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Review

Family matters: A systematic review and meta-analysis on the efficacy of family-oriented interventions for children with acquired brain injuries

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ABSTRACT

Introduction: Acquired brain injury (ABI) is a leading cause of disability among children. An increasing number of programs have emerged to involve family members as an integral component of post-ABI rehabilitation. This study aimed to conduct a systematic review and meta-analysis of such programs among children with ABI.
Methods: Following PRISMA guidelines, search among six databases (PsycINFO, PsycARTICLES, Scopus, Web of Science, PubMed, Cochrane CENTRAL) was conducted, followed by abstract/full-text screening and data extraction. *Hedge's g* was computed for effect sizes. The risk of bias was assessed using Cochrane guidelines. Meta-regression analyses were conducted on six moderators.
Results: A total of 32 studies (reported in 37 articles) were included in the qualitative analysis. Meta-analysis of 20 studies showed a positive small-to-medium effect of family-oriented interventions on child and parental outcomes but not on family functioning. Study design moderated the effect sizes of parent outcomes.
Conclusions: This study synthesized the latest empirical evidence of family-oriented rehabilitation programs for pediatric ABI across interventional strategies, study designs, and outcomes. The findings suggested an overall beneficial impact of such programs on both the pediatric patients and their caregivers.

Acquired brain injury (ABI), defined as brain damage caused by events after birth can include but not limited to traumatic brain injuries (TBI) due to physical trauma or non-TBI injuries due to neurosurgery, stroke, brain tumors, infection, poisoning, hypoxia, ischemia, or substance abuse (Gmelig Meyling, Verschuren, Rentinck, Engelbert, & Gorter, 2021). The Centers for Disease Control and Prevention (CDC) estimates that TBI, one of the most common forms of ABI, was responsible for approximately 2500 pediatric mortality cases in the U.S. in 2014 (Peterson, Xu, Daugherty, & Breiding, 2019). Post-injury consequences of pediatric ABIs span from physical sequelae such as fatigue (Botchway, Godfrey, Anderson, & Catroppa, 2019; Wilkinson et al., 2018) to emotional challenges such as frustration (Couch & Leathem, 2011), depression (Botchway et al., 2019; Durish, Pereverseff, & Yeates, 2018), and diminished participation in activities of daily life (Bedell, 2008) and quality of life (Botchway et al., 2019; Knight et al., 2019).

Although most existing interventional strategies for post-ABI rehabilitation have been designed with a sole focus on the pediatric patients (Gmelig Meyling et al., 2021; Laatsch et al., 2007), an increasing number of studies have emerged to involve the patient's family members as an integral component of their rehabilitation programs (Kelly, Dunford, Forsyth, & Kavčič, 2019; Laatsch et al., 2020). We define family-oriented intervention as the intervention programs that involve at least one family member. Such strategic efforts are consistent with the significant role family and parent-child interactions (such as parenting and family functioning) play in post-ABI rehabilitation from both *theoretical* and *empirical* perspectives. According to the Family Systems Theory (Kerr, 1981), families are complex social systems in which each individual member (including caregivers and children) interact with each other, while also exerting influence on each other's cognition, emotions, and behaviors (Gilbertson & Graves, 2018). Thus, ABI not

Abbreviations: ABI, acquired brain injury; TBI, traumatic brain injury; CDC, Centers for Disease Control and Prevention.

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only affects the child with injury but also other family members. It is conceivable that there might be a bi-directional relationship between family system functioning and children's behavioral, cognitive, and emotional dysfunction after ABI. ABI results in tremendous stress and burden to the family and damages family functioning, creating a context that may interfere with the recovery of injured children and lead to worse outcomes. However, if family members could receive necessary training and education and be better supported as caregivers, they could provide the necessary support to the injured children, which would benefit the injured children in the long run. Therefore, the family is viewed as a critical component of any comprehensive pediatric ABI rehabilitation program. Empirical evidence in the field of brain injury research further supports the bi-directional relationship between family context and outcomes of children with ABI as well as the importance of including family in the intervention (Taylor et al., 2001). On the one hand, there is mounting evidence showing the negative impact of ABI on the family system (Stancin, Wade, Walz, Yeates, & Taylor, 2008; Rashid et al., 2014). For example, parents reported significant emotional distress, tension and conflicts in family relationships, and difficulties in maintaining effective parenting after injury when children expressed the need for support and empowerment (Brown, Whittingham, Boyd, & Sofronoff, 2013). On the other hand, research has consistently identified the family/parental factors related to pediatric brain injury recovery, including parents' mental health and coping resources, parenting styles, and the family environment (Durber et al., 2017; Peterson et al., 2013; Schorr, Wade, Taylor, Stancin, & Yeates, 2020).

However, despite the increasing number of studies examining the effect of family-oriented interventions for pediatric ABI rehabilitation, few meta-analytic studies have been conducted to quantitatively synthesize the existing evidence. Most published meta-evidence for positive effects of family intervention has come from qualitative synthesis via systematic or scoping reviews rather than from quantitative analyses of aggregated effect sizes (Brown, Whittingham, Sofronoff, & Boyd, 2013; Cole, Paulos, Cole, & Tankard, 2009; Laatsch et al., 2020). For the few published reviews utilizing meta-analytic approaches, studies have either focused on a specific intervention program (Wade et al., 2018) or have limited analysis for pediatric patients with ABI (Spencer, Topham, & King, 2020). Moreover, no study has examined the factors that moderate the effectiveness of family-oriented intervention on ABI. Knowing why some intervention programs are more effective than others for certain subpopulations would provide valuable information to design individualized and more precise interventions in the future. The aim of this study was to address the need for a broader systematic review and meta-analysis to examine the effects of family-oriented rehabilitation programs on child and parent outcomes across different domains (child outcomes, parental outcomes, and family functioning outcomes) among pediatric patients with ABI. We also conducted exploratory moderation analyses to examine eight potential moderators of the magnitude of effect sizes, including five sample characteristic variables (age, age at injury, sex, type of ABI, and injury severity) and three methodological variables (outcome domain, study design, and intervention modality).

1. Method

1.1. Transparency and openness

PRISMA Guidelines were followed when conducting this systematic review (Moher, Altman, Liberati, & Tetzlaff, 2011). Raw data, analysis code, and other research protocol materials are available upon request by emailing the corresponding author. This study's protocol was not preregistered.

1.2. Search strategy

A total of six databases were searched, including PsycINFO, PsycARTICLES, Scopus, Web of Science, Pubmed (Medline), and Cochrane CENTRAL (The Cochrane Central Register of Controlled Trials). The following search terms were used for all databases searches: (parenting OR parent? OR parenthood OR child-rearing OR family) AND (brain injur* OR brain tumor? OR brain tumor? OR TBI OR ABI OR stroke OR hypoxia). Additional literature search methods were used to supplement these search results, including reaching out to prominent authors in the field, reviewing co-authors' libraries and professional networks, and following references in relevant articles (backward search), articles that cited relevant articles (forward search), conference presentations, and books when applicable. All database searches were limited to peer-reviewed articles published and indexed before May 25, 2022).

1.3. Inclusion and exclusion criteria

To be considered for inclusion in the meta-analysis, studies had to meet the following criteria: (1) The study sample comprised children and adolescents <18 years old. (2) At least a portion of the study sample comprised children with some type of ABI, as long as the data from the ABI group could be extracted independently from the non-ABI data. (3) Studies could involve any type of interventional research designs, including randomized controlled trials (RCTs), observational studies using case-control designs, and uncontrolled before-after designs. (4) Studies should have a sample size of at least 10 in any treatment arm. (5) Interventions must include a training component for family members, such as parents or caregivers. (6) Studies include efficacy data related to overall family functioning, and/or related to outcomes in at least one of the three domains: cognitive, behavioral, emotional, for pediatric patients with ABI and their parents. (7) Studies could originate from any region of the world published in any language. However, by nature of the keyword searching process, articles published in languages other than English had to include a translated title and/or abstract in the searched databases to appear in the search results. Moreover, non-English articles for which we were unable to locate suitable translators to assist in determining study characteristics and findings were not included for review.

1.4. Title and abstract screening

As detailed in Fig. 1, a total of 41,854 entries were identified following the initial database literature search, which resulted in 31,910 entries for the title and abstract screening stage after 9944 duplicates were removed. During this stage, two researchers reviewed the title and abstract of each entry and independently determined whether each entry should be included or excluded for the next stage according to the inclusion and exclusion criteria of this project. Strong interrater agreement (average proportionate agreement across reviewers = 0.93) was found for this stage and conflicts were resolved by one of the senior authors (JS, SZ). A total of 31,789 entries were excluded at this stage.

1.5. Full-text screening

Following the title/abstract screening, a total of 121 entries proceeded to the full-text screening stage. During this step, we attempted to retrieve the full text of all included entries from institutional library systems first. If the full text was not available at any of the co-authors' institutions, interlibrary loan requests were made. For those entries that we were unable to locate by either method, email requests were sent to the listed corresponding authors. As a result, 11 entries were excluded due to a lack of available full-text documents for further review. Next, as in the abstract/title screening stage, two researchers independently reviewed and voted on each retrieved full text based on the inclusion and exclusion criteria, with a strong inter-rater agreement (average proportionate agreement across reviewers = 0.96). Similarly, conflicts were resolved by one of the senior authors (JS, SZ). A total of 84 entries

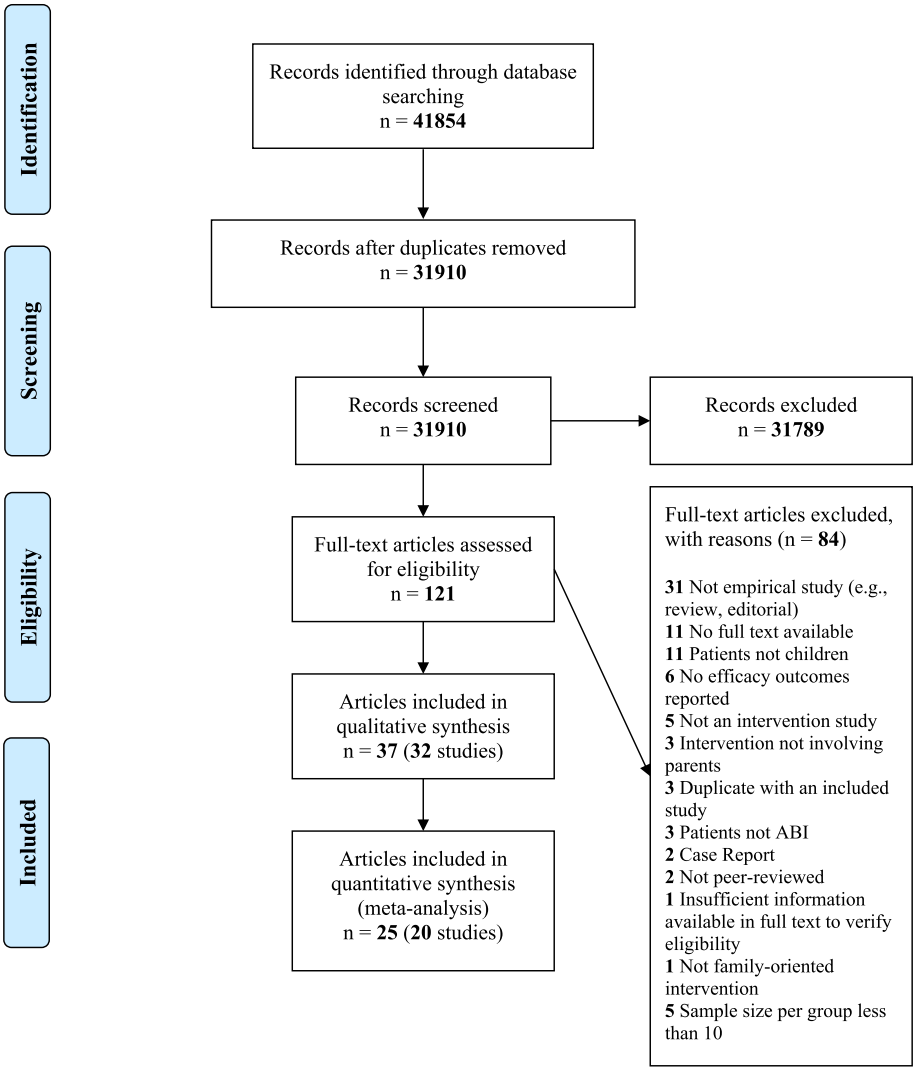

Fig. 1. PRISMA flow diagram and included studies.

were excluded at this stage, including 11 for missing full texts and the others with various exclusions reasons as listed in Fig. 1. Both the title/abstract and full-text screening stages were completed using the Covidence Systematic Review Software (Veritas Health Innovation, 2020).

1.6. Data extraction for synthesis

A standardized data extraction form was created by the senior authors to extract relevant data from the entries retained from the full-text screening stage for qualitative synthesis. The qualitative sections of the data extraction form included information regarding title, author list, journal, year of publication, the country where the study was conducted, sample size, sex ratio, descriptive statistics for age, outcome domain and measurement, and study design.

To aid in conducting a meta-analysis of the efficacy of family-oriented interventions for children with ABI, the quantitative sections of the data extraction form sought numerical data regarding the intervention efficacies as reported within each included study, which included calculated effect sizes, means and standard deviations for outcomes of interest, and/or other reported statistics that can be used to compute effect size statistics. For studies that did not report sufficient data to compute effect sizes for the present meta-analysis, extensive efforts were made to contact corresponding authors of those articles to request either computed statistics or raw data. Studies that were otherwise eligible for inclusion but lack sufficient quantitative data for effect size calculations – presented in one of the 100 data formats provided by software CMA3.0 – were excluded from the quantitative synthesis (after attempts to retrieve data from corresponding authors, if data were not available in published reports), but were still included in the qualitative synthesis.

Similar to earlier steps, all data extraction was performed by two independent co-authors with disagreement resolved by discussion among the coders and senior co-authors in regular project meetings. The number and characteristics of studies eligible for data extraction was performed are reported in detail in the Results section.

1.7. Types of outcomes

Primary outcomes in the included studies were systematically reviewed by the senior authors of the study to categorize them. The following seven outcome domains were identified upon review and were agreed upon by all co-authors: three for parent outcomes (parent cognition, parent emotion, parent behavior), three for child outcomes (child cognition, child emotion, child behavior), and one for child-parent interactions (family functioning). While there are no consensus in the literature on a singular definition of cognition, emotion, or behavior, present review conceptualized *cognition* as a group of hierarchical brain functions that are related to the nature of knowing,

learning, and motivational engagement such as perception, attention, memory, language, and executive functions (Greeno, Collins, & Resnick, 1996; Harvey, 2022; Posner, 1973); *emotion* as all forms of experiential and reactive mental state of feeling, arousal, or affection at any level of intensity (Barrett, Mesquita, Ochsner, & Gross, 2007; Cabanac, 2002; Cacioppo & Gardner, 1999; Keltner & Lerner, 2010; Lindsley, 1951); and finally, *behavior* as any type of objectively observable physical movement or action in response to internal or external environmental agents (Chance, 2013; Funder & Ozer, 1983; Hagger, Cameron, Hamilton, Hankonen, & Lintunen, 2020; Hull, 1943; Merleau-Ponty & Wild, 1963). Note that the three "parental" outcomes referred to parent self-reports of their cognition, emotion, and behavior (e.g., parenting knowledge or behavior or parents' emotional problems).

When data were available from multiple measures for a single outcome domain, a "primary measure" and its effect size was selected for inclusion in the meta-analysis. Considerations made in selecting this measure were based on the comprehensiveness and commonality of the selected outcome measures across the included studies and in the general literature. These considerations involved preference for comprehensive measures to assess the target outcome over a narrowly-scoped measure for the same target outcome and for measures that were more commonly used among all included studies. The detailed information regarding measures used for effect size computation from each included study is included in the online supplementary materials.

1.8. Risk of bias assessment

The risk of biases at the individual study level was assessed using the guidelines specified in the Cochrane Handbook for Systematic Reviews of Interventions (Higgins et al., 2019). Specifically, the following five domains of potential biases were rated as high risk, unclear risk, or low risk: random sequence generation (selection bias), allocation concealment (selection bias), masking of outcome assessment, incomplete outcome data, and selective reporting. Masking of interventional treatment was not included in this assessment due to the nature of behavioral interventions, which, unlike pharmacological drug treatment, are usually unable to be masked from participants or research staff. Risk of bias assessment was performed by two co-authors and verified by one of the senior co-authors. Publication bias was assessed using the funnel plot and Egger's Test of the Intercept. Risk of potential p-hacking was assessed by conducting p-curve analysis on the child, parent, and family functioning outcomes, respectively.

1.9. Data analysis plan

First, descriptive characteristics from each eligible study were extracted and summarized in Table 1, with distribution percentages calculated and reported in the first part of the Results section. Second, meta-analytic assessments of the effect of family-oriented interventions were performed on outcomes for child, parental, and family, respectively. For each study, Hedge's g was computed for applicable outcomes respectively. Hedge's g was chosen as an unbiased version of Cohen's d and can be similarly interpreted using the following criteria regarding the size of interventional effects: small (0.20–0.49), medium (0.50–0.79), and large (>0.80). As some studies reported multiple effect sizes from the same sample (i.e., both child behavioral outcome and child emotional outcome), some effect sizes obtained may not be independent. We applied robust variance estimation (RVE) technique to address the interdependence between effect sizes (Hedges, Tipton, & Johnson, 2010) and applied the small-sample corrections (Tipton, 2015). The RVE approach adjusts the standard error without requiring information on correlations between effect sizes and can be applied to any types of dependence and any types of effect sizes (Moeyaert et al., 2017). The overall effect sizes were estimated using random-effect models to account for potential between-study heterogeneity, with weighting applied to all studies according to respective sample sizes (Lipsey & Wilson, 2001; Schwebel et al., 2014; Shen et al., 2017; Stavrinos, Pope, Shen, & Schwebel, 2018). These effect sizes can be interpreted as the overall efficacy of family-oriented interventions in changing children's post-injury outcomes in various domains for the pediatric patient population across all applicable studies.

The heterogeneity was estimated using I^2 statistics, which is defined as the percentage of variance due to heterogeneity in the total variance (Higgins & Thompson, 2002). In light of the heterogeneity, moderating effects of outcome domains (behavioral, emotional and cognitive), age (mean sample age), age at injury (mean for the sample), sex (% female), TBI severity (mild, moderate, or severe), Type of ABI (TBI-only or non-TBI), study design (RCT or non-RCT), and intervention modality (online or in-person) were examined using meta-regression analysis for child, parent, and family outcomes, respectively. The TBI severity was defined based on Glasgow Coma Scale (GCS) according to the following criteria (Teasdale & Jennett, 1974): severe (GCS score of 8 or less), moderate (GCS score of 9 to 12), and mild (GCS score of 13 to15). For all categorical variables, dummy coding was applied when conducting the meta-regression analysis, where a series of dichotomous variables (variables that have a value of only 0 or 1) was created to represent different levels of a categorical variable (Hardy, 1993). Each regression model with its unique combination of available samples from respective outcomes and the moderator under investigation, was examined for its statistical power before proceeding with meta-regression analysis. As a result, meta-regression models with insufficient sample sizes were excluded from the analyses.

The study-level effect sizes were calculated using the software Comprehensive Meta-Analysis Version 3 (Borenstein, Hedges, Higgins, & Rothstein, 2013). All meta-analyses, including the meta-regressions, were conducted in R with the *robumeta* package using RVE approach with the small sample size correction (Fisher & Tipton, 2015).

2. Results

2.1. Basic characteristics of the included studies

A total of 32 studies (reported in 37 articles) met our inclusion criteria and were included in Table 1**, which** summarizes the basic characteristics of the included studies with more details for each article available in the supplemental materials (including study design, sample characteristics, comparison group choice for interpreting individual effect sizes). Distribution of the study characteristics across the included studies were calculated as percentages and reported below:

2.1.1. Sample characteristics

Data were collected in seven nations, with 21 of 32 conducted within the USA. Child participants ranged in age from 0 to 18 years. Thirty-one studies reported participant ages that had a range spanning across multiple developmental periods. Twenty-seven studies reported the percentage of girls in samples, ranging from 0% (Woods et al., 2014b) to 57% (Narad et al., 2015).

2.1.2. Study design

Of the 32 included studies, the majority (22/32) were RCTs. There were also six non-randomized studies with comparison groups, and four that used a non-randomized pre-post design.

2.1.3. Type of intervention

The most common primary interventions used (with some variations) were the I-InTERACT program (5/32) and the Counselor-Assisted Problem-Solving program (CAPS; 5/32;). The most used intervention for comparison groups (with some variations) was the Internet Resources Comparison (IRC; 16/32).

2.1.4. Type of outcomes

Twenty-one studies (65.6%) measured child outcomes, among which

Table 1
Characteristics of Studies Included in the Meta-Analysis.

Author(s), year	Overall Sample	Primary Intervention	Comparison / Control	Intervention description	Comparison groups	Methodology and procedure	Outcomes	Country
	N, M (SD) age in yrs, range in yrs, % female							
* Aguilar et al., 2019	N/A	39, 5.1 (2.1), 33%	36, 5.3(2.1), 42% 38, 5.7 (2.3), 42%	I-InTERACT	I-InTERACT Express IRC	RCT; follow-up at 6-months post-intervention.	Child outcomes: executive functions; internalizing problems	USA
* Antonini et al., 2014	N/A	20, 5.6(2.09), 30% (Groups1 and 2 combined)	20, 5.24 (2.14), 35% (Groups3 and 4 combined)	Group 1: I-InTERACT (low income) Group 2: I-InTERACT (high income)	Group 3: IRC (low income) Group 4: IRC (high income)	RCT; follow-up at around 3 months post-intervention	Child outcomes: child behaviors in parent-child interactions; behavioral problems Parent outcomes: parent behaviors in parent-child interactions	USA
Barakat et al., 2003	12, 10.77 (1.96), 8–14, 30.8%	N/A	N/A	Social Skills Intervention	N/A	Single arm pre and posttest; follow-up at 9 months post-intervention.	Child outcomes: internalizing and externalizing problems; social competence; social skills; problem behaviors; adaptive functioning	USA
* Baron Nelson et al., 2018	39, 9.74 (5.31)	19, 10.22(5.04)	20, 9.25(5.57)	Families with Veteran Parent	Families without Veteran Parent	Quasi experiment study; follow up immediately after intervention.	Parent outcomes: health-related quality of life; resilience Family functioning	USA
Braga, 2006	87, range 5–12	44, 97.66 mo (29.61mo)	43, 96.95mo (30.30mo)	Indirect Family-Supported Treatment	Direct, Clinician-Delivered Treatment	RCT; follow-up at 12 months post-intervention.	Child outcomes: cognitive function; physical and functional abilities	Brazil
* Braga et al., 2005	87 (72 retained), 8.12(2.5), 5–12, 45.83%	38, 8.14(2.47), 5–12, 47.37%	34, 8.08(2.53), 5–12, 44.12%	Indirect Family-Supported Treatment	Clinician-delivered treatment	RCT; follow-up at 12-months post-intervention	Child outcomes: physical functioning; cognitive functioning	Brazil
[a] * Brown et al., 2014, 2015a, 2015b	N/A	30 parents, M age: 38.87 (6.36), child age M 7.13(3.17), 43%	29 parents (M age 39.42, SD 5.95), child age M 6.87(3.03), 38%	10-week group SSTP and ACT program	Usual Care	RCT; follow up immediately after intervention and at 6 months post intervention (part of measures).	Child outcomes: behavioral and emotional problems Parent outcomes: parent and family adjustment; relationship adjustment; dysfunctional parenting styles; parenting confidence; psychological flexibility	Australia
* Chavez Arana et al., 2020	71, 43.66%	35, 9.4 (2.2)	36, 9.3(2.1)	Signposts	Telephone support group	RCT; follow-up immediately after intervention and at 3 months post intervention.	Child outcomes: disruptive behaviors at home and school; executive function; Parent outcomes: dysfunctional practices; self-efficacy; stress	Mexico
Dias et al., 2017	1,593,834, 0	N/A	N/A	PHC4: 0–11 months PHC4: 12–23 months	HCUP: 0–11 months HCUP: 12–23 months	Quasi experimental study; follow-up at 7 months post intervention.	Parent outcomes: parent learning about Shaken Baby Syndrome	USA
Epstein et al., 2021	35, 0.52 (0.04), >32 weeks, 40%	N/A	N/A	Skin-to-skin contact (SSC) with music therapy (MT)	N/A	Quasi experiment study	Child outcomes: infant behavioral states Parent outcomes: maternal anxiety	Israel
* Hickey et al., 2018	47, 9.3(5.4), 0–18, 42.55%	25, 10.1(5.2), 0–18, 44%	22, 8.5(5.6), 0–18, 40.90%	Family Forward	Usual Care	Quasi experiment study; follow-up at 6-weeks post-discharge.	Family functioning: Family functioning, family management	Australia and New Zealand
Jimenez et al., 2021	14, 9.7, 0–17 years, 42%	N/A	N/A	BEIN	N/A	Single arm pre and posttest; follow ups at 3-, 6-, and 12-months post-baseline	Child outcomes: physical, emotional, and social health-related quality of life, physical and social functioning. Parent outcomes: caregiver self-efficacy and health literacy.	USA
[c]* Kurowski et al., 2014	131, 14.55, 12–17, 34.4%	65, 14.4 (1.7),12–17, 32%	66, 14.7(1.8), 12–17, 36%	CAPS	IRC	RCT; follow up at 6-, 12- and 18-months post-intervention.	Child outcomes: executive function	USA

(*continued on next page*)

Table 1 (*continued*)

Author(s), year	Overall Sample	Primary Intervention	Comparison / Control	Intervention description	Comparison groups	Methodology and procedure	Outcomes	Country
	N, M (SD) age in yrs, range in yrs, % female							
[d] * Kurowski et al., 2020	150, 16.5 (1.1), 36%	34, 16.7(1.4), 41.2% 56, 16.4(1.5), 32.1%	60, 16.4(1.5), 36.7%	F-PST Therapist-guided online F-PST	Self-guided online F-PST	RCT; follow up at 6- and 9-months post-intervention	Child outcomes: executive function, internalizing and externalizing problems.	USA
McDougall et al., 2006	N/A	64, 11 (<4), 29 (4–11 yr), 24 (12–18 yr), 31.3% (Groups 1 and 2 combined)	Group 3: 32, 1 (<4), 13 (4–11 yr), 18 (12–18 yr), 21.9%	Group1: PABICOP (>10 contacts) Group2: PABICOP (<10 contacts)	Group 3: Usual Care	Quasi experiment study; followed up at 3- and 15-months post-intervention.	Child outcomes: internalizing and externalizing problems Parent outcomes: knowledge of ABI; Empowerment Family functioning: Injury-related burdens	Canada
* Mortenson et al., 2016	66, 12.25, 5–16, 30.3%	32, 11.9, 6.3–16.5 , 25%	34, 12.6, 5.2–16.8, 35.29%	Telephone counseling	Usual Care	RCT; follow up at 3-months post-injury for both groups and at 1 week and 1-month post injury for intervention group only.	Child outcomes: concussion symptoms change score Family functioning: Injury-related burdens	Canada
Narad et al., 2015	132, 14.83 (1.73), 12–17, 57%	65,14.68 (1.68), 12–17, 56%	67, 14.98 (1.78), 12–17, 58%	CAPS	IRC	RCT; follow up at 6, 12, and 18-months post-intervention.	Family functioning: parent-teen conflict; problem-solving; effective communication	USA
Narad et al., 2019	152, 14.87 (2.05), 11–18, 29.6%	49, 14.72(2.08), 11–18, 28.60%	51, 14.77 (1.95), 11–18, 31.40% 52, 15.11(2.11), 11–18, 28.8%	TOPS - Family	TOPS - Teens Only IRC	RCT; follow up 6-months post-intervention.	Parent outcomes: depression; distress Family functioning: global family functioning; parent-adolescent conflict; family cohesion	USA
* Petranovich et al., 2015	132, 14.84, 12–17, 34.9%	65, 14.7 (1.7),12–17, 32%	67, 14.99(1.76), 12–17, 37%	CAPS	IRC	RCT; follow up at 6-, 12- and 18-months post-intervention.	Parent outcomes: depression, distress, self-efficacy	USA
* Raj et al., 2015	37, 5.43 (2.11), 3–9, 32.5%	20, 5.6 (2.09), 3–9, 30%	17, 5.24 (2.14), 3–9, 35%	I-InTERACT	IRC	RCT; follow up at 6-months post-intervention.	Parent outcomes: distress; depression; stress; perceived parenting efficacy	USA
* Raj et al., 2018a	N/A	39,6.15(1.99), 33.3%	36, 6.16(2.07), 41.7% 38, 6.58(1.83), 42.1%	I-InTERACT	I-InTERACT Express IRC	RCT; follow up 6 months post-intervention.	Parent outcomes: parenting efficacy; psychological distress; depression; stress	USA
[b] * Raj et al., 2018b	132, 14.47 (1.62), 12–17, 67%	21,14.29(1.48), 28.57% 42,14.86(1.75), 33.33%	26, 15.02(1.75), 38.46% 40, 15.01(1.81), 37.50%	CAPS - single family CAPS – married family	IRC-single family IRC-married family	RCT; follow up at 6-, 12-, and 18-months post-intervention.	Child outcomes: adolescent functioning across 8 domains; adolescent mood and behavior	USA
[c] * Tlustos et al. 2016	132, 14.5 (1.7), 11–18, 35%	65, 14.4 (1.7),11–18, 32%	67, 14.7 (1.8),11–18, 37%	CAPS	IRC	RCT; follow up at 6-months post-intervention.	Child outcomes: executive function	USA
Wade et al., 2006a	45, 10.84 (3.1), 5–16, 37.8%	25,10.92(2.45), 46%	20, 11(3.93), 40%	FPS	IRC	RCT; follow-up at 8 weeks post-intervention.	Parent outcomes: problem solving skills; depression; anxiety; global psychiatric symptoms	USA
* Wade et al., 2006b	40, 11(3.27), 5–16, 42.5%	20,10.92(2.45), 45%	20, 11(3.93), 40%	FPS	IRC	RCT; follow-up at 8 weeks post-intervention	Child outcomes: internalizing and externalizing problems; interactions with peers; self-management/ compliance; social competence	USA
* Wade et al., 2006c	32, 10.83 (2.94), 5–16, 34.4%	16, 10.94(2.62), 37.5%	16, 10.72(3.31), 31.2%	FPS	Usual Care	RCT; follow-up at 6 months post-intervention.	Child outcomes: internalizing and externalizing behaviors Parent outcomes: depression and anxiety; Family functioning: parent-child conflicts	USA
* Wade et al., 2010	41	20, 14.02 (2.45), 62%	21, 14.49 (2.13), 42%	TOPS	IRC	RCT; follow up at 8-months post-intervention	Child outcomes: executive functioning	USA
Wade et al., 2012	41, 13.56, 11–18	20, 13.46(2.82), 11–18	21, 13.66(2.22), 11–18	TOPS	IRC		Parent outcomes: depression; distress	USA

(*continued on next page*)

Table 1 (*continued*)

Author(s), year	Overall Sample	Primary Intervention	Comparison / Control	Intervention description	Comparison groups	Methodology and procedure	Outcomes	Country
	N, M (SD) age in yrs, range in yrs, % female							
						RCT; follow up at 6-months post-intervention.	social problems solving skills	
* Wade et al., 2014	132, 14.53 weighted average	67, 14.96	65, 14.7	CAPS	IRC	RCT; follow-up a 6 months post-intervention.	Parent outcomes: caregiving efficacy; depression and stress	USA
[b] * Wade et al., 2015	132, 14.85, 12–17, 34.85%	65, 14.73, 32.31%	67, 14.97, 37.31%	CAPS	IRC	RCT; follow-ups at 6-, 12-, 18-, and 24-months -post-intervention.	Child outcomes: internalizing and externalizing problems	USA
* Wade et al., 2017	113, 5.4 (2.2), 3–9, 39%	39	36 38	I-InTERACT	I-InTERACT Express IRC	RCT; follow-ups at 3- and 6-months post-intervention.	Child outcomes: child behavioral problems Parent outcomes: positive/negative parenting behaviors	USA
* Wade et al., 2018	152, 14.87, 11–18, 29.61%	49, 14.7(2.1), 29%	51, 14.8(2), 31% 52, 15.1(2.1), 29%	TOPS-Family	TOPS-Teen only IRC	Single arm pre and posttest; follow-up at 6-months post-intervention.	Child outcomes: externalizing problems; executive functioning	USA
[d] * Wade et al., 2019	150, 16.5 (1.1), 36%	34, 16.7(1.4), 41.2% 56, 16.4(1.5), 32.1%	60, 16.4(1.5), 36.7%	F-PST Therapist-guided online F-PST	Self-guided online F-PST	RCT; follow up at 6- and 15- months post-intervention.	Parent outcomes: depression; distress	USA
Woods et al., 2014a	31	9, 8.67(2.1), 33% 22, 8.18(2.1), 50%	N/A	Signposts	N/A	Single arm pre and posttest; Follow-up at 1-, 6- and 18-months post-intervention.	Child outcomes: internalizing and externalizing problems Parent outcomes: parenting styles; parental function Family functioning	Australia
Woods et al., 2014b	48, 8.45, 3–12, 39.58%	6, 8(2.82), 0% 19, 9(2), 57.9%	14, 8.14(2.14), 42.9% 9, 8.67(2.17), 22.2%	Signposts Telephone Support (CBCL ≥ 60) Signposts Telephone Support (CBCL<60)	Signposts Group support (CBCL ≥60) Signposts Group support (CBCL <60)	Quasi experiment study; follow-up at 1-month post-intervention.	Child outcomes: internalizing and externalizing behaviors Parent outcomes: parenting style; distress Family functioning	Australia

Note. IRC – Internet Resource Control; PABICOP = Pediatric acquired brain injury community outreach programme; CAPS = Counselor-Assisted Problem-Solving; FPS = Online Family Problem Solving; PHC4 = Pennsylvania Healthcare Cost Containment Council; HCUP = Healthcare Cost and Utilization Project; BrainSTARS = Brain Injury: Strategies for Teams and *Re*-education for Students; BEIN = Brain Injury Education and Navigation; F-PST = Face-to-face Family Problem Solving Therapy; TOPS = Teen Online Problem Solving.

* indicates studies included in the quantitative analysis.

Superscripts indicate that studies were merged: [a]Brown et al. (2014), [a]Brown et al. (2015a), and [a]Brown et al. (2015b); [b]Raj et al. (2018) and [b]Wade et al. (2015); [c]Kurowski et al. (2014) and [c]Tlustos et al. (2016); [d]Kurowski et al. (2020) and [d]Wade et al. (2019).

eight reported on child cognition, 11 on child emotion, and 18 on child behaviors. The most common measurement tools for child cognition, emotion, and behavior were BRIEF2, Child Behavior Checklist Internalizing Problems Scale, and the Child Behavior Checklist Externalizing Problems Scale, respectively. A total of 20 (62.5%) studies assessed parental outcomes, among which nine reported data related to parent cognition, 13 for parent emotion, and eight for parent behaviors. The most common measurement tools for parent cognition, emotion, and behavior were the Caregiver Self-Efficacy Scale, Center for Epidemiologic Studies Depression scale, and Parenting Scale, respectively. Finally, nine studies (27.3%) included measures of family functioning, for which the Family Assessment Device was the most commonly used assessment tool.

2.2. Meta-analysis: Overall interventional effect on outcomes

Twenty studies were qualified for the meta-analysis. Meta-analysis of the overall effect (all domains combined) of family-oriented interventions on pediatric ABI rehabilitation was conducted for child outcome (Fig. 2), parental outcome (Fig. 3), and family functioning (Fig. 4), respectively. Specifically, for child outcome (14 studies, 24 effect sizes), the results indicated a small to medium effect ($g = 0.43$, $SE = 0.15$, $t = 2.86$, $p = .014$, *95% CI* = [0.11, 0.76], $N = 1145$). This suggests that family-oriented interventions can exert a small-to-medium and statistically significant positive effect on pediatric patients' overall outcomes following ABI.

Similarly, for the parental outcomes (11 studies, 19 effect sizes), the results indicated a small to medium effect ($g = 0.45$, $SE = 0.13$, $t = 3.48$, $p = .006$, *95% CI* = [0.16, 0.74], $N = 931$). This suggests that family-oriented interventions can exert a small-to-medium significant positive effect on patient parents' overall outcome following their children's ABI, which is similar to the interventional effect on child outcomes.

Unlike the other outcomes, for family functioning (5 studies, 5 effect sizes), the results indicated that family-oriented interventions exerted no significant impact on family functioning ($g = -0.04$, $SE = 0.23$, $t = -0.16$, $p = .88$, *95% CI* = [−0.49, 0.42], $N = 243$).

The heterogeneity indicator I^2 was 84.47% for child outcomes, 76.15% for parent outcomes, and 68.55% for family functioning outcomes. The high levels of heterogeneity suggest the need of conducting moderator analyses to account for the variations.

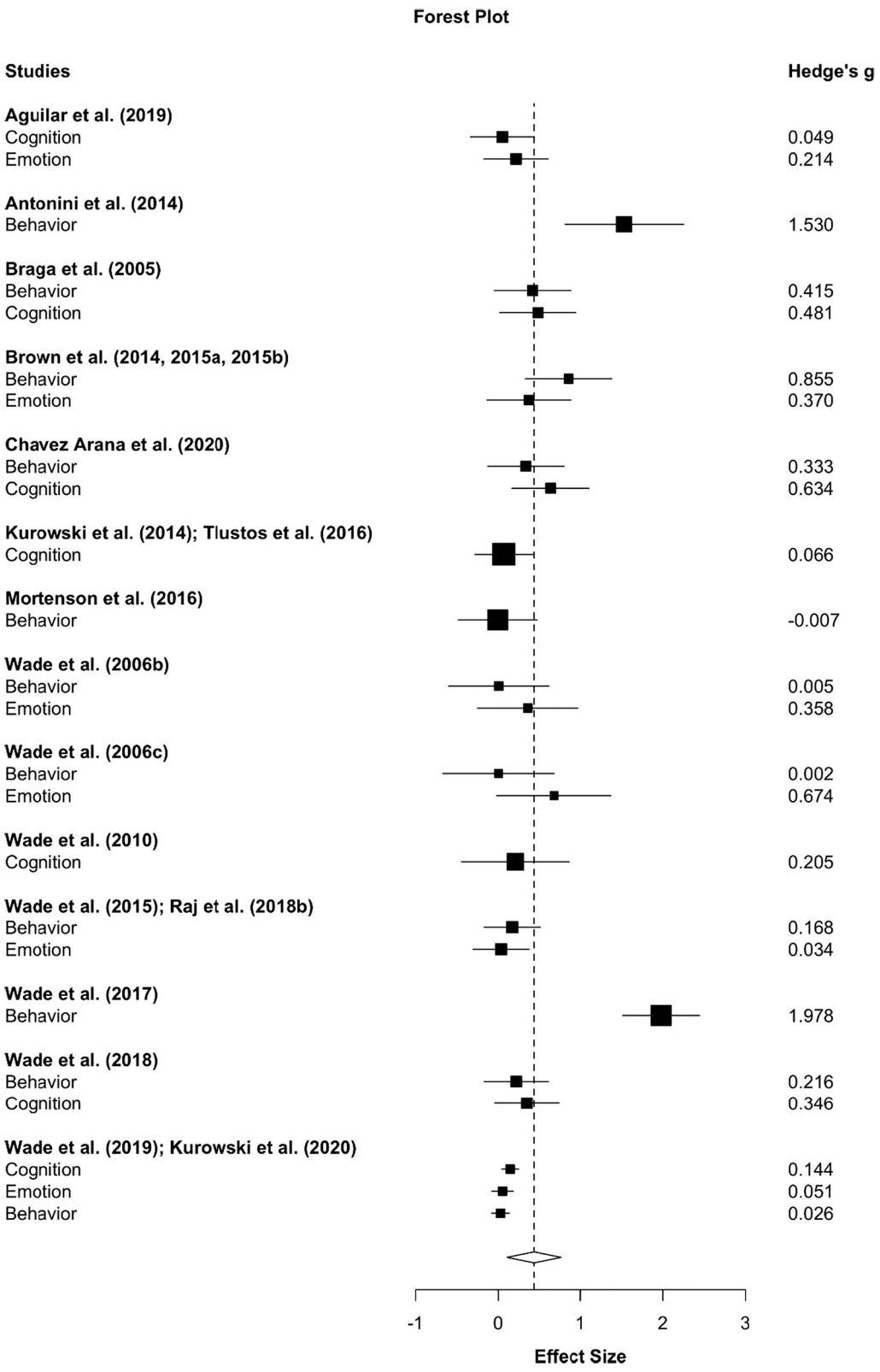

Fig. 2. Forest Plots for Overall Effects of Family-oriented Interventions on Child Outcomes.

2.3. Meta-analysis: Moderator analysis

Table 2 presents the detailed information of effect sizes and moderators in each included study and Table 3 presents results meta-regression models examining moderators on intervention effects, which revealed moderating effects of outcome domains, age of participants, age at injury, sex, type of ABI, severity, study design, and intervention type, separately for child outcomes and parent outcomes. There were not enough data for moderator analysis in family functioning outcomes. No cross-domain differences between behavioral, emotional, and cognitive outcomes in children and parents were found. Age of participants, age at injury, sex, TBI severity, type of ABI, and

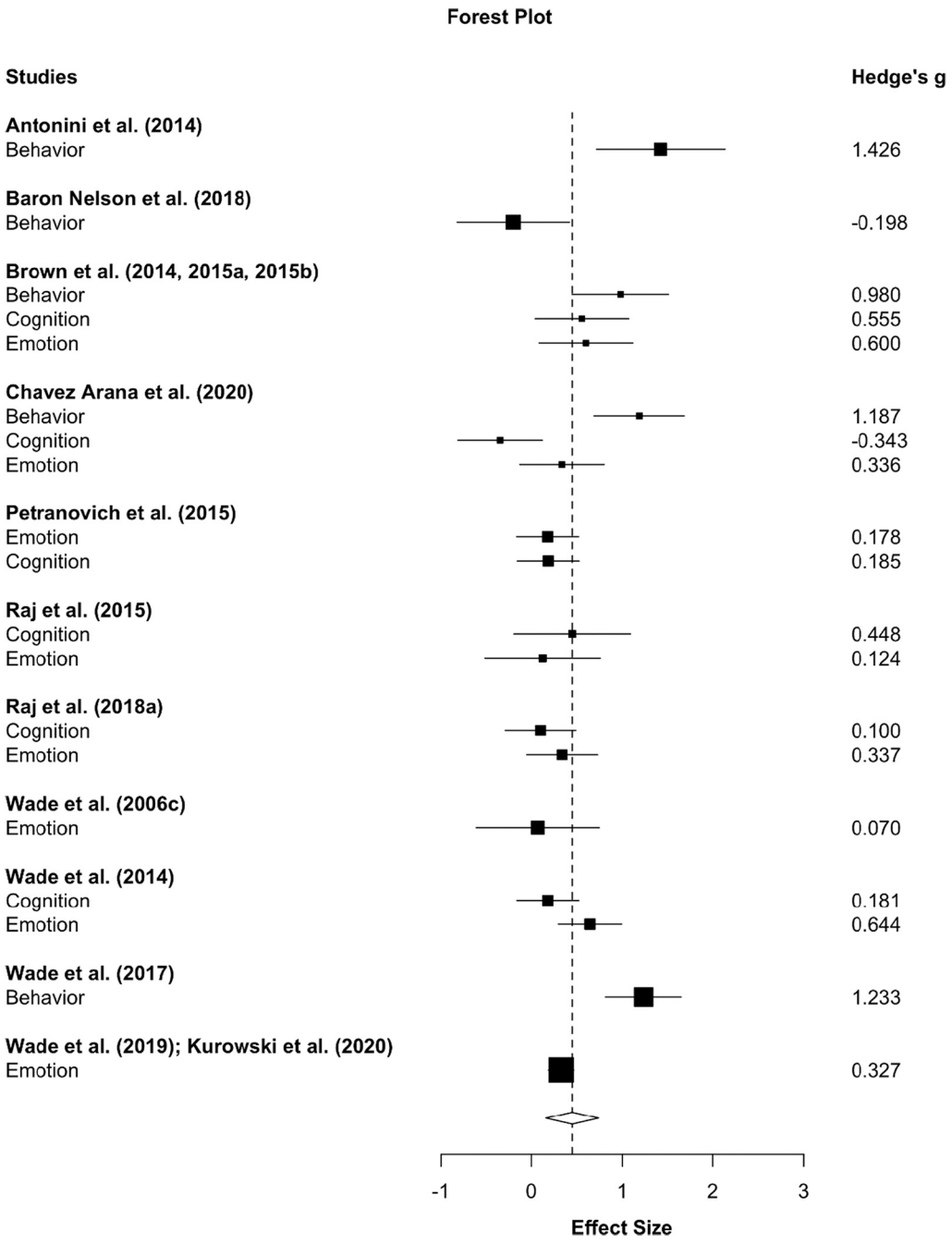

Fig. 3. Forest Plots for Overall Effects of Family-oriented Interventions on Parent Outcomes.

intervention type did not moderate the intervention effects (models only run when sufficient sample sizes were provided). The study design moderated the effects among parent outcomes. More specifically, family-oriented interventions promoted more beneficial parental outcomes in studies that adopted an RCT design.

2.4. The risk of bias

The risk of bias for studies included in the systematic review was rated based on five criteria as described in the Methods section. Ratings for each included studies appear in Table 4. For selection bias in random sequence generation, three articles provided insufficient information while five articles were rated as high risk. For selection bias in allocation concealment, six articles provided insufficient information while 13 articles were rated as high risk. For blinding of outcome assessment (detection bias), 11 articles provided insufficient information while 8 articles were rated as high risk. For incomplete outcome data (attrition bias), two articles provided insufficient information while six articles were rated as high risk. Finally, for selective reporting (reporting bias), one article provided insufficient information while three articles were rated as high risk. Furthermore, examination of the funnel plot (see supplemental materials) and the Egger's test ($t(19) = 1.08$, $p = .29$) failed to detect a significant publication bias among the included studies for the meta-analysis. P-curve analysis on the child and parent outcomes found no evidence of potential p-hacking, as suggested by evidential value present as yes and right-skewness test being significant ($p < .001$) for the half curve on both outcomes per p-curve interpretation guidelines recommended by Simonsohn, Simmons, & Nelson (2015). P-curve analysis for the family functioning outcome was not able to be conducted due to the fact that there were fewer than 2 significant results

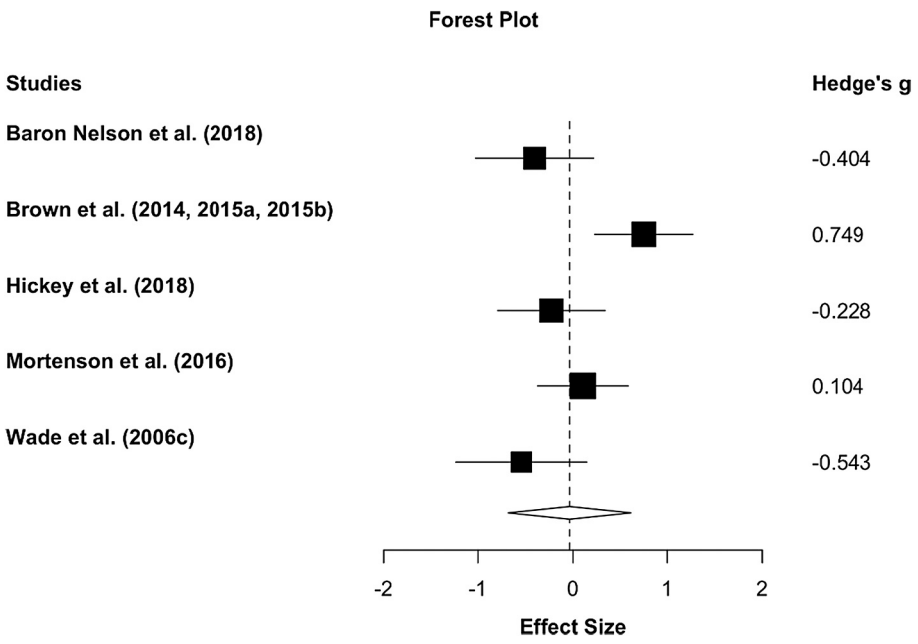

Fig. 4. Forest Plots for Overall Effects of Family-oriented Interventions on Family Functioning Outcomes.

under this outcome domain. Detailed statistics of the p-curve analyses can be found the supplementary resources.

3. Discussion

The present paper conducted a systematic review of 32 studies (reported in 37 articles) on the efficacy of family-oriented interventions for families of children (<18 years old) with mild, moderate, and/or severe TBI. Most reviewed studies adopted an RCT design. The I-InTERACT program was the most commonly implemented intervention, followed by Counselor-Assisted Problem-Solving, Signposts, and Teen Online Problem-Solving programs. Outcomes measured in included studies were child outcomes in the cognitive, emotional, and behavioral domains, parental cognitive, emotional, and behavioral outcomes, and family functioning.

We also conducted a quantitative meta-analysis and meta-regression analysis to examine the aggregate effect sizes and impactful moderators of family-oriented interventions. Findings from these analyses revealed small-to-medium positive effects of family-oriented interventions on child and parental outcomes with combined domains across cognition, emotion, and behavior. This finding is considered consistent with the intended goals of family-oriented interventions to provide a more holistic rehabilitation strategy that not only targets the pediatric patient's own struggles after suffering a TBI but also mobilizes other family members, particularly parents/caregivers, to create a more supportive home environment for the child to recover (Brown, Whittingham, Boyd, & Sofronoff, 2013; Kinsella, Ong, Murtagh, Prior, & Sawyer, 1999; Wade et al., 2008).

Interestingly, the present study found that the existing family-oriented interventions seemed to exert little influence on improving overall family functioning as measured by dedicated assessment tools such as Family Assessment Device (Mansfield, Keitner, & Dealy, 2015). One possible explanation might be that current family-oriented interventions largely focused on training *individual* family members' cognitive, emotional, and behavioral coping capacity (Narad et al., 2017), but have yet to fully address the interactive mechanisms *between* family members after pediatric TBI. This importance of between-individual dynamics in families of children with TBI has been supported by both theoretical and empirical literature of family functioning and pediatric TBI rehabilitation. Theoretically, the *Family Process Model Theory* asserts that proper family function requires flexible and adaptive interaction among seven dimensions, including task completion, communication, emotional expression, involvement, behavior, shared values, and agreed-upon rules (Dai & Wang, 2015; Skinner, Steinhauer, & Sitarenios, 2000). Empirically, researchers have found that interventional programs focusing on improving family cohesion would likely yield more beneficial outcomes for children with TBI across ethnic populations (Perrin et al., 2013; Rivara et al., 1993).

The meta-regression analyses revealed that only one methodological factor (study design) was a statistically significant moderator of interventional effects. Specifically, our analysis showed that intervention effects on parental behaviors were greater in RCT studies than non-RCT studies. One possible reason for this difference is that RCT designs typically employ rigorous randomization procedures and include parallel comparison/control groups, and post-intervention follow-up assessments, allowing for greater sensitivity in detecting intervention effects (Deaton & Cartwright, 2018; Li et al., 2016; Sibbald & Roland, 1998). However, it should be noted that the lack of significant findings for other moderators cannot be interpreted as suggesting the absence of moderating effects of these factors on the effectiveness of family interventions for our target population. The relatively small number of eligible studies for each of the meta-regression models with these moderators may have contributed to the models' inability to detect significant results due to lack of statistical power. Future research should include these important demographic, clinical, and methodological factors and report them in their publications, as this would enable future meta-analytic studies to re-examine their moderating effects on interventional efficacy (Gould et al., 2021; Lah et al., 2021; Schliep, Alonzo, & Morris, 2017).

Reflecting on both the qualitative and quantitative synthesis of findings from the present meta-analysis, especially in light of results from analyses of moderators, a few general observations are noteworthy in considering further research in the field of family-oriented interventions for pediatric ABI rehabilitation. First, although we categorized study designs into those involving RCTs versus non-RCTs, more contemporary trial design have been increasingly utilized in the field of brain injury research and clinical care practice, such as the multiple-baseline design (Rauwenhoff et al., 2022), step-wedge design (Schliep et al., 2017), and single-case design (Gould et al., 2021; Lah et al., 2021). Our dichotomous categorization reflected the inadequate representation

Table 2
Study-Level Effect Sizes and Moderators for Studies Included in the Meta-Analysis.

Study	Outcome	Effect Size and 95%CI			*Moderators*						
		g	*LL*	*UL*	*Age*	*Age at Injury*	*Sex (% F)*	*ABI Type*	*Severity*	*Study Design*	*Intervention Type*
Aguilar et al. (2019)	*Child Cognition*	0.05	−0.34	0.44	5.36	4.46	38.94	TBI	M/S	RCT	Online
	Child Emotion	0.21	−0.17	0.60	5.36	4.46	38.94	TBI	M/S	RCT	Online
Antonini et al. (2014)	*Child Behavior Parent*	1.53	0.81	2.25	5.43	n/a	32.43	Mixed	M/S	RCT	Offline
	Behavior Family	1.43	0.71	2.14	5.43	n/a	32.43	Mixed	M/S	RCT	Offline
Baron Nelson et al. (2018)	*Function Parent*	−0.40	−1.03	0.22	9.72	6.18	n/a	Mixed	n/a	Non-RCT	Offline
	Behavior	−0.20	−0.82	0.42	9.72	6.18	n/a	Mixed	n/a	Non-RCT	Offline
Braga et al. (2005)	*Child Behavior Child*	0.42	−0.05	0.88	8.12	n/a	45.83	TBI	M/S	RCT	Offline
	Cognition	0.48	0.02	0.95	8.12	n/a	45.83	TBI	M/S	RCT	Offline
Brown et al. (2014, 2015a, 2015b)	*Child Behavior Family*	0.86	0.33	1.38	7	3.62	42.37	Mixed	M/M/S	RCT	Offline
	Function Parent	0.75	0.23	1.27	7	3.62	42.37	Mixed	M/M/S	RCT	Offline
	Behavior Parent	0.98	0.45	1.51	7	3.62	42.37	Mixed	M/M/S	RCT	Offline
	Cognition Parent	0.56	0.04	1.07	7	3.62	42.37	Mixed	M/M/S	RCT	Offline
	Emotion	0.60	0.09	1.12	7	3.62	42.37	Mixed	M/M/S	RCT	Offline
	Child Emotion	0.37	−0.14	0.88	7	3.62	42.37	Mixed	M/M/S	RCT	Offline
Chavez Arana et al. (2020)	*Child Behavior Child*	0.33	−0.13	0.80	9.35	n/a	43.66	Mixed	n/a	RCT	Offline
	Cognition Parent	0.63	0.16	1.11	9.35	n/a	43.66	Mixed	n/a	RCT	Offline
	Behavior Parent	1.19	0.69	1.69	9.35	n/a	43.66	Mixed	n/a	RCT	Offline
	Cognition Parent	−0.34	−0.81	0.12	9.35	n/a	43.66	Mixed	n/a	RCT	Offline
	Emotion Family	0.34	−0.13	0.80	9.35	n/a	43.66	Mixed	n/a	RCT	Offline
Hickey et al. (2018)	*Function*	−0.23	−0.79	0.34	9.3	n/a	42.55	Mixed	n/a	Non-RCT	Offline
Kurowski et al. (2014); Tlustos et al. (2016)	*Child Cognition*	0.07	−0.28	0.42	14.55	14.55	34.4	TBI	M/S	RCT	Online
Mortenson et al. (2016)	*Child Behavior Family*	−0.01	−0.48	0.47	12.25	n/a	30.3	TBI	M	RCT	Online
	Function Parent	0.10	−0.37	0.58	12.25	n/a	30.3	TBI	M	RCT	Online
Petranovich et al. (2015)	*Cognition Parent*	0.18	−0.16	0.52	14.84	n/a	34.9	TBI	M/S	RCT	Online
	Emotion Parent	0.18	−0.16	0.52	14.84	n/a	34.9	TBI	M/S	RCT	Online
Raj et al. (2015)	*Cognition Parent*	0.45	−0.19	1.09	5.43	3.08	32.5	TBI	n/a	RCT	Online
	Emotion Parent	0.12	−0.51	0.76	5.43	3.08	32.5	TBI	n/a	RCT	Online
Raj et al. (2018a)	*Cognition Parent*	0.10	−0.29	0.49	6.3	5.38	39	TBI	M/S	RCT	Online
	Emotion	0.34	−0.05	0.73	6.3	5.38	39	TBI	M/S	RCT	Online
Wade et al. (2006b)	*Child Behavior*	0.01	−0.60	0.61	11	9.86	42.5	TBI	M/S	RCT	Online
	Child Emotion	0.36	−0.25	0.97	11	9.86	42.5	TBI	M/S	RCT	Online
Wade et al. (2006c)	*Child Behavior*	0.00	−0.67	0.68	10.83	n/a	34.4	TBI	M/S	RCT	Offline
	Child Emotion Family	0.67	−0.02	1.37	10.83	n/a	34.4	TBI	M/S	RCT	Offline
	Function Parent	−0.54	−1.23	0.15	10.83	n/a	34.4	TBI	M/S	RCT	Offline
	Emotion Child	0.07	−0.61	0.75	10.83	n/a	34.4	TBI	M/S	RCT	Offline
Wade et al. (2010)	*Cognition Parent*	0.21	−0.45	0.86	14.28	11.90	51.43	TBI	M/S	RCT	Online
Wade et al. (2014)	*Cognition Parent*	0.18	−0.16	0.52	14.53	14.54	n/a	TBI	M/S	RCT	Online
	Emotion	0.64	0.30	0.99	14.53	14.54	n/a	TBI	M/S	RCT	Online
Wade et al. (2015); Raj et al. (2018b)	*Child Behavior*	0.17	−0.17	0.51	14.85	14.53	34.85	TBI	M/S	RCT	Online
	Child Emotion	0.03	−0.31	0.37	14.85	14.53	34.85	TBI	M/S	RCT	Online
Wade et al. (2017)	*Child Behavior Parent*	1.98	1.51	2.44	5.4	4.50	39	TBI	M/S	RCT	Online
	Behavior	1.23	0.81	1.65	5.4	4.50	39	TBI	M/S	RCT	Online
Wade et al. (2018)	*Child Behavior*	0.22	−0.17	0.60	14.87	12.08	29.61	TBI	M/M/S	Non-RCT	Online
		0.35	−0.04	0.74	14.87	12.08	29.61	TBI	M/M/S	Non-RCT	Online

(*continued on next page*)

Table 2 (*continued*)

Study	Outcome	Effect Size and 95%CI			*Moderators*						
		g	*LL*	*UL*	*Age*	*Age at Injury*	*Sex (% F)*	*ABI Type*	*Severity*	*Study Design*	*Intervention Type*
	Child Cognition										
Wade et al. (2019); Kurowski et al. (2020)	*Child Cognition*	0.14	0.04	0.25	16.5	11.90	36	TBI	M/S	RCT	Offline
	Child Emotion	0.05	−0.08	0.18	16.5	11.90	36	TBI	M/S	RCT	Offline
	Child Behavior	0.03	−0.08	0.13	16.5	11.90	36	TBI	M/S	RCT	Offline
	Parent Emotion	0.33	0.19	0.47	16.5	11.90	36	TBI	M/S	RCT	Offline

Note. UL-Upper Limit; LL-Lower Limit; M-Mild TBI only; M/S-Moderate/Severe TBI only; M/M/S- Mild, Moderate, and Severe TBI.

Table 3
Meta-Regression Analysis of Moderating Effects of Demographic, Clinical, and Methodological Covariates on Child, Parental, and Family Functioning Outcomes.

Moderator	Child	Parent	Family Functioning
Outcome domain			
Behavior	0.39 [−0.29, 1.07]	0.72 [−0.17, 1.61]	–
Emotion	0.02 [−0.25, 0.30]	0.14 [−0.12, 0.40]	–
Cognition (ref.)	–	–	–
Age (mean)	−0.09 [−0.19, 0.01]	−0.05 [−0.12, 0.03]	n/a[1]
Age at injury (mean)	−0.08 [−0.23, 0.07]	n/a[1]	n/a[1]
Sex (%female)	−1.47[−6.59, 3.66]	n/a[1]	n/a[1]
Type of ABI			
TBI-only	n/a[1]	−0.15 (−0.97, 0.67)	n/a[1]
Mixed (ref.)	–	–	–
Severity			
Moderate/Sever	n/a[1]	n/a[1]	n/a[1]
Mild only	n/a[1]	n/a[1]	n/a[1]
All levels(ref.)	–	–	–
Study design			
RCT	0.17 (−0.19, 0.52)	**0.70(0.41, 0.99)**	n/a[1]
Non-RCT (ref.)	–	–	–
Intervention Type			
Online	−0.17 (−0.84, 0.49)	0.03 (−0.60, 0.66)	n/a[1]
In-Person (ref.)	–	–	–

Note. **Bolded** coefficients and confidence intervals indicate statistically significant moderating effects.
[1] Insufficient number of studies for meta-regression analysis.

of modern trial designs in this specific research area. Second, remote/online family-oriented interventional programs have received increasing attention. Whereas virtual training has always been important to pediatric patients whose family may have limited access to high-quality care in their local regions, this approach has become more relevant during the COVID-19 pandemic (Battistin et al., 2021; Stasolla, 2021). Finally, although significant advances have been made in the development and efficacy evaluation of family-oriented interventions for the pediatric ABI population, this systematic review revealed limited research examining ways to translate findings from research-based interventions into clinical practice. Efforts to apply research findings to clinical practice not only include calls for more implementation/translational science, but will also require financial and infrastructural supports to equip researchers and key stakeholders (community, clinicians, patients) with the expertise and skills needed to apply these interventions to clinical settings.

3.1. Study limitations

One of the limitations of this study is that our literature search did not include any 'gray' literature publications, which were defined in our study as those research reports that did not go through the rigorous peer-review process such as thesis or dissertation studies or government reports. This procedure may have excluded information of potential value to the scientific community. Additionally, the present review only used backward search, but not forward search, as its supplementary search method, which should be included in future systematic reviews to ensure the search is as comprehensive as possible. Second, all interventional effects reported in this paper should be interpreted in light of the relatively limited number of included studies being aggregated. Although the present study excluded small N studies with fewer than 10 participants in any treatment arm due to concerns with statistical power and quality of evidence (Whitehead, Julious, Cooper, & Campbell, 2016), small N studies have potential value as the empirical and methodological foundations for development of interventions in the field of brain injury research. Exclusion of studies with sample sizes of <10 also reduced the number of studies analyzed in the current meta-analysis. Third, while some studies included in this systematic review reported more than one outcome assessment tool, our meta-analysis was only able to aggregate one assessment score per outcome per study due to the heterogeneity of the assessment tools and their underlying conceptual constructs. Despite the co-authors' efforts to make the best conceptual decisions on selecting the appropriate assessment score for the meta-analysis, this procedure precluded potentially useful information from being considered in the meta-analysis. Finally, the meta-regression analysis on moderation effects was limited to those covariate-outcome pairs that were both present in the included studies and adequately powered. As a result, several important research questions could not be addressed, including (1) lack of data on intervention efficacy in acute vs. chronic ABI and (2) the impact of trial fidelity (e.g., training completion rates) on intervention efficacy. It should also be noted that although the present review coded the ABI severity using the widely adopted GCS metrics, research findings regarding its psychometric properties were mixed. For example, previous research has suggested that GCS scoring was accurate and reliable among experienced users but not inexperienced users (Rowley & Fielding, 1991, Reith et al., 2017). However, such information was rarely reported in the included studies. Therefore, the moderating effect of ABI severity should be interpreted with caution. Future meta-analysis studies are thus needed to re-examine potential moderating influences on intervention effects.

4. Conclusions

The present study conducted a systematic review of 32 studies (reported in 37 articles) using family-oriented interventions for children with acquired brain injuries. A quantitative meta-analysis of 20 studies on the intervention efficacy revealed a small to medium overall effect of family-oriented interventions on child and parent outcomes but not on family functioning. Study design was a significant moderator of

Table 4
Risk of bias ratings for articles included in the systematic review.

Manuscript	Random sequence generation (selection bias)	Allocation concealment (selection bias)	Blinding of outcome assessment (detection bias)	Incomplete outcome data (attrition bias)	Selective reporting (reporting bias)
*Aguilar et al., 2018	✓	✓	?	✓	✓
*Antonini et al., 2014	✓	?	?	✓	✓
*Baron Nelson et al., 2018	x	x	x	✓	✓
Barakat et al., 2003	x	x	x	✓	✓
*Braga et al., 2005	✓	✓	✓	?	✓
Braga et al., 2006	✓	?	✓	?	✓
[a]*Brown et al., 2014	✓	✓	✓	✓	✓
[a]*Brown et al., 2015a	✓	x	?	✓	✓
[a]*Brown et al., 2015b	✓	✓	✓	✓	✓
*Chavez Arana et al., 2020	✓	✓	✓	✓	✓
Dias et al., 2017	✓	✓	✓	✓	✓
Epstein et al., 2021	✓	✓	✓	✓	✓
*Hickey et al., 2018	✓	?	?	x	✓
Jimenez et al., 2021	x	x	x	✓	✓
[c]*Kurowski et al., 2014	✓	✓	✓	x	✓
[d]*Kurowski et al., 2020	?	?	?	✓	✓
McDougall et al., 2006	?	?	?	✓	✓
*Mortenson et al., 2016	✓	✓	✓	✓	x
Narad et al., 2015	✓	✓	✓	✓	x
Narad et al., 2019	✓	x	?	x	x
*Petranovich et al., 2015	✓	✓	✓	x	✓
*Raj et al., 2015	✓	x	x	✓	✓
*Raj et al., 2018a	✓	✓	✓	✓	✓
[b]*Raj et al., 2018b	✓	✓	✓	✓	?
[c]*Tlustos et al., 2016	✓	✓	✓	✓	✓
Wade et al., 2006a	✓	x	?	✓	✓
*Wade et al., 2006b	✓	x	?	✓	✓
*Wade et al., 2006c	x	x	x	✓	✓
*Wade et al., 2010	✓	x	x	✓	✓
Wade et al., 2012	✓	x	?	✓	✓
*Wade et al., 2014	✓	✓	✓	✓	✓
[b]*Wade et al., 2015	✓	✓	✓	✓	✓
*Wade et al., 2017	✓	✓	✓	x	✓
*Wade et al., 2018	✓	x	x	✓	✓
[d]*Wade et al., 2019	✓	✓	✓	✓	✓
Woods et al., 2014a	?	?	?	x	✓
Woods et al., 2014b	x	x	x	✓	✓

Note. Green circles with a check mark indicate low risk; yellow circles with a question mark indicate unclear risk; red circles with an x mark indicate high risk.
*included in quantitative analysis.
Superscripts indicate that studies were merged: [a]Brown et al. (2014), [a]Brown et al. (2015a), and [a]Brown et al. (2015b); [b]Raj et al. (2018) and [b]Wade et al. (2015); [c]Kurowski et al. (2014) and [c]Tlustos et al. (2016); [d]Kurowski et al. (2021) and [d]Wade et al. (2019).

interventional effects on parental outcomes, with more pronounced effects evident for RTC compared to non-RTC designs.

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Contributors

Jiabin Shen, Siman Zhao, and H. Gerry Taylor designed the study and wrote the protocol. Jiabin Shen and Siman Zhao conducted literature searches and provided summaries of previous research studies. Jiabin Shen, Siman Zhao, Timothy Horn, Rebekah Benkart, Tyler Busch, and Alison Vrabec conducted screening of title/abstracts, full text, data extraction, and qualitative data synthesis. Jiabin Shen conducted the quantitative data synthesis and wrote the first draft of the manuscript with contribution from all other co-authors for literature review, results interpretation, creation of tables and figures, and the reference list. Siman Zhao made critical contribution to the quantitative data synthesis during revisions. H. Gerry Taylor provided critical edits during the manuscript writing. All authors contributed to and have approved the final manuscript.

Conflict of Interest

H. Gerry Taylor is a co-author and served as a co-investigator on several of the studies included in the meta-analysis. All other authors declare that they have no conflicts of interest.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.cpr.2022.102218.

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[1] Reference list for the studies included in the systematic review is provided in a separate supplementary document.

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