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REVIEW

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Evaluating social rehabilitation of aggression for persons with Acquired Brain Injury: a systematic review

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ABSTRACT

Purpose: Social rehabilitation of aggression following an Acquired Brain Injury (ABI) is critically important for persons with ABI due to increased vulnerability of criminal behaviour related to post-injury changes in functioning. This review presents findings from studies that evaluated aggression interventions in both community and forensic populations of people with ABI.

Methods: We searched PsycINFO, EMBASE, SocINDEX, CINAHL and Medline databases for studies published between 1st January 2000 and 15th October 2023.

Results: There were 15 studies (14 community-based, one forensic) that met inclusion criteria. Pharmacological management (6) was largely ineffective and anger management interventions (6) presented with inconsistent effectiveness. Emotion regulation (1) may be effective for externalised aggression. Both mindfulness and transcranial direct current stimulation (1) were effective, and the results of a forensic peer group approach (1) were not tested for statistical significance. There was variability in the measurement of aggression, injury severity, and cognitive impairment.

Conclusions: Whilst community interventions for aggression in persons with ABI are prevalent, findings for effectiveness have been mixed and there is a paucity of evaluated interventions in forensic samples. Further research is needed to unravel the complex interplay of factors contributing to aggression and develop effective social rehabilitation for persons with ABI.

IMPLICATIONS FOR REHABILITATION

- Social rehabilitation is critical following an Acquired Brain Injury (ABI) due to increased risk of displaying challenging behaviours, such as aggression, that may significantly reduce an individual's quality of life.
- The current review highlights a lack of suitable interventions targeting aggression for individuals with ABI that account for injury-related impairments which impact capacity to engage in intervention.
- Findings emphasise the need to develop appropriate and relevant social rehabilitation interventions for aggression in ABI populations, particularly forensic populations, to prevent negative outcomes.

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Introduction

Acquired Brain Injury (ABI) refers to a range of non-congenital, non-degenerative, and non-hereditary brain injuries that are due to non-traumatic/traumatic (traumatic brain injury; TBI) causes, such as traffic accidents, assault, stroke or substance use [1–4]. Aggression is a frequent neuropsychiatric outcome associated with ABI [5, 6] that presents a significant challenge in post-ABI rehabilitation efforts. In Australia, ABI rehabilitation typically involves four stages: acute care, post-acute care, community-based rehabilitation, and longer-term support [7] but the availability and relevance of longer-term support is unclear [8, 9]. While immediate physical needs may be addressed through acute and post-acute care, survivors often have long-term social rehabilitation needs that may remain unmet [3, 7, 9]. Social rehabilitation is an umbrella term that has been defined broadly across time to cover a range of health, behaviour, or life-course related services that aim to restore or improve an individual's capacity to function effectively in society [10–13]. It can include social skills training, injury-related education, and community support or may target more challenging behaviours such as aggression. Social rehabilitation plays a crucial role in post-ABI reintegration given the significant impact of injury-induced changes in social skills that influence capacity for social engagement.

Prevalence estimates of post ABI-aggression range from 11-42% [5, 6] and experiences of aggression have significant consequences for quality of life of both survivors and their caregivers. For example, caregivers of people with ABI report profound negative effects on their psychological wellbeing related to aggressive outbursts exhibited by the recipient of care, who is often a loved one [7]. Post-injury aggression can reduce the quality of life for people with ABI in a range of areas such as exacerbating mental health and substance use challenges, increasing social isolation, and potentially creating risk for legal issues including charges for

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assault and potential incarceration [9, 14–19]. Lack of appropriate social rehabilitation for aggression is evidenced by high rates of incarceration for individuals with ABI. Whilst ABIs have been reported to occur in approximately 2-12% of the general population prevalence rates are estimated to be three to eight times greater in people who have engaged in offending behaviour, including violence [1, 3, 4, 9].

ABIs are complex and presentations can vary, but injuries occurring in the prefrontal lobes, temporal lobes, and anterior cingulate cortex can negatively impact executive function, perspective-taking, emotional dysregulation, and planning skills [20, 21] which may arise from decreased structural connectivity [22]. Additionally, a recent systematic review of TBI indicated that dysfunction within the frontal lobe, amygdala, and insula is associated with aggression and violence [16]. Disruption to brain regions implicated in social understanding (e.g., pre-frontal lobe and anterior cingulate cortex) may increase hostile attribution bias with other people's behaviour interpreted as confrontational, resulting in an aggressive response [23] that may be exacerbated by emotional dysregulation (temporal lobe damage) decreasing capacity to manage anger [24]. Further, executive dysfunction may hinder alternative response consideration to perceived provocation resulting in violence [15, 25]. Indeed, deficits in executive function and emotion regulation, and increases in anti-social behaviour, are all established predictors of criminal justice contact [4, 6, 24].

Traditional social rehabilitation programs for aggression may be less effective for individuals with ABI due to differences in cognitive functioning. People with cognitive impairment may have a reduced capacity to understand, actively participate, and learn from behavioural interventions [26]. In a forensic context, this may mean that individuals with ABI in prison for violent offences are not receiving effective social rehabilitation for aggression [9]. This can perpetuate a cycle of unmanaged aggression and criminal engagement, significantly diminishing the quality of life for those with ABI. Due to the far-reaching consequences of violence, it is of the upmost importance to have effective and responsive social rehabilitation aimed at reducing aggression and preventing violence.

The Risk Need Responsivity (RNR) model is one approach to social rehabilitation that can be used to develop effective evidence-informed interventions for violent behaviour [27–29]. According to the Risk principle, allocation of intervention resources should be based on the individual's risk of re-offending [30]. ABI increases the risk of recidivism as it can have an exacerbating role in the known risk factors for violence including aggression, disinhibition, impulsivity, poor emotional control, cognitive distortions/lack of insight, substance use, mental disorder, relationship instability, unemployment, and lack of community supports [30]. The Need principle posits interventions should be targeted toward dynamic risk factors, unique to each person, that are highly associated with criminal behaviour [30]. For people with ABI, substance use is such a key factor in offending [31]. As per the Responsivity principle, intervention should be flexible to individual differences. Within ABI populations this may include tailoring to level of cognitive impairment or other exacerbating factors such as mental health issues. Whilst the RNR model is typically applied to interventions in a forensic context, it provides a useful framework for understanding the key aspects of social rehabilitation, including interventions delivered in the community where the person may not have engaged in offending behaviour.

Intervention constitutes a crucial component of social rehabilitation due to its ability to address and mitigate challenges faced by people with ABI, including disruptive behaviours such as aggression that can impact social reintegration. Prior systematic reviews of cognitive behavioural therapy amongst community populations with ABI suggest it may have a small effect for reducing externalised aggressive behaviours, whereas pharmacological management presents mixed findings [5, 32]. A systematic review of interventions delivered in forensic samples of people with ABI reported mixed findings for behavioural interventions and small effect sizes for reducing offending behaviour; although this review was not specific to aggression or violent offending [33]. There has been limited systematic evaluation of interventions that specifically focus on reducing aggression and violence in people with ABI who have engaged in violent offending behaviour, despite the associations between ABI, aggression, and violence. Notably, a scoping review of service experiences in ABI populations indicated that there is a lack of social and community services that are suitable for ABI-specific needs [3] suggesting that there may be gaps in interventions delivered to this population and highlighting the importance of evaluating aggression interventions.

Previous reviews have noted that there is variation among individuals with ABI in how they respond to interventions that could be attributed to individual-specific variables or inconsistent study methodologies such as differing operationalisation of aggression [5, 32]. Further, previous studies have not considered whether there are differences in the effectiveness of interventions provided in non-forensic settings compared to forensic settings, despite evidence that people in prison with ABI have reported higher levels of general anger, verbal aggression, and physical violence than people with ABI in the community [25]. An important consideration, therefore, is whether there are key differences in intervention delivery, intervention aims, participant characteristics, and contextual (e.g., prison vs. community environment) factors that may influence effective social rehabilitation in these settings.

As such, the current review aims to synthesise literature on interventions targeted at reducing aggression in people with ABI across community and forensic samples. This will be guided by the following research questions:

1. How effective are interventions aimed at reducing aggression or violence for people with ABI in both community and forensic samples?
2. Are there differences in intervention delivery or population characteristics across settings and how may that impact intervention outcomes?

Method

The protocol for this systematic review was pre-registered with the International Register of Systematic Reviews (PROSPERO ID; CRD42022366418). When preparing the protocol, the PRISMA-P checklist was followed, and the final report followed PRISMA reporting guidelines.

Eligibility criteria

Eligible studies were published in any language, between 1 January 2000 and 31 October 2023, evaluated the effectiveness of an intervention aimed at reducing aggression, and had a sample of adult participants (aged 16 and above as adult samples frequently included participants in this range) in either a community or forensic setting, with a diagnosis of ABI. As the operationalisation of aggression varies in studies published on persons with ABI, studies were included if they measured anger or irritability as this has previously been

considered as aggression in a prior review [5]. This broader inclusion criteria allows for a wider range of studies to be considered, acknowledging the use of anger and irritability as potential precursors of violence in people with ABI [24, 25]. Included study designs were randomised control trials (RCT), interrupted time series, case control studies, case series, and cross-sectional studies. Excluded study designs were non-human research, qualitative studies, case reports, reviews, meta-analyses, and studies with a sample of individuals with dementia or Alzheimer's disease. Mixed method studies were included however only quantitative data were extracted. Studies were not excluded if they did not have a comparison or control group.

Information sources

PsycINFO, EMBASE, CINAHL, Medline COMPLETE, and SocINDEX were searched. Grey literature search strategies were also conducted through Google Scholar to capture literature not presented in formal databases. To maintain feasibility, the first 100 articles provided by Google Scholar for each search strategy were reviewed [34].

Search strategy

Literature search strategies were developed in line with the PICO framework with key words relating to Acquired Brain Injury, aggression, violent offending, and interventions [35]. The search strategy was developed (Appendix A, Table A1) and modified to the syntax of the databases (Appendix A). To conduct the grey literature searches, ten search strategies with variations of key terms were developed and ran in Google Scholar (Appendix A, Table A2). Additional articles were searched for by hand-searching the reference lists of relevant articles.

Selection process

One reviewer (TG) screened all titles, abstracts, and full texts and a second reviewer (KB) screened 10% of titles, abstracts, and full texts to ensure consistency. Screening was conducted in line with inclusion and exclusion criteria, and reasons for exclusion of articles during full-text screening were recorded. Disagreements between the two reviewers were resolved through discussion.

Data extraction process

One reviewer (TG) extracted data from the identified articles using a standardised data collection template. The data that was recorded included details of authors, country of authorship, publication year, intervention details (type, duration etc.), participant demographics, primary outcomes, results, and limitations.

Data items

Data related to the primary outcome of aggression were sought and included outcome measures of aggression, anger, or irritability. Other variables for which data was sought included participant characteristics of age, gender, type of ABI, and injury severity criteria.

Methodological quality assessment

The Effective Public Health Practice Project (EPHPP) Quality Assessment tool was used to assess the quality of evidence for included studies based on six criteria: selection bias, study design, blinding, control of confounders, data collection, and withdrawals [36]. Each criteria was rated as weak, moderate, or strong and an overall rating for each study was decided in accordance with EPHPP guidelines. As per EPHPP guidelines, a study is considered methodologically strong if it does not have a weak rating in any category. A moderate rating is applied if a study has only one weak rating, and a weak rating is applied when a study has two or more weak ratings. Two reviewers (TG & KB) independently conducted quality assessment with discrepancies resolved through discussion.

Synthesis methods

We conducted a narrative synthesis as the diversity of interventions, measures, and outcomes specified by inclusion criteria made a meta-analysis unfeasible. Tabular summaries of key information were developed to outline an initial description of results. The narrative synthesis was organised by outcomes and separated by different types of interventions. The effectiveness of treatment and factors that may explain differences across studies formed the focus of the synthesis. Sample characteristics, study design, variability in outcomes, and study limitations were considered in an overall synthesis for each category of intervention.

Results

Study selection

An initial database and grey literature search was conducted in December 2022 and re-run in October 2023. In total, 2315 articles from index databases were imported for screening, with 1340 studies screened following the removal of duplicates. Inter-rater agreement was strong (99.6%), and disagreements (0.4%) were resolved through discussion. See Figure 1 for the PRISMA Flow Chart. The grey literature search identified 12 potentially relevant articles however none met the inclusion criteria. One additional article was identified via backward snowballing.

Study characteristics

All details of the included studies (including study type, sample details, statistical significance of results) are available in Appendix B, Table B1. Twelve studies included samples of people with TBI, and three studies included samples of people with ABI (both non-traumatic and traumatic injuries).

There were nine randomised controlled trials (RCTs; 37–45], five pre-post intervention cohort studies [14, 46–49], and one pre-post case series study with quantitative data [50].

Included studies were conducted in the United States of America (U.S.A.; 7), Australia (2), Switzerland (2), the United Kingdom (U.K.; 3), and Iran (1). One study that met inclusion criteria included a forensic sample [50] and fourteen studies that met the inclusion criteria consisted of a sample drawn from the community such as health services (neurorehabilitation/neuropsychiatric etc.) online surveys, out-patient referrals, and brain injury support groups [14, 37–49].

Across studies, sample sizes ranged from three participants to 168 participants with an average sample size of 49 participants. All but one study [50] included both men and women however, consistent with past research [51], there was a considerably higher proportion of men (75%) compared to women (25%) in the overall sample of included studies.

The types of interventions evaluated included pharmacological treatment (6) [38–42, 47], anger-management (6) [14, 37, 43, 44, 46, 48], mindfulness and transcranial magnetic direct stimulation (tDCS) (1) [45], a forensic peer group approach (1) [50] and emotion regulation [49].

Six studies included participants with moderate-severe injuries [14, 37, 39–41, 43, 46]. Other studies included mild injuries (1) [45] severe injuries (2) [48, 50], all levels of severity (mild moderate, and severe; 3 [38, 41, 42];), or did not provide details about injury severity (3) [44, 47, 49]. The Glasgow Coma Scale (GCS) was most commonly used to assess severity (8) [14, 37, 39, 40, 43, 45, 46, 50], while the extended version, The Glasgow Outcome Scale-Extended (GOS-E), was utilised in two studies [38, 41]. Hart and colleagues [43] utilised the Weschler Abbreviated Scale of Intelligence (WASI) when GCS score was unavailable. Three studies did not record severity and/or did not provide the assessment criteria [42, 46, 47].

Methodological quality

The 15 studies were assessed for methodological quality using the EPHPP (see Table 1). Eight studies were rated as methodologically strong [14, 39–45], four were rated as methodologically moderate [37, 46, 48, 49], and three were rated as methodologically weak [38, 47, 50].

Synthesis of results

An overview of the included studies is presented in Table 2; a full summary of the results can be found in Appendix B (Table B1).

Outcome: Aggression

The following section presents a thematic synthesis of results pertaining to the outcome of aggression, which due to variability in how aggression was operationalised for this review, includes studies with outcome measures of aggression anger, and/or irritability.

Pharmacological management. Across the included studies the following pharmacological interventions were evaluated: amantadine, quetiapine, carbamazepine, and risperidone. All studies had a sample of participants with TBI. Except for two methodologically weak studies evaluating quetiapine and risperidone, all other studies were methodologically strong randomised controlled trials. The results of pharmacological management were ineffective overall (see Table 2).

Amantadine. Amantadine is a dopaminergic agent and is intended to reduce aggression or irritability by altering behaviour and mood regulation by altering the release of dopamine [39]. The effectiveness of amantadine in reducing irritability or aggression is unclear, with three methodologically strong rated studies reporting mixed effects. In Hammond et al. [39] amantadine reduced overall irritability scores but not frequency or severity of irritability or aggression scores whereas the results of Hammond et al. [41] demonstrated no reduction in irritability scores. Comparatively, Hammond et al. [40] demonstrated amantadine did not reduce overall aggression but did reduce self-rated scores on the Most-problematic subscale of the Neuropsychiatric Inventory-Aggression (NPI-A) indicating self-reported frequency and severity of aggression was reduced. However, this change was not reflected in observer-rated scores. All studies included observer ratings of aggression, thus relying on subjective assessment of participant behaviour. A point of difference between the studies was the operationalisation of aggression, with one study using the Neuropsychiatric Inventory-Aggression (NPI-A) [40], one study using the Neuropsychiatric Inventory-Irritability (NPI-I) [41] and the final study used both measures [39]. Additionally, duration of amantadine treatment differed and ranged from 28-60 days [39–41]. Findings suggest that a 100 mg dosage of amantadine taken over a longer period (i.e., 60 days) could reduce frequency and severity of aggression more effectively than shorter treatment durations [39–41]. Comparatively, of the two studies that measured changes in irritability scores the shorter administration period reduced irritability, whereas the longer period did not [39, 41]. Overall, the results of this review suggest that amantadine is not effective in reducing aggression.

Risperidone. Risperidone is a new generation anti-psychotic drug that targets the dopaminergic system through the mesocortical pathway and has been suggested to reduce aggression in individuals with neuropsychiatric conditions such as mood disorders [38]. A methodologically weak rated RCT conducted by Deb et al. [38] found that whilst risperidone did reduce aggression in comparison to placebo, and reductions in irritability were slightly greater for participants taking risperidone, there were no formal tests of the hypotheses to indicate if this difference was statistically significant [38].

Quetiapine. Quetiapine is a second-generation atypical antipsychotic drug that has been used effectively in nonpsychotic syndromes such as anxiety or mood disorders [47]. It may reduce aggression scores by modulating the dopaminergic system which can produce changes in the prefrontal lobe, and in turn, initiate changes in cognitions and behaviours. A methodologically weak rated feasibility trial indicated that quetiapine may reduce the frequency and severity of aggression [47]. However, the results of this study are limited due to noticeable issues regarding selection bias, control of confounders, blinding, reporting of withdrawals and drop-outs, and the study received industry funding from AstraZeneca (a potential conflict of interest). Additionally, there was no control group for comparison of aggression scores and the sample size was small which further limits generalisability of results to a broad population of people with TBI. Therefore, although quetiapine may have promising effects for reducing aggression, further rigorous evaluation of this intervention is needed.

Carbamazepine. Carbamazepine is a sodium-channel antagonist that is typically used in the treatment of epilepsy as its' function is to stabilise electrical activity in the brain, but it has been suggested to be useful for reducing post-TBI aggression [42]. Results of a methodologically strong rated RCT demonstrated that carbamazepine was not effective for reducing irritability or aggression compared to placebo [42]. However, the use of subjective measures of aggression and irritability (reported by both participants and observers as differences in personal perceptions of changes in aggression) may have reduced the validity of results.

Overall effectiveness of pharmacological management. Overall, pharmacological treatment of aggression experienced by individuals with TBI has been demonstrated by the included studies to be largely ineffective. There is no evidence to suggest risperidone or carbamazepine are effective for reducing anger or aggression, mixed evidence regarding the effects of amantadine, and limited evidence for quetiapine. There was heterogeneity in medication type, dosage, and duration and this variability may have impacted outcomes between studies. Varying dosage levels may influence the effectiveness of medication as higher dosages

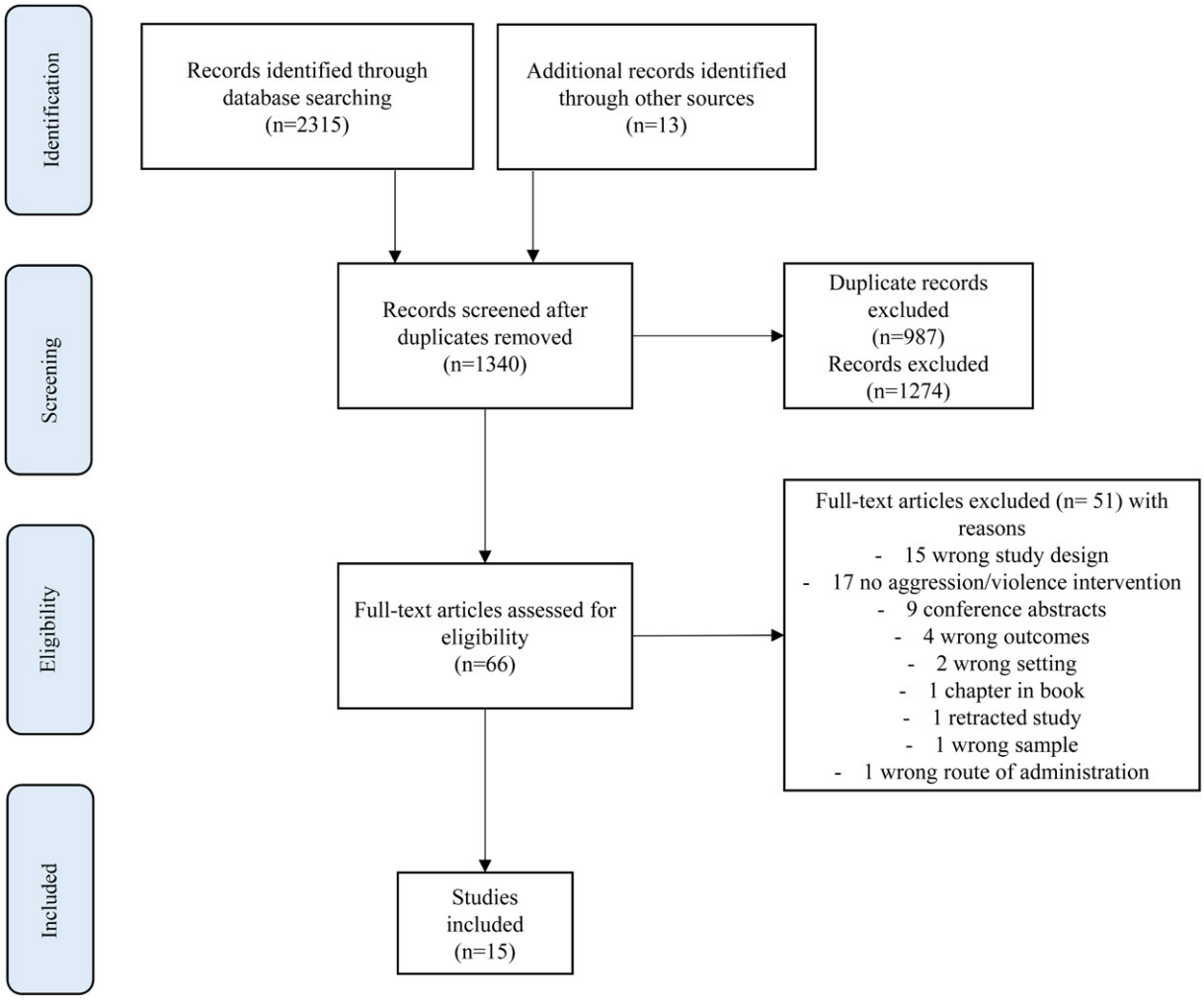

Figure 1. PRISMA flow chart of decision process.
Identification: 2315 articles were identified through databases and 13 through other sources. Screening: 1340 records remained after duplicates were removed and a further 1274 articles were excluded after title and abstract screening. Eligibility: 66 articles were assessed for eligibility. Inclusion: 51 articles were excluded, and 15 studies were included.

could produce different effects which is also impacted by participant variability in tolerance. Whilst the included studies accounted for tolerance the method of doing so varied e.g., some studies reduced the dosage [39–41] or terminated treatment whereas others increased the dosage. Furthermore, various types of medication may be used to target or reduce aggression, but the mechanisms of action may be different. Risperidone, amantadine, and quetiapine act on the dopaminergic system and alter chemical function whereas carbamazepine is a sodium-channel antagonist that decreases electrical activity. Therefore, it is challenging to draw comparisons as different medication types could have impacted the brain in vastly diverse ways and influenced different aspects of behaviour and cognitions relating to aggression. Based on the studies included in this review, there is insufficient evidence to support assert that pharmacological intervention can significantly reduce aggressive behaviour for people with TBI.

Behavioural modification: Anger management. Mindfulness and emotion regulation. Behavioural modification interventions such as individual anger management, group anger management, and mindfulness were utilised in studies within the current review. There were three RCTs and three cohort studies of varying methodological quality identified (see Table 2). Results were mixed across behavioural modification interventions, with inconsistent results across anger management interventions, and promising results for mindfulness and emotion regulation.

Cognitive-behavioural-based anger management. Cognitive-behavioural-based anger management interventions can be used for people with ABI to reduce the emotional response of anger by altering a person's cognitions related to anger-provoking situations [44, 46]. Results of both a methodologically strong rated individual, and a methodologically moderate rated group-based cognitive-behavioural-based anger management intervention [44, 46] demonstrated no immediate post-intervention changes but significant reductions in anger at follow-up assessments ranging between 2-5 months. In contrast, results of a methodologically moderate psycho-educational/cognitive-behavioural group-based anger management intervention demonstrated immediate decreases in anger and increases in anger control [48]. Educating about ABI and its connection to anger triggers, experiences, and expression could enhance self-awareness of anger, which may lead to improved identification of emotions, and knowledge of when to use anger management strategies. Individual cognitive-behavioural-based anger management may improve anger control and decrease anger by improving an individual's

Table 1. Methodological quality ratings using the EPHPP.

Study	Selection Bias	Study Design	Confounders	Blinding	Data Collection	Withdrawals	Global Rating
Aboulafia-Brakha et al. [46] Switzerland	W	M	S	M	S	S	M
Aboulafia-Brakha & Ptak [37] Switzerland	W	S	S	M	S	M	M
Deb et al. [38] U.K.	W	W	S	S	S	S	W
Hammond et al. [39] U.S.A.	M	S	S	S	S	S	S
Hammond et al. [41] U.S.A.	M	S	M	S	S	S	S
Hammond et al. [40] U.S.A.	M	S	S	S	M	S	S
Hammond et al. [42] U.S.A.	M	S	S	S	S	S	S
Hart et al. [14] U.S.A.	M	M	M	M	S	S	S
Hart et al. [43] U.S.A.	M	S	S	M	S	S	S
Kim & Bijlani [47] U.S.A.	W	M	S	W	S	W	W
Manchester et al. [50] U.K.	W	M	W	M	S	S	W
Medd & Tate [44] Australia	M	S	S	M	S	S	S
Shirvani et al. [45] Iran	W	S	S	M	S	S	S
Walker et al. [48] Australia	M	M	S	M	S	W	M
Witten et al. [49] U.K.	M	M	W	M	S	S	M

Note. Abbreviations: U.S.A; United States of America, U.K; United Kingdom, W; weak, M; moderate, S; strong.

ability to recognise anger-provoking situations, their emotions and cognitions related to these situations, and implementation of strategies to mitigate anger expression [44]. Similarly, anger management interventions may lead to the development of long-term strategies for identifying and coping with aggression-provoking events, improving self-monitoring of thoughts and emotions, and non-aggressive conflict resolution [46].

Psychotherapy-based anger management. Anger management interventions based on the principles of psychotherapy focus on psychoeducation, relaxation techniques, cognitive restructuring, and problem solving [37]. This intervention may help by improving anger appraisal skills including an individual's ability to identify their thoughts relating to an aggression-provoking situation and consider alternative viewpoints. The results of a methodologically moderate rated study suggest that whilst psychotherapy-based anger management may be effective for reducing aggression, these reductions did not reduce aggression more than a structurally similar control intervention [52]. The control intervention also targeted similar issues as the treatment intervention, such as psychosocial consequences of ABI and emotional problems. This may explain the absence of a statistically significant difference between the groups.

Psychoeducational-based anger management. Anger Self-Management Training (ASMT) is a psychoeducational intervention that uses a modification of typical anger management programs with a focus on anger-related problem solving and self-awareness [43]. Components of ASMT that focus on improving self-monitoring of anger and training in problem-solving may enhance an individual's capacity to recognise when they are experiencing intensification of anger. Findings from a methodologically strong rated study were mixed, with significant decreases in participant's self-rated aggression conflicting with non-significant observer-rated changes [14]. This result may be influenced by the subjective nature of observer ratings (compared to self-reported feelings), or individuals may be perceiving internal changes in anger or aggression that may not be an accurate reflection of behavioural change. Additionally, a methodologically strong rated study indicated that ASMT was not more effective when compared to a structurally similar (similar intensity, format, and provision of assignments) intervention called personal readjustment and education (PRE) [43]. PRE provides information about how TBI can impact personal characteristics and relationships and involves a therapist providing guidance on reflection, emphatic listening, and encouragement to adjust to life post-injury.

Mindfulness. Mindfulness involves gaining focus and awareness of feelings, thoughts, and perceptions about the body [45]. Available evidence for mindfulness indicates it may be effective in decreasing self-reported aggression for people with TBI. Results of the methodologically strong rated study testing mindfulness-based stress reduction (MBSR) found that post-intervention, and at follow-up, aggression scores significantly decreased compared to pre-intervention scores [45]. MBSR may be related to decreased aggression in people with TBI by improving self-control and increasing cognitive skills that can mitigate aggression [45].

Emotion regulation. A study that was rated methodologically moderate tested an emotional regulation therapy called "Talk and Chalk" and demonstrated that overall anger significantly decreased, and anger control significantly increased post-intervention, with mixed effectiveness for further significant decreases recorded at follow-up [49]. There were significant decreases in outward anger expression (e.g., anger directed towards others) but no significant decrease in internal anger expression at any timepoint (e.g., intensity of anger experienced by the individual). ER strategies such as "Talk and Chalk" may lead to greater control of anger and reduced expressions of anger by enhancing individual capacity to recognise when alternative strategies should be used during aggression provoking events and to implement these. However, there were significant pre-intervention differences in characteristic anger and anger expression among participants that were not controlled for in the analyses which creates confounders and limits the generalisability of results.

Overall effectiveness of behavioural modification. The effectiveness of behavioural modification yielded mixed results across anger management, whereas mindfulness and emotion regulation demonstrated preliminary effectiveness. Mixed results may be a product of varying intervention characteristics. Although the anger-management therapies were largely based on similar principles, there were noticeable differences across interventions such as individual or group anger management therapy. Individual treatments, as opposed to group treatments, may be easily adjusted to suit the specific deficits experienced by an individual with an ABI and can target specific triggers for aggression [49]. However, group treatments may be more beneficial for addressing social skills related to anger due to the opportunity for modelling and practice of prosocial behaviour [53].

Brain stimulation. Brain stimulation interventions such as transcranial direct stimulation (tDCS) involve application of a low-level direct current that is applied to a participants skull using cathodal and anodal stimulation to improve cognitive function [45]. The use of tDCS may lead to reduced aggression as Shirvani et al.

Table 2. Brief overview of included studies.

Quality Rating	Study	Participants	ABI or TBI	Intervention	Aggression	Overview
S	Hammond et al. [39] U.S.A.	76 participants (47 men, 29 women)	TBI	Amantadine	- / =	100mg of amantadine or matched placebo twice daily for 28 days. Utilised observer ratings of aggression and irritability recorded on the NPI-I and NPI-A. Significant reduction in aggression for amantadine and placebo groups.
S	Hammond et al. [41] U.S.A.	168 participants (146 men, 22 women)	TBI	Amantadine	=	100mg or matched placebo administered twice daily over 60 days. Participant and observer ratings of irritability recorded using NPI-I Amantadine did not reduce levels of irritability.
S	Hammond et al. [40] U.S.A.	118 participants (94 men, 24 women)	TBI	Amantadine	- / =	100mg of amantadine or matched placebo twice daily for 60 days. Changes in aggression measured by NPI-A and STAXI-2. No significant reduction in anger measured by STAXI-2, or overall aggression on NPI-A. Significant reduction in scores on the Most Problematic subscale of the NPI-A.
W	Deb et al. [38] United Kingdom	14 participants (10 male, 4 female)	TBI	Risperidone	?	1mg of risperidone (increased to 4 mg as needed) daily for 12 weeks. Aggression and irritability measured using MOA and IQ. Depression measured using the HADS. Risperidone not more effective at reducing aggression, irritability, or depression than placebo.
W	Kim & Bijlani [47] U.S.A.	7 participants (4 men, 3 women	TBI	Quetiapine	–	Feasibility trial with 7 participants with TBI who were administered 50-300mg of quetiapine daily for 6 weeks. Aggression measured using the MOAS pre-post intervention. Quetiapine reduced aggression scores.
S	Hammond et al. [42] U.S.A.	70 participants (53 men, 17 women)	TBI	Carbamazepine	=	Administered for 42 days. Participants initially received 200 mg of carbamazepine or placebo equivalent twice daily that was increased to thrice daily on the 8th day of the trial. On day 15 participants then received 400 mg of carbamazepine with dosage reduced to twice daily. Participants and observers completed NPI-I and NPI-A as measures of irritability and aggression. No significant changes in scores on the NPI-I and NPI-A.
M	Aboulafia-Brakha et al. [46] Switzerland	10 participants (8 men, 2 women)	TBI	Group AM	- / =	Evaluated semi-structured 8 session group anger management program using pre-post cohort design. Participants completed AQ-12 pre-intervention, post-intervention, and at 5-month follow-up. No changes in aggression scores post-intervention; aggression significantly reduced at follow-up.
S	Medd & Tate [44] Australia	16 participants (14 men, 2 women)	ABI	Individual AM	- / + / =	Individual anger management training for reducing anger over a duration of 5-8 weeks with a 2-month follow-up. Participants completed STAXI pre-intervention, post-intervention and at follow-up, and completed daily anger logs. Anger management decreased feelings and expression of anger but did not reduce overall anger scores or improve anger control.
M	Walker et al. [48] Australia	69 participants (54 men, 15 women)	TBI	Group AM	- / + / =	Psycho-educational group-based anger management program developed from CBT and consisted of weekly 2-hour sessions over 12 weeks. Anger was measured *via* STAXI pre-intervention, post-intervention, and follow-up. Follow-up assessments ranged in duration from 3-16 months post-treatment, with an average follow-up period of 7 months. Significant a reduction in anger expression and increase in anger control.
M	Aboulafia-Brakha & Ptak [37] Switzerland	19 participants (16 men, 3 women)	ABI	Group AM	- / =	Group psychotherapy anger management; 8 weekly 60-minute sessions. Aggression and anger measured by AQ12, STAXI, and MARS pre-intervention, at 4 weeks, 8 weeks and post-intervention. Group psychotherapy-based anger management may be effective for improving levels of anger.
S	Hart et al. [14] U.S.A.	10 participants (8 men, 2 women)	TBI	ASMT	- / =	Eight 60-90 min sessions of ASMT. Participants and observers completed STAXI and BAAQ pre- and post-intervention. Completion of ASMT was linked to reduced aggression and expression of anger.
S	Hart et al. [43] U.S.A.	90 participants (73 men, 17 women)	TBI	ASMT	- / =	Compared ASMT to a structurally similar intervention called personal readjustment and education (PRE). Participants randomised to either ASMT or PRE for 8 × 90-minute sessions. Although similar, the PRE intervention did not have specific components focusing on self-awareness training or problem-solving for anger-specific scenarios. Participants and observers completed the STAXI and BAAQ. Aggression reduced in both ASMT and PRE groups to a similar level.

(*Continued*)

Table 2. Continued.

Quality Rating	Study	Participants	ABI or TBI	Intervention	Aggression	Overview
S	Shirvani et al. [45] Iran	48 participants (11 men, 37 women)	TBI	Mindfulness/tDCS	- / =	Evaluated a mindfulness-based stress reduction (MBSR) intervention and tDCS using a parallel-group RCT with scores measured using BAQ at pre-intervention, post-intervention and at 2-month follow-up. 16 participants completed a 2-hour session of MBSR once a week for 8 weeks. Aggression scores significantly decreased post-MBSR intervention and at follow-up when compared to pre-intervention scores. The tDCS intervention involved anodal stimulation on the left dorsolateral prefrontal cortex and cathodal stimulation on the right dorsolateral prefrontal cortex. 16 participants underwent 3 sessions for 8 weeks. Aggression scores significantly decreased post-intervention and at follow-up when compared to pre-intervention scores.
M	Witten et al. [49]	24 participants (14 men, 10 women)	ABI	Individual ER	- / + / =	Individual emotion regulation intervention that taught reappraisal and distraction for anger-provoking events. Intervention consisted of 5×1-hour sessions conducted *via* Zoom. Anger was measured *via* STAXI-2 and AQ-12 pre-intervention, post-intervention, and at 3-month follow-up. Participants could complete a homework diary where they would log anger-provoking events and the technique used to resolve these events. Significant decrease in characteristic anger, and outward anger expression but not internal anger expression. Diary use was associated with significant reductions in anger and increase in anger control.
W	Manchester et al. [50] U.K	3 participants (3 men)	TBI	Peer group Approach	*	EQUIP programme teaching pro-social skills related to aggression with 30-minute sessions administered for 4 days per week for 6 weeks. Aggression measured using the HIT and OAS-MNR. Aggressive behaviour reduced in two participants.

Note. Abbreviations: AM; anger management, ASM; anger self-management, tDCS; transcranial direct stimulation, ER, emotion regulation+; significant positive effect, -; significant negative effect, =; no significant effect,? statistical significance of findings unknown, *; STAXI; State Trait Anger Expression Inventory STAXI-2; State Trait Anger Expression Inventory-2 BAAQ; Brief Anger-Aggression Questionnaire. AQ-12; Buss and Perry Questionnaire, MARS; Multidimensional Anger Scale, OAS-M; Overt Aggression Scale-Modified, NPI-I; Neuro-psychiatric Inventory-Irritability NPI-A; Neuropsychiatric Inventory-Aggression, HIT; How I Think Questionnaire, OAS-MNR; The Overt Aggression Scale Modified for Neurobehavioural Rehabilitation.

[45] posit that prefrontal up regulation can lead to improved perceptions of aggressive acts as morally wrong. The findings from one methodologically strong rated study found that tDCS was effective for reducing self-reported aggression scores in people with TBI compared to a control group, with the significant decrease maintained at follow-up [45]. Findings suggest that bilateral stimulation of the dorsolateral prefrontal cortex can lead to a decrease in the occurrence of aggressive behaviours. Although the study is methodologically strong, the results of Shirvani et al. [45] may be limited as quantitative electroencephalography was not recorded prior to the intervention which may impact the validity of results as doing so can improve selection of the best stimulation site for each participant. Whilst there are a range of brain stimulation techniques beyond tDCS which may be used for survivors of ABI to improve other neuropsychological sequalae [54], the results of the current review identified only tDCS as a method specifically used to target aggression.

Forensic peer group approach. The only forensic study identified in this review involved a forensic peer group approach called EQUIP [50]. This intervention was developed to reduce aggression in people who offend by enhancing prosocial skills and moral decision-making, and reducing pro-aggressive attitudes [50]. The EQUIP program, evaluated by one methodologically weak study, demonstrated a small reduction in levels of aggressive attitudes, and increases in prosocial behaviour and moral development, however as no statistical tests were conducted its effectiveness is not clear [50]. Further systematic evaluation of this intervention is necessary to determine whether this approach is effective for producing changes in aggression.

Differences in participant characteristics

Injury severity. There was variation across studies regarding ABI severity of participants (see Table 2), which may influence outcomes following intervention [15]. Individuals with moderate-severe injuries may have more significant impairments in cognitive function, potentially impacting the effectiveness of interventions due to difficulties understanding the content or assessment measures [15, 21]. However, among studies that included participants with moderate to severe ABI, not all these participants had severe cognitive impairment. This suggests that there may be various factors influencing the degree of cognitive impairment following ABI such as pre-morbid intelligence or comorbid substance use as these factors can exacerbate cognitive deficits. However, the reporting of injury severity was inconsistent across these studies. Consequently, it is challenging to determine whether there are discernible patterns regarding the potential impact of ABI severity levels on the effectiveness of interventions.

Age. Although participant ages across studies ranged from 19-46, 13 of the included studies had participants who were aged 30 or older, and only one community study had a sample where 13.7% of participants were aged under 30, whereas the forensic study featured a sample of individuals aged 19-21. The impact of age was not examined in any of the included studies, therefore the influence of age on intervention effectiveness remains unclear.

Gender. The articles included in the current review recorded binary gender, with samples consisting of a higher proportion of men. Women in prison with ABIs are 144% more likely to report violent behaviour compared to women in prison without ABIs which may suggest that ABI exerts a strong influence on aggression levels for women [15]. The impact of gender is unknown, as the articles

in the current review did not assess the impact of gender on intervention outcomes

Discussion

The current review aimed to assess the availability of social rehabilitation interventions delivered in community and forensic populations to people with ABI and evaluate their effectiveness. A further aim was to identify whether differences in intervention delivery or population characteristics impacted outcomes. There is little evidence for effective intervention for aggression in ABI populations with the majority of studies reporting non-significant results or significance was not tested. Due to a scarcity of forensic interventions, comparison of interventions and population characteristics across settings was limited.

Despite limited effective interventions for addressing aggression and violent behaviour in persons with ABI, some interventions were promising. For example, mindfulness may enhance introspective ability and increase recognition of aggression-provoking stimuli. Generating such awareness may then improve identification of situations where mindfulness-based techniques can be employed to reduce feelings of anger before they intensify into violence [45]. Interventions such as tDCS may improve moral behaviour implicated in aggression and subsequently may decrease violence by stimulating neurological structures that contribute to impaired moral cognition and emotion [45, 55]. Emotional regulation intervention could be effective for reducing anger by providing individuals with reappraisal or distraction strategies to respond to anger-provoking events [49].

Although other interventions such as anger-management studies reported mixed results, these interventions may reduce aggression by improving individual capacity to identify thoughts and emotions during provocation and delivering targeted strategies to resolve anger [14, 37, 43, 44, 46, 48]. However, there may be a delayed effect of these interventions as individuals need time and situations to practice. Cognitive Behavioural Therapy (CBT)-based interventions may reduce aggression by improving individual capacity to identify thoughts and emotions during provocation, and delivering targeted strategies to resolve anger before it becomes violence [14, 37, 43, 44, 46, 48]. However, the included interventions were not consistently effective for people with ABI as such populations may not have the capacity to engage with cognitively demanding tasks.

In forensic settings, a peer group approach modified for the impairments related to ABI demonstrated reductions in aggression, but results were not assessed for significance, so it is unclear if these reductions were greater than no intervention. Pharmacological interventions were predominately ineffective with limited evidence to suggest that amantadine and quetiapine may decrease the frequency and severity of aggressive behaviours. Overall, analysis of how the included interventions corresponded with the Risk Need Responsivity (RNR) model indicates inconsistent alignment in adherence to these principles.

Risk

This review indicates the risk principle may not be comprehensively addressed in current social rehabilitation efforts. There are specific factors within these studies that suggest the existence of influential risk factors for persons with ABI that should be considered when determining the intensity of intervention required to modify aggression. A critical consideration is the potential modulating effect of cognitive impairment as this may indeed be a significant factor in exacerbating the risk of violence among individuals with ABI. For instance, participants in the forensic study consistently reported high levels of cognitive impairment, particularly in domains such as working memory, executive function, and processing speed [50]. Comparatively, findings from some community sample studies indicated that participants did not exhibit severe levels of cognitive impairment [44, 46, 49]. For example, participants in the Witten et al. [49] study scored in the average range for measures of executive function such as inhibition and working memory. It is conceivable that greater impairment in executive function, often associated with poorer decision-making capacity, could elevate the likelihood of violence, especially when considered in conjunction with additional neuropsychiatric impairments such as impaired social perception. This suggests that cognitive impairment, particularly in specific domains, plays a pivotal role in shaping the risk profile for violence among individuals with ABI.

The included interventions may not be applicable to populations who more frequently display higher levels of aggression. This is problematic as higher levels of aggression presents a greater risk for offending behaviour [24] and level of aggression should inform intervention allocation. While some individuals with ABI may experience irritability or anger without manifesting into violence, there are discernible patterns linking ABI, especially the subset of TBI, to more pronounced forms of aggression. For example, individuals with TBI in prison report higher levels of physical aggression, verbal aggression, and anger compared to community samples [6, 25]. Minor fluctuations in irritability or anger may have less critical implications for violent offending trajectories, as these emotions could be effectively managed before escalating into violence, particularly in cases with less severe cognitive impairments that do not overly tax cognitive resources. However, a substantial intensification of irritability and anger, left unmanaged, potentially due to cognitive impairments and other moderating factors like mental health or substance use issues, could escalate into violence, increasing risk of criminal justice involvement and recidivism and highlighting the need for social rehabilitation for persons with ABI. In accordance with the Risk principle, individuals experiencing lower-level presentations of aggression and presenting with fewer factors that could potentially exacerbate irritability or anger into violence should be considered for less intensive interventions. Comparatively, people who experience severe levels of aggression (e.g., more frequent and more intense displays of physical violence) may require more intensive intervention to produce changes in behaviour that would lower risk of violent offending and recidivism [56, 57].

Pre-injury behaviour is suggested to impact post-injury trajectories of violence [24, 58, 59] and is considered a factor that influences offending and recidivism. All participants in the forensic study reported histories of offending behaviour, including violent offending, with marked increases in offending following their TBI [50]. Comparisons to community samples are limited as information regarding offending history was largely absent. One study reported that participants had significant differences in pre-injury and post-injury levels of aggression but further information about these differences was not provided, and nor were these differences accounted for in subsequent analyses [49]. It remains unclear whether the community-based samples included individuals with a history of violent offending, and it cannot be determined whether participants committed offences after the conclusion of the study. Notably, one study had a participant withdraw because they had been arrested for a violent offence [37]. Prior history of offending behaviour is an important consideration for intervention allocation, as it may suggest the presence of established patterns

that could be more resistant to change. Understanding the role of pre-injury behaviour in aggression experienced by people with ABI and its implications for social rehabilitation is a critical area for further investigation to inform intervention strategies.

Need

The majority of the included interventions had components that aimed to reduce aggression but, the interventions did not target, or accommodate for, the actual impairments experienced by people with ABI. A notable proportion of people with ABI experience severe cognitive deficits. Findings from this review indicates that there is limited evidence to suggest the evaluated interventions would be effective in these populations. Studies reported mixed levels of injury severity and impairment which may have considerable implications on the generalisability of intervention effectiveness. For example, Hart et al. [60] featured a sample of participants with significant cognitive impairment and low-to-average intelligence, with results suggesting that ASMT may be effective for reducing anger. However, limited conclusions can be drawn about the effectiveness of the included interventions due to some studies reporting that participants did not have severe cognitive impairment [44, 46, 49]. Comparatively, participants in the forensic study all reported significant cognitive deficits and received an intervention that was modified to be delivered to people with ABI. Whilst there were clinical reductions in aggression observed, the absence of significance testing makes it difficult to determine if this intervention successfully reduced aggression while accommodating for cognitive impairment. Cognitive function could be an influential factor in social rehabilitation as participants with intact cognitive ability are more readily able to learn and remember new information and therefore may be more likely to produce changes in behaviour (e.g., reduced externalised aggression) [26, 33]. The relationship between injury severity and cognitive impairment is also not linear; severe ABI does not necessarily mean cognitive impairments are severe. Sustaining multiple mild injuries could produce a cumulative effect that leads to significant impairment that may be as detrimental as a single severe ABI [15, 21]. Therefore, other factors beyond injury severity need to be considered when delivering social rehabilitation to people with ABI.

The age an individual sustains an ABI is a static risk factor that may impact perpetration of violence for people with ABI as it can have critical impacts on subsequent impairments. For example, when TBI occurs during key stages of brain development, such as maturation of the prefrontal cortex (e.g., between 15-25 years of age), foundational skills in decision-making, planning, and impulse control may be detrimentally impaired thus impacting development of higher order cognitive skills [15, 21, 61]. All participants in the forensic study were notably younger (aged 19-21) than the community samples where only 0.5% of individuals were aged under 30. This age difference could be particularly relevant during social rehabilitation as individuals who are younger may require more specialised interventions that address developmental needs. Indeed, the forensic peer group approach heavily focused on moral development by teaching pro-social skills and educating participants on why anti-social responses were not appropriate [50], whereas in the community samples behavioural intervention focused on strategies for identifying and managing aggression. Overall, there is limited generalisability of results to younger adults indicating a gap in current social rehabilitation approaches.

Research indicates that mental health and substance use are dynamic risk factors associated with heightened aggression and violence for people with ABI [62]. However, there were 11 studies where individuals who reported diagnosed mental illness or regular substance use were excluded due to potential confounding influence. Notably, two studies that included mental health outcomes excluded comorbid serious mental illness [38, 49]. However, depression following an ABI has strong associations with aggressive behaviour [6, 62] and rates of generalised anxiety are significantly higher than the general population (40% vs. 2.9%; 15]. Moreover, substance use has been independently linked to both cognitive impairment and violence [63], but research findings also suggest that aggression experienced after an ABI is associated with a history of substance abuse and current substance use [15, 24, 31, 64]. Thus, comorbid substance use may exacerbate ABI-related impairments that contribute to violence. Overall, the prevalence of substance use and mental health issues has been commonly documented alongside ABI in people who engage in violence. By excluding individuals with these comorbidities, the included studies may not have captured a key subset of the population that may be at a heightened risk of engaging in violence. Subsequently, results lack relevance to a vulnerable subset of people with ABI who are at a greater risk of engaging in violent behaviour and would most benefit from responsive intervention that addresses these dynamic needs and reduces violence. This contributes to a limited understanding of how a range of comorbidities may impact engagement with treatment for people with ABI and how they should be accounted for in interventions.

Responsivity

Many interventions were not adequately designed or adjusted to be appropriate for people with ABI demonstrating gaps in current interventions and their ability to be responsive for this population. Although CBT may target factors that influence anger, it is questionable whether such cognitively laborious interventions are suitable for populations experiencing cognitive impairment. Modifications in cognitive-behavioural-based interventions mostly comprised of reducing group size [37, 46], repetition of content to manage attentional deficits [14, 43], providing summary handouts, and including injury specific education [44]. The content was not tailored to accommodate the cognitive impairments of the participants and distributing handouts may have limited utility when individuals face challenges in comprehending the concepts presented [26]. Only one study [48] made modifications to the content that included simplifying concepts and providing concrete examples. Notably this study reported significant reductions in anger whereas other behavioural interventions were largely ineffective. Individuals with neurocognitive impairments may find it challenging to engage with cognitively demanding interventions as such approaches typically require intact memory, proficient decision-making skills, and sustained attention [26]. This raises concerns about the applicability of unmodified CBT-based anger management in populations where cognitive impairments are typically prevalent, highlighting the need for tailored interventions that consider the unique cognitive profiles of individuals with ABI.

Comparatively, effective interventions identified by this review, such as mindfulness, tDCS, and emotion regulation are less cognitively demanding. Individuals with ABI may find it challenging to identify appropriate moments to apply cognitive strategies for managing aggression. The mindfulness components targeted modifiable factors such as increasing bodily awareness, emotion understanding, and recognizing physical signs of negative emotions. This enhances individual'' ability to identify anger cues and use simpler strategies like breathing exercises and meditation to

regulate emotions. The mindfulness intervention, although not specifically designed for ABI, can be beneficial by emphasizing bodily awareness and offering simpler aggression management strategies [45]. instead of complex cognitive restructuring.

Additionally, tDCS requires no cognitive effort on the part of participants and does not require modification based on cognitive capacity. This technique is a potential method for reducing aggression, as it aims to address the consequences of neurological damage by enhancing upregulation in the prefrontal lobe [45]. The neuromoral theory of aggression postulates that damage to neurological structures, particularly the prefrontal lobe, can lead to impaired moral cognition, increasing violent behaviour [55]. Consequently, modifications to affected structures, such as through tDCS or other brain stimulation methods, could potentially reduce aggression in a way that is easy to administer to someone with cognitive impairments.

Similar to the mindfulness intervention, the included emotion regulation intervention taught participants how to identify both cognitive and physical signs of increased anger [49]. Participants learnt both an antecedent focused-strategy *via* a reappraisal technique such as alternative perspective-taking (e.g., think of positive side of the event) and a response-focused strategy using a distraction technique by engaging in a different activity (e.g., drawing a picture of a time they felt happy). Although only including one cognitive-based technique is less demanding than regular cognitive-behavioural based therapies, reappraisal strategies still require cognitive skills that are typically disrupted in people with ABI. Furthermore, whilst distraction techniques are less cognitively demanding they could be impractical to use in real-world settings. For instance, the intervention incorporated a distraction technique wherein participants were encouraged to create a drawing depicting a past moment of happiness [49]. In a real-world context, this would entail disengaging from a currently anger-provoking situation, seeking resources for drawing, and recalling a positive memory. In anger-provoking situations, individuals with ABI may struggle to disengage due to cognitive and emotional impairments that overwhelm their executive and decision-making capacities, making it difficult to engage in distraction activities. It should also be noted that the trials consisted of participants recalling anger-provoking events and using either technique to manage their responses. It may be unlikely that participants can effectively use reappraisal strategies during an active anger-provoking event as their emotions may be more intense and could over-burden cognitive capacity. This could explain lack of further statistical decrease in anger from post-treatment assessment to follow-up assessment. Although the distraction technique was included as a modification for ABI, it is unclear how this intervention would be suitable for individuals with severe cognitive impairments in real-world settings. Additionally, the intervention did not reduce internal anger with the authors contending that producing changes in externalised behaviours is more important than altering internal experiences [49]. However, managing internal experiences of anger is essential for addressing longer-term reductions in externalized aggression, and it is equally important to improve the overall well-being of individuals with ABI who are affected by emotional dysregulation.

Although it may be argued that medications require fewer cognitive resources than behavioural interventions, there is insufficient evidence to support the use of any pharmacological intervention to reduce aggression in ABI populations. The treatment regime of the included studies was not modified to be suitable for people with ABI. Studies consistently evaluated medications that had only been previously tested in other non-ABI patient populations (such as patients with dementia) or have been tested with ABI populations but produced non-significant or weak results. Such endeavours are problematic as ABIs can alter the structure of the brain [22] which may mean that medication works differently for people with brain injuries. Therefore, the results from non-ABI populations should not be used to support the implementation of these medications for people with ABI as a form of social rehabilitation.

The forensic peer group approach was modified to be suitable for people with ABI, with more frequent and shorter sessions, revised terminology, errorless learning practices, and visual cues. For example, sessions lasted 30 min [50] whereas community interventions often featured 1–2-h sessions [14, 43, 44, 46, 48, 52]. Individuals with ABI may benefit from shorter sessions, to ensure delivery does not exceed attentional capacity [50]. Additionally, errorless learning practices, where opportunities for mistakes are minimised, was employed using concrete communication to avoid misinterpretations of abstract concepts that require participants to infer meaning- a skill that is frequently disrupted in people with ABI [50]. Such modifications could be useful for survivors of ABI but as significance testing was not conducted it is not possible to determine whether this method effectively targeted aggression.

All the included studies aimed to reduce aggression however some studies did include irritability or anger as measures of aggression [14, 38–44, 48]. Although irritability and anger were included in this review as outcomes representing lower-level aggression, this review identified a lack of research evaluating intervention effectiveness on violence. Interestingly, some interventions that only measured irritability or anger produced non-significant results. Moreover, interventions such as anger-self-management significantly reduced anger, but not aggression [43]. This finding raises a plausible concern that these interventions, which may not be effective in reducing lower-level presentations of aggression that require less intensive treatment, might also be unable to produce changes in violence, a more severe manifestation that typically demands more intensive intervention. Potentially, for people with ABI there may not be a gradual progression from irritability to anger and then violence, with clear moments for aggression strategies to be implemented. They may more rapidly escalate into violence due to injury-related cognitive, social, and emotional impairments [20, 21]. Interventions should be evaluated on whether they reduce violence, which is the most severe presentation of aggression that is associated with offending outcomes [24].

Across the included studies, self-reported levels of irritability, anger, and aggression were used. This is problematic as individuals with ABI may not respond accurately to self-report measures. Accurately responding to self-report questionnaires requires skills in comprehension and attention, which may be significantly disrupted in people with cognitive impairment [26, 65] Additionally, they may be less able to accurately appraise their own performance due to impaired self-awareness [21]. Continued use of self-report measures to identify changes in aggression could create misinformed data based on potentially inaccurate responses. Observer-rated measures also present with issues of accuracy and reliability as observers may perceive outward changes in aggression but do not have the ability to judge another's internal experiences. Further research into changes in aggression for people with ABI should consider using methods that do not rely on self-report. Alternative methods that bypass active participation would be beneficial for overcoming the limitations of self-report in ABI populations such as data linkage [66].

Current interventions may be failing to address the risks, needs, and responsivity factors relevant to people with ABI who engage in aggressive or violent behaviour. Thus, indicating that social

rehabilitation for aggression in persons with ABI lacks applicability to this population. Understanding the suitability of interventions for people with ABI is crucial for clinical practice, as it can inform intervention allocation based on key factors such as injury severity and cognitive impairment levels. Despite research suggesting there may be a link between ABI and violent offending [6, 24, 25, 67] there is a substantial lack of knowledge regarding the effectiveness of aggression interventions for forensic populations. The results of this review cannot be generalised to people who have engaged in violent offending as there may be key distinctions between people who experienced increased aggression in the absence of formal offending compared to those who sustain an ABI and experience increases in aggression that lead to formal violent offending.

Limitations of current review

The results of this review may be subject to bias as all included studies were published in English and there was a set publication range of 2000-2023 which may have limited results by not capturing research published prior to 2000. However, this range was selected to ensure the review contained up-to-date and recent research to maintain generalisability within the context the results will be applied in. Also, all studies except one were conducted in high income, developed countries, which also impacts the generalisability of findings as economic variations can impact the way interventions are implemented (e.g., resource availability). Obtaining large sample sizes from clinical populations such as those with ABI is challenging [68], and subsequently the small sample sizes of the included studies may also limit generalisability.

Conclusion

The findings of this review highlighted that there is a relative absence of evaluation for interventions delivered to forensic samples or studies with measures of violence. A key implication for social rehabilitation is that standard interventions may not be responsive to ABI-related impairments and interventions that are less cognitively demanding may offer greater benefits. Intervention success may vary due to individual factors such as cognitive impairment, but additional research is required to further understand this impact. There is an urgent need for social rehabilitation efforts that are tailored to the unique needs and characteristics of forensic populations. However, due to a lack of forensic studies available for comparison, it remains unclear what factors influence the effectiveness of intervention for violence displayed by people with ABI. Further research is required to identify factors that influence aggression and violence as this knowledge can facilitate the modification of interventions to suit the needs of this population and thus enhance social rehabilitation. Findings of the current review illustrate current inadequacies in social rehabilitation for persons with ABI. Failing to address disrupted social functioning such as aggression and violence may not only limit progress in other rehabilitation domains but also diminishes quality of life and heightens risk of incarceration for individuals with ABI.

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Appendix A. Search strategies

Index database searches

The key terms used across the index databases are presented in Table A1.

PsycINFO

(TI violent offend*) OR (TI violent offen?e*) OR (TI violent behavio#r) OR (TI violent prisoner*) OR (TI aggressive offend*) OR (TI aggressive offen?e*) OR (TI aggressive behavio#r*) OR (TI violen*) OR (TI aggress*) OR (TI aggressive prisoner*) OR (TI violent crime) OR (TI incarcerat*) (TI imprisonment*) OR (TI prison*) OR (TI harass*) OR (TI antisocial behavio#r*) OR (TI anger) OR (TI episodic dyscont*) OR (AB violent offend*) OR (AB violent offen?e*) OR (AB violent behavio#r) OR (AB violent prisoner*) OR (AB aggressive offend*) OR (AB aggressive offen?e*) OR (AB aggressive behavio#r*) OR (AB violen*) OR (AB aggress*) OR (AB aggressive prisoner*) OR (AB violent crime) OR (AB incarcerat*) (AB imprisonment*) OR (AB prison*) OR (AB harass*) OR (AB antisocial behavio#r*) OR (AB anger) OR (AB episodic dyscont*) AND (TI acquired brain injur*) OR (TI traumatic brain injur*) OR (TI ABI) OR (TI TBI) OR (AB acquired brain injur*) OR (AB traumatic brain injur*) OR (AB ABI) OR (AB TBI) AND (TI intervention*) OR (TI treat*) OR (TI rehab*) OR (TI group intervention*) OR (TI manag*) OR (TI education) OR (TI psychoeducation) OR (TI neurorehabilitation) OR (TI service*) OR (TI program*) OR (TI treatment) OR (TI therap*) OR (AB intervention*) OR (AB treat*) OR (AB rehab*) OR (AB manag*) OR (AB education) OR (AB psychoeducation) OR (AB neurorehabilitation) OR (AB service*) OR (AB program*) OR (AB treatment*) OR (AB therap*) NOT (TI meta) OR (TI review) OR (TI animal*) OR (TI rat) OR (TI mice) OR (TI mouse) OR (TI case study) OR (TI case report) OR (TI case series) OR (TI schizophren*) OR (TI ADHD) OR (TI diabetes) OR (TI dementia) OR (TI Alzheimer* disease) OR (TI huntington* disease) OR (TI Parkinson* disease) (AB meta) OR (AB review) OR (AB animal*) OR (AB rat) OR (AB mice) OR (AB mouse) OR (AB case study) OR (AB case report) OR (AB case series) OR (AB schizophren*) OR (AB ADHD) OR (AB diabetes) OR (AB dementia) OR (AB Alzheimer* disease) OR (AB huntington* disease) OR (AB Parkinson* disease)

CINAHL, SocINDEX, Medline complete

(TI: "violent offend*") OR (TI: "violent offen?e*") OR (TI: "violent behavio#r") OR (TI: "violent prisoner*") OR (TI: "aggressive offend*") OR (TI: "aggressive offen?e*") OR (TI: "aggressive behavio#r*") OR (TI: violen*) OR (TI: aggress*) OR (TI: "aggressive prisoner*") OR (TI: "violent crime") OR (TI: incarcerat*) OR (TI: imprisonment*) OR (TI: prison*) OR (TI: harass*) OR (TI: "antisocial

behavio#r*") OR (TI: anger) OR (TI: episodic dyscont*) OR (AB: "violent offend*") OR (AB: "violent offen?e*") OR (AB: "violent behavio#r") OR (AB: "violent prisoner*") OR (AB: "aggressive offend*") OR (AB: "aggressive offen?e*") OR (AB: "aggressive behavio#r*") OR (AB: violen*) OR (AB: aggress*) OR (AB: "aggressive prisoner*") OR (AB: "violent crime") OR (AB: incarcerat*) OR (AB: imprisonment*) OR (AB: prison*) OR (AB: harass*) OR (AB: "antisocial behavio#r*") OR (AB: anger) OR (AB: episodic dyscont*) AND (TI: "acquired brain injur*") OR (TI: "traumatic brain injur*") OR (TI: ABI) OR (TI: TBI) OR (AB: "acquired brain injur*") OR (AB: "traumatic brain injur*") OR (AB: ABI) OR (AB: TBI) AND (TI: intervention*) OR (TI: treat*) OR (TI: rehab*) OR (TI: "group intervention*") OR (TI: manag*) OR (TI: education) OR (TI: psychoeducation) OR (TI: neurorehabilitation) OR (TI: service*) OR (TI: program*) OR (TI: treatment) OR (TI: therap*) OR (AB: intervention*) OR (AB: treat*) OR (AB: rehab*) OR (AB: manag*) OR (AB: education) OR (AB: psychoeducation) OR (AB: neurorehabilitation) OR (AB: service*) OR (AB: program*) OR (AB: treatment*) OR (AB: therap*) NOT (TI: meta) OR (TI: review) OR (TI: animal*) OR (TI: rat) OR (TI: mice) OR (TI: mouse) OR (TI: "case study") OR (TI: "case report") OR (TI: "case series") OR (TI: schizophren*) OR (TI: ADHD) OR (TI: diabetes) OR (TI: dementia) OR (TI: "Alzheimer* disease") OR (TI: "huntington* disease") OR (TI: "Parkinson* disease") OR (AB: meta) OR (AB: review) OR (AB: animal*) OR (AB: rat) OR (AB: mice) OR (AB: mouse) OR (AB: "case study") OR (AB: "case report") OR (AB: "case series") OR (AB: schizophren*) OR (AB: ADHD) OR (AB: diabetes) OR (AB: dementia) OR (AB: "Alzheimer* disease") OR (AB: "huntington* disease") OR (AB: "Parkinson* disease")

Table A1. Search syntax.

Outcome		Descriptor
Violent offending/Aggression	1	violent offend*
	2	violent offen?e*
	3	violent behavio#r*
	4	violent prisoner*
	5	aggressive offend*
	6	aggressive offen?e*
	7	aggressive behavio#r*
	8	violen*
	9	aggress*
	10	aggressive prisoner*
	11	violent crime*
	12	incarcerat*
	13	imprisonment*
	14	prison*
	15	antisocial behavio#r
	16	anger
	17	episodic dyscont*
	18	OR/ (TI 1-17) OR/ AB (1-17)
Acquired Brain Injury	19	acquired brain injur*
	20	traumatic brain injur*
	21	ABI
	22	TBI
	23	OR/ (TI 98-22) OR/ (AB 19-22)
Intervention	24	intervention*
	25	treat*
	26	rehab*
	27	group intervention*
	28	manag*
	29	education
	30	neurorehabilitation
	31	service*
	32	treatment*
	33	program*
	34	therap*
	35	OR/ (TI 24-34) OR/ (AB 24-34)
Exclusion Criteria	36	meta*
	37	review*
	38	animal*
	39	rat*
	40	mice
	41	case study
	42	case report
	43	Alzheimer* disease
	44	dementia
	45	Parkinson*
	46	Huntington*
	47	diabetes
	48	Schizophren*
	49	ADHD
	50	case series
	51	OR/ (TI 36-50) OR/ (36-50)
Combined Terms	52	18 AND 22 AND 35 NOT 51

EMBASE

acquired brain injur*':ti,ab OR 'traumatic brain injur*':ti,ab OR ABI:ti,ab OR TBI:ti,ab NOT 'Alzheimer* disease':ti,ab NOT 'huntington* disease':ti,ab NOT 'Parkinson* disease':ti,ab NOT Meta:ti,ab NOT review:ti,ab NOT animal*:ti,ab NOT rat:ti,ab NOT mice:ti,ab NOT mouse:ti,ab NOT 'case study':ti,ab NOT 'case report':ti,ab NOT 'case series':ti,ab NOT ADHD:ti,ab NOT diabetes:ti,ab NOT dementia:ti,ab NOT 'case series':ti,ab NOT 'schizophren*':ti,ab AND Treat*:ti,ab OR rehab*:ti,ab OR therap*:ti,ab OR manage*:ti,ab OR intervention*:ti,ab OR education:ti,ab OR neurorehabilitation:ti,ab OR service:ti,ab OR program*:ti,ab OR treatment*:ti,ab OR therap*:ti,ab NOT 'Alzheimer* disease':ti,ab NOT 'huntington* disease':ti,ab NOT 'Parkinson* disease':ti,ab NOT Meta:ti,ab NOT review:ti,ab NOT animal*:ti,ab NOT rat:ti,ab NOT mice:ti,ab NOT mouse:ti,ab NOT 'case study':ti,ab NOT 'case repNOTt':ti,ab NOT 'case series':ti,ab NOT ADHD:ti,ab NOT diabetes:ti,ab NOT dementia:ti,ab NOT 'case series':ti,ab NOT 'schizophren*':ti,ab AND 'violent offend*':ti,ab OR 'violent offen#e*':ti,ab OR 'violent behaviour*':ti,ab OR 'violent prisoner*':ti,ab OR 'aggressive offend*':ti,ab OR 'aggressive offen#e*':ti,ab OR 'aggressive prisoner*':ti, ab OR 'aggresive behaviour*':ti,ab OR violen*:ti,ab OR aggress*:ti,ab OR 'violent crime*':ti,ab OR incarcerat*:ti,ab OR imprisonment*:ti,ab OR prison*:ti,ab OR harass*:ti,ab OR 'antisocial behavio#r':ti,ab OR anger:ti,ab OR 'episodic dyscont*':ti,ab NOT 'Alzheimer* disease':ti,ab NOT 'huntington* disease':ti,ab NOT 'Parkinson* disease':ti,ab NOT Meta:ti,ab NOT review:ti,ab NOT animal*:ti,ab NOT rat:ti,ab NOT mice:ti,ab NOT mouse:ti,ab NOT 'case study':ti,ab NOT 'case repNOTt':ti,ab NOT 'case series':ti,ab NOT ADHD:ti,ab NOT diabetes:ti,ab NOT dementia:ti,ab NOT 'case series':ti,ab NOT 'schizophren*'

Grey literature search strategy

The ten search strategies input into Google Scholar are presented in Table A2.

Table A2. Google scholar search strategy.

	Search Strategy
1	Violent OR violence AND offend OR prisoner AND intervention OR group intervention OR program AND acquired brain injury OR traumatic brain injury
2	Violent OR violence AND intervention OR group intervention OR program AND acquired brain injury OR traumatic brain injury
3	Violent OR violence AND treatment OR therapy AND acquired brain injury OR traumatic brain injury
4	Violent OR violence AND offend OR prisoner AND treatment OR therapy AND acquired brain injury OR traumatic brain injury
5	Aggression OR aggressive AND offend OR prison AND intervention OR group intervention OR program AND acquired brain injury OR traumatic brain injury
6	Aggression OR aggressive AND intervention OR group intervention OR program AND acquired brain injury OR traumatic brain injury
7	Aggression OR aggressive AND treatment OR therapy AND acquired brain injury OR traumatic brain injury
8	Aggression OR aggressive AND prison OR offend AND treatment OR therapy AND acquired brain injury OR traumatic brain injury
9	Antisocial behaviour OR anger AND intervention OR group intervention OR program AND acquired brain injury OR traumatic brain injury
10	Antisocial behaviour OR anger OR episodic dyscontrol AND treatment OR therapy AND acquired brain injury OR traumatic brain injury

Appendix B.

Table B1. Summary of included studies.

Authors (year)/ Country	Design	Participants	Severity	Intervention	Outcomes	Measures	Analysis	Results	Limitation(s)	Industry Funded
Medd & Tate (2000) [44], Australia	Repeated-Measures (matched randomised)	16 participants (14 men, 2 women)	Not provided	Individual Anger management Duration: five-eight weeks 2-month follow-up	Anger (Anger control, Anger expression)	STAXI (self-reported and observer-rated)	Repeated Measures ANOVA	Trait Anger: not significant Anger Expression: Significant group/time interaction Anger Control: not significant Anxiety: significant main effect for time Depression: not significant **Follow-Up of Treat** Trait Anger: significant decrease Anger Expression-Outward: not significant Anger Control: Significant improvement	Small sample size Daily Anger Logs were not analysed due to a high level of missing data Self-report measures	No
Kim & Bijlani (2006) [47], U.S.A.	Pre-post intervention (cohort)	7 participants (4 men, 3 women)	2 participants with severe ABI (others not provided)	50-300mg dose of Quetiapine Duration: Daily for 6 weeks	Aggression	OAS-M (self-reported)	Paired t-test	Mean reduction in OAS-M score of 84.5% (p=.002)	Small sample size Open label noncontrolled design	Yes
Manchester et al. (2007) [50], United Kingdom	Pre-post intervention	3 participants (men)		EQUIP programme: targets social interaction skills, sociomoral development, and social cognitive distortions	Aggression	OAS-M (observer-rated) HIT (participant rated)	Descriptive	Aggressive episodes reduced in two participants One participant increased Pro-aggressive attitudes were modified in 2/3 participants **Follow-up** Changes in aggression maintained in the 2 participants that returned	Small sample size, does not assess long-term effects	No
Walker et al. (2010) [48], Australia	Repeated measures	69 (54 men, 15 women)	Severe	Psycho-educational group anger management Duration: 2-hour sessions for 12 weeks Follow-Up 3-16 months	Anger (Anger expression, anger control)	STAXI (self-reported)	Chi-square	Trait Anger: significant reduction Anger Expression-Outward: significant reduction Anger Control: significant increase **Follow-Up (31 participants)** Trait Anger: significant reduction compared to pre-treatment but not post Anger Expression-Outward: significant reduction compared to pre-treatment but not post Anger Control: not significant compared to pre or post treatment	No waitlist or comparison group Not all participants completed follow-up Self-report measure used	No

(*Continued*)

Table B1. Continued.

Authors (year)/ Country	Design	Participants	Severity	Intervention	Outcomes	Measures	Analysis	Results	Limitation(s)	Industry Funded
Hart et al. (2012) [14], U.S.A.	Cohort	10 participants (8 men, 2 women)	Moderate-Severe	Anger self-management Duration: 60-90 minutes, eight sessions	Anger (anger expression), Aggression	STAXI-2, BAAQ (self-reported and observer-rated)	Paired t-test	**Participant rated:** Trait Anger: significant decrease post-treatment (large effect size) Anger Expression-Outward: significant decrease post-treatment (large effect size) Aggression: significant decrease post-treatment (large effect size) **Observer rated:** Trait Anger: not significant Anger Expression-Out: significant decrease post-treatment (large effect size) Aggression: not significant	Small sample size Absence of control group Absence of follow-up	No
Aboulafia-Brakha et al. (2013) [46], Switzerland	Cohort	10 participants (8 men, 2 women)	Moderate-severe	Group Anger management (based on a cognitive-behavioural therapy framework) Duration: 8 sessions 5-month follow-up	Aggression	AQ-12 (self-reported)	Wilcoxon Signed-Rank test	Aggression: no significant change at Time 1 or Time 2 (post-intervention, or between Time 2 and Time 3. Significant difference between Time 1 and Time 3 (follow-up)	Small sample size Absence of control Participants had low severity in cognitive impairment and had high levels of education	No
Hammond et al. (2014) [39], U.S.A.	Randomised controlled trial	76 participants (47 men, 29 women)	Moderate-severe	100mg Amantadine or matched placebo Duration: Daily for 28 days	Irritability, Aggression	NPI-I, NPI-A (observer-rated)	Chi-square, Wilcoxon Signed-Rank test	Irritability: Overall score significant reduction compared to placebo (p=.0085). Significant reduction in frequency and severity in both treatment and placebo (p=.0156 and p=.0055 respectively Aggression: no significant change in treatment compared to placebo. When participants with low baseline NPI-A were excluded this became significant (p=.046)	Large placebo effect may arise from subjective observer ratings Subjective measures Underpowered Focused on chronic irritability	No
Hammond et al. (2015) [41] U.S.A.	Randomised controlled trial	168 participants (146 men, 22 women)	Mild, moderate, or severe	100mg Amantadine or matched placebo Duration: daily for 60 days	Irritability	NPI-I (self-reported and observer -rated)	Student t-test, Wilcoxon Signed-Rank test	**Participant rated:** Irritability: No significant difference between groups **Observer rated:** Irritability: No significant difference between groups	Subjective measures Observers had different relationships to each participant	No

(*Continued*)

Table B1. Continued.

Authors (year)/ Country	Design	Participants	Severity	Intervention	Outcomes	Measures	Analysis	Results	Limitation(s)	Industry Funded
Aboulafia-Brakha 7 Ptak (2016). [37], Switzerland	Paired-randomised controlled trial	19 participants (16 men, 3 women)	Moderate-severe	Group anger management Duration:60 minutes for 12 weeks. Anger-management sessions one per week for 8 weeks (4 weeks of psychosocial education about brain injury) (Control first group waited 4 weeks before starting the program) Assessment conducted every 4 weeks	Aggression, Anger	AQ12, STAXI, MARS (self-reported)	Chi-square analysis, Kruskal-Wallis test, Student's t tests, paired t-tests	Aggression (AQ-12): significant main effect of time but non-significant effect of group or interaction Anger (STAXI): significant main effect of time but non-significant effect of group or interaction Anger (MARS): no significant interaction or main effects observed. No significant difference between groups at Time 1 (pre-intervention), Time 2 (4 weeks), Time 3 (8 weeks), or Time 4 (12 weeks). Control First group significant increase in anger expression from Time 1 to Time 2, significant decrease in anger expression between Time2 and Time 3 and Time 3 and Time 4.	Unequal difference in intervention duration Self-report measures	No
Hammond et al. (2017) [40], U.S.A.	Randomised controlled trial	118 participants (94 men, 24 women)	Moderate-severe	100mg of amantadine or placebo equivalent Duration: Twice daily for 60 days	Aggression, Anger	NPI-A: subscales Most Problematic and Distress STAXI (self-reported and observer -rated)	Wilcoxon Rank sum test, Fisher exact test	**Participant Rated:** Aggression: Overall not significant (p=.6189). significant change in Most Problematic subscale (p=.0118) compared to placebo. Significant improvement in subscale Distress (p=.0118) compared to placebo Anger: No significant group differences **Observer Rated:** Aggression: Overall not significant improvement in Distress subscale (p=.11 Anger: No significant group differences	Subjective measures Self-report measures, Observers were not required to have a caregiving role No level of distress was required for enrolment	No

(*Continued*)

Table B1. Continued.

Authors (year)/ Country	Design	Participants	Severity	Intervention	Outcomes	Measures	Analysis	Results	Limitation(s)	Industry Funded
Hart et al. (2017) [43], U.S.A.	Randomised controlled trial	90 participants (73 men, 17 women)	Moderate-severe	Anger-self management training (ASMT) + comparison condition personal readjustment and education (PRE) Duration:90-minute sessions, 8 weeks Post-intervention 8-week follow-up	Anger (trait anger and anger expression), Aggression	STAXI-2, BAAQ, (self-reported and observer rated)	Chi-square analysis, Fisher's exact test, Mann-Whitney test	Anger: no significant treatment effect overall. Significant treatment effect in favour of ASMT on scores on the STAXI-2 TA (participant and observer rated) Aggression: no significant treatment effect on any measure (participant and observer rated) Follow-up: Anger: no significant treatment effect on any measure (participant and observer rated) Aggression: no significant treatment effect on any measure (participant and observer rated)	Self-report measures All participants resided in the community Excluded participants with serious communication limitations	No
Deb et al. (2020) [38], United Kingdom	Randomised controlled trial	14 participants (10 male, 4 female)	Mild, moderate, or severe	1mg (increased up to 4mg if needed) of risperidone or placebo equivalent Duration: Daily, 12 weeks	Aggression, Irritability	OAS-M, Irritability Questionnaire (self-reported)	Descriptive data	Aggression: reduced in both groups to a similar level Irritability: score changes slightly greater in treatment group Depression: score changes slightly greater in placebo group Anxiety: score changes slightly greater in treatment group	Self-report measures Small sample size	No
Hammond et al. (2021) (42], U.S.A.	Randomised controlled trial	70 participants (53 men, 17 women)	Mild, moderate, or severe	200mg of carbamazepine or placebo equivalent. Increased to 400mg on day 15 Duration: twice daily (increased to thrice daily on day 8, then reduced to twice daily for 400mg amount on day 15), 42 days	Irritability, Aggression	NPI-I, NPI-A (self-reported and observer rated)	Student's t test, chi-square analysis, Fisher's exact test	**Participant Rated:** Irritability: no significant difference Aggression: no significant difference **Observer Rated:** Irritability: no significant difference Aggression: no significant difference	Self-report measures Subjective measures	No
Shirvani et al. (2021) [45], Iran	Randomised controlled trial	48 participants (11men, 37women)	Mild	tDCS: anodal stimulation on left dorsolateral prefrontal cortex. Cathodal stimulation on right dorsolateral prefrontal cortex Duration: three sessions per week for eight weeks Mindfulness: Mindfulness-based stress reduction (MBSR) meditations Duration: 2- hour sessions once a week for eight weeks	Aggression	AQ-12 (self-reported)	Repeated Measures ANOVAs	tDCS: aggression decreased from pre to post-test, and pre-test to follow-up (p<.001) compared to control Mindfulness: aggression decreased from pre to post-test, and pre-test to follow-up (p<.001) compared to control There was no significant difference in scores between tDCS and mindfulness	Small sample size Quantitative electroencephalography was not taken before applying electrical stimulation	No

(*Continued*)

Table B1. Continued.

Authors (year)/ Country	Design	Participants	Severity	Intervention	Outcomes	Measures	Analysis	Results	Limitation(s)	Industry Funded
Witten et al. (2023) [49], United Kingdom	Cohort	24 (10 female, 14 male)	Not provided	Emotion regulation (ER) training using reappraisal and distraction strategies in response to anger-provoking events. Homework diary (optional) participants practiced ER techniques using a diary to document anger-provoking events and rate anger intensity before and after the event Duration: five 1-hour Zoom meetings held over four months	Anger,	STAXI-2, AQ-12 (self-reported)	One-way repeated ANOVA	Trait Anger: STAXI Post-intervention: significant decrease in overall anger (p<.001) AQ-12 Post-intervention: No significant decrease in overall anger (p<.001) STAXI Baseline to Follow-up: significant decrease in overall anger (p=.001) Post-intervention to Follow-up: no significant decrease in overall anger AQ-12 Baseline to Follow-up: significant decrease in overall anger (p<.001) Post-intervention to Follow-up: significant decrease in overall anger (p<.01) Internal Anger Expression STAXI: no significant improvements at any timepoints External Anger Expression STAXI Post-intervention: significant decrease in anger expression (p<.05) Baseline to Follow-up: significant decrease in anger expression (p<.01) Post-intervention to Follow-up: no significant decrease in anger expression (p<.01) Anger Control-In STAXI: significant improvement at all time points (p<.01) Anger Control-Out: Post-intervention: significant increase in anger control (p<.05) Baseline to Follow-up: significant increase in anger control (p<.05) Post-intervention to Follow-up: no significant increase in anger control	Self-report measures	No

Note. Abbreviations: AM; anger management, ASM; anger self-management, tDCS; transcranial direct stimulation, +; significant positive effect, -; significant negative effect, =; no significant effect, ? statistical significance of findings unknown, *; not measured/recorded, MS; moderate-severe, M; mild, S; severe STAXI; State Trait Anger Expression Inventory STAXI-2; State Trait Anger Expression Inventory-2 BAAQ; Brief Anger-Aggression Questionnaire. AQ-12; Buss and Perry Questionnaire, MARS; Multidimensional Anger Scale, OAS-M; Overt Aggression Scale-Modified, NPI-I; Neuro-psychiatric Inventory-Irritability NPI-A; Neuropsychiatric Inventory-Aggression, HIT; How I Think Questionnaire, OAS-MNR; The Overt Aggression Scale Modified for Neurobehavioural Rehabilitation.