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REVIEW ARTICLE

Attention-deficit/hyperactivity disorder in hearing loss: A systematic review

İşitme kaybında dikkat eksikliği ve hiperaktivite bozukluğu: Bir sistematik derleme

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Abstract

This systematic review primarily aimed to evaluate the frequency of clinically diagnosed attention-deficit/hyperactivity disorder (ADHD) and its association with hearing loss (HL) in children and adolescents. Secondary aims were to synthesize evidence on ADHD-related symptoms identified by rating scales, general attention problems, differential diagnosis, and rehabilitation outcomes. PubMed and Web of Science Core Collection were searched from inception through April 2024 in accordance with PRISMA 2020. English-language original studies addressing HL and ADHD or attention-related outcomes were eligible, and reference lists were screened manually. Fourteen studies were included from 352 identified records. Two reviewers independently appraised methodological quality using design-specific Joanna Briggs Institute (JBI) critical appraisal checklists. Clinically diagnosed ADHD, rating-scale symptoms, general attention outcomes, and rates from selected clinical samples were analyzed separately. One retrospective cohort study reported higher crude ADHD rates in children with HL (12.1% vs. 3.6%), but the association was not significant after adjustment (OR=0.9, 95% CI: 0.4-1.9; p=0.70). A nationwide population-based study reported severe ADHD in 0.65% of adolescents with HL and 0.29% of those without HL (adjusted OR=1.70, 95% CI: 1.29-2.20). Rating-scale and general-attention findings varied across studies. Limited and heterogeneous evidence suggests that children with coexisting HL and ADHD may benefit from individualized auditory rehabilitation.

Current evidence suggests that ADHD diagnoses or ADHD-related behaviors may be reported more frequently in some groups of children with HL. However, clinical diagnoses, symptom scores, and general attention measures are not equivalent outcomes. Methodological heterogeneity, comorbidities, language ability, fatigue, and residual confounding limit certainty, and the available evidence does not establish that HL independently causes ADHD.

Keywords: Hearing loss, hearing impairment, attention deficit hyperactivity disorder, cochlear implants, comorbidity.

Özet

Bu sistematik derlemenin birincil amacı, çocuk ve adölesanlarda klinik olarak tanılanmış dikkat eksikliği ve hiperaktivite bozukluğunun (DEHB) sıklığını ve işitme kaybı (İK) ile ilişkisini değerlendirmektir. İkincil amaçlar, ölçeklerle belirlenen DEHB ile ilişkili belirtileri, genel dikkat sorunlarını, ayırıcı tanı güçlüklerini ve rehabilitasyon sonuçlarını sentezlemektir. PubMed ve Web of Science Core Collection veri tabanları, PRISMA 2020 doğrultusunda başlangıçtan Nisan 2024'e kadar tarandı. İK ile DEHB veya dikkatle ilişkili sonuçları inceleyen İngilizce özgün çalışmalar değerlendirildi ve kaynakçalar manuel olarak tarandı. Belirlenen 352 kayıttan 14 çalışma derlemeye dahil edildi. Metodolojik kalite, iki değerlendirici tarafından çalışma tasarımına uygun Joanna Briggs Institute (JBI) kritik değerlendirme araçlarıyla bağımsız olarak incelendi. Klinik DEHB tanıları, ölçekle belirlenen belirtiler, genel dikkat sonuçları ve seçilmiş klinik örneklemlerdeki oranlar ayrı değerlendirildi. Bir retrospektif kohort çalışmasında İK olan çocuklarda ham DEHB oranı daha yüksek bulunmuştur (%12,1'e karşı %3,6); ancak düzeltilmiş analizde ilişki anlamlı değildir (OR=0,9; %95 GA: 0,4-1,9; p=0,70). Ülke çapında yürütülen toplum temelli bir çalışmada şiddetli DEHB oranı İK olan adölesanlarda %0,65, İK olmayanlarda %0,29 olarak bildirilmiştir (düzeltilmiş OR=1,70; %95 GA: 1,29-2,20). Ölçek ve genel dikkat bulguları çalışmalar arasında değişkenlik gösterdi. Sınırlı ve heterojen kanıtlar, İK ve DEHB birlikteliği bulunan çocukların bireyselleştirilmiş işitsel rehabilitasyondan yarar görebileceğini düşündürmektedir. Mevcut kanıtlar, bazı İK gruplarında DEHB tanılarının veya DEHB ile ilişkili davranışların daha sık bildirilebileceğini düşündürmektedir. Bununla birlikte klinik tanılar, belirti ölçekleri ve genel dikkat ölçümleri eşdeğer değildir. Yöntemsel heterojenlik, eşlik eden durumlar, dil becerileri, yorgunluk ve karıştırıcı etmenler kanıtın kesinliğini sınırlamaktadır; mevcut bulgular İK'nin bağımsız olarak DEHB'ye neden olduğunu göstermemektedir.

Anahtar Kelimeler: İşitme kaybı, işitme yetersizliği, dikkat eksikliği ve hiperaktivite bozukluğu, koklear implantlar, eş tanı.

INTRODUCTION

Attention-deficit/hyperactivity disorder (ADHD) is a neurodevelopmental disorder with childhood onset that may persist into adolescence and adulthood. Its core symptoms are inattention, hyperactivity, and impulsivity (1,2). A meta-analysis estimated ADHD prevalence at 5.9%-7.1% among children and adolescents (3), and boys are diagnosed approximately three times more often than girls (4).

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Hearing loss (HL) is a health condition that has significant effects on individuals' communication, speech, and social interaction skills. Particularly when it occurs during childhood, HL may lead to adverse outcomes in social and behavioral development (5). Furthermore, the early identification and intervention of HL are critical for children's language and communication development. It has been reported that children who are identified and receive intervention early achieve better language development outcomes, whereas delays in diagnosis and intervention may adversely affect language development (6).

The adverse effects of ADHD and HL on individuals' academic, social, and behavioral functioning are well established (1,5). In recent years, studies have focused on the potential association between HL and ADHD, particularly the effects of early sensory deprivation on attention and executive functions, language and communication difficulties, listening effort and fatigue, and behavioral adaptation mechanisms aimed at compensating for auditory information deficits (7–9). In addition, HL and ADHD are among the most common developmental disorders in childhood (10). Therefore, evaluating the potential contribution of HL to attention deficits is of considerable importance.

Several studies have suggested that HL may be associated with attention problems and ADHD. Theunissen et al. (2014) reported that parents of children and adolescents with HL reported more ADHD symptoms than parents of their typically hearing peers (11). Similarly, Tsur et al. (2024) reported that, in a study including more than 1.1 million adolescents, individuals with HL had 70% higher odds of severe ADHD than those without HL (12). These findings suggest a potential association between HL and ADHD.

However, there is no consensus in the literature regarding the existence of this association. Kelly et al. (1993) reported that the prevalence of attention deficits among children who were deaf or hard of hearing did not differ from normative data. However, the same study indicated that attention problems may vary according to the etiology of HL, with attention deficits observed in 38.7% of children with acquired deafness and 14.1% of children with congenital deafness (13). Similarly, in their meta-analysis investigating emotional and behavioral difficulties in children and adolescents with HL, Stevenson et al. (2015) reported that behavioral and emotional problems may occur more frequently in this population. Nevertheless, the authors emphasized that, due to methodological differences among the available studies, the association between HL and ADHD has not yet been conclusively established (5).

ADHD assessment is particularly difficult in children with HL. Behaviors such as failing to respond, appearing distracted, requiring repeated instructions, or frequently shifting visual attention may reflect reduced auditory access, language difficulties, listening effort, fatigue, or adaptive visual monitoring rather than a primary attention disorder (8,9). Accordingly, questionnaire scores and behavioral observations should be interpreted within the context of auditory access, communication modality, and language development and should not be treated as equivalent to a clinical ADHD diagnosis.

Previous reviews have addressed emotional and behavioral difficulties in children with HL broadly, whereas the present review specifically integrates evidence concerning HL and ADHD across clinically diagnosed ADHD, symptom-rating outcomes, and general attention measures. The primary objective was to evaluate the frequency of clinically diagnosed ADHD and the potential association between HL and ADHD in children and adolescents. Secondary objectives were to synthesize evidence on ADHD-related symptoms, general attention problems, differential-diagnosis challenges, and rehabilitation outcomes.

METHODS

This systematic review was conducted in accordance with PRISMA 2020 (14). PubMed was selected for biomedical and clinical coverage, whereas Web of Science Core Collection was used to provide complementary multidisciplinary coverage. The database search was supplemented by manual screening of the reference lists of included studies. The original search strategy was developed using MeSH terms and free-text keywords with input from an experienced librarian. The documented core search concept is reported below; the exact field-tagged Web of Science export was not retained in the available search records.

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Search strategy used in the original review: ((((((Attention Deficit Disorder with Hyperactivity) OR (ADHD)) OR (Attention Deficit Hyperactivity Disorder)) OR (ADDH)) OR (Attention Deficit Disorder)) OR (Minimal Brain Dysfunction)) AND (hearing loss).

Limits: English language; document type: Article. The English-language restriction was applied to permit consistent full-text eligibility assessment and data extraction within the linguistic resources available to the review team. This restriction is acknowledged as a potential source of language bias.

The final searches were completed in April 2024. Web of Science Core Collection included SCI-EXPANDED, SSCI, A&HCI, and ESCI. PubMed and Web of Science each yielded 176 records (352 records in total). Available information on database coverage, search period, limits, record counts, and the documented search concept is provided in Supplementary Table S1. The original two-database scope and search syntax were retained to preserve the evidence base on which the review and study-selection process had been completed. No updated search was performed during revision; therefore, studies published or indexed after April 2024 were outside the review period. The limited database coverage and search terminology are acknowledged as limitations.

Study Selection and Eligibility Criteria

Eligible reports were English-language original human studies examining HL together with clinically diagnosed ADHD, ADHD-related symptoms or risk, general attention outcomes, or ADHD-relevant rehabilitation and differential-diagnosis outcomes. Reviews, editorials, letters, commentaries, case reports, clinical practice guidelines, conference abstracts, poster presentations, and reports without extractable data relevant to HL and ADHD or attention were excluded.

The eligibility criteria were defined according to an adapted PICOS (Population, Intervention/Exposure, Comparison, Outcome, and Study Design) framework as follows:

Population: Eligible participants were children, adolescents, and young people aged 0–21 years with peripheral HL or deafness, including hearing-aid and cochlear-implant users. Typically hearing participants and children with ADHD without HL were eligible as comparison groups. Central auditory processing disorder (CAPD) was not considered equivalent to peripheral HL; Chermak et al. (15) was retained only as contextual evidence for the secondary differential-diagnosis objective. Studies of additional disabilities were eligible only when ADHD-specific information could be extracted; aggregate rehabilitation outcomes were not interpreted as ADHD-specific effects.

Intervention/Exposure: Peripheral HL and, where relevant, hearing-aid or cochlear-implant use. Auditory intervention and rehabilitation were considered only for the secondary rehabilitation objective.

Comparison: Typically hearing participants, participants with HL with versus without ADHD, participants with ADHD without HL, published normative data, or clinically relevant subgroup comparisons.

Outcomes: For the revised data extraction and narrative synthesis, outcomes were classified into separate categories: 1- clinically diagnosed ADHD; 2- ADHD symptoms or risk identified through parent or teacher rating scales; 3- general attention or response-inhibition outcomes; and 4- ADHD diagnoses or rates in selected clinical populations. Rehabilitation outcomes and differential-diagnosis findings were treated as secondary outcomes and were not combined with prevalence estimates.

Study Design: Analytical cross-sectional, cohort, prevalence/registry, and quasi-experimental studies were eligible. Ineligible publication types were excluded regardless of topic relevance.

After duplicate removal, two review authors independently screened titles and abstracts and assessed potentially eligible full texts. Reference lists of the included studies were also screened manually. Data were independently extracted by the two review authors using a standardized data-extraction form. Disagreements during study selection or data extraction were resolved through discussion and consensus.

The standardized extraction form captured author/year, country, study design, sample size and participant age,

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type and degree of HL, hearing-aid or cochlear-implant use, comparison group, ADHD assessment method, classification of the outcome as a clinical diagnosis, rating-scale symptom/risk, general attention outcome, or selected clinical-sample rate, comorbidities, crude and adjusted effect estimates, variables included in adjusted analyses, rehabilitation outcomes, and key conclusions.

Risk of Bias Assessment

Two reviewers independently assessed methodological quality and risk of bias using Joanna Briggs Institute (JBI) critical appraisal checklists selected according to study design (16): analytical cross-sectional, cohort, prevalence, and quasi-experimental. Each item was rated as Yes, No, Unclear, or Not applicable. No numerical summary score was calculated; item-level judgments informed the narrative synthesis. Disagreements were resolved through discussion, with adjudication by a third reviewer when necessary. Detailed results are presented in Table 2.

Data Synthesis

Substantial heterogeneity in populations, HL characteristics, ADHD definitions, outcomes, and designs precluded quantitative pooling. Findings were therefore synthesized narratively in separate categories: clinically diagnosed ADHD; ADHD symptoms or risk identified by rating scales; general attention problems; ADHD rates in selected clinical populations; and secondary rehabilitation and differential-diagnosis evidence. Crude and adjusted results were reported separately.

Study Selection Process

Articles were systematically identified using the **PRISMA 2020** flow diagram (14) (Figure 1).

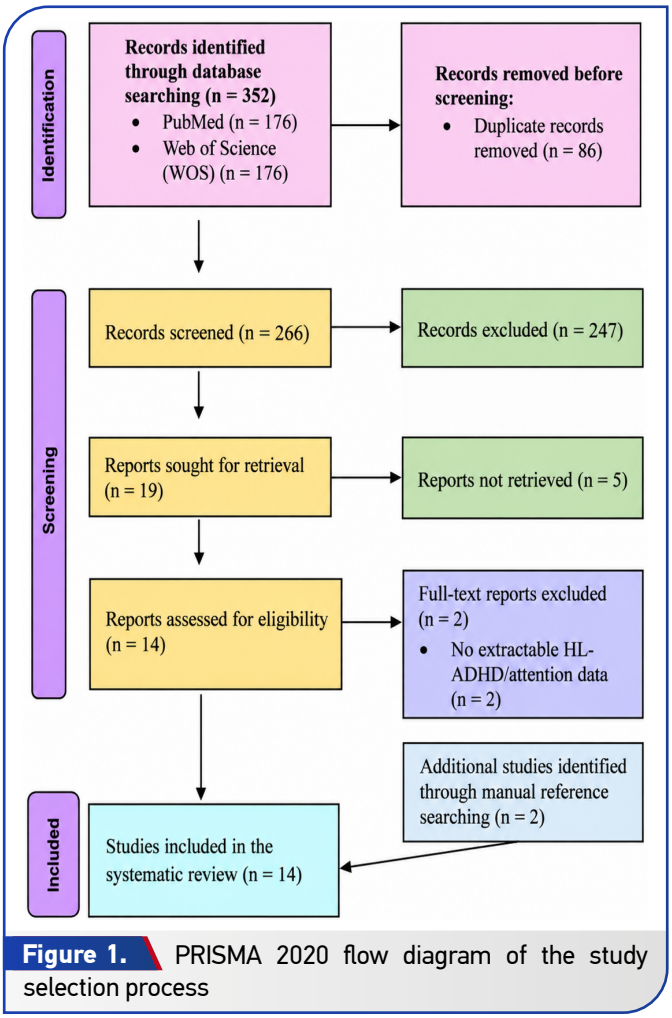

Figure 1. PRISMA 2020 flow diagram of the study selection process

RESULTS

The database searches identified 352 records (PubMed, n=176; Web of Science Core Collection, n=176). After 86 duplicates were removed, 266 records underwent title and abstract screening and 247 were excluded. Full texts were sought for 19 potentially eligible reports; five reports could not be retrieved. Fourteen full-text reports were assessed for eligibility, and two were excluded because they did not provide extractable HL-ADHD/attention data. Twelve studies were included from database searching, and two additional studies were identified through manual reference-list screening, resulting in 14 included studies.

The 14 included studies were published between 1993 and 2024. Nine were appraised as analytical cross-sectional studies, three as retrospective cohort studies, one as a prevalence/registry study, and one as quasi-experimental. Sample sizes ranged from 34 participants to 1,175,534 adolescents, and participant ages ranged from infancy to 21 years. HL populations included deaf or hard-of-hearing children, hearing-aid users, cochlear-implant users, and samples spanning mild to profound HL. ADHD outcomes comprised specialist-confirmed diagnoses, registry diagnoses, parent- or teacher-rated symptoms/risk, and general attention or response-inhibition measures. These outcomes were synthesized separately and are summarized in Table 1.

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Clinically Diagnosed ADHD

Soleimani et al. (2020) identified ADHD through expert psychiatric interview and ADHD Rating Scale-IV and reported diagnoses in 29.2% of children with severe-to-profound HL and 12.3% of typically hearing controls (p=0.017) (17). Ramanathan et al. (2023) reported higher crude diagnosis rates in children with permanent HL than in those with normal hearing (12.1% vs. 3.6%; crude OR = 3.7, 95% CI: 2.0-6.9), but the association was not significant after adjustment for age, sex, age at tube placement, and obstructive sleep apnea (OR=0.9, 95% CI: 0.4-1.9; p=0.70) (18).

Tsur et al. (2024) reported severe ADHD in 0.65% of adolescents with HL and 0.29% of those without HL. The crude association (OR=1.93, 95% CI: 1.47-2.49) remained significant after multivariable adjustment (OR=1.70, 95% CI: 1.29-2.20), although the absolute difference was small and the outcome was restricted to severe ADHD (12).

ADHD Symptoms Identified by Rating Scales

Theunissen et al. (2014) reported higher parent-rated ADHD symptom scores in children with HL than in typically hearing peers (11). Daza González et al. (2021) found more teacher-rated ADHD- and conduct-related behaviors in deaf children, but these were scale-based risk classifications rather than clinical diagnoses (8). Mattingly et al. (2023) found that language ability and parent-reported fatigue were associated with ADHD-linked questionnaire scores; no participant had an ADHD diagnosis at study entry (9).

General Attention Problems

Kelly et al. (1993) found overall ratings similar to historical norms, but attention problems were more frequent in acquired than hereditary HL (38.7% vs. 14.1%; p=0.002) (13). Bell et al. (2020) assessed inhibition and fNIRS patterns rather than ADHD prevalence (7).

Table 1. Characteristics and principal findings of the included studies

Study / design	Participants / age	HL / device	ADHD/ attention assessment and outcome type	Comparator	Comorbidities / adjustment variables	Key findings / adjusted results	Risk-of-bias summary
Kelly et al., 1993 Analytical cross-sectional survey	n=238; 4-21 y; median 16 y	Severe or greater HL; residential school; 69% fitted with HA; hereditary/ acquired subgroups	ACTeRS, Conners PRS, abbreviated ANSER; general attention/ hyperactivity ratings	Historical norms; hereditary vs. acquired HL	No multivariable adjustment reported; hereditary vs. acquired HL analyzed as etiological subgroups.	Overall scores similar to norms; attention problems: 38.7% acquired vs. 14.1% hereditary (p=0.002); no adjusted analysis	Historical norms; rater and instrument limitations
Daneshi and Hassanzadeh, 2007 Retrospective cohort	n=398 CI users; implantation age 15-240 mo; 60 with additional disabilities	Prelingual profound HL; CI use>=1 y	Leiter assessment; ADHD clinical classification; Persian auditory perception test	Disability subgroups; pre- vs. 1-y post-CI	Additional-disability subgroup (60/398); no multivariable confounder adjustment reported.	15 ADHD cases: 25% of the disability subgroup and 3.8% of the full cohort; auditory perception improved, but ADHD-specific rehabilitation effects were not reported	Selective verification; no comparator or confounder control

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Study / design	Participants / age	HL / device	ADHD/ attention assessment and outcome type	Comparator	Comorbidities / adjustment variables	Key findings / adjusted results	Risk-of-bias summary
Theunissen et al., 2014 Analytical cross-sectional	n=261; mean 11.8 y	Moderate to profound HL; 75 HA, 57 CI; 129 normal-hearing	Parent CSI-4 ADHD symptom scale; symptom score, not clinical diagnosis	Normal-hearing; HA vs. CI; school/device subgroups	Sex, SES, language, school, and device-related factors were examined; no single comprehensive adjusted effect estimate was reported.	Higher ADHD symptom scores in HL; associations with sex, SES, language, school, and device factors; no comprehensive adjusted estimate	Incomplete confounder control; multiple testing
Soleimani et al., 2020 Analytical cross-sectional	n=130; 9-17 y	65 severe-to-profound HL; 65 normal-hearing	Expert psychiatric interview plus ADHD-RS-IV/ DSM-IV-TR; clinical diagnosis	Age- and sex-matched normal-hearing controls	Age- and sex-matched groups; no multivariable adjusted analysis reported.	29.2% vs. 12.3%; OR=2.94 (95% CI 1.10-8.45); no adjusted analysis	Small single-school sample; age-at-onset criterion not applied
Oerbeck et al., 2022 Prevalence/ registry	17,824 youth with HL; 3,235 CAMHS-referred; 0-18 y	Registry-coded conductive, sensorineural, other/ unspecified HL	CAMHS ICD-10 diagnosis; selected clinical-sample rate	Published CAMHS general-population data	Selected CAMHS-referred population; no individual-level adjusted ADHD effect estimate reported.	29.8% among CAMHS-referred youth with HL; selected clinical-sample rate, not population prevalence; no individual-level adjusted estimate	Registry diagnoses unvalidated; selected clinical population
Ramanathan et al., 2023 Retrospective cohort	n=919; <18 y; 141 HL, 778 normal-hearing	Permanent HL after tympanostomy history; mostly mild; SNHL or persistent conductive HL	Qualified-provider diagnosis with documented testing; clinical diagnosis	Normal-hearing; analyses with/without comorbidities	Adjusted for age, sex, age at tympanostomy-tube placement, and obstructive sleep apnea; analyses also considered comorbidities.	Crude: 12.1% vs. 3.6% (OR=3.7); adjusted OR=0.9 (95% CI 0.4-1.9; p=0.70)	Temporal precedence not established

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Study / design	Participants / age	HL / device	ADHD/ attention assessment and outcome type	Comparator	Comorbidities / adjustment variables	Key findings / adjusted results	Risk-of-bias summary
Tsur et al., 2024 Population-based analytical cross-sectional	n=1,175,534 adolescents; 8,769 HL	Conductive or sensorineural HL; severity classified audiometrically	Specialist-confirmed severe ADHD with sustained medication criteria; clinical diagnosis	Adolescents without HL	Adjusted for age, sex, socioeconomic status, educational status, cognitive performance, and immigrant status.	0.65% vs. 0.29%; adjusted OR=1.70 (95% CI 1.29-2.20)	Cross-sectional design; restricted to severe ADHD
Chermak et al., 1998 Analytical cross-sectional professional survey	200 sampled; 81 analyzable professionals	CAPD context; not peripheral HL	Custom 41-item behavior-ranking survey; differential-diagnosis/ context outcome	Audiologists vs. pediatricians	Professional survey; no patient-level comorbidity or confounder adjustment applicable.	Inattention and distractibility overlapped; most highly ranked behaviors differed; no prevalence inference	Nonvalidated survey; 41% analyzable response
Birman et al., 2012 Retrospective cohort/case review	n=88; 0-16 y	Pediatric CI cohort; congenital/ progressive/ acquired severe-profound HL	Record-based additional disabilities; one ADHD case; 12-mo CAP outcome	Additional disabilities vs. none	Additional disabilities were grouped together; no multivariable confounder adjustment reported.	One ADHD case; aggregate CAP >=5: 52% with vs. 96% without additional disabilities; not ADHD-specific	Grouped disabilities; no confounder adjustment; one ADHD case
Noori et al., 2018 Quasi-experimental	n=40; 3-7 y; 12 ADHD, 28 non-ADHD	Prelingual HL; HA or CI; device imbalance between groups	Multidisciplinary ADHD assessment; Newsha developmental outcomes	ADHD vs. non-ADHD; sequential quiet/noise phases; no untreated control	ADHD group received methylphenidate; device distribution differed between groups; no multivariable adjustment reported.	Both groups improved; no valid causal evidence for a specific noise-based approach	No untreated/ counterbalanced control; limited pre/post measurement

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Study / design	Participants / age	HL / device	ADHD/ attention assessment and outcome type	Comparator	Comorbidities / adjustment variables	Key findings / adjusted results	Risk-of-bias summary
Omidvar et al., 2020 Analytical cross-sectional	n=42; 37-60 mo; 19 ADHD, 23 controls	Congenital severe-profound SNHL; unilateral CI	Pediatric neurologist DSM-5 diagnosis; Newsha and ASQ outcomes	Age/sex/ implant-matched CI users without ADHD	Groups were matched for age, sex, age at implantation, and duration of CI use; no multivariable adjusted analysis reported.	ADHD group had poorer auditory, language, cognitive, motor, and communication scores; no adjusted analysis	Small sample; multiple outcomes without stated correction
Bell et al., 2020 Analytical cross-sectional	n=62; 6-13 y; 15 bilateral HA, 20 ADHD, 27 typical	Bilateral HL with bilateral HA; ADHD and typical groups had normal hearing	Clinical ADHD group; rating scales; go/no-go and fNIRS attention/ inhibition outcomes	HA vs. ADHD vs. typically developing	Group characteristics and sex were considered; no ADHD-prevalence effect estimate was calculated.	Behavioral similarities but different neural patterns; no ADHD prevalence estimate	Uncorrected channel analyses; post-QC attrition
Daza González et al., 2021 Analytical cross-sectional	n=34; 9-10 y; 17 deaf, 17 hearing	Prelingual moderate to profound deafness; 9 unilateral CI	Teacher EDAH/ Conners-type scale; symptom/risk plus inhibition tasks	Age- and sex-matched hearing controls	Age- and sex-matched groups; no multivariable adjusted effect estimate reported.	More ADHD-linked behaviors/ risk in the deaf group; inhibition did not differ; no adjusted effect estimate	Very small sample; scale not validated in deaf children; uncorrected testing
Mattingly et al., 2023 Analytical cross-sectional	n=53; grades 2-6; mean about 9.5 y	13 HA, 16 CI, 24 typical; spoken-language sample	Modified parent NICHQ ADHD-linked behaviors; symptom/risk, not diagnosis; language/ fatigue measures	HA vs. CI vs. typical hearing	Language ability and fatigue were examined as relevant correlates; no clinical ADHD diagnosis was made.	Language linked to academic/ social outcomes; parent fatigue linked to symptom scores; Bonferroni pairwise correction	Modified NICHQ scoring not independently validated

Note: Clinical ADHD diagnoses, rating-scale symptoms or risk, general attention outcomes, and rates from selected clinical samples are reported as distinct outcome categories. Detailed item-level JBI critical appraisal results are presented in Table 2.

Abbreviations: *ACTeRS, Attention Deficit Disorder With Hyperactivity Comprehensive Teacher Rating Scale; ADHD, attention-deficit/hyperactivity disorder; ADHD-RS-IV, Attention-Deficit/Hyperactivity Disorder Rating Scale-IV; ANSER, Aggregate Neurobehavioral Student Health and Education Review; ASQ, Ages and Stages Questionnaire; CAMHS, Child and Adolescent Mental Health Services; CAP, Categories of Auditory Performance; CAPD, central auditory processing disorder; CI, cochlear implant; 95% CI, 95% confidence interval; CSI-4, Child Symptom Inventory-4; DSM-IV-TR, Diagnostic and Statistical Manual of Mental Disorders, Fourth Edition, Text Revision; DSM-5, Diagnostic and Statistical Manual of Mental Disorders, Fifth Edition; EDAH, Evaluation of Attention Deficit Hyperactivity Disorder Scale; fNIRS, functional near-infrared spectroscopy; HA, hearing aid; HL, hearing loss; ICD-10, International Classification of Diseases, 10th Revision; NICHQ, National Institute for Children's Health Quality Vanderbilt Assessment Scale; OR, odds ratio; PRS, Parent Rating Scale; QC, quality control; SES, socioeconomic status; SNHL, sensorineural hearing loss; mo, months; y, years.*

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Table 2. Design-specific JBI critical appraisal results

Study	*JBI checklist*	*Item-level judgments*	*Principal methodological concern*
Soleimani et al., 2020	Analytical cross-sectional	C1-C8: Y,Y,Y,Y,Y,Y,Y,Y	Small single-school sample; age-at-onset criterion not applied
Omidvar et al., 2020	Analytical cross-sectional	C1-C8: Y,Y,Y,Y,Y,Y,U,Y	Small sample; multiple outcomes without stated correction
Kelly et al., 1993	Analytical cross-sectional	C1-C8: Y,U,U,U,Y,Y,U,Y	Historical norms; rater/instrument limitations
Bell et al., 2020	Analytical cross-sectional	C1-C8: Y,Y,Y,Y,Y,Y,N,Y	Uncorrected channel analyses; attrition after quality control
Tsur et al., 2024	Analytical cross-sectional	C1-C8: Y,Y,Y,Y,Y,Y,Y,Y	Cross-sectional; severe ADHD only
Chermak et al., 1998	Analytical cross-sectional	C1-C8: Y,Y,Y,N,N,N,N,N	Nonvalidated survey; 41% analyzable response
Theunissen et al., 2014	Analytical cross-sectional	C1-C8: Y,Y,Y,Y,Y,U,U,Y	Incomplete confounder control; multiple testing
Daza González et al., 2021	Analytical cross-sectional	C1-C8: Y,Y,Y,U,Y,Y,N,Y	Very small sample; scale not validated in deaf children
Mattingly et al., 2023	Analytical cross-sectional	C1-C8: Y,Y,Y,U,Y,Y,Y,Y	Modified NICHQ scoring not independently validated
Ramanathan et al., 2023	Cohort	K1-K11: Y,Y,Y,Y,Y,N,Y,U,NA,NA,Y	Temporal precedence not established
Birman et al., 2012	Cohort	K1-K11: Y,Y,U,Y,N,U,Y,Y,Y,NA,U	Grouped disabilities; no confounder adjustment; one ADHD case
Daneshi and Hassanzadeh, 2007	Cohort	K1-K11: Y,U,Y,N,N,Y,Y,Y,U,N,U	Selective verification; no comparator/confounder control
Oerbeck et al., 2022	Prevalence	P1-P9: Y,Y,Y,Y,Y,N,U,Y,NA	Registry psychiatric diagnoses not validated
Noori et al., 2018	Quasi-experimental	Q1-Q9: Y,N,U,U,N,Y,Y,Y,N	No untreated/counterbalanced control; one pre and one post measure

Abbreviations: *JBI, Joanna Briggs Institute; C, analytical cross-sectional checklist; K, cohort checklist; P, prevalence checklist; Q, quasi-experimental checklist; Y, Yes; N, No; U, Unclear; NA, Not applicable. Note: Item numbers correspond to the respective design-specific JBI critical appraisal checklist. No numerical total score was calculated.*

ADHD Rates in Selected Clinical Populations

Oerbeck et al. (2022) reported that 3,235 of 17,824 youth with HL (18.1%) had been referred to Child and Adolescent Mental Health Services (CAMHS). ADHD was recorded in 29.8% of this CAMHS-referred subgroup. This percentage represents a selected clinical population and is not a population prevalence estimate for all youth with HL (19).

Daneshi and Hassanzadeh (2007) identified 15 ADHD cases among 60 cochlear-implant users with additional disabilities (25%), corresponding to approximately 3.8% of the complete cohort of 398 cochlear-implant users (20). Birman et al. (2012) identified only one child with ADHD among 88 consecutive pediatric cochlear-implant users; the study was retained as contextual evidence and its aggregate additional-disability outcomes were not attributed specifically to ADHD (21).

Rehabilitation and Differential-Diagnosis Evidence

Omidvar et al. (2020) reported poorer auditory, language, cognitive, motor, and communication outcomes in 19

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cochlear-implant users with ADHD than in 23 matched users without ADHD (22). Noori et al. (2018) observed improvement in children with HL with and without ADHD across sequential rehabilitation phases; however, the small sample, device imbalance, medication, absence of an untreated or counterbalanced control, and repeated unadjusted testing limit causal claims about a specific rehabilitation approach (23).

Chermak et al. (1998) was retained solely for the secondary differential-diagnosis objective. CAPD is not equivalent to peripheral HL, and the study was not used to estimate ADHD prevalence in HL. Its professional survey suggested that inattention and distractibility may overlap across CAPD and ADHD, while many other behaviors differ (15).

Risk-of-bias appraisal identified substantial variation in methodological quality (Table 2). Tsur et al. (12) used specialist-confirmed diagnoses, multivariable adjustment, and sensitivity analyses. Several smaller cross-sectional studies had incomplete confounder control, outcome-measure limitations, or unadjusted multiple comparisons. Oerbeck et al. (19) provided national registry coverage, but the psychiatric diagnoses had not been independently validated. Chermak et al. (15) relied on a nonvalidated survey with a 41% analyzable response, and Noori et al. (23) lacked an untreated or counterbalanced control.

DISCUSSION

This review indicates that evidence concerning HL and ADHD must be interpreted according to how ADHD or attention was measured. Clinically confirmed diagnoses, registry diagnoses, rating-scale symptoms, general attention performance, and rates from selected clinical services represent different outcomes and should not be combined into a single prevalence range. The design-specific JBI appraisal further showed that certainty varied considerably across studies.

The strongest population-based evidence came from Tsur et al. (12), which combined specialist-confirmed diagnoses with adjusted and sensitivity analyses. Even in that study, however, severe ADHD affected 0.65% of adolescents with HL and 0.29% without HL, so the adjusted OR should be interpreted together with the small absolute difference. The study by Ramanathan et al. (18) illustrates the importance of confounding: its significant crude association disappeared after adjustment. These findings do not support a simple or independent causal effect of HL on ADHD.

Clinical ADHD Diagnoses and Selected Clinical Samples

Soleimani et al. (17) reported a higher proportion of clinically diagnosed ADHD in children with severe-to-profound HL, whereas Ramanathan et al. (18) found no adjusted association and Tsur et al. (12) examined only severe ADHD in adolescents. Differences in age, HL severity, case definition, referral pathway, and covariate control probably contribute to the inconsistent estimates. Accordingly, crude proportions and adjusted effect estimates should be considered separately.

Rates derived from selected clinical groups also require denominator-specific interpretation. Oerbeck et al. (19) described youth with HL already referred to CAMHS, and its 29.8% figure cannot be generalized to all children with HL. Similarly, the 15 ADHD cases in Daneshi and Hassanzadeh (20) represented 25% of participants with additional disabilities but approximately 3.8% of the entire cochlear-implant cohort. Birman et al. (21) included only one child with ADHD and therefore cannot support ADHD-specific rehabilitation conclusions.

Potential shared causes and confounders include prematurity, congenital infections, genetic syndromes, neurological conditions, autism spectrum disorder, sleep-disordered breathing, and other developmental disabilities. These factors may contribute to both HL and attention-related difficulties. Consequently, an independent association between HL and ADHD should not be inferred from studies that do not adequately identify and control these variables.

ADHD Symptoms and General Attention Problems

An important distinction should be made between clinically diagnosed ADHD and ADHD-like behaviors identified through questionnaires. Reduced auditory access, language difficulties, listening effort, fatigue, and adaptive visual monitoring may increase parent- or teacher-reported symptom scores without necessarily

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indicating a primary neurodevelopmental attention disorder. This distinction is particularly important because some instruments were developed or validated in hearing children and may contain language-dependent items.

The results of Daza González et al. (8), Mattingly et al. (9), Kelly et al. (13), and Bell et al. (7) support this cautious interpretation. Higher symptom ratings or differences in response inhibition may reflect language ability, fatigue, HL etiology, listening demands, or altered distribution of visual attention. General attention measures and ADHD risk thresholds can inform further assessment, but they should not be treated as clinical diagnoses.

Rehabilitation and Differential Diagnosis

Rehabilitation evidence was limited to small and heterogeneous studies using different samples, devices, outcomes, medication conditions, and training procedures. Limited evidence suggests that children with coexisting HL and ADHD may benefit from individualized auditory rehabilitation, but the available studies do not establish the superiority of a particular listening condition or rehabilitation approach. Recommendations should therefore emphasize individualized assessment rather than a specific protocol.

The study by Chermak et al. (15) contributes only contextual evidence about behavioral overlap between CAPD and ADHD and was not used as evidence of ADHD prevalence in peripheral HL. The study by Birman et al. (21) similarly provides context concerning additional disabilities in pediatric cochlear-implant programs, but its grouped outcomes cannot be attributed to the single participant with ADHD. Explicitly limiting the role of these studies reduces the risk of overgeneralization.

Clinically, reports of inattention, impulsivity, or hyperactivity in a child with HL should prompt assessment of device access, auditory function, language development, fatigue, communication modality, educational context, and relevant medical or neurodevelopmental conditions before an ADHD diagnosis is inferred. When concerns persist across contexts, multidisciplinary assessment involving audiological, language, developmental, and mental-health expertise is appropriate.

The contribution of this review is the separate synthesis of clinically diagnosed ADHD, rating-scale symptoms, general attention outcomes, and selected clinical-sample rates, together with secondary evidence on differential diagnosis and rehabilitation. This structure clarifies why apparently similar percentages or behaviors do not necessarily represent the same clinical construct.

Several limitations should be considered. Only PubMed and Web of Science Core Collection were searched; PsycINFO, Scopus, Embase, CINAHL, and grey-literature sources were not included. The search was restricted to English-language articles, was last completed in April 2024, and centered the hearing component on the term “hearing loss”; therefore, reports indexed primarily under terms such as deafness, deaf, hard of hearing, hearing aid, or cochlear implant may have been missed. Clinical diagnoses, symptom-rating results, general attention outcomes, population-based samples, and selected clinical samples were heterogeneous and could not be pooled. HL type and severity also varied, and the evidence was predominantly cross-sectional or retrospective. Although formal JBI appraisal was added, several included studies had small samples, incomplete confounder control, unvalidated or context-limited measures, or unadjusted multiple comparisons.

Future studies should use prospectively defined diagnostic categories, validated and communication-accessible ADHD measures, appropriate hearing and typically hearing comparison groups, and adequate adjustment for language, fatigue, socioeconomic factors, sleep, prematurity, congenital conditions, neurological disorders, and other relevant comorbidities. Prospective follow-up is needed to clarify temporal relationships and rehabilitation outcomes.

CONCLUSION

Current evidence suggests that clinically diagnosed ADHD or ADHD-related behaviors may be reported more frequently in some groups of children and adolescents with HL. However, estimates differ substantially according to outcome definition, study population, HL characteristics, and assessment method. Clinical diagnoses, questionnaire-based symptoms, and general attention problems should not be interpreted as equivalent.

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Methodological heterogeneity, comorbidities, language ability, listening effort, fatigue, and residual confounding limit the certainty of the observed association. The available evidence does not demonstrate that HL independently causes ADHD. Rehabilitation findings are limited and heterogeneous; they suggest that individualized support may be beneficial but do not establish the effectiveness of a specific rehabilitation approach.

Attention concerns in children with HL should therefore be evaluated in a multidisciplinary framework that considers auditory access, language and communication development, medical and neurodevelopmental history, and behavior across settings. ADHD should neither be assumed solely from ADHD-like behaviors nor overlooked when diagnostic criteria are met.

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