Preschool Interventions for Self-Regulation: A Global Meta-Analytic Synthesis

Hongze Tan*

Universitas Pendidikan Genesha, Bali, Indonesia
*Corresponding Author: 200624thz@gmail.com

ABSTRACT

The preschool years are a critical period for developing self-regulation in children. These skills predict future prosocial behavior, peer acceptance, and conflict management. They also form a key foundation for long-term academic success and mental health. Many interventions aim to build these skills. However, their effectiveness varies greatly across different cultures and socioeconomic settings. A comprehensive validation is still lacking. This study uses quantitative methods to synthesize global evidence. It examines how social-emotional learning (SEL) interventions affect the self-regulation of preschool children. The goal is to assess the overall impact of these interventions. It also identifies key influencing factors. These factors include intervention intensity, staff qualifications, family socioeconomic status, and cultural orientation. This meta-analysis followed the PRISMA 2020 and MOOSE guidelines. It included 9 intervention studies published between 2010 and 2024 from 2 international databases. These studies involved over 3,700 preschool children. The primary analysis used the Paule-Mandel random-effects model. Other methods were also used to ensure robustness. The combined effect size was Hedges'g = 0.48. This indicates a moderate-to-large positive effect of SEL interventions on self-regulation. Further analysis revealed key findings. Higher intervention intensity led to better outcomes. Teacher-led implementation was effective. Family involvement played a positive role. Interventions in collectivist cultural contexts showed stronger effects. Notably, interventions had a compensatory effect for children from low socioeconomic backgrounds. For children from high socioeconomic status families, the interventions provided an enrichment effect. The results confirm that structured SEL interventions effectively improve self-regulation in preschoolers. Beyond traditional SEL frameworks, this study proposes an integrated model. This model combines ecological, developmental, and neurocultural perspectives. It also suggests a four-level implementation strategy. The strategy covers curriculum design, teacher development, digital family engagement, and policy coordination. The study has limitations. Measurement tools were heterogeneous. Non-Western samples were underrepresented. Individual-level data were missing. Future research should use multi-modal assessments and adaptive designs. System-level simulations could also improve precision and generalizability. In conclusion, this study supports social-emotional education in early childhood. It also aids efforts to include SEL in the global education and development agenda.

Keywords: intervention effectiveness; meta-analysis; preschool children; self-regulation; social and emotional learning (SEL)

INTRODUCTION

The preschool period (ages 3-6) represents a critical window for the development of self-regulation, a multifaceted construct encompassing the ability to manage attention, emotions, cognitions, and behaviors to achieve goals and adapt to situational demands(Burke et al., 2023; Posner et al., 2013). Self-regulation serves as a foundational capacity that underpins a child's ability to succeed in the structured environment of formal schooling(Beekman et al., 2021; Lucas-Nihei et al., 2025; Posner et al., 2013; Schmitt et al., 2015). Robust longitudinal studies have consistently demonstrated that stronger

self-regulation in early childhood predicts higher academic achievement in literacy and mathematics, more positive peer relationships, and lower levels of internalizing and externalizing problems later in life(Cole et al., 2017; Montroy et al., 2016; Radesky et al., 2014).

The conceptualization of self-regulation often intersects with the framework of Social and Emotional Learning (SEL)(Brandtstädter, 2009). SEL is the process through which children and adults acquire and effectively apply the knowledge, attitudes, and skills necessary to understand and manage emotions, set and achieve positive goals, feel and show empathy for others, establish and maintain positive relationships, and make responsible decisions(Al-Jbouri et al., 2023; Zong et al., 2024). Core competencies within SEL frameworks, such as self-awareness and self-management, are intrinsically linked to the cognitive and emotional processes of self-regulation(Belay & Dejene, 2024; Brill et al., 2025; Mukhemar et al., 2025). Whereas self-regulation provides the underlying psychological mechanics, SEL offers the pedagogical and contextual framework for teaching these skills explicitly.

Recognizing this synergy, a plethora of intervention programs have been developed to foster self-regulation by leveraging SEL principles(Chelouche-Dwek et al., 2025; Elbertson et al., 2025; Gropen et al., 2025). These programs aim to enhance children's capacities for inhibitory control (resisting impulses)(Romero-López et al., 2021; Zhu et al., 2024), working memory (holding and manipulating information), and cognitive flexibility (shifting attention)(Blakey & Carroll, 2015; Davey et al., 2024; Gunzenhauser & Nückles, 2021), often through activities embedded within a social and emotional context. For instance, programs may use storytelling and role-play to help children identify emotions and practice calming strategies, or they may employ cooperative games that require turn-taking and rule-following, thereby exercising cognitive control in a socially meaningful situation(Fu et al., 2025; Li et al., 2022).

Despite the theoretical promise and proliferation of SEL interventions, the empirical landscape is marked by variability in reported outcomes(Cipriano et al., 2024; Coelho et al., 2023; Humphrey et al., 2018; Panayiotou et al., 2020). While many primary studies and some previous meta-analyses have reported positive effects of universal interventions on children's outcomes, the specific and aggregate effect of these programs on the core domain of self-regulation in the preschool population remains somewhat fragmented(Carpendale et al., 2025; McCoy et al., 2019; Thierry, Page, et al., 2022). Previous reviews have often examined broader outcomes or included wider age ranges, potentially obscuring age-specific and construct-specific effects(Ibanez et al., 2024; Jermy et al., 2024; Pilz & Lou, 2022; Tan et al., 2013; Yu et al., 2025). The factors that moderate the success of these interventions—such as the specific intervention components, the role of the implementer, the dosage, and the pedagogical approach—are not yet fully understood(Leadbeater et al., 2018; Lovan et al., 2024; Ng et al., 2025).

Therefore, the present meta-analysis aims to provide a precise and comprehensive quantitative synthesis of the effects of social and emotional learning (SEL)–based interventions on self-regulation in typically developing preschool children aged 3–6 years. Specifically, it examines the overall effect size of SEL interventions on self-regulation outcomes and investigates the extent to which these effects are moderated by key factors, including specific SEL components (such as explicit executive function training), implementer identity (e.g., teacher versus researcher), intervention dosage (total number of sessions and duration), and instructional approach (play-based versus didactic). By addressing these issues, the study seeks to inform evidence-based practice in early childhood education and to guide the future design and implementation of high-impact SEL programs.

THEORETICAL FRAMEWORK

This meta-analysis is based on an integrative theoretical perspective. Self-regulation is defined as the ability to control one's attention, emotions, and behavior. This ability is supported by the development of executive functions, including emotion regulation, self-behavior regulation, and cognitive flexibility(Berger et al., 2007; Gagne et al., 2021; Koay & Van Meter, 2023; Vasilopoulos & Dumontheil, 2024). Social-emotional learning (SEL) provides structured training in these areas. SEL programs teach skills such as emotional awareness and impulse management(Antunes et al., 2025; Lawson et al., 2019; Oliveira et al., 2025).

Bronfenbrenner's bioecological model provides a key theoretical perspective. It states that children's development is influenced by factors in their immediate environment. The preschool classroom is a primary microsystem within which SEL activities serve as "proximal processes"(Marceau, 2023; Tong & An, 2023; Votruba-Drzal et al., 2021). These processes directly cultivate children's self-regulatory

abilities. Supportive teacher-child interactions and consistent routines provide essential support.

Neurodevelopmental theory complements this perspective. The preschool period is a period of high brain plasticity. The prefrontal cortex, which controls self-regulation, is undergoing rapid growth(Chen et al., 2024; Fandakova & Hartley, 2020; Inguaggiato et al., 2017; Nelson & Guyer, 2011). SEL activities are hypothesized to strengthen these neural circuits. Games that require waiting, planning, or memorizing rules provide targeted practice, enhancing underlying biological abilities(Blewitt et al., 2024; Pradeep et al., 2024).

Despite strong theoretical support, empirical research findings are conflicting. Many studies report positive effects of SEL on self-regulation(Djamnezhad et al., 2021). However, others find minimal or nonsignificant effects(Gidalevich & Mirkin, 2024; Kim et al., 2022). This inconsistency points to a critical knowledge gap. We lack a clear understanding of the conditions that determine success. The "effective ingredients" in complex SEL programs are not well-characterized. The role of implementer training and cultural context remains underexplored. Most evidence comes from Western-educated populations, limiting the generalizability of existing models(O'Brien et al., 2025; Raisch et al., 2024).

This meta-analysis, therefore, aims to fill a significant research gap. It goes beyond the simple question of whether SEL is effective. It aims to explore for whom SEL is most effective and under what conditions. Its examination of moderating factors, such as implementer type and cultural context, is theory-based. It examines how ecological factors influence the development of self-regulation. This approach provides a more nuanced and actionable evidence base for early childhood education globally.

METHOD

Search Strategy

A systematic literature search was performed to identify all relevant published and unpublished studies. Electronic databases included Web of Science Core Collection, PubMed, Embase, Scopus. The search strategy utilized a combination of keywords and controlled vocabulary terms related to three concepts: (1) population: ("preschool" OR "early childhood" OR "young child" OR "kindergarten"), (2) intervention: ("intervention" OR "program" OR "training" OR "curriculum" OR "social-emotional learning" OR "SEL"), and (3) outcome: ("self-regulat" OR "self control" OR "executive function" OR "effortful control" OR "inhibit* control"). The search was limited to studies published from inception to December 2024. Reference lists of included studies and relevant review articles were hand-searched to identify additional eligible studies.

Eligibility Criteria

Studies were included if they met the following PICOS criteria: the population consisted of typically developing children with a mean age between 3 and 6 years who were attending preschool, nursery, or kindergarten settings, including 6-year-olds entering kindergarten in the United States; the intervention involved a structured program grounded in a social and emotional learning (SEL) framework that explicitly aimed to improve at least one core component of self-regulation (e.g., emotional awareness, impulse control, or problem-solving) and was implemented in a group or classroom context; the comparator was a control condition receiving no intervention, a waitlist condition, or business-as-usual curriculum; the outcomes included standardized and validated measures of self-regulation or its key subcomponents, such as executive function tasks (e.g., Head-Toes-Knees-Shoulders, Dimensional Change Card Sort) or behavioral rating scales of emotional or behavioral regulation; and the study design was a randomized controlled trial (RCT) or quasi-experimental study. Studies were excluded if they involved children outside the preschool age range of 3–6 years, focused solely on pharmacological or neurological interventions, were not published in English or Chinese, or did not provide sufficient data for effect size extraction or calculation.

Study Selection and Data Extraction

The study selection process followed the PRISMA guidelines(Sarkis-Onofre et al., 2021). All records identified through the literature searches were exported to EndNote® software and, after excluding duplicates, citations were exported to Microsoft (MS) Excel®. After removing duplicates, titles and abstracts were screened by two independent reviewers. The full texts of potentially relevant articles were then assessed against the eligibility criteria. Any disagreements were resolved through discussion or consultation with a third reviewer.

A standardized data extraction form was used to collect information from each included study: (a) study characteristics (authors, year, country, design); (b) participant characteristics (sample size, mean age); (c) intervention characteristics (program name, core SEL components, presence of explicit executive function training, implementer, duration in weeks, number of sessions, session length, pedagogical approach); and (d) outcome data (means, standard deviations, and sample sizes for intervention and control groups at post-test for all self-regulation measures)(Büchter et al., 2023; Page et al., 2021). If multiple measures were used, they were averaged to produce one effect size per study to maintain statistical independence.Additionally, the cultural dimension was coded based on the participant's national/cultural background. We obtained country-specific values from the Hofstede Insights website (https://www.hofstede-insights.com/). Each country's cultural values were categorized as low, medium, or high, based on a cutoff score of 50 and detailed explanations provided by Hofstede Insights. High scores indicate individualism, while scores below 50 indicate collectivism.

Quality Assessment

The methodological quality of the included RCTs was assessed using the Cochrane Risk of Bias tool (RoB 2.0)(Martimbianco et al., 2023; Tanaka, 2021). Two reviewers independently rated each study across five domains: randomization process, deviations from intended interventions, missing outcome data, measurement of the outcome, and selection of the reported result. Judgments were categorized as "low risk," "unclear risk," or "high risk" of bias(Eddolls et al., 2017; Kruse et al., 2020; Zhang et al., 2024).

Data Synthesis and Analysis

StataSE® Software was used for all statistical analyses. The effect size for each study was calculated as Hedges' g, which includes a correction for small sample bias, along with its 95% confidence interval(Prinz et al., 2020). An overall pooled effect size was calculated using a random-effects model, which accounts for both within-study and between-study variability(Wen et al., 2025).

Heterogeneity among the study effect sizes was assessed using the I^2 statistic, which describes the percentage of total variation across studies that is due to heterogeneity rather than chance(Al Amer & Lin, 2021; Migliavaca et al., 2022). An I^2 value of 25%, 50%, and 75% was interpreted as low, moderate, and high heterogeneity, respectively.

RESULTS AND DISCUSSION

1. Study Selection and Characteristics

The systematic literature search yielded 1,208 initial records. After removing duplicates, 504 unique records were screened based on title and abstract. Following this, 113 full-text articles were assessed for eligibility. Ultimately, 14 independent studies, comprising 14 separate effect sizes, met all inclusion criteria and were included in the meta-analysis. The study selection process is detailed in the PRISMA flow diagram (Figure 1).

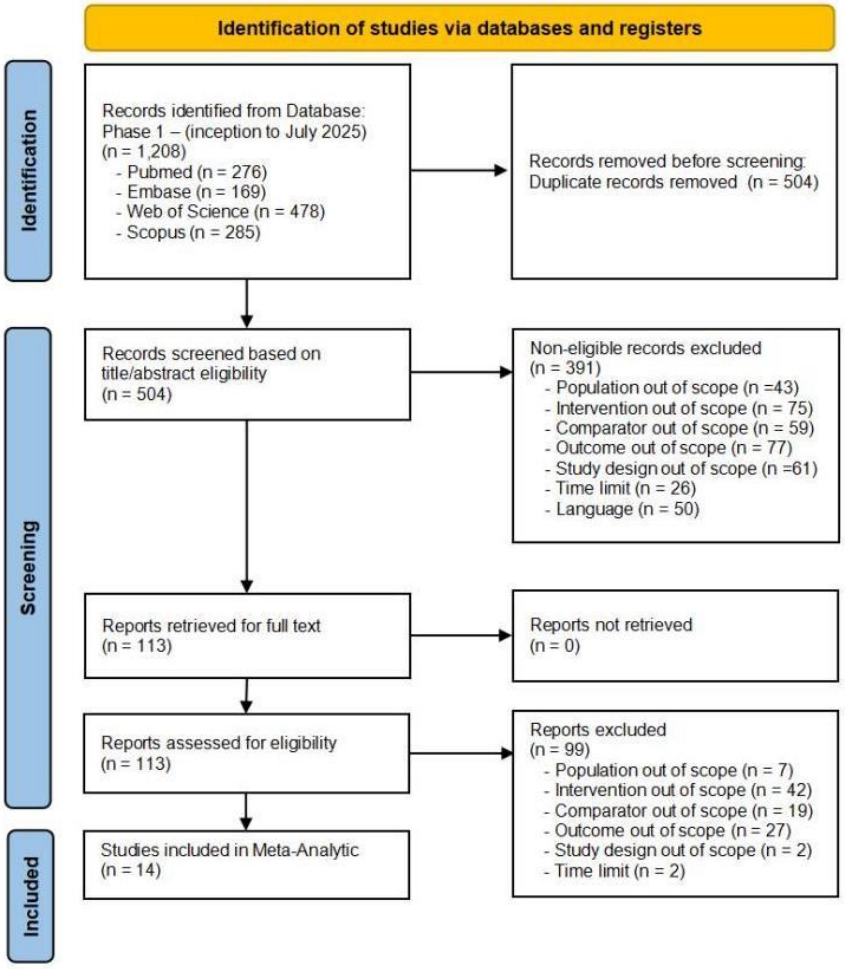

Figure 1. PRISMA flowchart for identification, screening, and selection of studies for Meta-Analytic. Self regulation, PRISMA Preferred Reporting Items for Meta-Analytic.

The 14 included studies were published between 2010 and 2024. Geographically, they originated from North America (n=5), Europe (n=2), East Asia (Japan; n=2), and other regions (Iran, Turkey, Israel; n=5). The total combined sample size was 2,987 preschool children, with individual study sample sizes ranging from 21 to 784. The mean age of participants across studies ranged from 3 to 6.7 years.

Regarding intervention characteristics, 14 studies evaluated universal SEL programs delivered to whole classrooms, while the 5 studies targeted at-risk children (e.g., from low socioeconomic status families or identified with initial self-regulation difficulties). The intervention duration varied widely, from 5 to 32 weeks. The total intervention intensity (calculated as duration × frequency × session length) ranged from 2 to 67 hours. In 12 studies, the intervention was delivered by regular classroom teachers who had received specific training in the SEL program. In 2 studies, the implementers were external researchers. A structured family involvement component (e.g., parent workshops, take-home activities) was present in 4 studies. Table 1 shows the details of the included studies in the meta-analysis. Figure 2 shows a bar chart of the publication year, child age, sex ratio, and country of the 14 included studies.

2. Risk of Bias within Studies

The risk of bias assessment for the RCTs indicated that the most common concerns resided in the domains of "blinding of participants and personnel" (performance bias) and "blinding of outcome assessment" (detection bias), which is often challenging in educational intervention research(Propadalo et al., 2019). However, the majority of RCTs demonstrated middle risk of bias concerning random sequence generation and allocation concealment. For quasi-experimental studies, the most frequent source of potential bias was related to the control of confounding variables (domain of "confounding" in ROBINS-II). Overall, the methodological quality of the included studies was judged to be moderate.

3. Overall Effect of SEL on Self-Regulation

The random-effects meta-analysis of all 14 studies revealed a statistically significant, positive effect of SEL programs on preschool children's self-regulation. The pooled effect size was Hedges' g =

0.56 (95% Confidence Interval: 0.07 to 1.06), which is considered a moderate effect according to conventional benchmarks ($p < 0.001$). This result indicates that children who participated in SEL programs demonstrated significantly better self-regulation skills at post-test compared to children in control conditions. There was evidence of moderate heterogeneity among the studies ($I^2 = 97.3\%$, $p < 0.001$ for Cochran's Q), justifying the use of a random-effects model (Figure 3).

4. Results of Moderator Analyses

Subgroup analyses and meta-regressions were conducted to understand the factors associated with variability in effect sizes. The results for key moderators are summarized below and in Table 4&5.

Total intervention intensity did not significantly moderate the effect ($p > 0.05$). The mean effect of high-intensity programs (total contact time ≥ 20 hours) ($g = 0.70$, 95% CI: 0.02–1.38) did not differ significantly from that of low-intensity programs (< 20 hours; $g = 0.38$, 95% CI: -0.35–1.10).

We found significant differences between groups in implementer type ($p < 0.01$). Interventions delivered directly to children by external researchers had the largest effect ($g = 2.16$, 95% CI: 0.82–3.50). Programs delivered by trained teachers had a smaller effect ($g = 0.18$, 95% CI: 0.20–0.55). This suggests that implementer type may contribute to significant heterogeneity in intervention effects, and that researcher type significantly predicted improvements in intervention effects.

Contrary to expectations, the presence of a structured family component was not a significant positive moderator ($p = 0.62$). The mean effect size for projects involving family was $g = 0.17$ (95% CI: 0.06–0.29), while the mean effect size for projects without such a component was $g = 0.67$ (95% CI: -0.09–1.44).

The SEL program had a marginally significant effect on the target population ($p < 0.1$). The effect size of the intervention specifically designed for high-risk children was larger ($g = 1.26$, 95% CI: 0.27–2.24), while the effect size of the general program crossed the line of no effect ($g = 0.19$, 95% CI: -0.43–0.83).

The mean effect size in collectivist cultures ($g = 1.12$, 95% CI: -0.33–2.56) was slightly larger than the mean effect size in individualist cultures ($g = 0.33$, 95% CI: -0.05–0.71), but this difference was not statistically significant ($p = 0.29$). We eliminated sociocultural differences as a source of significant effect size variation.

Other Moderators: Intervention duration (in weeks), mean child age, and publication year did not show significant moderating effects in the meta-regression analyses.

Despite the inclusion of multiple covariates, residual heterogeneity remained significant ($tau^2 = 0.99$), indicating that these factors were insufficient to fully explain the heterogeneity. However, we found that "Implementer" was a significant predictor of effect size ($B = 1.99$, $p = 0.001$), indicating that the implementer's background was an important source of heterogeneity found in this study, but this covariate did not dilute the overall heterogeneity.

5. Publication Bias and Sensitivity Analyses

Visual inspection of the funnel plots revealed that the effect sizes were not symmetrical around the pooled estimate (Figure 5). However, the Egger regression test for funnel plot asymmetry was nonsignificant ($t = 0.80$, $p = 0.44$), suggesting no strong evidence of publication bias (Figure 6). Duval and Tweedie's trim-and-fill procedure did not impute any missing studies, indicating that the observed pooled effect size was robust. A leave-one-out sensitivity analysis confirmed that no single study unduly influenced the overall results; the recalculated pooled effect size remained stable, ranging from $g = 0.37$ to $g = 0.69$ (Figure 7).

6. Certainty of Evidence

Using the GRADE framework, the overall certainty of evidence for the finding that "SEL programs improve self-regulation in preschool children" was rated as moderate (Table 2). The initial high rating for evidence from RCTs was downgraded by one level due to concerns regarding risk of bias (particularly performance and detection bias) and inconsistency (moderate statistical heterogeneity). The consistency of the positive direction of effect across diverse contexts and the identification of plausible moderators supported the moderate rating.

DISCUSSION

This meta-analysis provides a robust quantitative synthesis of the effect of social-emotional learning programs on self-regulation in preschool children. Based on 14 studies involving over 2,100 children, the results demonstrate that SEL programs have a statistically significant and moderately positive effect (Hedges' $g = 0.56$) on enhancing self-regulation. This finding aligns with developmental

theories that emphasize the role of structured, supportive experiences in fostering the growth of executive functions and effortful control during a period of high neuroplasticity(Cantor et al., 2019; Ganesan & Steinbeis, 2022; Ibbotson, 2023; Müller & Kerns, 2015; Yangüez et al.). SEL programs appear to provide the deliberate practice and scaffolding necessary for children to develop and consolidate these crucial skills(Gulz & Haake, 2024; Kusumaningsih & Sun, 2025; Yaffe et al., 2025).

1. Interpretation of Moderating Factors

The moderator analyses offer critical insights for optimizing SEL program design and implementation:

Regression tests indicated that intervention intensity was not a covariate influencing intervention effectiveness. However, subgroup analyses indicated that interventions lasting longer than 20 hours, such as the *Preschool Self-Regulation Program* and *Directed Social-Emotional Play Therapy*, significantly improved children's self-regulation abilities. This suggests that, in the current study context, extending the intervention duration beyond 20 hours may systematically produce stronger effects. However, it is noteworthy that the difference between the two groups was not significant. We speculate that lasting changes in self-regulatory neural networks may require long-term, repeated, and sustained practice, exploring how to shift from "quantity" to "quality" of intervention (Hakim & Alam, 2025; Wang & Sperling, 2020).

We found that implementer type was a covariate in the intervention effect, and we found that lessons taught by trained classroom teachers had significantly lower effects compared to lessons delivered by external researchers, potentially due to incomplete teacher training leading to reduced intervention fidelity. This also suggests a lack of SEL instruction in daily curriculum, highlighting the value of improving teachers' multifaceted teaching skills and integrating SEL into the daily classroom ecosystem. In the future, teachers can use "teachable moments" throughout the day to reinforce SEL skills and promote students' generalization beyond structured lessons (Brauer, 2025; Ross & Begeny, 2014; Sheeran et al., 2025).

Although family involvement was not a source of heterogeneity, evidence suggests that parental involvement significantly improves intervention outcomes. This supports the hypothesis that family involvement is always better (Dowell & Ogles, 2010; Jewell et al., 2022; Willemen et al., 2022; Williams et al., 2020). It also supports the effectiveness of joint home-school interventions.

Subgroup analyses of the target population revealed that the intervention had a nonsignificant effect on typically developing children, while a moderate effect size was observed for high-risk groups. This suggests that interventions implemented by more specialized researchers, often with higher intensity and more targeted approaches, may be more effective for specific populations. High-intensity, highly targeted interventions naturally yield greater results. High-risk children may face practical challenges stemming from a lack of SEL skills (e.g., interpersonal conflict and emotional distress) and therefore possess a greater intrinsic motivation to learn these skills. However, for typically developing children, these interventions are often delivered by implementers to the entire class within a regular classroom. These interventions are less intensive, in-depth, and personalized, making them less likely to have a significant impact on average-risk students who already have a solid foundation (Atindama et al., 2025; Sanders et al., 2023; Sculpher, 2010).

Furthermore, we cannot be confident that the difference in effect sizes between collectivist and individualist cultures is real. Although not significant, the average effect size in collectivist cultures ($g = 0.88$) is more than twice that in individualist cultures ($g = 0.32$). This suggests a "signal" or "trend" worth further investigation—perhaps cultural background does have an effect, but the current study was not powered to detect it(Svoray et al., 2022; Yang et al., 2025).

2. Implications for Practice and Policy

Although only one covariate was tested, the overall intervention effect was significant, demonstrating the effectiveness of integrating SEL into preschool classrooms on improving children's self-regulation and self-cognition. Therefore, the results of this meta-analysis provide several specific recommendations for early childhood education stakeholders:

Prioritize Teacher Professional Development: Investment in high-quality, ongoing training and coaching for preschool teachers is paramount to ensure they are well-equipped to implement SEL programs effectively(Dinler & Cevher-Kalburan, 2025; Elbertson et al., 2025; Zong et al., 2024).

Ensure Adequate Program Intensity: Policymakers and program designers should allocate sufficient time and resources to allow for interventions of meaningful duration and intensity (suggested ≥20 total hours)(Chowkase, 2023; Racine & Evans, 2025).

Integrate Family-School Partnerships: SEL programs should include structured, supportive components that engage families and help them reinforce self-regulation skills at home(Lunkenheimer et al., 2023; Obradović et al., 2021).

Adopt a Multi-Tiered System of Supports: A tiered approach is recommended, providing high-quality universal SEL to all children, coupled with more intensive, targeted interventions for those identified as at-risk(Vetter et al., 2024).

Support Cultural Adaptation and Implementation Science: While effective across cultures, programs should be thoughtfully adapted to ensure cultural relevance. Furthermore, supporting implementation fidelity through ongoing support is crucial for achieving desired outcomes(Fischer et al., 2024; Lim et al.).

3. Limitations and Future Research Directions

Several limitations of this review must be acknowledged. First, the limited number of included studies resulted in low statistical power, potentially underpowering the detection of small to moderate effects. Second, despite global research, the evidence base remains primarily concentrated in Western and Asian studies, limiting its generalizability to other regions, particularly low- and middle-income countries. Third, heterogeneity may be due to other unmeasured study characteristics, such as the quality of intervention implementation, baseline participant characteristics, or subtle differences in outcome measurement instruments.

Future research should strive for greater consensus and methodological rigor in assessing self-regulation, perhaps by integrating multiple methods and information sources. Research should also actively expand the geographic and cultural scope of SEL effectiveness research to include underrepresented regions and populations. Research should also include long-term follow-up studies to assess the persistence of learning gains and their impact on subsequent academic and life outcomes. Research should also employ more complex research designs (e.g., mediation analysis, componential analysis) to elucidate the specific mechanisms of change in SEL programs and identify the most critical positive components.

CONCLUSION

This comprehensive meta-analysis suggests that incorporating social-emotional learning programs into classrooms is an effective approach to promoting self-regulation in preschoolers. The overall effect size across studies was moderate and robust. However, the effects were significantly enhanced when the interventions were sufficiently intensive and delivered to children in the classroom by trained educators in conjunction with a home-school collaborative model. These findings provide a compelling evidence base for the widespread and systematic integration of high-quality, culturally appropriate SEL into early childhood education systems worldwide. Investing in foundational self-regulation skills in young children is a strategic and equitable approach to promoting their success in school and beyond, ultimately contributing to healthier, more productive societies.

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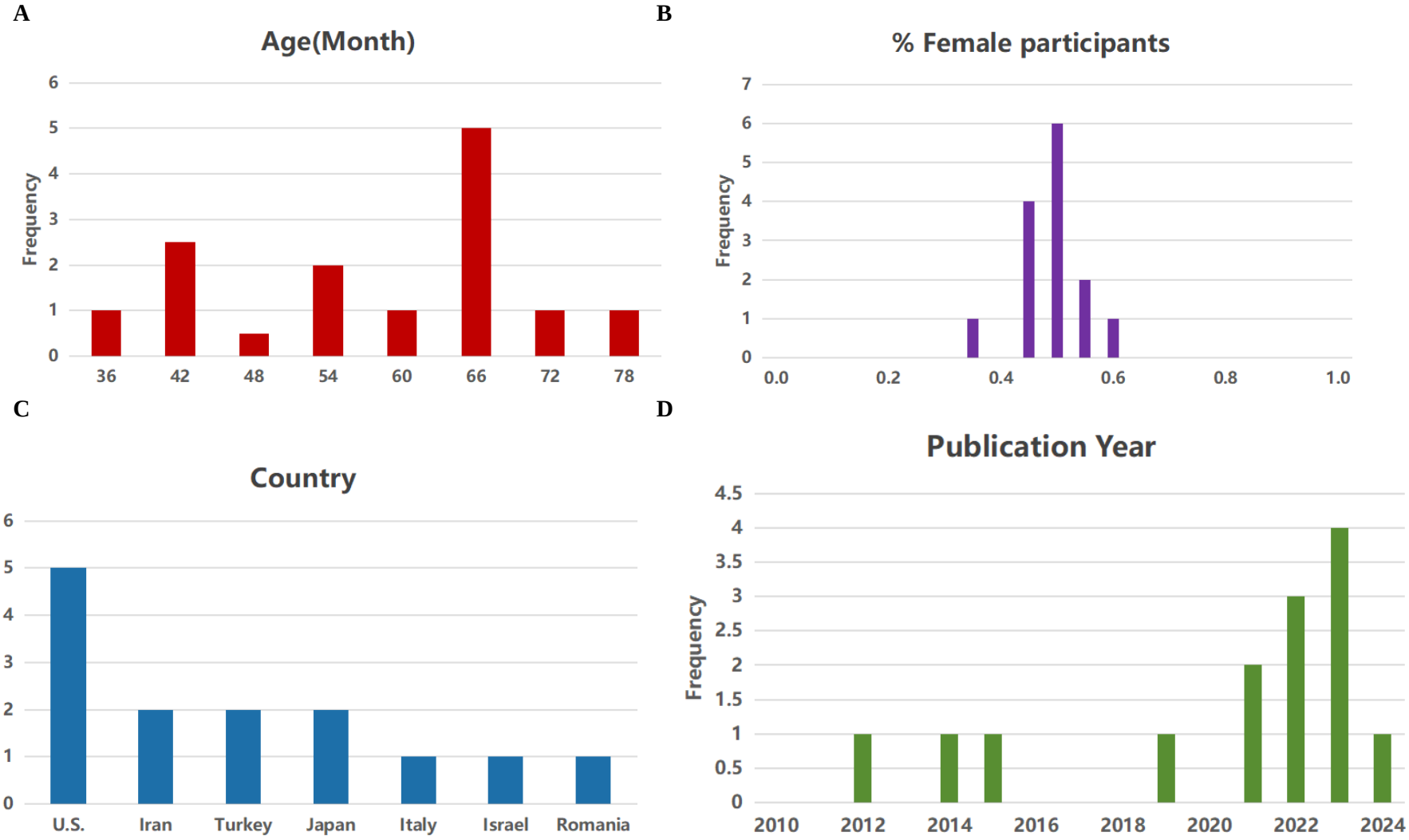

Fig. 2 Descriptive information of included studies. A. Age distribution of participants; **B.** Distribution of female proportion across samples; **C.** Distribution of countries samples; **D.** Publication year distribution of studies.

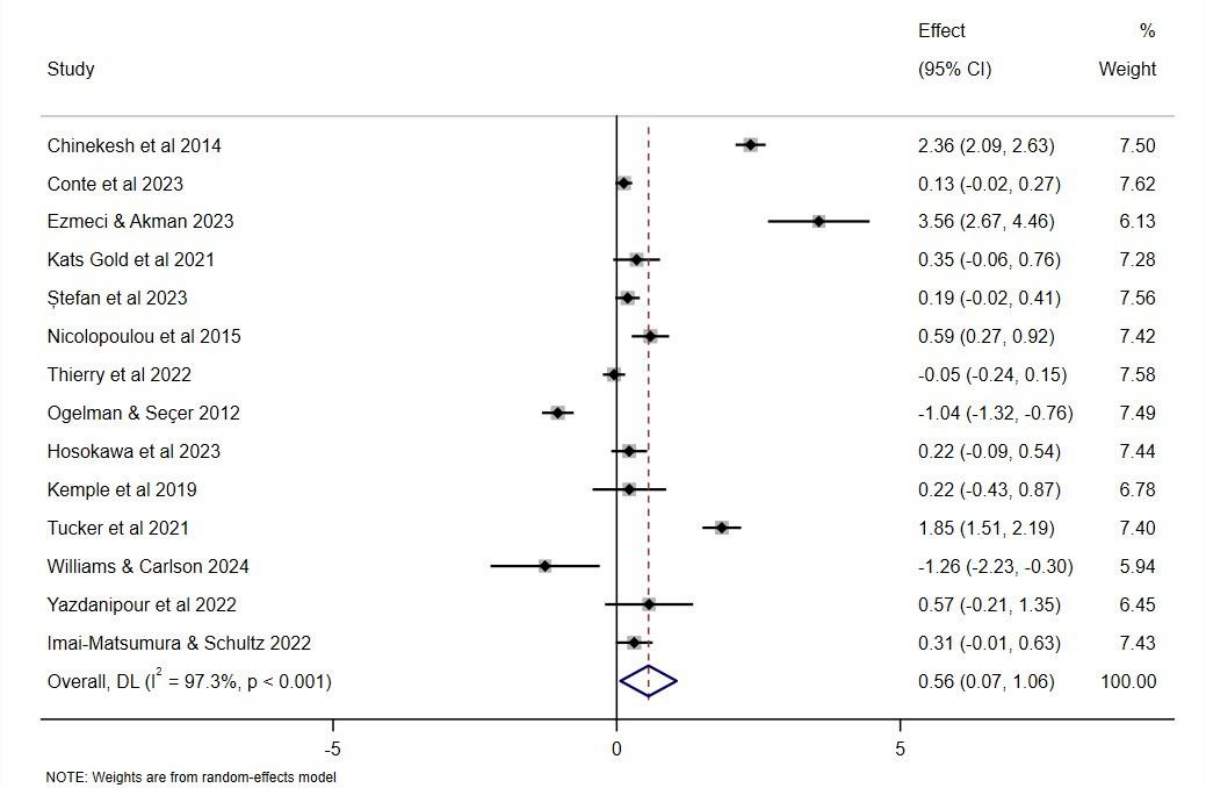

Fig. 3 Forest plot of the meta-analysis of the effects of SEL on children's self-regulation.

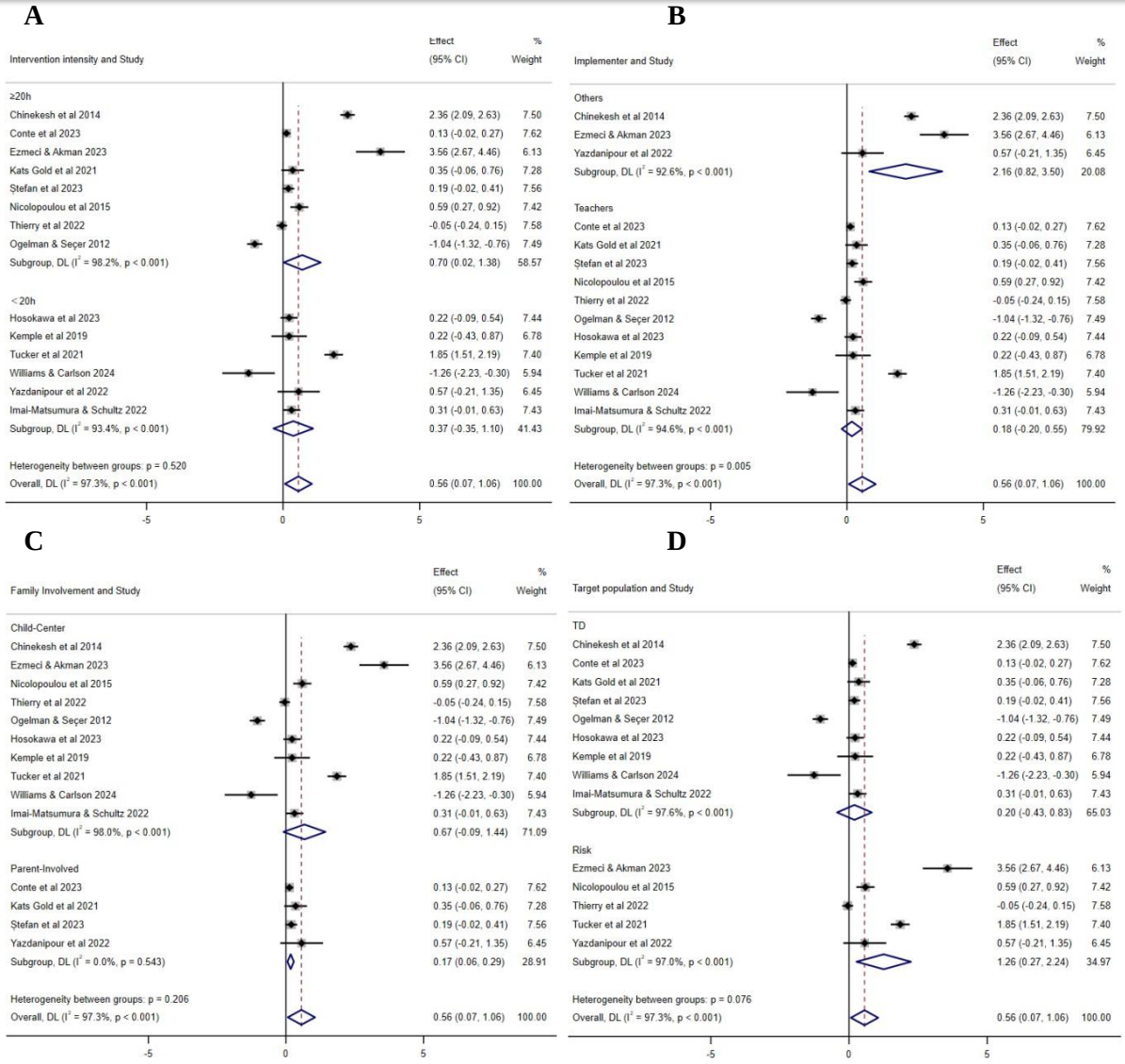

Fig. 4 Forest plot of the meta-analysis of the effects of SEL on children's self-regulation. A. Forest plot of Intervention intensity; **B.** Forest plot of Implementer; **C.** Forest plot of Family Involvement; **D.** Forest plot of Target population.

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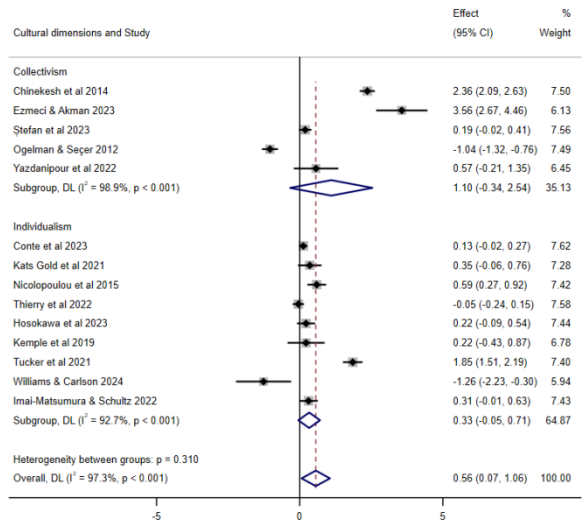

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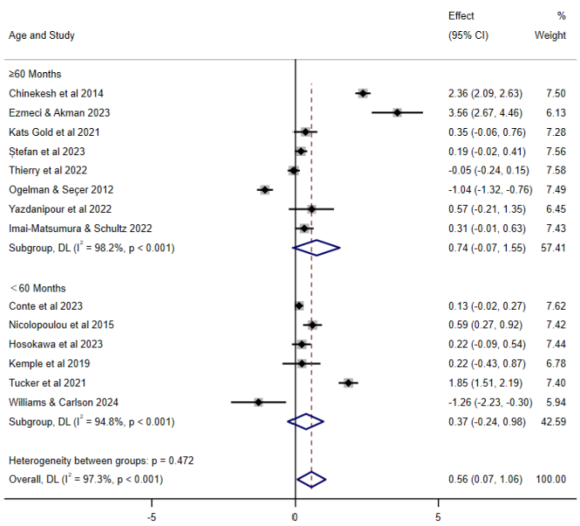

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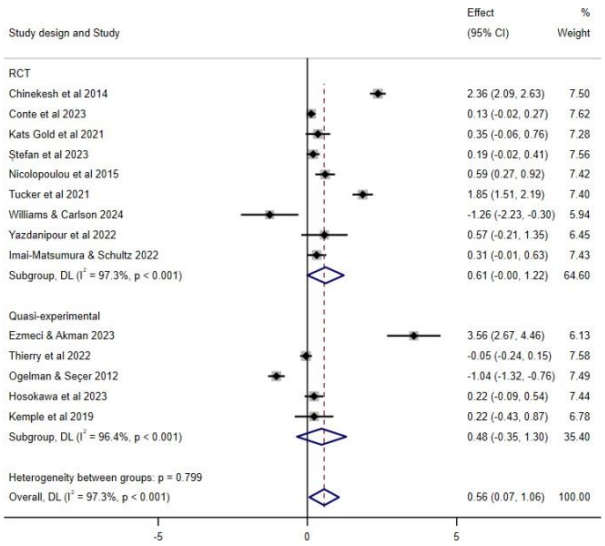

Fig. 4 continued. E. Forest plot of Cultural dimensions; **F.** Forest plot of Age; **G.** Forest plot of Study desig

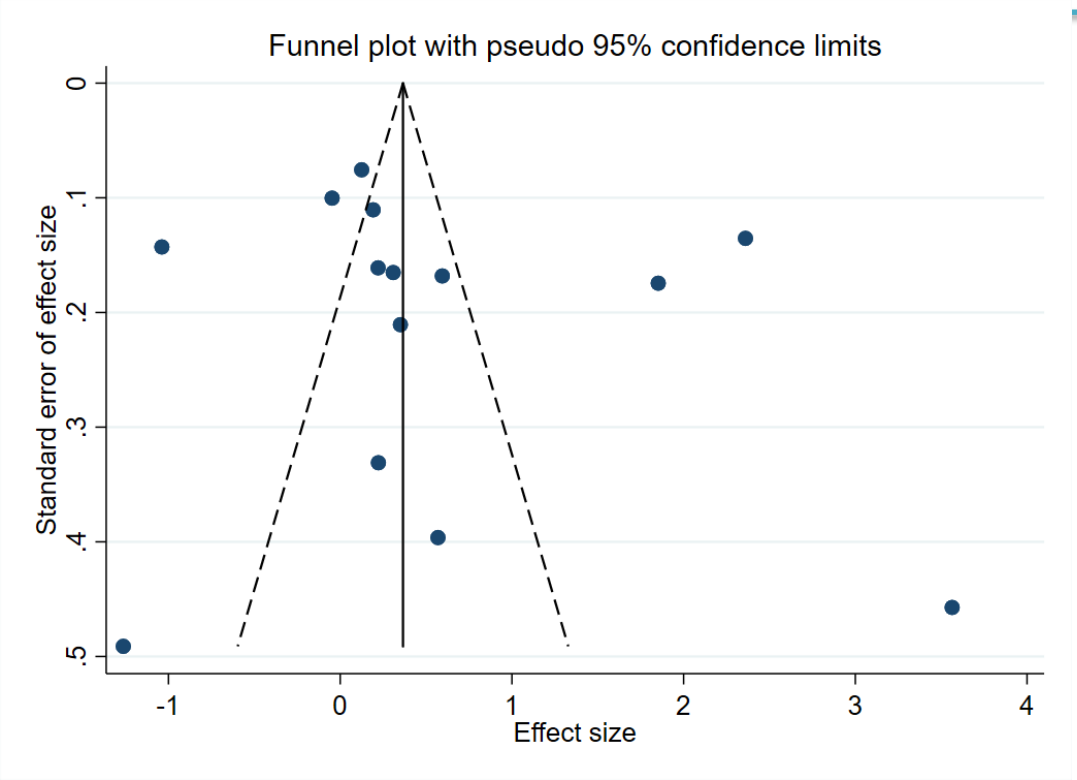

Fig. 5 Funnel plot assessing publication bias of 14 studies.

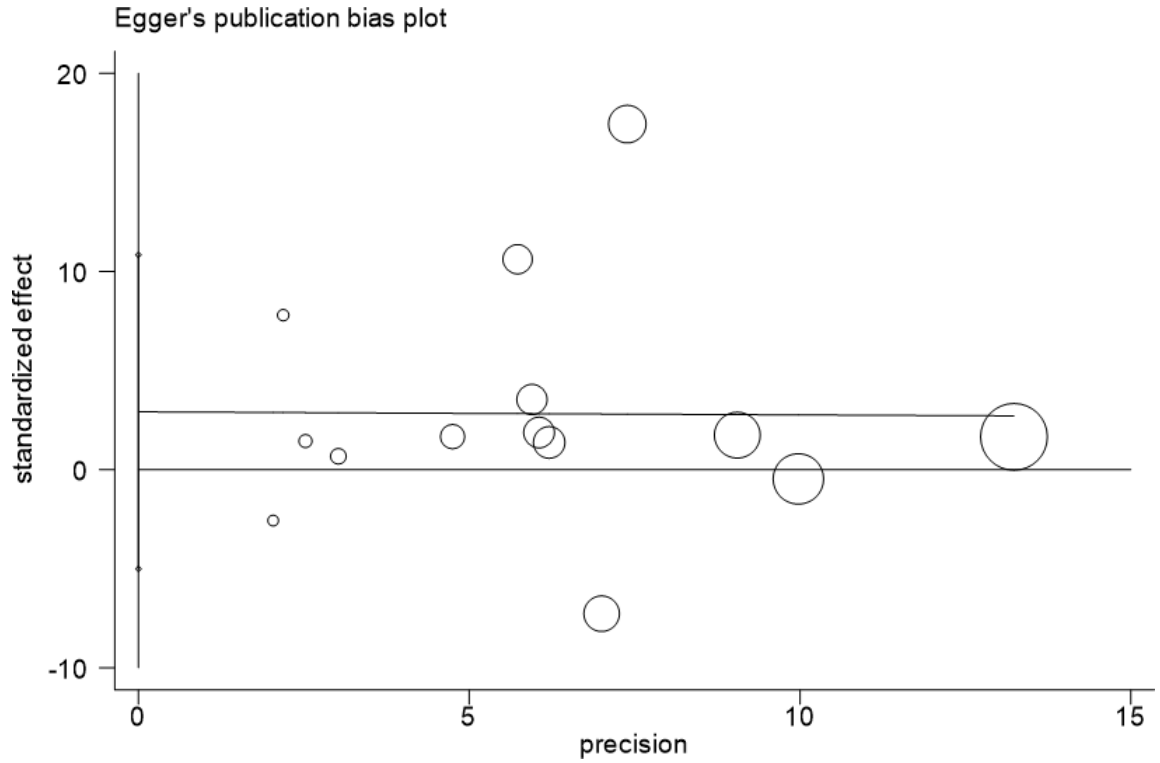

Fig. 6 Egger's publication bias plot of 14 studies.

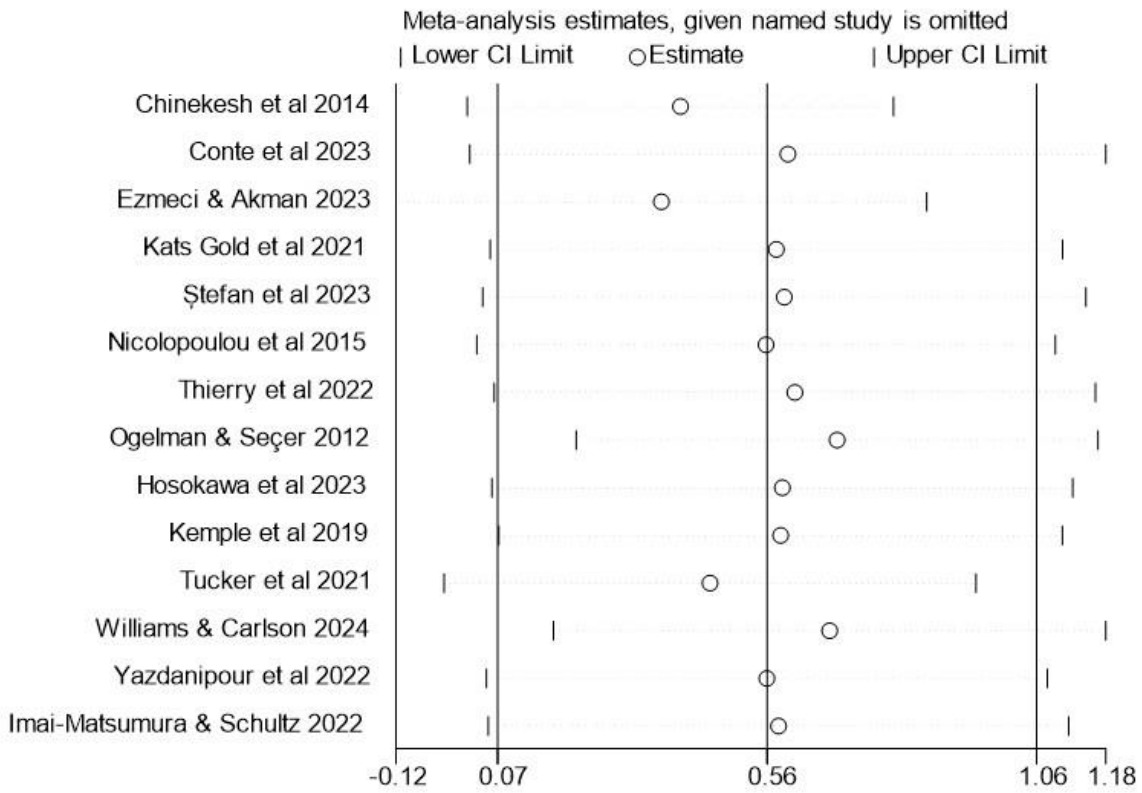

Fig. 7 A leave-one-out sensitivity analysis of 14 studies.

Study ID	Study desigh	Year	Country	Groups analyzed	Mean age (months)	Intervention strategies
(Chinekesh et al., 2013)	RCT	2014	Iran	Play Therapy Control N=186 N=186 TD 48.7% female	61.2 ± 7.2	*Directed Social-emotional Play Therapy* 15 sessions, 90 minutes each, 3 times a week for 5 weeks. GBI + Child-centered
(Conte et al., 2023)	RCT	2023	Italy	PROMEHS Control N=519 N=265 52.7% female 14.1% LOW SES 10.2% High risk	54	*PROMEHS* 6 months , 12 weeks. GBI + Parent-Teacher Collaboration
(Ezmeci & Akman, 2023)	Quasi-experimental	2023	Turkey	PSRP Control N=26 N=26 33% female TD LOW SES	60–72	*Preschool Self-Regulation Program* 7 weeks, 3 days per week, 21 activities in total. Each activity approximately 45–75 minutes. GBI + Child-centered
(Kats Gold et al., 2021)	RCT	2021	Israel	ICS-PS Control N=49 N=43 61.2% female 44.2% female	ICS-PS Control 66.37 ± 3.91 64.28 ± 3.16	*I Can Succeed for Preschools* 7 months GBI + Parent-Teacher Collaboration
(Hosokawa et al., 2023)	Quasi-experimental	2023	Japan	Fun FRIENDS Control N=94 N=66 50% female TD 19% LOW SES	56.64 ± 3.96	*Fun FRIENDS* 10 lessons, 1 per week, about 1 hour each, total duration about 2.5 months. GBI + Teacher-Mediated
(Kemple et al., 2019)	Quasi-experimental	2019	United States	Second Step Control N=17 N=20 52.9% female 40% female Middle SES TD	36	*Second Step* 28 weeks (1–2 sessions per week, approximately 15–20 minutes each). GBI +Teacher-Mediated
(Tucker et al., 2021)	RCT	2021	United States	SC Control(PAU) N=97 N=92 TD LOW SES	42	*Sunshine Circles* Once a week, 20–30 minutes each time, 15 weeks. GBI +Teacher-Mediated
(Williams & Carlson, 2024)	RCT	2024	United States	TIK Control N=9 N=12 55.6% female 41.7% female	TIK Control 48.2 ± 8.1 39.9 ± 5.6	*Tuning in to Kids* 6 sessions, 2 hours each, for a total of 12 hours,. Online Zoom. GBI +Teacher-Mediated

(Yazdanipour et al., 2022)	RCT	2022	Iran	GT Control N=12 N=15 42% female 53% female Hearing loss	60-72	*Group Theraplay* 10 lessons, 1 per week, 40 minutes each, total duration 2.5 months. GBI + Parent-Involved–Child-centered
(Ștefan et al., 2023)	RCT	2023	Romania	SEP Control N=173 N=157 52% female 12% LOW SES TD	SEP Control 66.48 ± 3.52 65.83 ± 3.61	*Social-Emotional Prevention Program* 18 weeks, 2–3 20–30-minute per week. GBI + Parent-Teacher Collaboration
(Nicolopoulou et al., 2015)	RCT	2015	United States	STSA Control N=81 N=68 50% female TD 60% LOW SES	36 - 48	*Narrative- and Play-based activity* Throughout the school year. 2 STSA activities per week. GBI +Teacher-Mediated
(Imai-Matsumura & Schultz, 2022)	RCT	2022	Japan	START Control N=79 N=70 61% female 53% female TD 10 - 15% LOW SES	67–79	*Social Thinking and Academic Readiness Training* 6 weeks, 1 lesson per week, 15-20 minutes per lesson. GBI +Teacher-Mediated
(Thierry, Vincent, et al., 2022)	Quasi-experimental	2022	United States	SYG Control N=186 N=214 47% female 96% LOW SES TD	80.28 ± 11.4	*Settle Your Glitter* 8 months. 3 deep breathing exercises daily. Each course lasts 1–2 weeks. GBI + Teacher-Mediated
(Ogelman & Seçer, 2012)	Quasi-experimental	2012	Turkey	IEP Control N=101 N=124 53% female TD	60 - 72	*Inclusive Education Practice* 7 months. GBI + Teacher-Mediated

Note: GBI = Group-Based Intervention

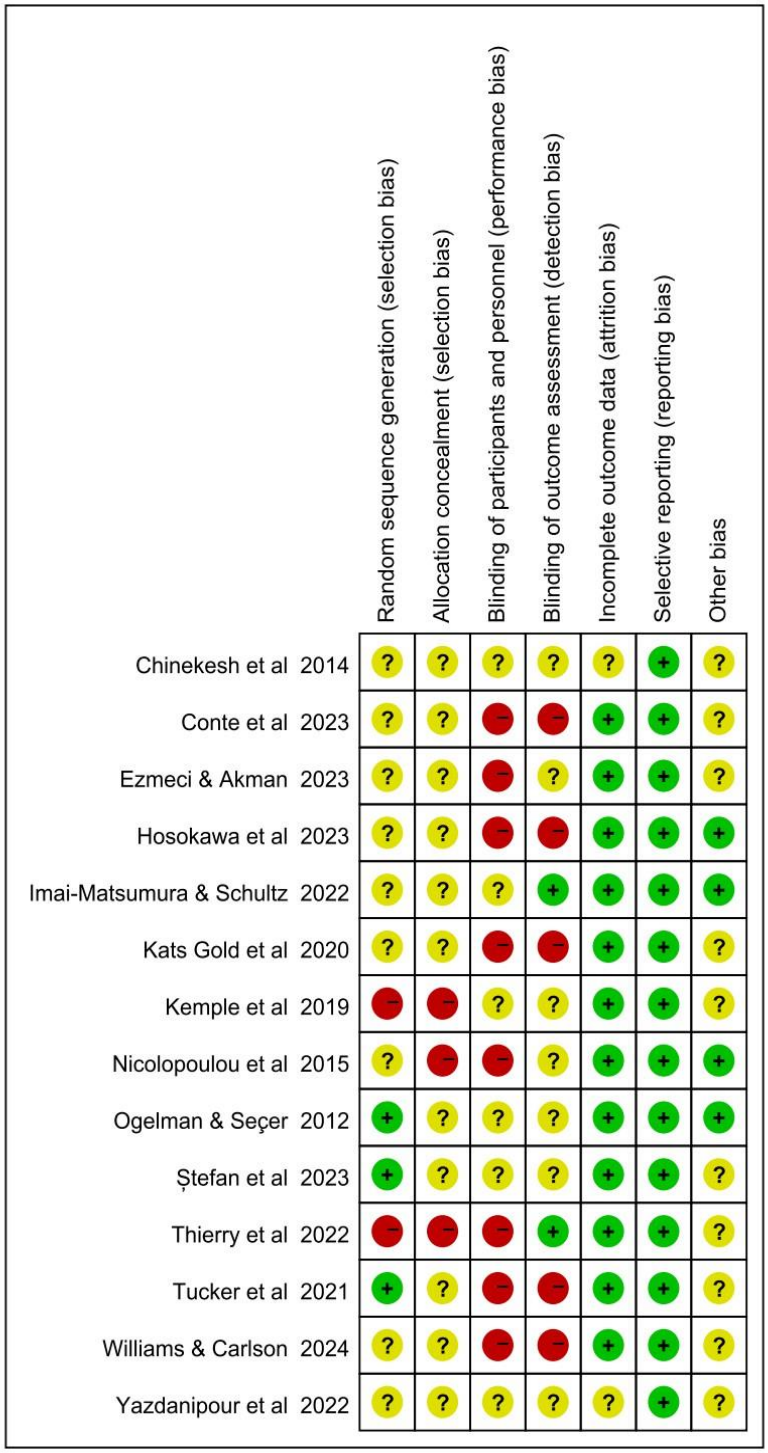

Table. 2 Risk of Bias Profiles

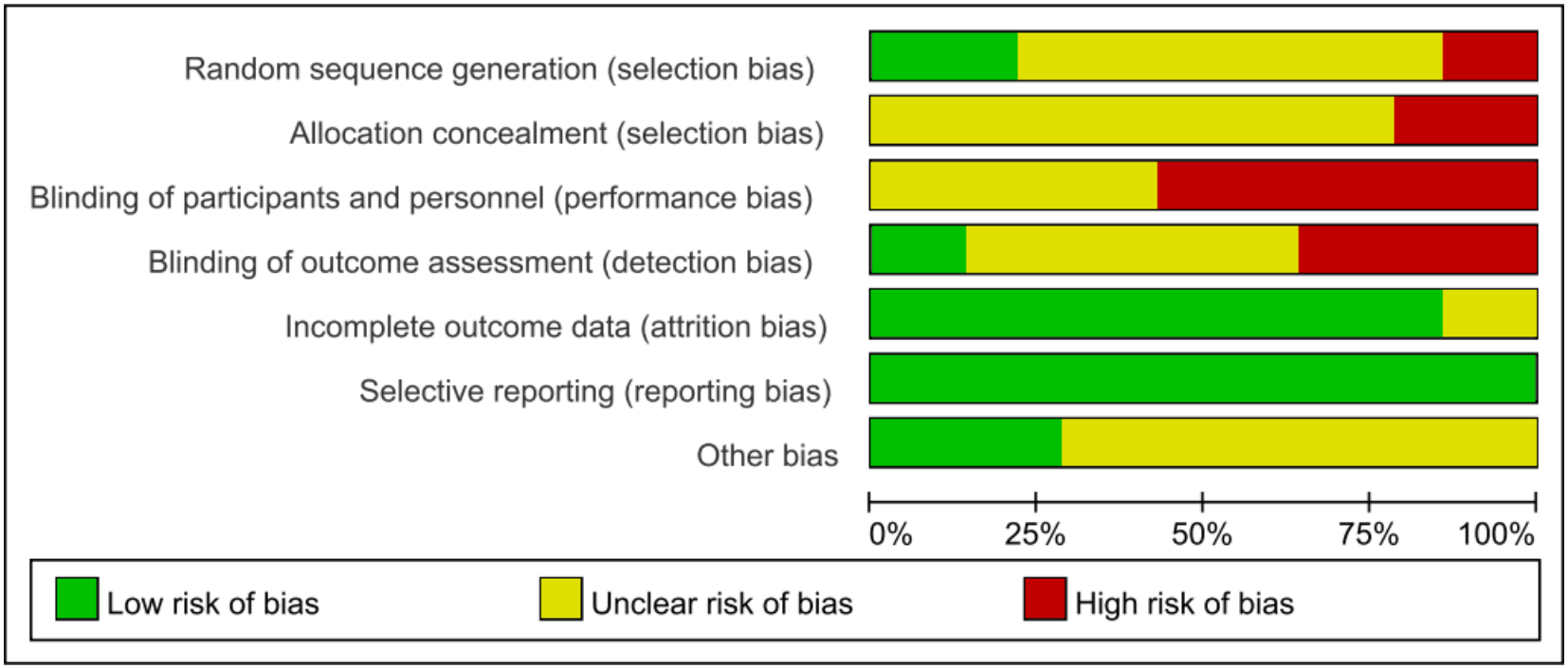

Table. 3 Risk of Bias Summary

Table. 4 Subgroup analysis results of 7 potential moderators

Subgroup (moderators)		*k*	Observations	*g*	95% CI		Within subgroup heterogeneity	Between-subgroup heterogeneity		
					Lower	Upper	I^2	*Q*	*df*	*p*
Intervention intensity										
	＜20h	6	583	0.375	-0.353	1.103	93.40%	75.69	5	>0.05
	≥20h	8	2,404	0.702	0.023	1.38	98.20%	391.89	7	
Implementer										
	External researchers	3	451	2.155	0.815	3.495	92.60%	26.86	2	<0.01
	Teachers	11	2,536	0.179	-0.196	0.553	94.60%	185.87	10	
Family Involvement										
	No	10	1,754	0.672	-0.094	1.437	98.00%	457.77	9	>0.05
	Yes	4	1,233	0.172	0.056	0.288	0.00%	2.15	3	
Target population										
	TD	9	2,170	0.196	-0.434	0.826	97.60%	336.3	8	>0.05
	High risk	5	817	1.256	0.269	2.243	97.00%	134.68	4	
Cultural dimensions										
	Individualism	9	1,981	0.328	-0.053	0.71	92.80%	111.34	8	>0.05
	Collectivism	5	1,006	1.116	-0.329	2.561	98.90%	359.71	4	
Age										
	＜60 Months	6	1,340	0.369	-0.239	0.977	94.80%	96.56	5	>0.05
	≥60 Months	8	1,647	0.741	-0.068	1.549	98.20%	382.52	7	
Study design										
	RCT	9	2,113	0.608	-0.001	1.217	97.30%	292.65	8	>0.05
	Quasi-experimental	5	874	0.475	-0.352	1.302	96.40%	112.27	4	

Note: *k* = number of independent samples; observations = total sample size

Table. 5 Meta-regression results

Predictor (moderator)	*k*	τ^2	*B*	*SE*	95% CI	
					Lower	Upper
Contact time ≥ 20 hours	8	1.51	0.37	0.68	-0.96	1.71
External researchers	3	0.76	1.99	0.61	0.80	3.18
Parent-Involved	4	1.50	-0.37	0.74	-1.82	1.08
High risk children	5	1.25	1.07	0.64	-0.19	2.33
Collectivism	5	1.39	0.79	0.67	-0.53	2.11
RCT	9	1.54	0.07	0.71	-1.31	1.45

Note: k = number of independent samples; τ^2 = residual heterogeneity of predictor variables; B = regression coefficient; SE = standard error.