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Prevalence of Developmental Dyslexia among Primary School Children in Iran: A Systematic Review and Meta-Analysis

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Abstract

Objective: Developmental dyslexia is a specific learning disability related to reading that often leads to lifelong challenges. Accurate prevalence estimates are essential for the timely diagnosis, intervention, and formulation of appropriate educational policies. This systematic review and meta-analysis aimed to provide a reliable estimate of the prevalence of developmental dyslexia in primary school students in Iran.

Method: We conducted a comprehensive search of international databases, including PubMed, Web of Science, and Scopus, alongside national databases such as SID and MagIran, using relevant search terms from 1991 to April 2024. Two researchers independently assessed the articles for the risk of bias using the Hoy checklist and extracted the data. Subgroup meta-analysis examined variations in prevalence across different subgroups.

Results: A total of 18 studies, comprising 28,952 participants, were included. The overall prevalence of developmental dyslexia was 5.7% (95% CI: 4.5%-6.9%), with a higher prevalence observed in boys (7.5%, 95% CI: 5.8%-9.2%) compared to girls (4%, 95% CI: 3%-5%). Subgroup analysis revealed a statistically significant impact of diagnostic material on prevalence estimates, with informal reading tests reporting a prevalence of 3.4% (95% CI: 2.4%-4.4%) and the screening inventory reading test showing 8.8% (95% CI: 4.5%-13.2%) (P = 0.002). Prevalence also varied by sample size, with smaller studies (< 500 participants) reporting a prevalence of 6.8% (95% CI: 5%-8.6%) compared to larger studies (> 2000 participants) at 3.9% (95% CI: 2.3%-5.4%) (P = 0.034). Most studies (66.7%) had sample sizes under 2000 participants.

Conclusion: This systematic review and meta-analysis indicate that developmental dyslexia affects 5.7% of Iranian primary school students, with boys being more affected than girls. These findings highlight the urgent need for standardized diagnostic criteria and evidence-based interventions to enhance early identification and support for students with dyslexia. Addressing these gaps is essential for improving educational outcomes and guiding effective policy planning.

Key words: *Dyslexia; Meta-Analysis; Prevalence; Students; Systematic Review*

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Individual with developmental dyslexia are thought to have persistent and significant challenges in reading-related skills, even when they have normal IQ and access to sufficient educational options (1, 2). According to the DSM-5 guidelines, developmental dyslexia is categorized as a learning impairment within the spectrum of neurodevelopmental conditions that may affect individuals throughout their lives (3). This disorder is multidimensional, with risk factors influenced by language, culture, and ethnicity that vary by population (4). Dyslexia primarily affects various aspects of reading, including word recognition, decoding, and spelling. These difficulties can have significant impacts on academic achievement, self-esteem, and overall quality of life – highlighting the importance of early identification and intervention.

The prevalence of dyslexia is influenced by linguistic and orthographic structures, cultural factors, and regional education systems. One key factor is the depth of a language's orthographic structure, which refers to how closely written symbols map onto spoken sounds. Orthographic depth theory posits that the transparency of a language's orthographic structure can impact both reading development and dyslexia prevalence (5). Studies on reading acquisition across languages consistently show that orthographic depth affects reading development and the presentation of dyslexia symptoms (6-8).

In languages with shallow orthographies, such as German and Italian, the consistent sound-symbol correspondences facilitate reading acquisition, enabling children to acquire reading skills more rapidly and accurately (5). In contrast, deep orthographies, such as English, involve irregular correspondences that challenge reading fluency and phonological processing (9). As a result, children learning to read in languages with deep orthographies often face greater difficulties in reading acquisition and dyslexia symptoms than those learning shallow orthographies (10, 11).

The orthographic depth theory is relevant to Persian, the primary language spoken in Iran. Persian has several unique orthographic characteristics, including position-dependent letter shapes, a lack of uppercase/lowercase distinctions, and short vowels indicated only by diacritics. These features result in one-to-many and many-to-one correspondences between letters and sounds, posing decoding and fluency challenges that can intensify dyslexic symptoms in young learners (12, 13). Recent studies in Arabic-speaking countries, where orthographic complexity also affects reading, show a pooled dyslexia prevalence rate of 11%, with higher rates in regions where orthographic depth is more pronounced (14). Given Persian's specific challenges, it is essential to conduct studies within Iran to understand how its orthographic characteristics affect dyslexia prevalence, screening, and intervention.

Diagnosis of developmental dyslexia typically occurs after a child has been formally introduced to reading and writing, as familiarity with these skills is a prerequisite for dyslexia assessments (9). Therefore, the elementary school period is crucial for screening reading disorders, identifying associated risk factors, and implementing relevant interventions. To our knowledge, no prior systematic reviews or meta-analyses have specifically addressed the prevalence of developmental dyslexia among primary school students in Iran. This study aims to fill that gap, representing the first systematic review and meta-analysis on this topic. While primary studies have reported the prevalence of developmental dyslexia across various cities and regions in Iran, the rates vary widely, ranging from 1.2% to 12% (15-30). These discrepancies may stem from several factors. Firstly, different operational definitions of developmental dyslexia may be associated with varying prevalence rates across studies (31, 32). Secondly, other variables such as gender, grade level, or socioeconomic status (SES) may influence the prevalence of developmental dyslexia (33). For instance, the gender ratio of developmental dyslexia varies across studies, with most reporting a higher prevalence in boys compared to girls, although some studies have not shown these differences (34, 35). This inconsistency highlights the need for a comprehensive systematic review and meta-analysis to synthesize these findings and provide a more accurate prevalence estimate. Accurate identification of developmental dyslexia is essential for implementing effective educational and clinical interventions, preventing negative outcomes, and guiding educational policy (36, 37).

This systematic review and meta-analysis aim to consolidate findings from previous studies to generate a clearer picture of dyslexia prevalence among elementary school children in Iran. Given the unique linguistic and cultural characteristics of the Iranian education system, this analysis will explore variations in prevalence by gender, grade level, and subject scale. The results will inform educational policy, enable more effective resource allocation, and guide the development of targeted screening and intervention programs, ultimately improving academic performance and psychological well-being for affected students.

Materials and Methods

This systematic review and meta-analysis was conducted in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA 2020) guidelines, and its protocol has been registered in PROSPERO and is achievable (registration number [CRD42024560629] and grant number: 11565 from Zahedan University of Medical Sciences). Approval was obtained from the Ethics Committee of Zahedan University of Medical Sciences (code: IR. ZAUMS. REC. 1403.325).

The findings of this study are based on research conducted between 1991 and April 2024 on the prevalence of developmental dyslexia in Iranian children during elementary school. To identify relevant articles, the researcher (F.A.) examined international databases including PubMed, Web of Science, Scopus, and national Iranian databases such as SID (Scientific Information Database) and MagIran (Iranian Magazines Database). Additionally, articles presented at national seminars and conferences, as well as thesis related to the prevalence of developmental dyslexia, were reviewed and included if the full text was accessible.

To identify relevant articles in international databases, we used a combination of search terms related to developmental dyslexia (e.g., dyslexia, reading disability, reading disorders, learning disability), prevalence (e.g., detectable rate, incidence rate, epidemiology), and Iran, combined with Boolean operators (AND, OR). Equivalent Persian terms were used for searching national databases (Table 1). No language restrictions were applied in this search. Primary studies were selected for analysis based on their adherence to these requirements: (a) participants were elementary school children (grades 1-6); (b) the prevalence of developmental dyslexia was examined as a primary or secondary objective; (c) at least total sample size and number of individuals with dyslexia were provided; and (d) for studies on learning disabilities, specific information on dyslexia was included. Studies were excluded if they were case-control studies, clinical trials, letters to the editor, or conducted on specific subgroups (e.g., individuals with chronic or acute diseases). For studies including both adults and elementary school children, only data related to the elementary school group were considered. If multiple articles from a single study existed, only the most comprehensive or largest sample size article was used. Finally, articles whose full text was inaccessible through online databases or upon request from the corresponding author were also excluded.

Table 1. Search Terms and Syntaxes Applied in Databases for Identifying Studies on Developmental Dyslexia Prevalence

Pubmed	(“dyslexia” [ti] OR “reading disabilit*” [ti] OR “reading disorder*” [ti] OR “word blindness” [ti] OR “specific reading retardation” [ti] OR “backward reading” [ti] OR “reading difficult*” [ti] OR “learning disabilit*” [ti) AND (“prevalence” [tiab] OR “detectable rate” [tiab] OR “incidence rate” [tiab] OR “epidemiology” [tiab]) AND (1991/01/01:2024/04/30[dp]) AND (Iran[tiab] OR Iran[pl] OR Iran[ad]))
Google Scholar	All in title: (“dyslexia” | “reading disability” | “reading disorder” | “word blindness” | “specific reading retardation” | “backward reading” | “reading difficult” | “learning disability”) + (“prevalence” | “detectable rate” | “incidence rate” | “epidemiology”) + (Iran | Iran[pl] | Iran[ad]))
Web of Science	TI = (Dyslexia OR (reading disabilit*) OR (reading disorder*) OR (word blindness) OR (specific reading retardation) OR (backward reading) OR (reading difficult*) OR (learning disabilit*)) AND (TS = (prevalence OR (detectable rate) OR (incidence rate) OR epidemiology)) AND PY = (1991-2024) AND (AD = (Iran)OR TS = (Iran) OR FT = (Iran))
Scopus	TITLE (Dyslexia OR (reading disabilit*) OR (reading disorder*) OR (word blindness) OR (specific reading retardation) OR (backward reading) OR (reading difficult*) OR (learning disabilit*)) AND (TITLE-ABS (prevalence OR (detectable rate) OR (incidence rate) OR epidemiology)) AND ((PUBYEAR > 1991 AND PUBYEAR < 2024 AND PUBDATETXT (April 2024)) AND) TITLE-ABS (Iran)OR AFFIL (Iran) OR PUBLISHER (Iran))

Two researchers (F.A. and G.G.) independently assessed the titles and abstracts of all records retrieved from the search using inclusion and exclusion criteria after eliminating duplicates from various bibliographic sources. If a study's eligibility was unclear, it was cautiously retained for full-text review in the next stage. In the selection phase, two researchers (F.A. and F.S.) independently reviewed the full text of studies from the previous stage, and those meeting the inclusion criteria were advanced to the next stage. To ensure retrieval of all relevant documents, the reference lists of included articles were also examined. Any disagreements in these two screening and selection stages were resolved through discussion between researchers, with no unresolved disagreements remaining.

The risk of bias assessment for included articles was independently conducted by two researchers (F.A. and G.G.) using Hoy's risk of bias assessment checklist (2012) (38). This screening instrument contains ten criteria to measure potential risk of bias in studies focusing on prevalence. For risk of bias assessment, this checklist evaluates both item-by-item (each question) and overall risk of bias, categorizing studies into low, moderate, and high risk of bias groups. In using this quality assessment checklist, each question answered "yes" (low risk of bias) received a score of 0, while a "no" answer (high risk of bias) received a score of 1. The total score was then calculated; an overall risk of bias score of 0-3 was considered low risk, 4-6 moderate risk, and 7-9 high risk. Both the overall risk of bias score for

included studies was reported and an item-by-item assessment was conducted.

Finally, for data extraction from the records, two researchers independently extracted information using a researcher-made form, including study title, first author's name, publication year, study location, sample size, number of individuals with developmental dyslexia, sampling strategy, diagnostic tool, and diagnostic criteria (Table 2). To address any missing data, our strategy involved reaching out to the author(s) via email to request the necessary information when needed. If we were unable to acquire enough data after sending three emails, the study would be excluded from the data synthesis process.

Table 2. Summary of the Characteristics of Studies Included in the Analysis, Including Study Sampling Strategy, Sample Size, and Population Details

Author (Year)	City	Sampling Strategy	SES	Diagnostic Material and Criteria	Sample Size	Prevalence Number	Prevalence Rate
Rahimian Bougar et al., 2007 (29)	Shahreza	Random stratified	Not mentioned	Children IQ test; Reading level; Diagnostic test With Criteria: Reading level; Diagnostic test	Total: 1184 Boys: 598 Girls: 586 2nd: 300 3rd: 300 4th: 293 5th: 291	Total: 137 Boys: 91 Girls: 46 2nd: 57 3rd: 23 4th: 21 5th: 23	Total: 6.8 Boys: 66.42 Girls: 33.58 2nd: 10.4 3rd: 6.8 4th: 5.6 5th: 4.3
Pouretemad et al., 2011 (25)	Qom	Random sampling	Not Mentioned	WISC-III; APRA With Criteria: IQ > 85; Reading score > 1.5 SE below expected match score in first trimester; No medical History of brain damage, Hearing loss and blindness	Total: 1562 Boys: 773 Girls: 789 1st: 298 2nd: 271 3rd: 309 4th: 330 5th: 354	Total: 82 Boys: 59 Girls: 23 1st: 11 2nd: 9 3rd: 22 4th: 20 5th: 20	Total: 5.2 Boys: 71.9 Girls: 28.1 1st: 13.3 2nd: 10.9 3rd: 26.822 4th: 24.420 5th: 24.4
Sedaghati et al., 2010 (18)	Esfahan	Random multi cluster	Not mentioned For controlling it sampling was done in one zone in city	Screening Reading Inventory Test (Shafeei); Word Reading score < 90%; Reading comprehension < 50% With Criteria: Normal IQ; Intact hearing and Visual; Completing at least 6 months of the academic year	Total: 200 Boys: 100 Girls: 100 1st: 40 2nd: 40 3rd: 40 4th: 40 5th: 40	Total: 20 Boys: 12 Girls: 8 1st: 8 2nd: 5 3rd: 3 4th: 3 5th: 1	Total: 10 Boys: 66 Girls: 34 1st: 20 2nd: 12.5 3rd: 7.5 4th: 7.5 5th: 2.5
Sharifi et al., 2012 (58)	ChaharMahal Bakhtiari	Cluster	Not mentioned	Mathematic Test Kimac; Phonological awareness test; Spelling test With Criteria: Students in grade 1 and 2	Total: 415 Boys: 209 Girls: 206 1st: 40 2nd: 40	Total: 28 Boys: 16 Girls: 9 1st: 12 2nd: 16	Total: 6.75 Boys: 9.09 Girls: 4.37 1st: 5.42 2nd: 7.55

Gholamiyan Arefi et al., 2022 (22)	Mashhad	Stratified cluster Sampling	Population & education and background	Screening Reading Inventory Test (Shafeei) With Criteria: Farsi Language Children from preschool to 3th grade	Total: 2770 Boys: 1389 Girls: 1381 1st: 830 2nd: 865 3rd: 592	Total: 112 Boys: 50 Girls: 62 1st: 71 2nd: 20 3rd: 21	Total: 4.04 Boys: 3.6 Girls: 4.5 1sd: 8.55 2nd: 2.31 3rd: 3.55
Hosseinaee et al., 2007 (59)	Qom	Stratified	Not mentioned	Raven's intelligence Test With Criteria: Learning reading and writing inventory (at least 3 signs); Researcher made Test	Total: 3282 Boys: 1696 Girls: 1587 3rd: 1056 4th: 1103 5th: 1124	Total: 51 Boys: 31 Girls: 20 3rd: 20 4th: 22 5th: 9	Total: 1.55 Boys: 1.83 Girls: 1.26 3rd: 1.89 4th: 1.99 5th: 80
Echreshavi et al., 2020 (16)	Ahvaz	Multi stage clustering	Not mentioned	Raven's intelligence Test; NAMA test With Criteria: IQ > 85; NAMA test scores 2SD bellow Mean based on teachers & students weak reading skills	Total: 387 Boys: 144 Girls: 208	Total: 29 Boys: 15 Girls: 14	Total: 7.49 Boys: 10.41 Girls: 6.73
Shahbodaghi 2002 (21)	Tehran	Random	Not mentioned	Texts of educational books from the last year of student's grade; Pictures; Oral motor examination With Criteria: Not mentioned	Total: 1010 Boys: - Girls: - 1st: 218 2nd: 198 3rd: 194 4th: 201 5th: 199	Total: 16 Boys: - Girls: - 1st: 6 2nd: 2 3rd: 2 4th: 2 5th: 4	Total: - Boys: - Girls: - 1st:2.75 2nd: 1.01 3rd: 1.03 4th: 0.99 5th: 2.01
Pashapour et al., 2000 (47)	Urmieh	Random cluster	Not mentioned	Informal reading test With Criteria: Students in grade 3	Total: 2067 Boys: 1061 Girls: 1007	Total: 69 Boys: 47 Girls: 22	Total: 3.3 Boys: 4.43 Girls: 2.18
Mohammadyfar et al., 2007 (17)	Shiraz	Random cluster	Not mentioned	Michel Bast checklist; Learning disability checklist for shiraz With Criteria: Students in grade 3 & 4; No behavioral disorder; Based on teacher comment	Total: 401 Boys: 200 Girls: 201 3rd: 197 4th: 204	Total: 35 Boys: 22 Girls: 13 3rd: 15 4th: 20	Total: - Boys: 11 Girls: 6.5 3rd: 7.6 4th: 9.8

Yavari et al., 2019 (20)	Arak	Multistage cluster sampling	Not mentioned	IRT With Criteria: Normal intelligence; Normal vision; No history of psychiatric or neurological disorders; Assessment after 6 months from the start of the academic year; Word Reading score < 90%; Reading comprehension < 50%	Total: 2135 Boys: 1198 Girls: 937 1st: 394 2nd: 346 3rd: 363 4th: 374 5th: 328 6 th: 330	Total: 212 Boys: 127 Girls: 85 1st: 34 2nd: 14 3rd: 48 4th: 76 5th: 27 6 th: 13	Total: 9.93 Boys: 10.60 Girls: 9.07 1st: 8.63 2nd: 4.05 3rd: 13.22 4th: 20.32 5th: 8.23 6 th: 3.94
Hakim et al., (2015) (15)	Ahvaz	Multi stage clustering random	Not mentioned	Screening Reading Inventory Test (Shafeei) With Criteria: Word Reading score < 90%; Reading comprehension < 50%	Total: 1000 Boys: 1000 Girls: - 1st: 200 2nd: 200 3rd: 200 4th: 200 5th: 200	Total: 118 Boys: 118 Girls: - 1st: 35 2nd: 58 3rd: 14 4th: 7 5th: 4	Total: 11.8 Boys: 11.8 Girls: - 1st: 17.5 2nd: 29 3rd: 7 4th: 3.5 5th: 2
Bavazin et al., 2019 (23)	Khorama bad	Cluster	Not mentioned	Diagnostic Reading level test With Criteria: Students in grade 2 & 3	Total: 400 Boys: 197 Girls: 203 2nd: 198 3rd: 202	Total: 25 Boys: 16 Girls: 9 2nd: 12 3rd: 13	Total: - Boys: - Girls: - 2nd: - 3rd: - 4th: - 5th: -
Gholami Kerahroodi et al., 2015 (28)	Arak	Cluster random	Not mentioned	DSM-V; Raven's test; Goodenough test Teacher made tests; Body health notebook; Informal reading test With Criteria: Student's grad 3; DSM-V; Raven's test; Goodenough test; Teacher made tests	Total: 2700 Boys: 1350 Girls: 1350	Total: 93 Boys: 57 Girls: 36	Total: 3.44 Boys: 4.22 Girls: 2.66
Arab Ameri et al., 2015 (30)	Semnan	Stratified random	Not mentioned	Primary & secondary diagnostic questioner; Test of teacher awareness of dyslexia; Weksler test With Criteria: IQ	Total: 6872 Boys: 3436 Girls: 3437	Total: 94 Boys: 55 Girls: 39	Total: 1.36 Boys: 1.60 Girls: 1.30

Zare Bahramabadi et al., 2014 (27)	Hamedan	Cluster random	Not mentioned	Diagnostic Reading level test With Criteria: DSM-V	Total: 1938 Boys: 988 Girls: 950	Total: 72 Boys: 60 Girls: 12	Total: 3.71 Boys: 6.07 Girls: 1.26
Shaghaghi, 2015 (48)	Khorramdarre	Cluster random	Not mentioned	Colorado Learning disability; Questioner With Criteria: Not mentioned	Total: 229 Boys: - Girls: -	Total: 6 Boys: - Girls: -	Total: 2.92 Boys: - Girls: -
Sharifi et al., 2009 (58)	Shahrekord	Cluster	Not mentioned	Diagnostic Reading level test With Criteria: Reading fluency subtest of Diagnostic Reading level test Without cut off	Total: 400 Boys: 185 Girls: 215 3nd: 199 4rd: 201	Total: 30 Boys: 18 Girls: 12 3nd: 12 4rd: 18	

SES: Socioeconomic Status; WISC-III: The Wechsler Intelligence Scale for Children—Third Edition; APRA: Analysis of Persian Reading Ability; NAMA: The NAMA reading and dyslexia test; IRT: Screening Inventory Reading Test

Statistical Analysis

All analyses were performed using Stata V.14 software. The primary outcome measure was the prevalence of developmental dyslexia, analyzed as a proportion. Heterogeneity was assessed using the I^2 index and Cochran's Q test. For the Cochran's Q test, a p-value less than 0.05 was considered significant heterogeneity (39, 40). I^2 values were interpreted as follows: 0-40% as potentially unimportant heterogeneity, 30-60% as moderate heterogeneity, 50-90% as substantial heterogeneity, and 75-100% as considerable heterogeneity (41). Expecting heterogeneity in research methodologies, researchers applied the random-effects combination model to calculate the overall pooled prevalence of developmental dyslexia with a 95% confidence interval using the binomial exact method.

Sensitivity analyses involved the use of: (1) the one-out removed method, systematically excluding one study at a time while rerunning the analytical process, (2) sensitivity analysis related to publication bias, and (3) sensitivity analysis related to the methodological quality of primary studies. Publication bias was assessed using funnel plots, Egger's test, and the trim and fill method (42). To identify sources of heterogeneity, we conducted subgroup analyses based on gender, grade level, and diagnostic criteria.

Results

Our systematic search identified 32,269 records, of which 18 studies met the inclusion criteria, comprising a total sample of 28,952 participants (Figure 1: PRISMA flowchart). Key characteristics of included studies are summarized in Table 2.

15 out of 18 records (83.3%) reported prevalence data for developmental dyslexia for both boys and girls. The third grade was examined more frequently than other grades in dyslexia prevalence studies (12 studies, 66.6%). The largest sample size was from Arab Ameri's study (2015) (30) in Semnan (n = 6,822), and the smallest sample size was from Sedaghati's study (n = 200) (18) in Isfahan. The highest prevalence of developmental dyslexia was found in Ahvaz (11.8%) (15), and the lowest in Semnan (1.3%) (30).

The Reading Level Diagnostic Test (43) was used in 4 studies (22.2%), the Inventory Reading Test (44) in 4 studies (22.2%), the NAMA test in one study (5.55%), and other informal tests in 9 studies (50%).

The pooled prevalence of developmental dyslexia using random-effects meta-analysis was 5.7% (95% CI: 4.5%-6.9%) (Figure 2). Substantial heterogeneity was observed among studies ($Q = 541.757$, $P < 0.001$; $I^2 = 96.86\%$).

Table 3 illustrates the prevalence of developmental dyslexia across gender, educational grade, sample size, and various diagnostic tools. The prevalence of dyslexia in boys was 7.5% (95% CI: 5.8%-9.2%) and in girls 4% (95% CI: 3%-5%), showing a statistically significant difference ($p < 0.05$). The heterogeneity test results for the studies, based on heterogeneity indices, were $Q = 541.757$ and $I^2 = 96.86$ ($P < 0.001$), indicating considerable heterogeneity.

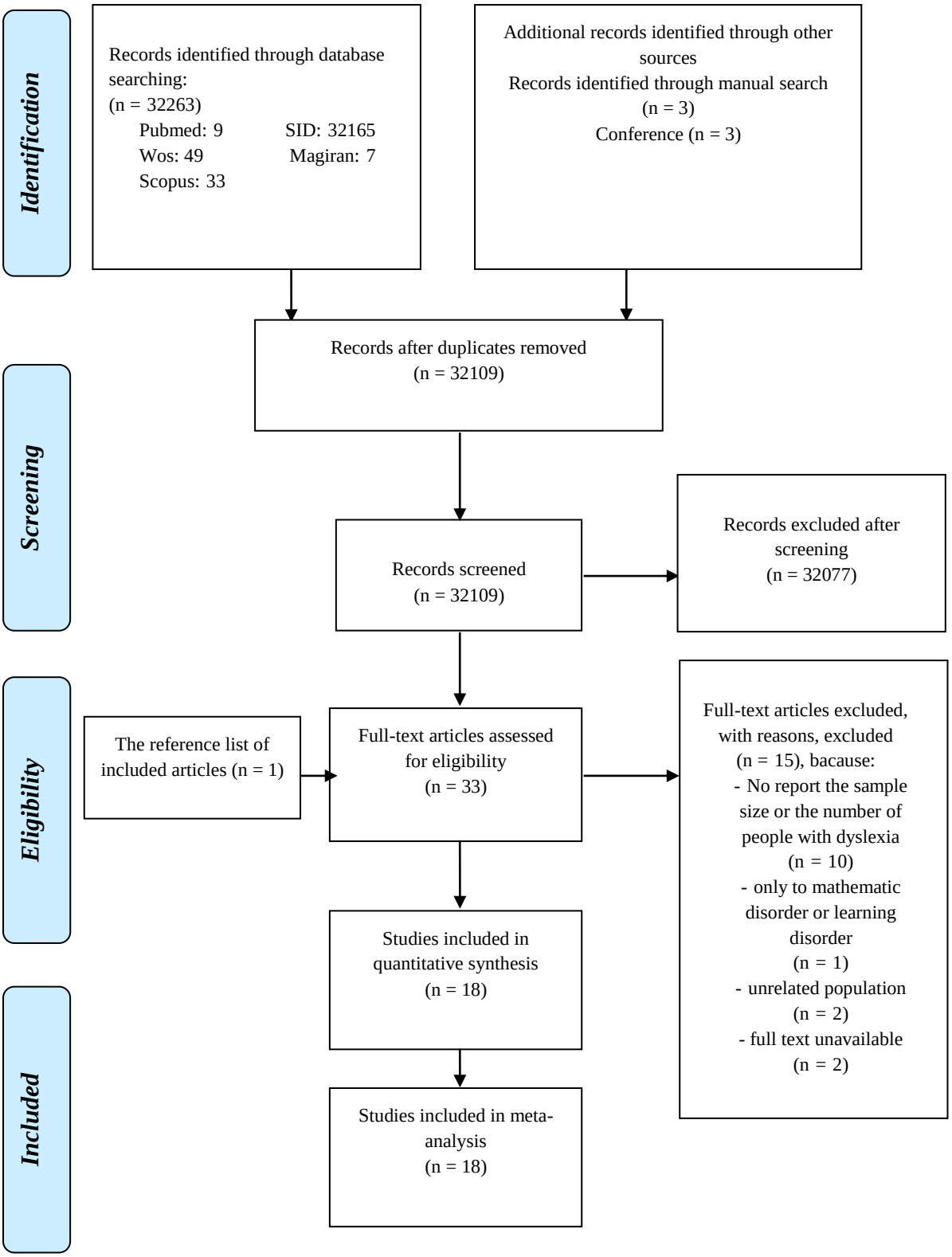

Figure 1. PRISMA Flowchart for the Search and Selection Steps of Systematic Reviews and Meta-Analyses

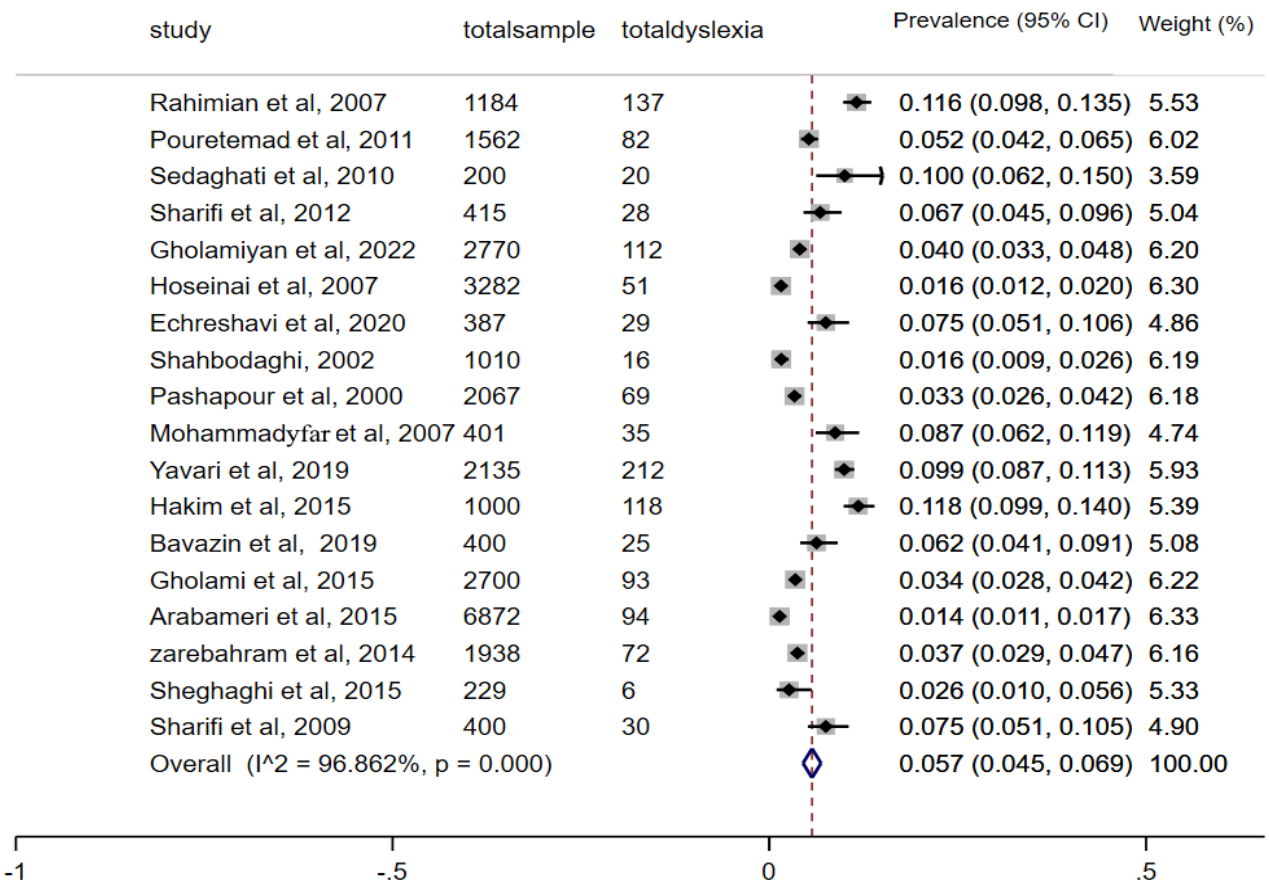

Figure 2. Forest Plot of the Prevalence of Developmental Dyslexia Based on Random-Effects Meta-Analysis

Table 3. Prevalence of Developmental Dyslexia Based on Random-Effects Meta-Analysis and Subgroup Analysis.

Variable		Number of Studies	Prevalence (95% CI), %	I^2	P-value	
					Q-test	Subgroup Difference
Overall DD Analysis		18	5.7% (4.5%, 6.9%)	96.80	< 0.001	Not applicable
Gender	Boys	16	7.5% (5.8%, 9.2%)	96.01%	< 0.001	< 0.001
	Girls	15	4% (3%, 5%)	91.88%	< 0.001	
Grade	1	6	8.5% (4.8%, 12.1%)	89.15%	< 0.001	0.90
	2	8	8.4% (4.9%, 12%)	94.71%	< 0.001	
	3	12	6.3% (3.9%, 8.6%)	89.20%	< 0.001	
	4	9	6.3% (3.1%, 9.6%)	93.83%	< 0.001	
	5	7	5.3% (2.6%, 8%)	77.98%	< 0.001	
Subject scale	< 500	7	6.8% (5%, 8.6%)	69.83%	< 0.001	0.034
	500-2000	5	6.7% (3.4%, 9.9%)	97.61%	< 0.001	
	2000 <	6	3.9% (2.3%, 5.4%)	96.86%	< 0.001	
Diagnostic material	Reading Level Diagnostic Test	4	7.2% (3.2%, 11.2%)	95.19%	< 0.001	0.002
	IRT	4	8.8% (4.5%, 13.2%)	96.99%	< 0.001	
	Other Informal Tests	9	3.4% (2.4%, 4.4%)	93.59%	< 0.001	

Subgroup Meta-Analysis

Given the heterogeneity in the prevalence results of developmental dyslexia across studies, subgroup analysis was employed to identify influential factors. The subgroup meta-analysis results revealed a statistically significant relationship between the prevalence of developmental dyslexia and the sample size of the studies. The prevalence of developmental dyslexia differed significantly between two subgroups: less than 500 participants and more than 2000 participants (heterogeneity between groups, P = 0.034) (Figure 3). In the subject scale variable subgroups, we observed a 9% reduction in I^2. Therefore, this variable could be considered a factor contributing to heterogeneity in the prevalence results of developmental dyslexia studies.

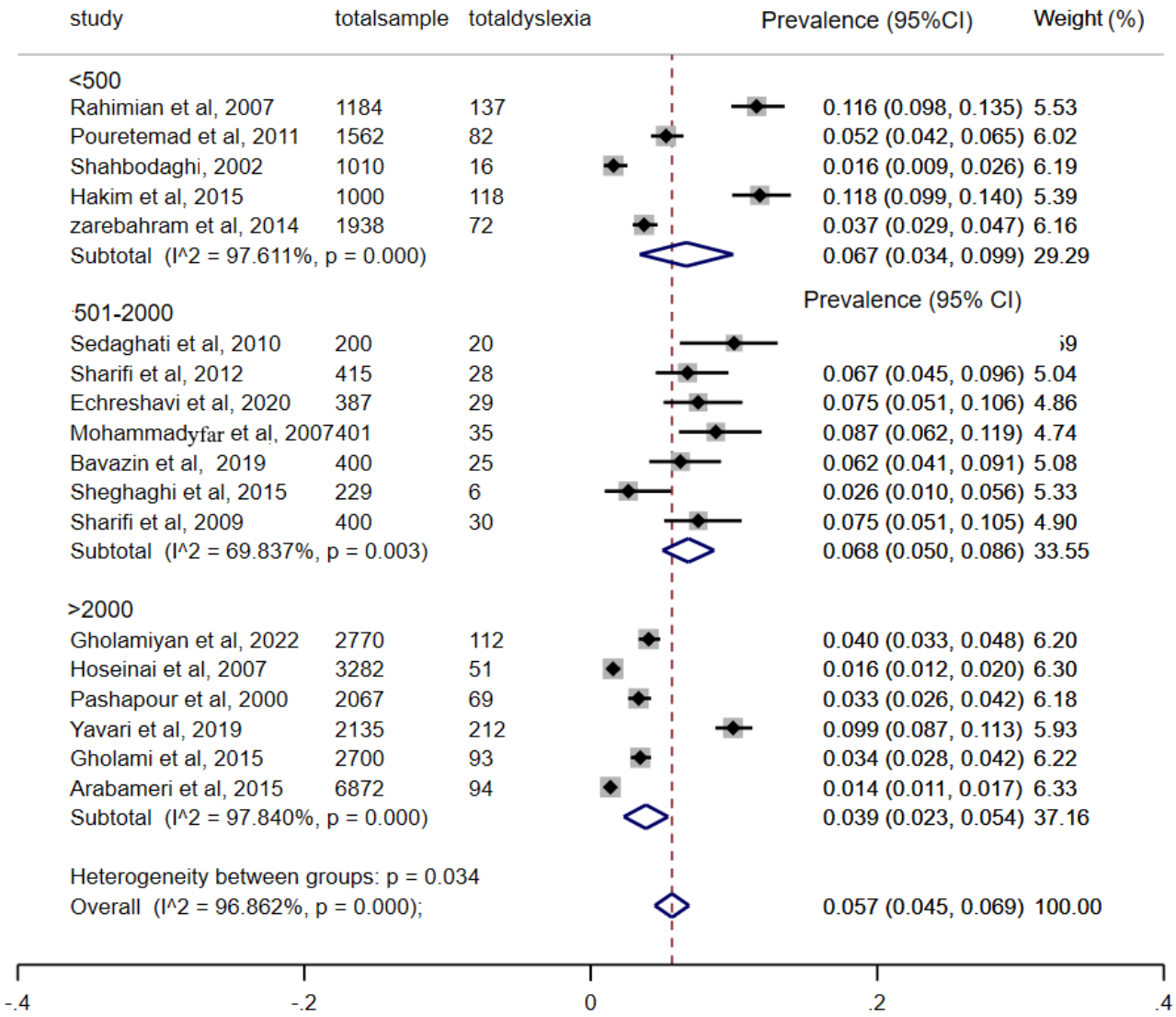

Figure 3. Forest Plot of Developmental Dyslexia Prevalence across Subgroups Categorized by Sample Size

To examine the effect of diagnostic material on the prevalence results of developmental dyslexia, subgroup analysis was also utilized. The results indicated a statistically significant relationship between the prevalence of developmental dyslexia and diagnostic material. A statistically significant difference in the prevalence of developmental dyslexia was found between two subgroups of studies that used informal reading tests and the screening inventory reading test (heterogeneity between groups: P = 0.002).

In the subgroups of diagnostic material variable, we observed a 1.6% reduction in I^2. Consequently, the subject scale variable (with a 9% reduction in I^2) was considered the most important factor in this study for differences in the prevalence of developmental dyslexia (Figure 4).

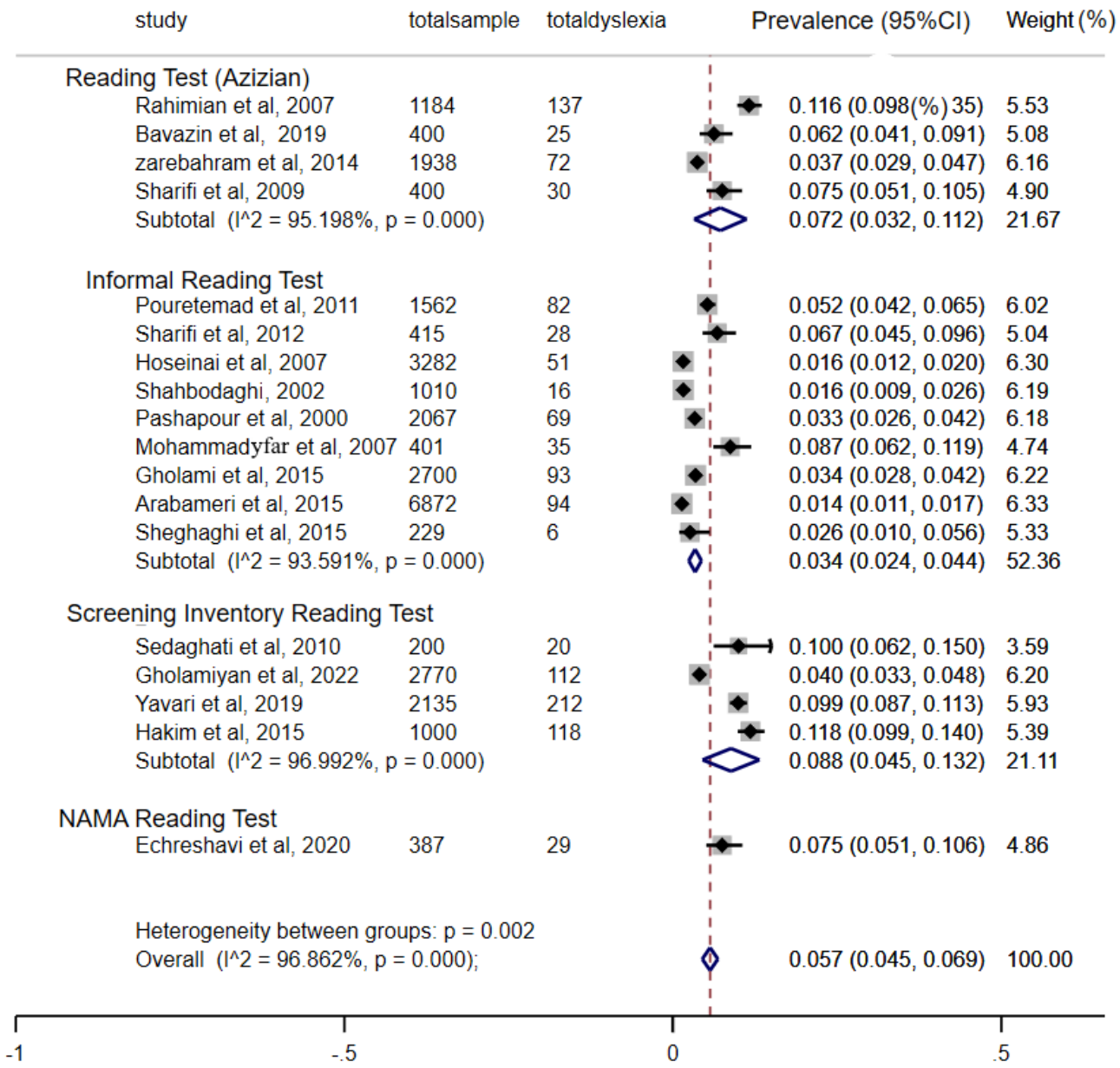

Figure 4. Forest Plot of Developmental Dyslexia Prevalence across Subgroups Categorized by Diagnostic Materials

It should be noted that subgroup analysis was not performed for the diagnostic criteria. This is because in the included studies, except for one study that used 2SD below the mean as a cut-off for diagnosing developmental dyslexia (16), other studies did not specify any criteria for considering a subject's performance below a certain SD as developmental dyslexia.

Quality Assessment

Figure 5(A) shows the summary plot and Figure 5(B) displays the traffic light plot of the risk of bias assessment based on the Hoy checklist items. Five studies had a low overall risk of bias (27.8%), while the remaining studies had a moderate overall risk of bias (72.2%). The predominance of moderate-risk studies suggests caution in interpreting the overall results and highlights areas for improvement in future research.

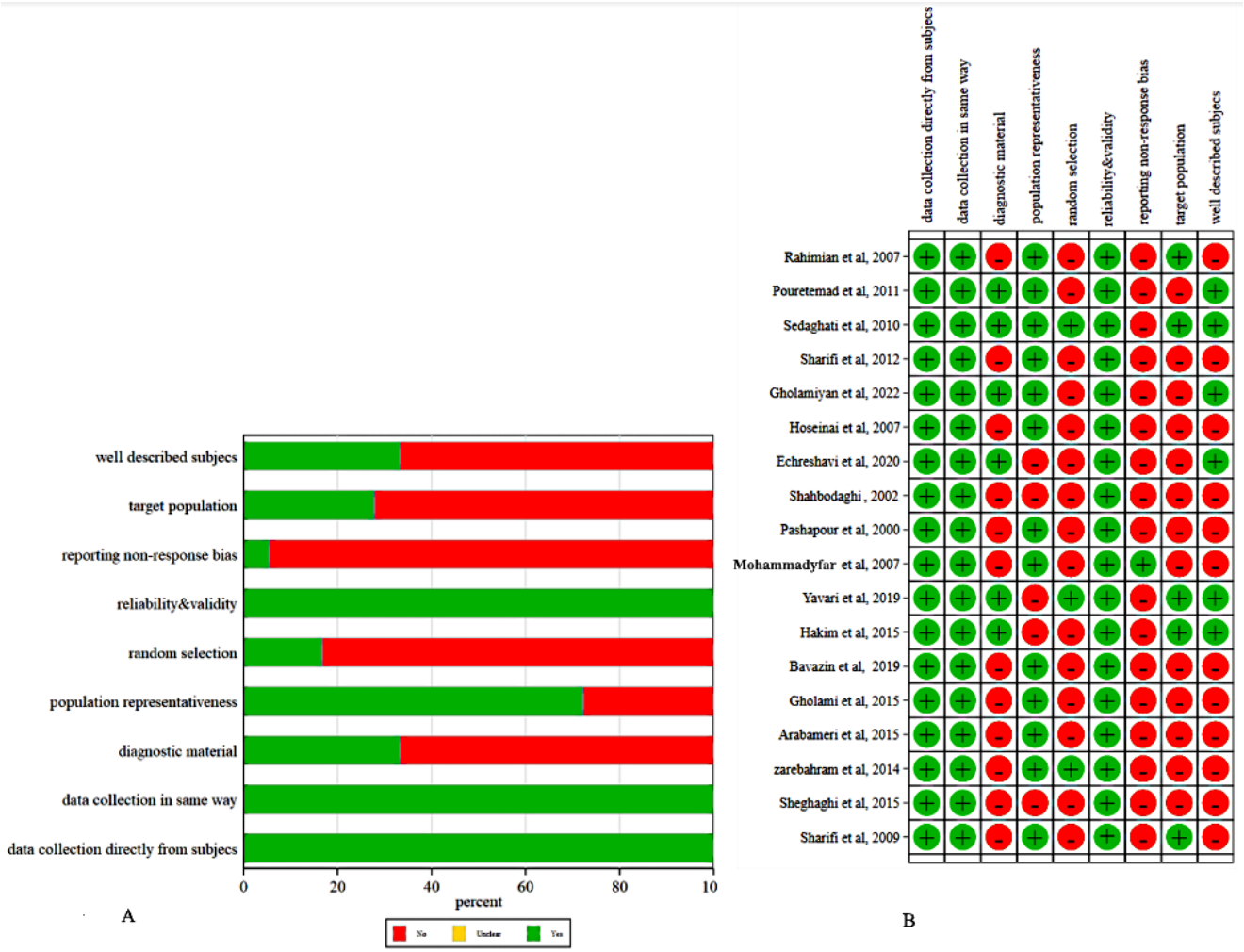

Figure 5. Risk of Bias Assessment of Included Studies Using the Hoy Checklist for Dyslexia Prevalence: (A) Traffic Light Plot of Bias Assessment (B) Summary Plot of Risk of Bias Assessment

Sensitivity Analysis and Publication Bias

To verify our results' reliability, we performed triple sensitivity analysis. a) To analyze the sensitivity related to the effect of a particular study, in each interval, one study was removed from the analysis and the final estimate of developmental dyslexia prevalence was calculated. The results showed that the removal of any of the studies did not affect the overall prevalence and did not create a significant difference. b) For sensitivity analysis regarding publication bias, we used three methods hierarchically: funnel plot, Egger's statistical test, and the trim and fill method. The funnel plot is shown in Figure 6. To draw the funnel plot, which requires a normal distribution, we used the logit variable transformation. Based on Egger's statistical test ($t = 5.02$, $P > 0.1$), publication bias is inconsiderable.

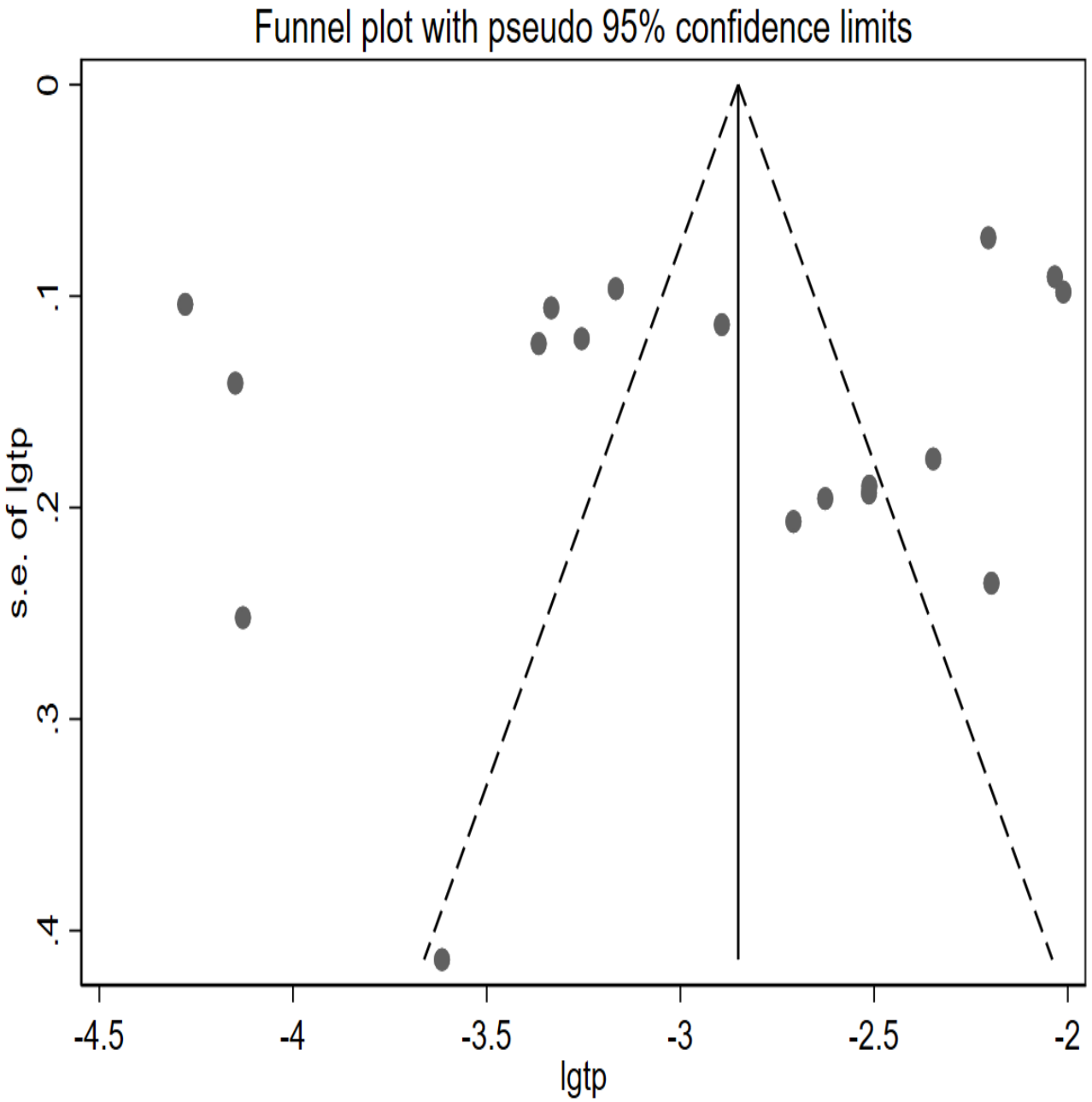

Figure 6. Funnel Plot Visualization for the Assessment of Publication Bias in Meta-Analysis of Developmental Dyslexia Prevalence

The results of the trim & fill test showed that no study was added to this combination; therefore, the overall publication bias is inconsiderable.

c) For sensitivity analysis related to the methodological quality of primary studies, we examined the role of methodological quality (moderate risk of bias and low risk of bias) on the final conclusion. For this purpose, studies were compared in two groups: moderate risk of bias and low risk of bias (Figure 7).

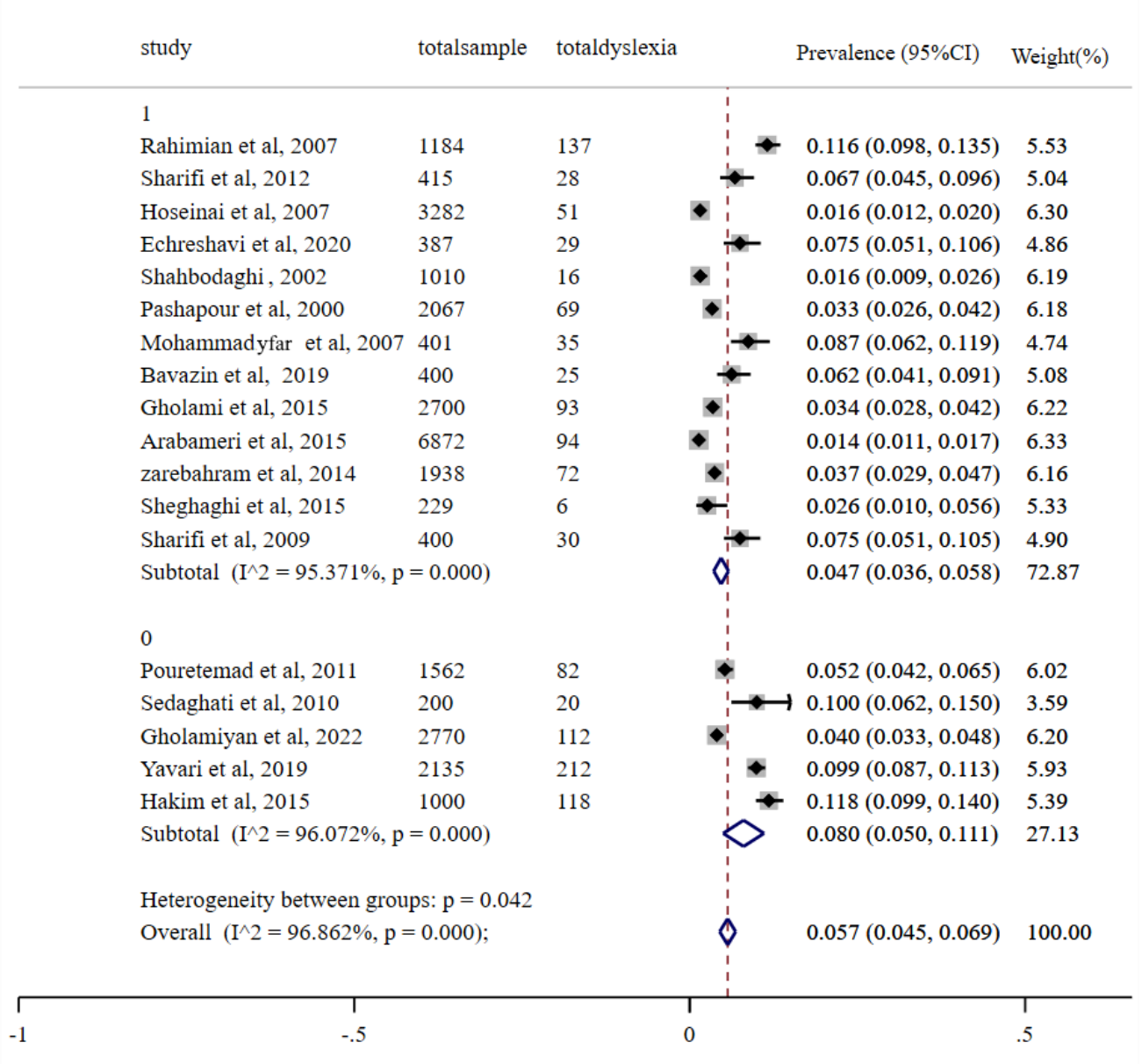

Figure 7. Sensitivity Analysis of Developmental Dyslexia Prevalence Associated with Methodological Quality of Primary Studies

It should be noted that no study was placed in the high risk of bias category, which is why only these two categories were compared. The results showed that the overall prevalence in the subgroup of low risk of bias studies was 8% (95% CI: 5%-11.1%), while in the moderate risk of bias subgroup was 4.7% (95% CI: 3.6%-5.8%), which is a considerable difference. This means that studies with higher quality showed a higher prevalence of developmental dyslexia.

Discussion

This systematic review and meta-analysis examined the prevalence of developmental dyslexia among elementary school students in Iran from 1991 to April 2024. To our knowledge, this is the first meta-analysis on the prevalence of developmental dyslexia in Iran and provides valuable insights into the epidemiology of dyslexia within this population. In this study, the overall prevalence of developmental dyslexia was found to be 5.7% (95% CI: 4.5%, 6.9%), which aligns with the range estimated in other review studies (5-17.5%) conducted in various parts of the world (45, 46). However, the prevalence rate of dyslexia in Iran falls in the lower range of this spectrum (5.7%), which is contrary to our initial assumption that Persian's deep orthography might yield higher prevalence rates. This finding may reflect the impact of diagnostic methodologies in Iranian studies rather than inherent differences in dyslexia prevalence.

The relatively lower prevalence rate observed in Iran may be attributed to the diagnostic criteria and tools

commonly used in Iranian studies. These studies employed a range of assessments, from informal reading error tests and inventory reading tests (44) to reading level diagnostic tests (43). The better the psychometric properties of these diagnostic tests, the more accurately they can identify developmental dyslexia. Studies using less standardized measures (21, 24, 47, 48) reported the lowest prevalence rates, suggesting that non-standardized tools may underestimate dyslexia prevalence by failing to capture the full spectrum of reading difficulties. Only one study (16) used the standardized Persian Reading Disorder Test (NAMA), which set the diagnostic criterion for dyslexia as 2 SD below the mean score (i.e., a score below 30), which may offer a more accurate prevalence estimate. Standardized and culturally appropriate diagnostic tools are therefore recommended to enhance the precision of dyslexia identification in Iran.

In recent years, the landscape of dyslexia diagnosis has undergone significant transformation, with important implications for prevalence assessment. Frameworks such as DSM-5 and ICD-11 advocate for multidimensional assessment, recognizing dyslexia's variability across individuals (49). The limitations of non-standardized tools widely used in Iran underscore the need for culturally tailored standardized tests and cross-study comparability to address systematic underestimation of dyslexia prevalence. Future research should prioritize the development and validation of diagnostic instruments for Persian-speaking populations to facilitate uniform assessments that capture the complete range of dyslexia symptoms.

The investigation uncovered a boys-to-girls developmental dyslexia ratio of 1.9: 1 in Iran, consistent with documented worldwide patterns (14, 31, 32, 34). Although we did not investigate specific causes, genetic and neurodevelopmental hypotheses have been proposed to explain this difference (35, 50-52). It is suggested that future research in Iran explore gender differences in dyslexia to deepen our understanding of these factors .

The study revealed a slight but statistically insignificant decrease in dyslexia prevalence with increasing grade levels. The impact of grade level differences on dyslexia prevalence shows conflicting results across studies. This finding aligns with studies suggesting that as children advance through grades, improved reading skills may reduce observable dyslexia symptoms (53). However, conflicting results in the literature (25, 54, 55) suggest that further investigation is needed to understand grade-level influences on dyslexia prevalence .

Another notable finding was the impact of sample size on prevalence estimates. Studies with smaller samples (< 500 participants) reported higher prevalence rates, whereas larger studies (> 2000 participants) observed lower rates, consistent with findings from other studies (56). This difference may result from the thoroughness of assessment in smaller studies, though no clear pattern emerged regarding the diagnostic criteria used across sample size categories. This limitation should be addressed in future research by ensuring sufficient sample sizes and uniform diagnostic standards across studies.

Given the heterogeneity of developmental dyslexia prevalence results in the present study, subgroup and sensitivity analyses were performed on the variables of interest. These analyses revealed that differences in sample size and diagnostic methods significantly influenced the variability in prevalence estimates across studies. Although heterogeneity is a common challenge in prevalence meta-analyses (57), identifying primary sources of variability, such as sample size and assessment tools, allows for more accurate data interpretation. Sensitivity analyses confirmed that prevalence estimates remained stable regardless of the removal of any individual study. Additionally, higher-quality studies (15, 18, 20, 25, 28) tended to report higher prevalence rates, underscoring the importance of employing rigorous diagnostic criteria to avoid underestimating the true prevalence of dyslexia.

Overall, the strengths of this study include a comprehensive search strategy to identify studies and the use of at least two reviewers for the three stages of screening, risk of bias assessment, and selection. Given that the included studies focused on Iranian elementary school students and that elementary education in Iran has at least 85% school coverage, the results of this study can be generalized to the broader population of elementary school-age children in Iran.

Limitation

However, this study also faced limitations. First, despite having overall dyslexia prevalence in studies, limited information was provided on the sample size of each subgroup and the number of individuals with developmental dyslexia within them. Consequently, we faced insufficient data in some subgroup analyses. Second, the included studies did not report factors related to developmental dyslexia, such as socioeconomic status. Therefore, in the present study, prevalence was not examined in relation to these factors. Third, the different criteria used to identify developmental dyslexia in various included studies may have affected the accuracy of developmental dyslexia estimation in the present study. Finally, prevalence studies of developmental dyslexia were not available for all regions of Iran. Therefore, it is recommended that future studies address the aforementioned issues, use precise diagnostic criteria and appropriate tools, have adequate sample sizes, and report detailed results for subgroups to provide more comprehensive results on the prevalence of developmental dyslexia in Iran.

Conclusion

This systematic review and meta-analysis study aimed to determine the prevalence of developmental dyslexia among primary school children in Iran, addressing the

lack of consolidated prevalence data in the country. Our analysis revealed significant variability in prevalence rates across studies, influenced primarily by differences in sample sizes and diagnostic methodologies. The findings highlight critical gaps in standardized diagnostic approaches and emphasize the need for consistent assessment tools across educational settings. Our meta-analysis also identified that higher-quality studies reported greater prevalence rates, suggesting potential underdiagnosis in studies with less rigorous methodologies. These findings have important implications for educational policy and practice in Iran. First, there is an urgent need to implement standardized diagnostic criteria and screening tools across all regions to ensure accurate identification of dyslexia. Second, early screening programs must be prioritized in educational settings to prevent long-term academic challenges. Third, policymakers should focus on developing evidence-based intervention programs that account for regional disparities and socioeconomic factors. Future research should emphasize rigorous diagnostic frameworks and investigate the impact of socioeconomic variables on dyslexia identification and treatment outcomes. These coordinated efforts will be crucial in providing equitable educational opportunities and enhancing the academic and psychological well-being of children with dyslexia across Iran.

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Conflict of Interest

None.

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