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Attention Deficit Hyperactivity Disorder-Related Sleep Disorders: A Bibliometric Analysis of Global Research Trends

Dikkat Eksikliği Hiperaktivite Bozukluğu ile İlişkili Uyku Bozuklukları: Küresel Yayın Eğilimlerinin Bibliyometrik Analizi

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ABSTRACT

Objective: The aim of this study was to conduct a bibliometric analysis of global research on sleep disorders associated with Attention-Deficit/Hyperactivity Disorder (ADHD).

Methods: A bibliometric analysis was performed using the Web of Science (WOS) Core Collection (1990–2025). Publications were filtered by research field and analyzed using the Bibliometrix R package and VOSviewer. Bibliometric indicators, including publication trends, citation impact, the most productive authors, institutions, journals, and keyword networks, were examined to identify global research patterns.

Results: A total of 1,732 publications were identified, showing a steady increase in annual output and a marked rise after 2010. United States (735 articles) led in productivity, while Harvard University ranked first among institutions. Keyword analysis revealed four main clusters: (1) pharmacotherapy and treatment outcomes; (2) developmental and pediatric spectrum disorders; (3) epidemiology and risk factors; and (4) psychiatric comorbidities and sleep disorders. Since 2018, research has shifted toward neurobiological and circadian mechanisms.

Conclusion: Scientific interest in sleep disorders associated with ADHD has expanded significantly over the past two decades, supported by interdisciplinary collaboration and advances in neuroimaging and sleep assessment. Methodological heterogeneity and the limited representation of low- and middle-income countries remain persistent gaps in the literature.

Keywords: ADHD, sleep disorders, bibliometrics, circadian rhythm, global research trends

ÖZ

Amaç: Bu çalışmada, Dikkat Eksikliği ve Hiperaktivite Bozukluğu (DEHB) ile ilişkili uyku bozuklukları üzerine yapılan küresel araştırmalaraın bibliyometrik analizinin yapılması amaçlanmıştır.

Yöntem: Web of Science (WOS) Core Collection (1990–2025) kullanılarak bibliyometrik bir analiz gerçekleştirilmiştir. Yayınlar araştırma alanlarına göre filtrelenmiş; Bibliometrix R paketi ve VOSviewer ile analiz edilmiştir. Küresel araştırma modellerini belirlemek amacıyla yayın eğilimleri, atıf etkisi, en üretken yazarlar, kurumlar, dergiler ve anahtar kelime ağlarını içeren bibliyometrik göstergeler incelenmiştir.

Bulgular: Yıllık çıktı sayısında istikrarlı bir artış ve 2010'dan sonra belirgin bir yükseliş (bileşik yıllık büyüme oranı ≈ %14,2) gösteren toplam 1.732 yayın belirlenmiştir. Amerika Birleşik Devletleri (735 makale) üretkenlikte liderliği çekerken, kurumlar arasında Harvard Üniversitesi ilk sırada yer almıştır. Anahtar kelime analizi dört ana küme ortaya koymuştur: (1) farmakoterapi ve tedavi sonuçları; (2) gelişimsel ve pediyatrik spektrum bozuklukları; (3) epidemiyoloji ve risk faktörleri; ve (4) psikiyatrik komorbiditeler ve uyku bozuklukları.

Sonuç: DEHB ile ilişkili uyku bozukluklarına yönelik bilimsel ilgi, disiplinler arası iş birliği ile nörogörüntüleme ve uyku değerlendirmesindeki ilerlemelerin desteğiyle son yirmi yılda önemli ölçüde genişlemiştir. Metodolojik heterojenlik ve düşük-orta gelirli ülkelerin sınırlı temsili, literatürdeki kalıcı boşluklar arasındadır.

Anahtar sözcükler: DEHB, uyku bozuklukları, bibliyometri, sirkadiyen ritim, küresel araştırma eğilimleri

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Introduction

Attention-Deficit/Hyperactivity Disorder (ADHD) is one of the most common neurodevelopmental disorders of childhood and often continues into adolescence and adulthood. Beyond inattention, hyperactivity, and impulsivity, the disorder is associated with clinically relevant impairments in emotional regulation, executive functioning, academic performance, and quality of life (American Psychiatric Association 2022). Sleep disturbances are among the most common and clinically important comorbid features of ADHD because they may both mimic and worsen core symptoms and may also influence treatment response (Cortese et al. 2024, Uygur 2025).

According to the DSM-5-TR, sleep-wake disorders include insomnia disorder, hypersomnolence disorder, narcolepsy, breathing-related sleep disorders, circadian rhythm sleep-wake disorders, parasomnias, and sleep-related movement disorders (APA 2022). In ADHD populations, insomnia symptoms, delayed sleep phase patterns, parasomnias, restless legs syndrome, and sleep-disordered breathing have all been reported, although their relative prominence varies across age groups and clinical subgroups (Ahlberg et al. 2023, van der Ham et al. 2024, Marten et al. 2025). This heterogeneity makes ADHD-related sleep research clinically important but also difficult to synthesize from a methodological perspective.

The relationship between ADHD and sleep disturbances is widely considered bidirectional. Sleep disruption may worsen attention problems, mood instability, and daytime functioning, whereas ADHD-related neurobiological, circadian, and behavioral mechanisms may further disturb sleep architecture and timing (Cortese et al. 2024). In addition, reliance on a single assessment modality can lead to inconsistent findings; studies based only on parent report, self-report, actigraphy, or polysomnography may capture different aspects of the same problem. For this reason, multimodal assessment and careful phenotyping have been repeatedly emphasized in the literature (Díaz-Román et al. 2016).

From a clinical perspective, this literature is not limited to symptom description. Sleep problems in ADHD affect diagnostic interpretation, treatment monitoring, and intervention planning. Behavioral strategies and sleep hygiene remain central components of management, whereas pharmacological approaches such as melatonin require individualized clinical judgment based on age, comorbidity profile, and the relevant sleep-wake phenotype (Rishi et al. 2023, Shenoy et al. 2024). Mapping how these topics have changed over time may help clarify which themes have dominated the field and which areas are still underdeveloped.

Although bibliometric studies have examined ADHD research more broadly and some recent analyses have started to focus on sleep in ADHD, the field still lacks a clearly reported overview of publication growth, institutional and country contributions, collaboration structure, and thematic clustering within a single reproducible bibliometric workflow. In particular, the way screening logic, keyword cleaning, supplementary labeling, and thematic interpretation are reported can strongly affect reproducibility and interpretability in science-mapping studies (Donthu et al. 2021, Dougnon and Matsui 2025, Chen et al. 2025). Accordingly, the present study aimed to describe global publication trends, leading contributors, citation patterns, and keyword clusters in ADHD-related sleep research indexed in the Web of Science Core Collection using a transparent and reproducible bibliometric workflow. We hypothesized that the literature would show marked post-2010 growth, concentration in a limited number of high-output countries and institutions, and a thematic shift toward circadian, comorbidity-focused, and clinically integrative topics.

Method

Data Source and Search Strategy

The data for this bibliometric analysis were obtained from the Web of Science Core Collection (WoSCC), a multidisciplinary citation database commonly used in science-mapping studies. The search was conducted on November 14, 2025. Searches were performed using the Topic field tag (TS), which retrieves terms from the title, abstract, author keywords, and Keywords Plus. The full Boolean query is reported in Supplementary Table 1. Records were initially retrieved without language or document-type restrictions.

During screening, records were retained only if they were English-language research articles addressing ADHD in relation to sleep disorders, sleep symptoms, sleep physiology, or sleep-related comorbidity. Records were excluded if they were duplicates, non-English publications, non-article document types (e.g., editorial material, meeting abstracts, letters, corrections, and reviews), or clearly unrelated to ADHD-related sleep research on the basis of title and abstract screening. No additional manual restriction was applied at the individual citation index level beyond selecting the Web of Science Core Collection database. National or regional bibliographic data sources were not searched; therefore, the dataset reflects only records retrieved from the Web of Science Core Collection.

Data Screening and PRISMA Workflow

An adapted PRISMA 2020 flow structure was used to report record identification, screening, eligibility, and final inclusion in the bibliometric dataset. In this study, PRISMA was used as a transparent reporting framework for database selection and record filtering rather than as a full systematic review protocol (Page et al. 2021, Donthu et al. 2021). Screening was conducted as an author-led bibliometric curation process. Initial title and abstract screening was performed by one author, and eligibility decisions were then reviewed by a second author. Any disagreements were resolved through discussion. Records were reviewed iteratively on the basis of titles, abstracts, document types, language, and topical relevance to ADHD-related sleep research. A total of 2,185 records were initially identified from the Web of Science Core Collection. After removal of 309 duplicate records, 1,876 records were screened. Of these, 173 records were excluded during title and abstract screening. The remaining 1,703 reports were assessed for eligibility, and 63 were excluded because they were not directly relevant to ADHD-related sleep research. As a result, 1,640 eligible research articles remained for analysis (Figure 1). The exclusion of non-English publications was adopted to improve bibliometric comparability and maintain consistency in title-, abstract-, and keyword-based analyses.

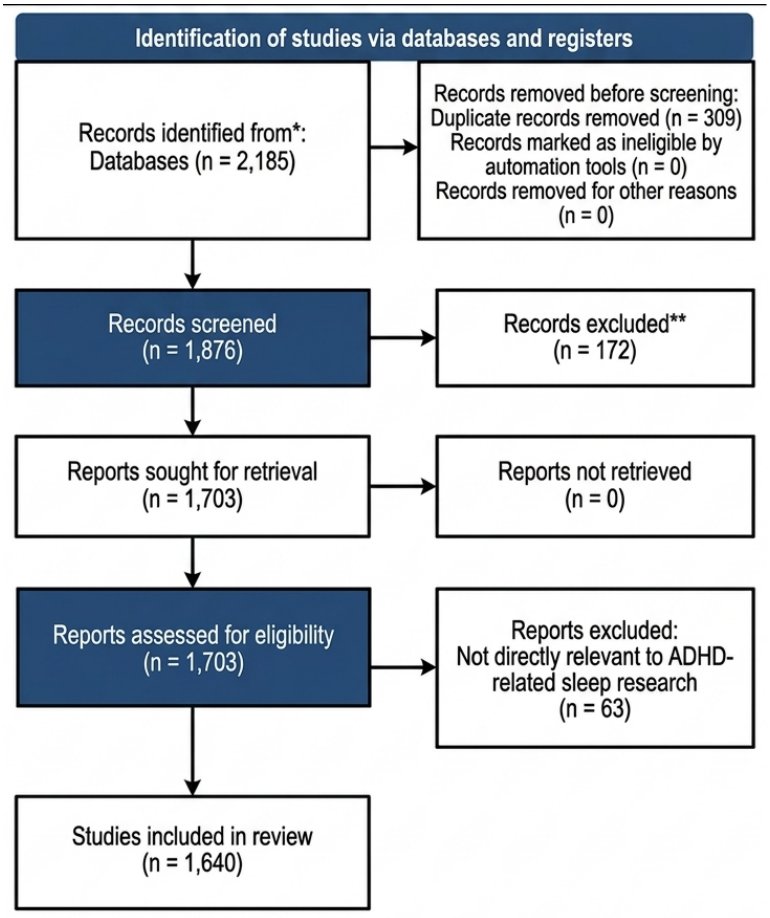


Figure 1. PRISMA 2020 flow diagram

Data Processing and Analytical Tools

Bibliometric indicators, including annual publication trends, prolific authors, country and institutional productivity, citation analysis, and keyword co-occurrence networks, were analyzed using the Bibliometrix R package (version 4.1.2), VOSviewer (version 1.6.20), and Microsoft Excel. The dataset was exported from WoSCC in plain-text (.txt) and Excel (.xls) formats. Before network construction, Author Keywords and Keywords Plus were manually harmonized to reduce unnecessary fragmentation caused by spelling, punctuation, abbreviation, and grammatical variants. Harmonization was limited to standardization that preserved the original concepts and did not introduce new ones. Specifically, preprocessing included (1) case standardization, (2) correction of obvious spelling and typographical variants, (3) unification of hyphenated and non-hyphenated forms, (4) merging of singular and plural variants, (5) harmonization of British and American spellings, and (6) consolidation of clear synonym pairs and abbreviation/full-form equivalents referring to the same concept. For full reproducibility, the complete machine-readable keyword harmonization log is provided in Supplementary Data S1, which reports each original keyword, its standardized form, the transformation type, the rule category, and the rationale for harmonization. No stemming, lemmatization, or automated thesaurus expansion was applied beyond the manually documented standardization rules. In the author productivity analyses, fractionalized publications were used as a co-authorship-adjusted productivity indicator, whereby each publication was weighted according to the number of co-authors in the Bibliometrix output.

VOSviewer Network Construction Parameters

After manual keyword preprocessing, keyword co-occurrence networks were generated in VOSviewer (version 1.6.20) using association-strength normalization and binary counting. In this context, association-strength normalization refers to the standard VOSviewer link-scaling procedure used during network construction and visualization; it is analytically distinct from the manual keyword harmonization performed before the map was built. Binary counting was selected so that each keyword contributed at most once per publication, thereby reducing overweighting caused by repeated within-record occurrences. Both Author Keywords and Keywords Plus were included to broaden thematic coverage. A minimum occurrence threshold of 20 was applied to reduce sparse, weakly connected terms and improve map interpretability. The LinLog layout (Attraction = 3, Repulsion = 0) was used to optimize cluster spacing and visual readability. Communities were identified using the software's modularity-based clustering routine, with a minimum cluster size of 10 keywords. Temporal patterns were explored using the overlay visualization option in VOSviewer, in which node colors reflect the average publication year associated with each keyword. A concise summary of the VOSviewer settings is presented in Figure 2. Any additional supplementary parameter tables or appendices should be labeled consistently as Supplementary Table/Figure/Data items to avoid confusion.

Parameter	Setting
Software version	VOSviewer 1.6.20
Data type	Author keywords + Keywords Plus
Normalization	Association strength
Counting method	Binary counting
Minimum occurrence	≥20
Layout algorithm	LinLog (Attraction=3, Repulsion=0)
Clustering	Greedy modularity optimization

Figure 2. VOSviewer parameter structure.

This figure summarizes the co-occurrence network settings and parameters used for thematic clustering in VOSviewer (v1.6.20).

Data Validation and Visualization

Data screening, manual keyword cleaning, descriptive validation of the thematic maps, and interpretation of the cluster structure were performed by the study authors through iterative inspection of titles, abstracts, keywords, frequency distributions, and cluster contents. One author conducted the initial title and abstract screening and the first-pass keyword harmonization, whereas a second author reviewed eligibility decisions, cross-checked the harmonization outputs, and reviewed the thematic interpretation. Because this was a bibliometric mapping study rather than a formal risk-of-bias review, validation was limited to author-led internal review rather than external adjudication. The reviewer configuration was explicitly defined: initial title and abstract screening was performed by one author, and all eligibility decisions were subsequently reviewed by a second author. Any disagreements between the two authors were resolved through discussion until consensus was reached. Manual keyword harmonization was reviewed iteratively against titles, abstracts, Author Keywords, Keywords Plus, and frequency distributions to minimize duplicate or conceptually fragmented nodes. No formal inter-rater agreement statistic was calculated for keyword harmonization. Visualization maps were then refined in VOSviewer for clarity and exported as high-resolution images. Cluster labels were assigned descriptively on the basis of dominant keywords and thematic proximity rather than through formal causal inference. Because the study analyzed only bibliographic metadata from published records and did not involve human participants, patient data, or identifiable personal information, formal ethics committee approval and informed consent were not required.

Results

Distribution of Publications by Year

A total of 1,640 research articles on ADHD-related sleep disorders were included in the bibliometric analysis from 1990 to 2025. Annual output increased overall, with a clearer rise after 2010 despite year-to-year fluctuations. Peak productivity was observed in 2023 (approximately n = 120), followed by lower counts in 2024 (approximately n = 110) and 2025 (approximately n = 90). The compound annual growth rate (CAGR) for the study period was 14.2%. Because 2025 represents the most recent year in the dataset, the corresponding count should be interpreted cautiously (Figure 3). Citation counts also increased over time, especially after 2010, broadly following the growth in publication output. Figure 3 presents the yearly distribution of publications and citations.

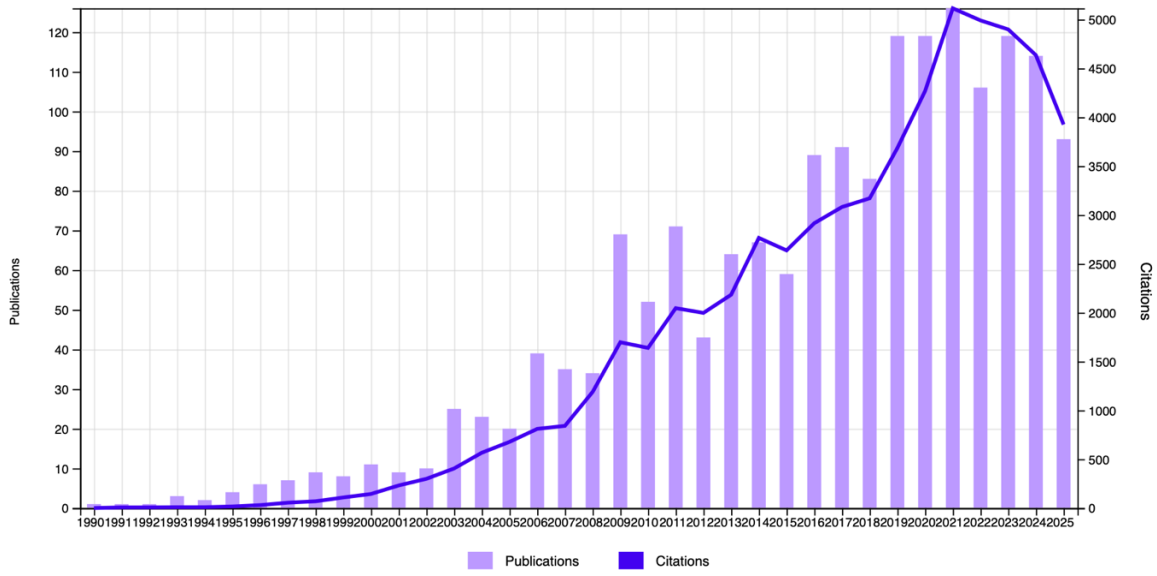


Figure 3. Annual publication and citation trends in ADHD-related sleep-disorder research (1990-2025).
A marked increase is observed after 2010, peaking in 2023 with approximately 120 publications and 5,000 citations, followed by a slight decline thereafter.

Most Cited Publications

A total of 1,640 research articles published between 1990 and 2025 were included in the analysis. Across the citation fields available through the Web of Science platform at the time of data extraction, these records accumulated 61,129 citations in total and 53,016 citations excluding self-citations. The dataset was cited by 35,128 citing articles (33,778 excluding self-citations), indicating substantial visibility in the broader literature.

The most cited publication was the epidemiological report by Wittchen et al. (2011), with 2,675 citations in WoS Core and 3,050 in the All Databases field. It was followed by the clinical guideline on childhood obstructive sleep apnea by Marcus et al. (2012) (1,177; 1,299) and the international Tourette syndrome survey by Freeman et al. (2000) (656; 768). Other highly cited studies included the clinical guidance paper on autism spectrum disorder by Hyman et al. (2020) (639; 742), Beebe's review of insufficient sleep in children and adolescents (2011) (473; 584), the ADHD candidate-gene analysis by Brookes et al. (2006) (436; 486), the EEG theta/beta ratio meta-analysis by Arns et al. (2013) (410; 451), the study linking sleep-disorder symptoms with inattention and hyperactivity in children by Chervin et al. (1997) (406; 463), the structural-variant study by Elia et al. (2010) (400; 439), and the description of sleep and neurobehavioral characteristics in children with parent-reported ADHD symptoms by O'Brien et al. (2003) (396; 477).

As is common in bibliometric datasets, some highly cited papers were not exclusively focused on ADHD-related sleep disorders but occupied conceptually adjacent positions within the retrieved literature and attracted substantial cross-disciplinary attention. Overall, the most cited literature spanned epidemiology, sleep-disordered breathing, genetics, neurophysiology, and child mental health, illustrating the heterogeneous knowledge base surrounding ADHD-related sleep research (Table 1).

Table 1. Most cited publications

Authors	Publication Year	Times Cited, WoS Core	Times Cited, All Databases
Wittchen et al.2011	2011	2675	3050
Marcus et al.2012	2012	1177	1299
Freeman et al.2000	2000	656	768
Hyman et al.2020	2020	639	742
Beebe,2011	2011	473	584
Brookes et al.2006	2006	436	486
Arns et al.2013	2013	410	451
Chervin et al.1997	1997	406	463
Elia et al.2010	2010	400	439
O'Brien et al.2003	2003	396	477

This table lists the ten most highly cited publications in the dataset, ranked according to the citation counts recorded in the Web of Science Core Collection. The 'All Databases' values refer to the corresponding citation field displayed in the Web of Science platform at the time of data extraction. WoS: Web of Science.

Country-Based Publication Distribution

Country-level productivity was led by the United States (735 publications), followed by England (152), Canada (143), Australia (109), Germany (105), Italy (97), the Netherlands (96), China (94), and Japan (49). In the Web of Science export, the United Kingdom was represented primarily by the metadata label 'England.' Records from Türkiye also appeared under both 'Turkey' (61) and 'Türkiye' (26); after harmonization, this corresponded to 87 publications. Overall, publication output was concentrated in North America and Western Europe, with additional notable contributions from Asia. These findings describe the geographic distribution of the literature but should not be interpreted as direct evidence of funding structures or causal differences in research capacity.

Most Productive Authors

Based on author productivity, Stephen P. Becker ranked first with 44 publications. He was followed by Emma Sciberras (39), Samuele Cortese (25), Ann Childress (25), Harriet Hiscock (21), Susan L. Calhoun (21),

Joshua M. Langberg (19), Robert L. Findling (19), David Gozal (18), and J.A. Owens (18) (Table 2). Overall, publication output was concentrated among a relatively small group of highly active researchers.

Table 2. Most productive authors

	Author	Number of Publications	Number of Fractionalized Publications	Times Cited, WoS Core
1	Becker, Stephen P.	44	16.83	1463
2	Sciberras, Emma	39	14.72	1339
3	Cortese, Samuele	25	10.15	1034
4	Childress, Ann	25	8.43	475
5	Hiscock, Harriet	21	7.56	1131
6	Calhoun, Susan L.	21	6.72	729
7	Langberg, Joshua M.	19	7.34	668
8	Findling, Robert L.	19	6.11	1238
9	Gozal, David	18	7.09	2735
10	Owens, J.A.	18	6.87	1540

WoS: Web of Science.

Most Productive Institutions

The institutional productivity analysis indicated that output was concentrated in a limited number of large academic centers and academic systems. Harvard University ranked first with 202 publications (11.69%), followed by the University of Cincinnati (115; 6.66%), the University System of Ohio (109; 6.31%), the University of California System (72; 4.17%), and the University of London (67; 3.88%). Other prominent contributors included the Pennsylvania Commonwealth System of Higher Education (56; 3.24%), the University of Melbourne (51; 2.95%), King's College London (49; 2.84%), the Murdoch Children's Research Institute (42; 2.43%), and Massachusetts General Hospital (41; 2.37%) (Table 3). These findings indicate that the literature was concentrated in a relatively small number of institutions, particularly in North America, Europe, and Australia.

Table 3. Most productive institutions

	Institution Name	Number of Publications	% (n = 1640)	Times Cited, WoS Core
1	Harvard University	202	12.36	3018
2	University of Cincinnati	115	7.01	3213
3	University System of Ohio	109	6.65	4435
4	University of California System	72	4.39	2943
5	University of London	67	4.09	3146
6	Pennsylvania Commonwealth System of Higher Education (PCSHE)	56	3.41	2853
7	University of Melbourne	51	3.11	1731
8	King’s College London	49	2.99	1969
9	Murdoch Children’s Research Institute	42	2.56	1603
10	Massachusetts General Hospital	41	2.50	1925

WoS: Web of Science

Table 4. Journals with the highest publication counts

Journal	Number of Publications	Times Cited, WoS Core	Average citation per item
Sleep Medicine	98	3110	31.73
Journal of Attention Disorders	92	2316	25.17
Journal of Child and Adolescent Psychopharmacology	65	2276	35.02
Sleep	54	4925	91.20
European Child and Adolescent Psychiatry	43	1498	34.84

WoS: Web of Science.

Journals with the Highest Publication Volume

The journals with the highest publication counts were Sleep Medicine (n = 98; 3,110 citations), Journal of Attention Disorders (n = 92; 2,316 citations), and Journal of Child and Adolescent Psychopharmacology (n = 65; 2,276 citations). Although Sleep published fewer articles (n = 54), it showed the highest average citation rate (91.20 citations per item), followed by European Child and Adolescent Psychiatry (n = 43; 34.84 citations per item) (Table 4). These journals reflect the field's overlap with sleep medicine, child and adolescent psychiatry, psychopharmacology, and neurodevelopmental research.

Keyword Analysis and Clustering

The keyword co-occurrence analysis identified four major thematic clusters representing the conceptual structure of ADHD-related sleep research (Table 5). Across the network, 140 keywords met the inclusion threshold (>=20 occurrences), generating 911 weighted co-occurrence links. Central terms such as 'ADHD,' 'attention-deficit/hyperactivity disorder,' 'children,' and 'sleep' occupied the core of the map.

The first cluster mainly comprised pharmacological and treatment-related terms, including 'methylphenidate,' 'atomoxetine,' 'stimulants,' 'treatment,' and 'efficacy.' The second cluster included developmental and pediatric terms such as 'children,' 'autism,' 'sleep-disordered breathing,' 'parasomnias,' and 'restless legs syndrome.' The third cluster was centered on epidemiological descriptors, including 'prevalence,' 'risk factors,' 'gender differences,' and 'longitudinal study.' The fourth cluster contained affective and sleep-related terms such as 'insomnia,' 'depression,' 'anxiety,' 'circadian rhythm,' and 'sleepiness.'

Temporal overlay visualization suggested that earlier work more frequently emphasized terms such as 'hyperactivity,' 'behavioral problems,' and 'methylphenidate,' whereas more recent studies more often included 'sleep disorders,' 'autism,' 'circadian rhythm,' and 'restless legs syndrome.' This pattern suggests a broader move toward more integrative neurodevelopmental and sleep-focused topics.

Table 5. Thematic cluster structure of ADHD and sleep research based on keyword co-occurrence analysis

Cluster	Key Topics	Featured Keywords	Focus
1	Pharmacotherapy and treatment outcomes	methylphenidate, atomoxetine, stimulants, guanfacine, efficacy, executive function, side effects, daytime sleepiness	Drug response, treatment efficacy, and pharmacological modulation of sleep and behavior
2	Developmental and paediatric spectrum disorders	children, adolescents, autism, sleep-disordered breathing, parasomnias, restless legs syndrome, pediatric, behavior problems	Neurodevelopmental comorbidities and sleep pathophysiology in paediatric ADHD populations
3	Epidemiology and risk factors	prevalence, risk factors, comorbidity, gender differences, longitudinal, meta-analysis, population studies	Large-scale observational research and epidemiological characterization of ADHD and sleep issues
4	Psychiatric comorbidities and sleep disturbances	insomnia, depression, anxiety, circadian rhythm, hypersomnia, sleepiness, emotional dysregulation	Affective dysregulation, circadian and chronobiological mechanisms, and sleep quality in ADHD cohorts

ADHD: attention-deficit/hyperactivity disorder.

Discussion

This bibliometric analysis mapped ADHD-related sleep-disorder research indexed in the Web of Science Core Collection from 1990 to 2025. The literature showed an overall upward trend in publication output, although year-to-year fluctuations were present, with a clearer acceleration after 2010. Citation accumulation also increased over time, consistent with the growing visibility of the topic. Taken together, these findings suggest that ADHD-related sleep research has moved from a relatively fragmented topic

toward a broader interdisciplinary field involving child psychiatry, sleep medicine, neurodevelopment, and psychopharmacology (Wittchen et al. 2011, Cortese et al. 2024).

One of the clearest patterns was the concentration of output in a relatively small number of countries, institutions, and journals. The United States dominated publication volume, and several high-output academic systems accounted for a disproportionately large share of the literature. This distribution should be interpreted descriptively rather than causally; bibliometric mapping can identify where publications cluster, but it cannot determine whether this pattern reflects funding availability, database coverage, language advantage, research infrastructure, or topic-specific expertise. The coexistence of metadata labels such as 'Turkey' and 'Türkiye' further illustrates how minor preprocessing choices can affect country-level counts and therefore should be reported transparently. Similar concentration of bibliometric productivity in well-resourced academic settings has also been emphasized in related ADHD-focused mapping studies (Dougnon and Matsui 2025).

The thematic structure of the field was also informative. The keyword network suggested four recurring domains: pharmacotherapy and treatment outcomes, developmental and pediatric spectrum disorders, epidemiology and risk factors, and psychiatric comorbidities with sleep disturbances. The prominence of pediatric and neurodevelopmental terms suggests that the literature has been driven mainly by child and adolescent populations, whereas adult and lifespan perspectives appear less visible. Overlay visualization also suggested a relative shift from earlier emphasis on behavioral problems and stimulant-related terms toward more recent attention to circadian rhythm, insomnia, autism, and other comorbidity-oriented themes. This pattern is consistent with a field moving from narrower symptom descriptions toward more integrative models of sleep heterogeneity in ADHD and is broadly compatible with DSM-5-TR-informed sleep-wake conceptualization and recent clinical literature emphasizing circadian disruption, insomnia, psychiatric comorbidity, and the continuing predominance of pediatric samples over adult or lifespan perspectives (Hyman et al. 2020, APA 2022, van der Ham et al. 2024, Marten et al. 2025, Uygur 2025).

The intervention-related cluster should be interpreted carefully. Treatment-related terms were clearly present in the network, indicating that intervention research is not absent from the field. However, the literature appears to be weighted more heavily toward descriptive, epidemiological, and comorbidity-oriented work than toward rigorous sleep-specific intervention studies. This distinction matters clinically because sleep problems in ADHD influence diagnosis, medication monitoring, daytime functioning, and family burden. Future empirical studies would benefit from evaluating not only stimulant and non-stimulant medication effects but also behavioral sleep interventions, multimodal assessment protocols, and longitudinal treatment outcomes supported by objective sleep measures, particularly because melatonin-based and behavioral approaches remain clinically relevant and multimodal sleep assessment is increasingly recommended in this population (Díaz-Román et al. 2016, Rishi et al. 2023, Cortese et al. 2024, Shenoy et al. 2024).

The concern about reproducibility is methodologically important. In bibliometric research, apparently small decisions, such as database selection, search-field definitions, screening logic, keyword harmonization, threshold settings, and figure/table labeling, can alter both the final dataset and the thematic structure of the maps. For that reason, bibliometric studies should report the full Boolean query, the exact inclusion and exclusion criteria, the number of reviewers involved in screening, the disagreement-resolution process, and the complete preprocessing or harmonization log in a transparent supplementary file. They should also distinguish manual keyword harmonization from network-level normalization settings such as association-strength scaling in VOSviewer. Without these details, readers can interpret general trends but may still find it difficult to reproduce the workflow precisely.

Overall, the field shows continued growth and thematic diversification, but future work should place more emphasis on methodological transparency, adult and lifespan populations, and sleep-specific interventions.

The limitations of the present study should be seen as an extension of methodological transparency rather than as a routine formality. Restriction to a single database, English-only screening, threshold-based filtering, and manual keyword harmonization may all have influenced which countries, themes, and

comorbidities became most visible in the final map. Future bibliometric work would be strengthened by multi-database designs, fully reproducible preprocessing logs, explicitly reported screening workflows, and sensitivity analyses comparing alternative thresholds or keyword-merging strategies. Parallel empirical research should place greater emphasis on adult ADHD, underrepresented regions, and longitudinal or intervention-oriented sleep outcomes.

Several limitations should be acknowledged in the study. First, the dataset was restricted to the Web of Science Core Collection. Although this improved citation standardization within a single database environment, it may also have limited coverage of records indexed elsewhere and therefore may have affected both publication counts and network structure. Second, only English-language research articles were retained after screening. This decision improved bibliometric comparability for title-, abstract-, and keyword-based analyses, but it may also have introduced language bias and reduced the visibility of region-specific or non-Anglophone scholarship. Third, manual keyword standardization and synonym merging were necessary for data cleaning, and some harmonization decisions inevitably depended on author judgment. Even when the harmonization workflow is reported transparently, the lack of a formal inter-rater agreement statistic for these preprocessing decisions remains a methodological limitation. Fourth, the minimum occurrence threshold of 20 and the use of binary counting improved map interpretability, but they may also have excluded emerging, low-frequency, or methodologically niche topics. As a result, newer research lines may be underrepresented even when they are conceptually important. Fifth, the study design was descriptive and cross-sectional. Bibliometric mapping can characterize publication patterns, thematic concentrations, and associations among terms, but it cannot establish causal explanations for publication growth or determine the clinical effectiveness of the interventions represented in the literature.

Future studies should address these limitations by using multi-database retrieval strategies, explicitly reported screening workflows, complete machine-readable keyword-harmonization logs, clear differentiation between manual keyword preprocessing and network-level normalization settings, and sensitivity analyses comparing alternative preprocessing thresholds and mapping decisions.

Conclusion

Research on ADHD-related sleep disorders expanded overall from 1990 to 2025, with increasing thematic breadth and continuing concentration in a limited number of countries, institutions, and journals. The keyword structure of the field was organized mainly around pharmacotherapy, developmental comorbidity, epidemiology, and psychiatric-sleep interactions. The present findings are informative but should be interpreted in light of the reporting and reproducibility constraints of bibliometric work. Future studies should provide fully transparent screening workflows, complete machine-readable preprocessing logs, a clear distinction between manual keyword harmonization and network-level normalization, consistent supplementary labeling, and sensitivity analyses across alternative databases and keyword-threshold settings. More rigorous reporting will strengthen both bibliometric reproducibility and the clinical interpretability of future ADHD-sleep research. Future work should expand bibliometric retrieval beyond a single international database and, where relevant, incorporate national or regional indexing sources to improve geographic representativeness. Studies that combine transparent screening workflows with objective sleep metrics, longitudinal designs, and intervention-focused analyses may further strengthen the clinical relevance of ADHD-sleep research.

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Addendum

Supplementary Table 1. Full Web of Science Core Collection search query used in the study
TS=(("attention deficit hyperactivity disorder" OR "attention-deficit/hyperactivity disorder" OR ADHD OR adhd OR attention deficit hyperactivity disorder OR attention-deficit hyperactivity disorder) AND (sleep OR pediatric insomnia OR insomnia OR "sleep disorder*" OR "sleep-disordered breathing" OR "sleep disordered breathing" OR OSA OR "obstructive sleep apnea" OR "obstructive sleep apnoea" OR circadian OR "delayed sleep phase" OR "delayed sleep-wake phase" OR DSWPD OR hypersomnia OR narcolepsy OR parasomnia* OR "restless legs" OR RLS OR "periodic limb movement*" OR PLMD OR bruxism OR "sleep bruxism" OR "REM sleep behavior disorder" OR RBD OR nightmare* OR "night terror*" OR sleepwalking OR somnambul*) AND (child* OR adolescent* OR pediatric* OR paediatric* OR youth* OR teen* OR children*))
Search field: TS (Topic), which searches the title, abstract, author keywords, and Keywords Plus. No additional manual restriction was applied at the individual citation index level beyond selecting the Web of Science Core Collection database.

Supplementary Data S1. Full keyword harmonization log used during preprocessing prior to network construction

Original keyword	Standardized keyword	Operation type	Rule category	Rationale
attention deficit hyperactivity disorder	ADHD	synonym merging	Abbreviation/full-form merging	Merged full expression with the preferred abbreviated disorder label to avoid duplicate nodes.
attention-deficit/hyperactivity disorder	ADHD	synonym merging	Abbreviation/full-form merging	Punctuation variant of the same disorder concept merged under a single preferred label.
attention-deficit hyperactivity disorder	ADHD	hyphenation unification	Hyphenation and punctuation unification	Formatting variant standardized to the same disorder label.
adhd	ADHD	case standardization	Abbreviation/full-form merging	Lowercase abbreviation normalized to preferred capitalization.
sleep disorder	sleep disorders	singular/plural unification	Singular/plural unification	Identical concept differing only by grammatical number was merged to one preferred term.
sleep disordered breathing	sleep-disordered breathing	hyphenation unification	Hyphenation and punctuation unification	Hyphenation was standardized to prevent artificial separation of the same concept.
obstructive sleep apnoea	obstructive sleep apnea	spelling harmonization	British/American spelling harmonization	British spelling was standardized to the preferred American spelling.
OSA	obstructive sleep apnea	abbreviation expansion	Abbreviation/full-form merging	Common abbreviation merged with the corresponding full disorder name.
delayed sleep phase	delayed sleep-wake phase disorder	term consolidation	Synonym consolidation	Older or shortened diagnostic wording was consolidated under the preferred contemporary term.
delayed sleep-wake phase	delayed sleep-wake phase disorder	term consolidation	Synonym consolidation	Shortened wording was standardized to the full disorder label.
DSWPD	delayed sleep-wake phase disorder	abbreviation expansion	Abbreviation/full-form merging	Abbreviation merged with the corresponding full disorder name.
parasomnia	parasomnias	singular/plural unification	Singular/plural unification	Identical concept differing only by grammatical number was merged to one preferred term.

Supplementary Data S1. Full keyword harmonization log used during preprocessing prior to network construction				
Original keyword	**Standardized keyword**	**Operation type**	**Rule category**	**Rationale**
restless legs	restless legs syndrome	synonym expansion	Synonym consolidation	Shortened clinical expression was standardized to the conventional syndrome label.
RLS	restless legs syndrome	abbreviation expansion	Abbreviation/full-form merging	Abbreviation merged with the corresponding full syndrome name.
periodic limb movement	periodic limb movement disorder	term consolidation	Synonym consolidation	Generic shortened expression was standardized to the full disorder label used for mapping.
periodic limb movements	periodic limb movement disorder	term consolidation	Synonym consolidation	Plural shortened expression was standardized to the full disorder label used for mapping.
PLMD	periodic limb movement disorder	abbreviation expansion	Abbreviation/full-form merging	Abbreviation merged with the corresponding full disorder name.
REM sleep behaviour disorder	REM sleep behavior disorder	spelling harmonization	British/American spelling harmonization	British spelling was standardized to the preferred American spelling.
RBD	REM sleep behavior disorder	abbreviation expansion	Abbreviation/full-form merging	Abbreviation merged with the corresponding full disorder name.
night terror	night terrors	singular/plural unification	Singular/plural unification	Identical concept differing only by grammatical number was merged to one preferred term.
somnambulism	sleepwalking	synonym merging	Synonym consolidation	Equivalent clinical terminology was standardized to one preferred common-language label.
paediatric	pediatric	spelling harmonization	British/American spelling harmonization	British spelling was standardized to the preferred American spelling.
paediatric insomnia	pediatric insomnia	spelling harmonization	British/American spelling harmonization	British spelling was standardized within a multiword phrase.
child	children	singular/plural unification	Singular/plural unification	Age-group term was standardized to the preferred plural keyword form.
adolescent	adolescents	singular/plural unification	Singular/plural unification	Age-group term was standardized to the preferred plural keyword form.
teen	adolescents	synonym consolidation	Synonym consolidation	Closely overlapping age-band descriptor was merged to the preferred developmental keyword.
teens	adolescents	synonym consolidation	Synonym consolidation	Plural colloquial age-band descriptor was merged to the preferred developmental keyword.
youth	adolescents	synonym consolidation	Synonym consolidation	Broad adolescent age-band descriptor was merged to the

Supplementary Data S1. Full keyword harmonization log used during preprocessing prior to network construction				
Original keyword	**Standardized keyword**	**Operation type**	**Rule category**	**Rationale**
				preferred developmental keyword to reduce fragmentation.
behaviour problems	behavioral problems	spelling harmonization	British/American spelling harmonization	British spelling was standardized to the preferred American spelling.
behavioural problems	behavioral problems	spelling harmonization	British/American spelling harmonization	British spelling was standardized to the preferred American spelling.
circadian rhythms	circadian rhythm	singular/plural unification	Singular/plural unification	Identical concept differing only by grammatical number was merged to one preferred term.
stimulant	stimulants	singular/plural unification	Singular/plural unification	Identical concept differing only by grammatical number was merged to one preferred term.
meta analysis	meta-analysis	hyphenation unification	Hyphenation and punctuation unification	Punctuation was standardized to prevent artificial separation of the same concept.
sleep wake disorder	sleep-wake disorder	hyphenation unification	Hyphenation and punctuation unification	Hyphenation was standardized to the preferred diagnostic wording.
sleep wake disorders	sleep-wake disorders	hyphenation unification	Hyphenation and punctuation unification	Hyphenation was standardized to the preferred diagnostic wording.