).	Adolescents with fewer crashes scored higher in mindfulness, but mindfulness was not retained as an independent predictor after controlling for emotional dysregulation and impulsivity.
El Mendelek et al. (2023) (El Mendelek et al., 2023)	Cross-sectional	176	Lebanon	MAAS	Intersection safety / violations	Driving simulator	Positive	In a mixed-effects stopping-difference model, higher mindfulness predicted safer stopping behavior at the stop bar, estimate = 1.09, SE = 0.44, 95% CI [0.22, 1.96], $t = 2.46$, $p = .01$; model ICC = 0.57. No standardized effect size reported.	Higher mindfulness associated with greater stopping distance and fewer stop-line violations.
Ehsani et al. (2024a) (Ehsani et al., 2024b)	Cross-sectional	NR	USA	MAAS	Risky driving (texting, impaired, no seatbelt)	Self-report	Positive	MAAS direct effect on risky driving β = −0.068 ($p < .001$). Indirect effect via mindfulness β = −0.004 ($p = .007$). $R^2 = 0.239$.	Mindfulness had a significant negative direct effect on multiple risky driving behaviors in U.S. teenagers.

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Table 1B (*continued*)

Citation	Study Design	N	Country	Mindfulness Measure	Driving Outcome Category	Driving Measure Method	Impact	Effect Size	Key Finding
Ehsani et al. (2024b) (Ehsani et al., 2024a)	Cross-sectional	267	USA	MAAS	Crashes; risky driving behaviors	Self-report	Positive	Moving from the average MAAS score to the target score of 75 was associated with lower predicted probabilities of texting/emailing while driving (−6.9 percentage points), marijuana-impaired driving (−8.9), seatbelt non-use (−10.7), and crash involvement (−8.6). No standardized effect size reported.	Higher mindfulness significantly associated with lower likelihood of all risky driving behaviors and crash involvement.
Feldman et al. (2011) (Feldman et al., 2011b)	Cross-sectional	231	USA	Cognitive & Affective Mindfulness Scale (CAMS)	Texting while driving	Self-report	Positive	CAMS total effect on texting while driving β = −0.164 (p = .008); fully mediated by emotion-regulation motives. R^2 = 0.22.	Lower mindfulness associated with more frequent texting while driving via attention and emotion-regulation motives.
Herrero-Fernández et al. (2022) (Herrero-Fernández et al., 2022)	Cross-sectional	392	Spain	MAAS	Aggressive driving (DAX)	Self-report	Mixed	MAAS correlations with driving aggression subscales r = −0.14 to −0.22 (all p < .01). Direct SEM path to aggression β = −0.08 (ns). MAAS significant mediator between attachment style and three of four aggression forms.	MAAS significantly correlated with all four aggression subscales (r = −0.14 to −0.22); direct path non-significant in final SEM model, with mindfulness functioning as a significant mediator.
Karras et al. (2024) (Karras et al., 2024)	Cross-sectional	1686	France	MAAS	Driving violations; distracted driving	Self-report	Positive	MAAS correlations — violations r = −0.41 (females), −0.26 (males); distracted driving r = −0.43 (females), −0.28 (males); prosocial r = 0.29/0.25; all p < .05. Regression: violations β = −0.13 (females), −0.08 (males); distracted driving β = −0.25 (females), −0.22 (males); all p < .001.	Mindfulness was linked to fewer violations and engagement in distracting activities while driving.
Kita & Luria (2020) (Kita & Luria, 2020b)	Cohort	221	Israel	CAMS	Smartphone use while driving	Objective (screen touches/min)	Mixed	Overall, MAAS r = −0.10 (ns). Males r = −0.21 (p < .05); females r = 0.09 (ns). Sex × mindfulness interaction β = 1.11 (p < .05). Simple slope males t = −2.6 (p < .01); females ns.	No direct relationship found between mindfulness and smartphone use while driving.
Stephens (2018) (Stephens et al., 2018)	Cross-sectional	309	Australia	MAAS; Freiburg Mindfulness Inventory (FMI)	Aggressive driving; driving anger	Self-report	Positive	MAAS/FMI negatively correlated with anger and aggression (r = −0.21 to −0.44). SEM: MAAS predicted anger (16% variance); anger predicted aggression (44% variance). MAAS effect on aggression fully mediated by anger (direct path ns; r	Mindfulness (MAAS, not FMI) was associated with less driving anger and aggression, with anger fully mediating the mindfulness–aggression relationship via SEM.

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Table 1B (*continued*)

Citation	Study Design	N	Country	Mindfulness Measure	Driving Outcome Category	Driving Measure Method	Impact	Effect Size	Key Finding
								= −0.29 without anger in model).	
Koppel et al. (2018) (Koppel et al., 2018a)	Cross-sectional	318	Australia	MAAS; FMI	Aberrant driving; crashes; infringements	Self-report	Positive	SEM results showed mindfulness was negatively related to aberrant driving behaviors, with the strongest associations for driving-related lapses (−0.58) and errors (−0.46). Participants who practiced mindfulness meditation reported fewer crashes than non-practitioners, 9.3% vs. 18.8%, $p <$ .05, and fewer aberrant driving behaviors, including violations and errors. No standardized effect size was reported for the meditation-practice group differences.	Mindfulness was most strongly associated with fewer lapses and errors. Mindfulness meditation practitioners also reported fewer crashes and aberrant driving behaviors, although the cross-sectional design does not support causal inference.
Koppel et al. (2022) (Koppel et al., 2022)	Cross-sectional	991	Australia	MAAS	Driving errors; crashes; technology engagement	Self-report	Positive	MAAS correlations — errors $r = -0.518$ (large); lapses $r = -0.402$ (medium–large); violations $r = -0.344$ (medium); aggressive violations $r = -0.232$; technology engagement $r = -0.283$; all $p < .01$. SEM: mindfulness to nomophobia $\beta = -0.41$; technology engagement $\beta = -0.30$; aberrant driving $\beta = -0.29$. Model explained 51% variance in aberrant driving. Crash comparison Mdn = 56.0 vs. 61.0 ($p < .01$).	Lower mindfulness associated with higher driving errors, lapses, and crash involvement. Mindful drivers more attentive to primary driving task.
Miller & Taylor-Piliae (2018) (Miller & Taylor-Piliae, 2018)	Cross-sectional	58	USA	MAAS	Driving performance (older adults)	Self-report; Driving Health Inventory	Mixed	Participants scored higher than normative reference values on MAAS, $p < .001$, d = 0.75. However, MAAS was not significantly correlated with Driving Scenes Test performance within the study sample, $r = -0.19$, ns. The digit span backward test was the strongest predictor of safe driving performance, $\beta = 0.34$, $p = .009$.	Participants had higher dispositional mindfulness than reference norms and performed better on the driving assessment (association not fully characterized).
Moore & Brown (2019) (Moore & Brown, 2019)	Cross-sectional	170	Australia	MAAS; Brief Self-Control Scale	Texting while driving	Self-report	Mixed	MAAS–texting while driving $r = -0.01$ (ns). MAAS–habitual texting $r = -0.44$ ($p <$ .01). Conditional	Habitual texting predicted texting while driving among those low-to-moderate in mindfulness; effect

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Table 1B (*continued*)

Citation	Study Design	N	Country	Mindfulness Measure	Driving Outcome Category	Driving Measure Method	Impact	Effect Size	Key Finding
								indirect effect significant at low mindfulness β = −0.21 ($p < .05$) and moderate mindfulness β = −0.17 ($p < .05$); ns at high mindfulness. R^2 = 0.09.	diminished at high mindfulness.
Murphy & Matvienko-Sikar (2019) (Murphy & Matvienko-Sikar, 2019)	Cross-sectional	657	Ireland	MAAS	Violations; aggression; errors; lapses; anxiety	Self-report	Positive	MAAS correlations — lapses $r = -0.41$; errors $r = -0.35$; ordinary violations $r = -0.28$; aggressive violations $r = -0.20$; all $p < .001$. Regression β range −0.21 to −0.41 across 10 models; adjusted R^2 range 0.05–0.21.	Mindfulness was a significant predictor across every regression model including violations, aggressive driving, errors, lapses, and anxious driving.
Murphy & Murphy (2018) (Murphy & Murphy, 2018)	Cross-sectional	386	Ireland	MAAS	Risk and safety-related driving behavior	Self-report	Positive	MAAS correlations (higher score = more mindful): violations $r = 0.236$; phone use $r = 0.209$; tire checking $r = 0.232$; all $p < .01$. Regression: violations β = 0.208; phone use β = 0.179; tire checking β = 0.185; all $p < .01$.	Trait mindfulness significantly predicted both risky and safe driving behavior independent of future-orientation scale.
Murphy et al. (2020) (Murphy et al., 2020)	Cross-sectional	95	Australia	MAAS	Intention to monitor smartphone while driving	Self-report	Mixed	MAAS–intention $r = -0.04$ (ns). Regression: mindfulness β = 0.11 ($p < .05$, $sr^2 = 0.01$) for intention after controls. At Time 2, mindfulness did not predict actual behavior β = −0.17 (ns).	Mindfulness predicted intention to use smartphone while driving only after controlling for all TPB constructs (β = 0.11, sr^2 = 0.01); did not predict actual behavior at follow-up.
Panek et al. (2015) (Panek et al., 2015)	Cross-sectional	925	USA	Five Facet Mindfulness Questionnaire (FFMQ)	Texting while driving	Self-report	Mixed	Acting with awareness β = −0.24 ($p < .001$) only significant FFMQ facet for texting while driving. Path coefficient = −0.15 ($p < .001$). $R^2 = 0.29$.	'Acting with awareness' and sensation components of mindfulness predicted less texting while driving; other facets non-significant.
Qu et al. (2024) (Qu et al., 2024)	Cross-sectional	350	China	MAAS	Aggressive driving; driving anger	Self-report	Positive	MAAS correlations — driving anger $r = -0.41$; anger rumination $r = -0.55$; driving anger expression $r = -0.39$; all $p < .001$. MAAS predicted driving anger expression β = −0.40 ($p < .001$). Total indirect effect b = −0.14 (95% CI −0.18 to −0.10).	Mindfulness is linked to less aggressive driving, mediated by driving anger and anger rumination.
Sabek et al. (2024) (Sabek et al., 2024)	Cross-sectional	111	Lebanon	MAAS	Unsafe overtaking	Self-report; Driving simulator	Mixed	MAAS non-significant across all four overtaking scenarios (Hedges' g = 0.186, small, for TS1). Older driver subsample: over takers vs. non-over takers MAAS 3.37 vs. 4.73 ($p = .086$, Hedges'	MAAS non-significant across all overtaking scenarios; impulsivity rather than mindfulness drove unsafe overtaking decisions.

(*continued on next page*)

Table 1B (*continued*)

Citation	Study Design	N	Country	Mindfulness Measure	Driving Outcome Category	Driving Measure Method	Impact	Effect Size	Key Finding
								$g = 2.143$; $n = 2$ over takers, interpret with caution).	
Salazar & Khandelwal (2021) (Salazar & Khandelwal, 2021)	Cross-sectional	609	USA	FFMQ	Texting while driving; near-misses	Self-report	Mixed	FFMQ correlations with texting while driving — aware $r = -0.27$; observe $r = -0.14$; nonjudgment $r = -0.11$; nonreact $r = -0.09$; describe $r = 0.06$ (ns). Regression: aware $\beta = -0.28$ ($p < .001$); observe $\beta = -0.10$ ($p < .05$); describe $\beta = 0.12$ ($p < .05$, positive). Self-control partial mediation indirect effect $b = -0.23$ ($p < .001$). Near-miss moderation interaction $b = -0.25$ ($p < .05$); conditional effect strengthened at high near-miss exposure $\beta = -0.37$ ($p = .001$).	Mindfulness inversely related to texting while driving; self-control partially mediates; near-miss accidents moderate the relationship.
Terry & Terry (2015) (Terry & Terry, 2015b)	Cross-sectional	385	USA	FFMQ	Cell phone near-accidents	Self-report	Positive	Acting with awareness correlations — talking $r = -0.21$; texting $r = -0.26$ (both $p < .01$). Nonjudging — talking $r = -0.23$; texting $r = -0.22$ (both $p < .01$). Regression: acting with awareness $\beta = -0.16$ (texting, $p < .01$); nonjudging $\beta = -0.15$ (talking, $p < .01$). $R^2 = 0.28$.	'Acting with awareness' and 'nonjudging of inner experience' facets negatively associated with near accidents.
Tinella et al. (2022) (Tinella et al., 2022)	Cross-sectional	904	Australia / Italy	Spontaneous & Deliberate Mind-Wandering Scales	Aberrant driving behavior	Self-report	Positive	MW predicted aberrant driving $\beta = 0.540$ ($p < .001$). Model $R^2 = 0.282$ (Australia), 0.264 (Italy); Cohen's $f^2 = 0.39$ and 0.35 (both medium).	Mind-wandering tendency positively influenced aberrant driving behaviors; mediated personality–driving associations across both countries.
Valero-Mora et al. (2015) (Valero-Mora et al., 2015)	Cross-sectional	67	Spain	MAAS; ARCES	Speed control; lateral control	Self-report; Driving simulator	Negative	MAAS–speed $r = 0.17$ (ns); MAAS–lateral control (MTLC) $r = -0.08$ (ns); both Spearman correlations, $N = 67$. ARDES–MTLC $r = -0.32$ ($p < .01$); ARDES–speed $r = 0.25$ ($p < .05$). Regression: ARDES significant predictor of MTLC ($\beta = -0.42$, $p < .05$); MAAS not significant for MTLC ($\beta = 0.17$, ns) or speed ($\beta = 0.01$, ns).	No significant correlations between MAAS scores and speed or lateral control. (MAAS was not reverse coded.)
Valero-Mora et al. (2021) (Valero-Mora et al., 2021)	Cross-sectional	98	Spain	MAAS; NEO-FFI	Lateral driving control	Self-report; Driving simulator	Mixed	MAAS–lateral control $r = 0.10$ (ns); MAAS–speed $r = -0.09$ (ns). Indirect effect via neuroticism and state anxiety: $b = 0.066$ (95% CI	Lower mindfulness significantly related to poorer lateral control (staying within lane lines); anxiety and consciousness mediated effect.

(*continued on next page*)

Table 1B (*continued*)

Citation	Study Design	N	Country	Mindfulness Measure	Driving Outcome Category	Driving Measure Method	Impact	Effect Size	Key Finding
								0.007–0.157). Total effect partial $r = 0.15$; 73% mediated. $R^2 = 0.309$.	
Yanko & Spalek (2014) (Yanko & Spalek, 2014)	Cross-sectional	NR	Canada	Button-press mind-wandering task	Reaction time; speed; headway distance	Driving simulator	Mixed	No standardized effect size reported. Exp. 1: braking RT was longer during mind-wandering than on-task, 1182 vs. 1062 ms, $t(16) = 2.39$, $p = .03$; velocity was higher during mind-wandering, 19.2 vs. 18.2 m/s, $t(15) = 3.83$, $p < .01$. Exp. 2: braking RT was longer during mind-wandering, 1107 vs. 967 ms, $t(31) = 2.98$, $p < .01$; headway distance was shorter during mind-wandering, 42.1 vs. 47.13 m, $t(30) = 2.27$, $p = .03$; peripheral RT was longer during mind-wandering, 1269 vs. 1113 ms, $t(20) = 2.30$, $p = .03$. Mind-wandering increased across time-on-task blocks, $F(3,141) = 23.49$, $p < .01$.	Mind-wandering was associated with slower responses to sudden events, higher velocity in Experiment 1, shorter following distance in Experiment 2, and increasing attentional disengagement over time, indicating a broad negative effect of mind-wandering on simulated driving performance.
Young et al. (2019) (Young et al., 2019)	Cross-sectional	312	Australia	MAAS	Multiple distraction sources	Self-report	Positive	MAAS correlations — daydreaming $r = -0.52$ (large); external distraction $r = -0.34$ (medium); technology use $r = -0.19$; texting $r = -0.19$; ADAS $r = -0.23$; all $p < .05$ or $p < .01$; passenger interaction $r = -0.04$ (ns). Lost-in-thought OR = 0.148 per MAAS point ($p < .001$); external distraction OR = 0.320 ($p < .001$).	Mindfulness negatively associated with engagement in all distraction sources (texting, sat-nav, social media, eating) except passenger interaction.
Galéra et al. (2012) (Galéra et al., 2012)	Case-control	455	France	CAMS; interview questions	Crash responsibility	Robertson & Drummer crash responsibility instrument	Positive	Intense mind wandering vs. none: crash responsibility adjusted OR = 2.12 (95% CI 1.37–3.28). Low-intensity mind wandering OR = 1.06 (ns). Sensitivity analyses: OR range 1.91–3.05 across cut-point variations.	Highly disrupting mind-wandering content was independently associated with crash responsibility.
Gil-Jardiné et al. (2017) (Gil-Jardiné et al., 2017)	Case-control	954	France	State & Trait Mind-Wandering (DDFS)	Crash responsibility	Self-report; Robertson & Drummer tool	Positive	Mind wandering state adjusted OR = 2.51 (95% CI 1.64–3.83). Mind wandering trait adjusted OR = 1.62 (95% CI 1.22–2.16); $p < .01$. Attributable risk approximately 10%.	Both trait and state mind wandering were independently and strongly associated with crash responsibility.

Note Effect sizes and statistical indicators are reported as presented in the original studies. "No standardized effect size reported" indicates that the study reported statistical evidence such as correlations, regression coefficients, odds ratios, test statistics, p-values, model accuracy, or predicted probabilities, but did not report a standardized effect size for the relevant mindfulness–driving outcome relationship.
Abbreviations: MAAS = Mindful Attention Awareness Scale; CAMS = Cognitive & Affective Mindfulness Scale; FFMQ = Five Facet Mindfulness Questionnaire; FMI = Freiburg Mindfulness Inventory; ARCES = Attention-Related Cognitive Errors Scale; DDFS = Daydreaming Frequency Scale; DBQ = Driver Behavior Questionnaire; DAX = Driving Anger Expression Inventory; NR = Not Reported.

Table 2
Mindfulness Measurement Instruments Used Across Included Studies. *Studies using each instrument were counted across all 37 included articles (intervention and non-intervention). Some studies used more than one instrument; counts reflect distinct study-instrument pairings.*

Instrument (Full Name)	Abbrev.	Mindfulness Type	Items	Key Dimensions / Facets Measured	Studies Using (n)	Notes & Relevance to Driving Research
Mindful Attention Awareness Scale	MAAS	Trait	15	Single dimension: present-moment attentional awareness	24	Most widely used in this review. Unidimensional; captures general attentiveness but cannot distinguish specific mindfulness facets relevant to driving (e.g., non-reactivity, non-judging). Not designed for driving contexts.
State Mindful Attention Awareness Scale	State MAAS	State	5	Single dimension: present-moment attentiveness (momentary)	2	Captures moment-to-moment awareness; particularly relevant for pre-driving or in-simulation assessments. Underutilized in the literature given its relevance to driving as a dynamic attentional task.
Five Facet Mindfulness Questionnaire	FFMQ	Trait	39	Observing; Describing; Acting with Awareness; Non-judging of Experience; Non-reactivity	4	Multi-dimensional; allows identification of specific facets linked to driving safety (e.g., acting with awareness, non-reactivity). Studies in this review found non-reactivity, observing, non-judging, and acting with awareness associated with safer driving.
Cognitive & Affective Mindfulness Scale – Revised	CAMS-R	Trait	12	Attention; Present-focus; Awareness; Acceptance/non-judgment	4	Broader than MAAS; includes acceptance component. Used in texting and crash-responsibility studies. Provides more nuance than MAAS but remains a general trait measure not tailored to driving.
Freiburg Mindfulness Inventory	FMI	Trait	14	Presence; Non-judgmental acceptance	2	Originally developed for meditators; used alongside MAAS in two Australian studies on aggressive driving. Complementary to MAAS by capturing acceptance dimension.
State Mindfulness Scale	SMS	State	21	Mind: present-focused awareness of mental events; Body: present-focused awareness of bodily sensations	1	One of the most psychometrically robust state mindfulness tools. Used in Albert et al. (2023) intervention study. Recommended for future pre/post intervention driving research.
Daydreaming Frequency Scale (Mind-Wandering subscale)	DDFS	Trait & State	Varies	Trait mind-wandering propensity; State mind-wandering (custom items)	1	Used in Gil-Jardiné et al. (2017) crash-responsibility study. Captures both stable tendency and in-the-moment mind wandering, which are theoretically the inverse of mindfulness.
Attention-Related Cognitive Errors Scale	ARCES	Trait	12	Attentional lapses; cognitive failures	1	Measures everyday cognitive failures linked to inattention. Used alongside MAAS in one simulator study (Valero-Mora et al., 2015). More closely tied to attentional control than general mindfulness.
Custom / behavioral mind-wandering tasks	Custom	State	Varies	Task-unrelated thought; on-task vs. off-task attention	2	Button-press paradigms (Yanko & Spalek, 2014) or experience sampling during driving. Provides objective, real-time index of attentional lapses. Recommended for ecological validity in simulator research.

Abbreviations: MAAS = Mindful Attention Awareness Scale; FFMQ = Five Facet Mindfulness Questionnaire; CAMS-R = Cognitive & Affective Mindfulness Scale–Revised; FMI = Freiburg Mindfulness Inventory; SMS = State Mindfulness Scale; DDFS = Daydreaming Frequency Scale; ARCES = Attention-Related Cognitive Errors Scale.

Appendix B
Search Strategy.

Review type	Systematic Literature Review
Inclusion criteria	
Exclusion criteria	None
Study type	
Main search concepts	Mindfulness, Driving

(*continued on next page*)

Appendix B (*continued*)

Review type	Systematic Literature Review	
Databases	PsycInfo, Cinahl, Medline, Scopus, Web of Science	
#1 Concept		#2 Concept
Mindfulness		Driving Driver Traffic safety Road safety Traffic offenses
Index terms	TIABSU	TIABSU
Medline, Cinahl: (MH "Mindfulness+") (MH "Automobile Driving+") PsycInfo: MAINSUBJECT.EXACT.EXPLODE("Mindfulness") MAINSUBJECT.EXACT.EXPLODE("Driving Behavior")	Mindfulness	Driving Driver Traffic Road
mindful*	(driving OR driver OR traffic OR road)	

MEDLINE (EBSCOhost).

	Query	Results
#1	TI mindful*	7823
#2	AB mindful*	14,410
#3	SU mindful*	8884
#4	(MH "Mindfulness+")	6192
#5	#1 OR #2 OR #3 OR #4	16,298
#6	TI (driving OR driver OR traffic OR road)	65,270
#7	AB (driving OR driver OR traffic OR road)	253,508
#8	SU (driving OR driver OR traffic OR road)	72,409
#9	(MH "Automobile Driving+")	23,418
#10	#6 OR #7 OR #8 OR #9	311,316
#11	#5 AND #10	146

Scopus (Elsevier).

	Query	Results
#1	TITLE-ABS-KEY (mindful*)	34,762
#2	TITLE-ABS-KEY (driving OR driver OR traffic OR road)	1,629,906
#3	#1 AND #2	510

CINAHL (EBSCOhost).

	Query	Results
#1	TI mindful*	6389
#2	AB mindful*	9098
#3	SU mindful*	7584
#4	(MH "Mindfulness+")	7789
#5	#1 OR #2 OR #3 OR #4	13,467
#6	TI (driving OR driver OR traffic OR road)	22,930
#7	AB (driving OR driver OR traffic OR road)	43,547
#8	SU (driving OR driver OR traffic OR road)	25,478
#9	(MH "Automobile Driving+")	10,877
#10	#6 OR #7 OR #8 OR #9	71,019
#11	#5 AND #10	103

PsycInfo (ProQuest).

	Query	Results
#1	tiab(mindful*)	19,313
#2	subject(mindful*)	15,772
#3	MAINSUBJECT.EXACT.EXPLODE("Mindfulness")	12,379
#4	#1 OR #2 OR #3	21,038
#5	tiab(driving OR driver OR traffic OR road)	59,806
#6	subject(driving OR driver OR traffic OR road)	27,213
#7	MAINSUBJECT.EXACT.EXPLODE("Driving Behavior")	16,557
#8	#5 OR #6 OR #7	64,073
#9	#4 AND #8	177

Web of Science (Clarivate).

	Query	Results
#1	TS = (mindful*)	29,210
#2	TS = (driving OR driver OR traffic OR road)	667,152
#3	#1 AND #2	223

Appendix C
Risk of Bias Table.

Yes	No	N/A	Unclear						
	Author, Year, Covidence number	1. Were the criteria for inclusion in the sample clearly defined?	2. Were the study subjects and the setting described in detail?	3. Was the exposure measured in a valid and reliable way?	4. Were objective, standard criteria used for measurement of the condition?	5. Were confounding factors identified?	6. Were strategies to deal with confounding factors stated?	7. Were the outcomes measured in a valid and reliable way?	8. Was appropriate statistical analysis used?
Cross-sectional	Bolla 2023 # 1366	yes	yes	N/A	N/A	yes	yes	yes	yes
Cross-sectional	Burdett 2016 #273	No	Yes	N/A	N/A	Yes	Yes	Yes	Yes
Cross-sectional	Chahine 2022 #609	Yes	Yes	N/A	N/A	Yes	Yes	Yes	Yes
Cross-sectional	Cimino 2022 #582	Yes	Yes	N/A	N/A	Yes	Yes	Yes	Yes
Cross-sectional	Ehsani 2024 #1422	No	No	N/A	N/A	yes	yes	yes	yes
Cross-sectional	Ehsani 2024 #1423	No	yes	N/A	N/A	No	No	yes	yes
Cross-sectional	EI Mendelek 2023 #1424	No	yes	N/A	N/A	yes	yes	yes	yes
Cross-sectional	Feldman 2011 #319	Yes	No	N/A	N/A	Yes	Yes	Unclear	Yes
Cross-sectional	Herrero-Fernandez 2022 #612	Yes	Yes	N/A	N/A	Yes	Yes	Yes	Yes
Cross-sectional	Karras 2024 #1500	yes	yes	N/A	N/A	yes	yes	yes	yes
Cross-sectional	Koppel 2018 #147	Yes	Yes	N/A	N/A	Unclear	Unclear	Yes	Yes
Cross-sectional	Koppel 2022 #613	Yes	Yes	N/A	N/A	Yes	Yes	Yes	Yes
Cross-sectional	Miller 2018 #312	Yes	Yes	N/A	N/A	Yes	Yes	Yes	Yes
Cross-sectional	Moore 2019 #258	No	Unclear	N/A	N/A	Yes	Unclear	Yes	Yes
Cross-sectional	Murphy 2018 #402	Unclear	Yes	N/A	N/A	Yes	Yes	Yes	Yes
Cross-sectional	Murphy 2019 #408	Yes	Yes	N/A	N/A	Yes	Yes	Yes	Yes
Cross-sectional	Murphy 2020 #267	Yes	Yes	N/A	N/A	Yes	Unclear	Yes	Yes
Cross-sectional	Panek 2015 #936	No	No	N/A	N/A	No	No	Unclear	Yes

(*continued on next page*)

Appendix C (*continued*)

Yes	No	N/A	Unclear						
	Author, Year, Covidence number	1. Were the criteria for inclusion in the sample clearly defined?	2. Were the study subjects and the setting described in detail?	3. Was the exposure measured in a valid and reliable way?	4. Were objective, standard criteria used for measurement of the condition?	5. Were confounding factors identified?	6. Were strategies to deal with confounding factors stated?	7. Were the outcomes measured in a valid and reliable way?	8. Was appropriate statistical analysis used?
Cross-sectional	QU 2024 #1630	yes	yes	N/A	N/A	yes	yes	yes	yes
Cross-sectional	Sabek 2024 #1650	yes	yes	N/A	N/A	yes	No	yes	yes
Cross-sectional	Salazar 2021 #437	Yes	Yes	N/A	N/A	Yes	Yes	Yes	Yes
Cross-sectional	Stephens 2018	Unclear	Yes	N/A	N/A	Yes	No	Yes	Yes
Cross-sectional	Terry 2015 #255	Yes	Unclear	N/A	N/A	Unclear	Unclear	Yes	Yes
Cross-sectional	Tinella 2022 #1095	Yes	Yes	N/A	N/A	Yes	Yes	Yes	Yes
Cross-sectional	Valero-Mora 2015 #937	Yes	Yes	N/A	N/A	Yes	No	Yes	Yes
Cross-sectional	Valero-Mora 2021 #483	Yes	Yes	N/A	N/A	Yes	Yes	Yes	Yes
Cross-sectional	Yanko 2014 #172	Yes	Yes	N/A	N/A	Unclear	Unclear	Unclear	Yes
Cross-sectional	Young 2019 #464	No	Yes	N/A	N/A	Yes	Yes	Yes	Yes
	Author, Year, Covidence number	1. Were the two groups similar and recruited from the same population?	2. Were the exposures measured similarly to assign people to both exposed and unexposed groups?	3. Was the exposure measured in a valid and reliable way?	4. Were confounding factors identified?	5. Were strategies to deal with confounding factors stated?	6. Were the groups/ participants free of the outcome at the start of the study (or at the moment of exposure)?	7. Were the outcomes measured in a valid and reliable way?	8. Was the follow up time reported and sufficient to be long enough for outcomes to occur?
Cohort	Kita 2020 #215	Unclear	Yes	N/A	No	No	Unclear	Yes	Yes
Cohort	Trub 2017 #465	N/A	N/A	Yes	Yes	Yes	Unclear	Yes	Yes
	Author, Year, Covidence number	1. Were the groups comparable other than the presence of disease in cases or the absence of disease in controls?	2. Were cases and controls matched appropriately?	3.Were the same criteria used for identification of cases and controls?	4. Was exposure measured in a standard, valid and reliable way?	5. Was exposure measured in the same way for cases and controls	6.Were confounding factors identified?	7. Were strategies to deal with confounding factors stated?	8. Were outcomes assessed in a standard, valid and reliable way for cases and controls?
Case Control	Gil-Jardine 2017 #1320	Unclear	N/A	Yes	Yes	Yes	Yes	Yes	N/A
Case Control	Galera 2012 #1318	Yes	N/A	Yes	Yes	Yes	Yes	Yes	N/A
Case Control	Baltruschat 2021 #256	Unclear	Unclear	No	Yes	Yes	Yes	Yes	Yes
Case Control	Kass 2011 #409	Unclear	No	Yes	Yes	Yes	No	No	Yes
Study Design	Author, Year, Covidence number	1. Was true randomization used for assignment of participants to treatment groups?	2. Was allocation to treatment groups concealed?	3. Were treatment groups similar at the baseline?	4. Were participants blind to treatment assignment?	5. Were those delivering treatment blind to treatment assignment?	6. Were treatment groups treated identically other than the intervention of interest?	7. Were outcomes assessors blind to treatment assignment?	8. Were outcomes measured in the same way for treatment groups?
RCT	Rohl 2016 #307	Yes	N/A	Yes	No	Unclear	Yes	Unclear	Yes
RCT	Balconi 2019 #309	Unclear	Unclear	Unclear	No	No	No	No	Yes
RCT	Albert 2023 #1347	yes	yes	yes	yes	yes	yes	yes	yes

Data availability

No data was used for the research described in the article.

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