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Attention deficit hyperactivity disorder and dental traumatic injuries: a systemic review and meta-analysis

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Abstract. – OBJECTIVE: The objective of this study was to assess whether individuals with attention deficit hyperactivity disorder (ADHD) exhibit a higher prevalence of traumatic dental injuries (TDIs) compared to those without ADHD through a systematic review and meta-analysis of the existing literature.

MATERIALS AND METHODS: A search strategy using the Medical Subject Heading (MeSH) vocabulary was employed for a comprehensive search across various databases, including PubMed, Scopus, Web of Science, Cochrane Library, and Embase. The Joanna Briggs Institute Summary was utilized for data collection. Additionally, quality assessment, meta-analysis, and bias control were conducted to ensure the reliability of the included studies. A meta-analysis was performed to consolidate the findings of the individual studies.

RESULTS: The prevalence of TDIs among individuals with ADHD ranged from 9.6% to 68.2%, while in the healthy control group, it ranged from 0.8% to 44.7%. The meta-analysis findings revealed that individuals with ADHD had 1.98 times higher odds (OR = 1.98, ranging from 1.51 to 2.59 with 95% CI) of experiencing TDIs compared to individuals without ADHD.

CONCLUSIONS: The findings of this study suggest a significant association between ADHD and an increased risk of TDIs. Individuals with ADHD were found to be nearly twice as likely to experience TDIs compared to those without ADHD. Efforts should not only be directed towards improving the oral health of this vulnerable group of individuals, but also healthcare practitioners need to be provided with opportunities to create awareness and implement preventive measures to mitigate the risk of TDIs among individuals with ADHD.

Key Words:

Dental injuries, Attention deficit hyperactivity disorder, Dental public health, Disability, Disabled individuals, Oral health.

Introduction

Attention deficit hyperactivity disorder (ADHD) is a neurobehavioral disorder, and its prevalence has increased over the last few years[1,2]. It is mainly characterized by inappropriate levels of impulsivity, inattention, distractibility, and motor overactivity (or hyperactivity). The ADHA starts in childhood and causes major functional and developmental difficulties. With a global prevalence of 5.3%, it is regarded among the most frequent chronic health disorders in school-aged children. Despite the fact that ADHD is frequently diagnosed early in life, it contributes to the lifelong quality of life impairment since cognitive and behavioral symptoms generally stay into adulthood[2,3].

Recently, the Diagnostic and Statistical Manual of Mental Disorders (DSM-5)[4] revised the diagnostic criteria for identifying ADHD. It was revealed that firstly, a child or younger adolescent needs to meet six out of the nine possible inattentive symptoms (such as failing to give close attention to details or being easily distracted) and/or six out of nine possible hyperactivity/impulsivity symptoms mentioned (such as being "on the go" or difficulty waiting their turn). The symptoms need to be present for at least six months, occur in at least two different settings, be present before 12 years of age, and not be better explained by another disorder. For older adolescents and adults, the number of required symptoms per category is reduced to five out of nine[5,6].

ADHD has three key presentations: first, predominantly inattentive; second, predominantly hyperactive/impulsive; and third, combined, based on how many symptoms an individual meets in each diagnostic category[7]. Moreover, ADHD that does not clearly fit into these categories can be referred to as ADHD-Not Otherwise Specified.

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Children with ADHD share several characteristics, such as inattention, hyperactivity, and impulsive symptoms. These are frequently correlated with emotional, behavioral, and learning issues, such as oppositional defiant ailment, depression, conduct disorder, anxiety, and learning disabilities[8,9]. The difficulties that can be seen are sleep abnormalities, encopresis, and incontinence, or they may be related to medical illnesses such as traumatic brain injury, fetal alcohol exposure, lead poisoning, premature delivery, and epilepsy[9].

Orofacial trauma has been considered a significant dental public health issue that has medical, aesthetic, and psychological consequences on children and their parents. The incidence of such TDIs has increased over the past few decades[10]. Glendor[11] (2009) stated that oral health determinants (increased overjet with protrusion), environmental factors (material deprivation), and behavior of a person (risk-takers, bullied youngsters, emotionally unfortunate circumstances, obesity, and attention deficit hyperactivity disorder) are all linked to an increased incidence of TDIs.

ADHD children experience impaired cognitive and executive functions, leading to significant behavioral problems in everyday life. Due to their hyperactivity and poor motor skills, the risk of trauma increases, and impulsivity leads a child to act without thinking of the consequences. Therefore, it is not surprising that ADHD has been associated with the occurrence of major injuries affecting the face and/or teeth (TDIs)[5,12-15].

Children with ADHD often face challenges when it comes to dental treatment. Their symptoms of impulsivity, inattention, and hyperactivity can make it difficult for them to cooperate during dental appointments, leading to increased levels of stress for both the child and the dental practitioner. Furthermore, their behavioral issues may result in poor oral hygiene habits, such as irregular tooth brushing and dietary choices high in sugar, exacerbating the risk of dental caries and periodontal disease[16,17]. Additionally, the use of stimulant medications commonly prescribed for ADHD may lead to xerostomia (dry mouth), which can further contribute to oral health problems[18]. Therefore, it is crucial for dental professionals to have strategies in place to effectively manage and accommodate the needs of children with ADHD during dental visits.

TDIs not only have immediate physical consequences but also affect the quality of life of affected individuals. In children with ADHD, the occurrence of TDIs may exacerbate existing behavioral and emotional difficulties, leading to increased levels of anxiety and stress. Furthermore, the aesthetic consequences of facial injuries resulting from TDIs can have a profound impact on self-esteem and social interactions, particularly during critical developmental stages in childhood and adolescence[19]. Therefore, understanding the association between ADHD and TDIs is essential for implementing preventive measures and providing appropriate support and interventions to mitigate the impact of TDIs on the overall well-being of affected individuals.

Given the complex interplay between ADHD, TDIs, and oral health, a multidisciplinary approach involving collaboration between dental professionals, pediatricians, psychologists, and educators is essential for effectively managing these conditions. Early identification and intervention for ADHD symptoms can help mitigate the risk of TDIs through targeted behavioral and educational interventions. Furthermore, dental professionals play a crucial role in educating parents and caregivers about the importance of oral hygiene practices and injury prevention strategies tailored to the unique needs of children with ADHD. By working together, healthcare providers can improve outcomes and enhance the overall quality of life for children with ADHD, and reduce the burden of TDIs in this vulnerable population.

This consequently may highlight the significance of exploring this territory of research in depth and comparing the association of TDIs with individuals affected by ADHD and those without. The present systematic review aimed to assess whether individuals with ADHD have a higher prevalence of TDIs compared to those without ADHD.

Materials and Methods

Overview

This study was designed as a systematic review and meta-analysis. It examines whether individuals with ADHD have a higher prevalence of TDIs compared to those without ADHD. The present review was registered in PROSPERO with registration number CRD42023434440. The study protocol was based on the PRISMA guidelines with the application of the Joanna Briggs Institute Summari software (Adelaide, Australia). The software was leveled with various stages like overview, protocol, screening, appraisal, and data

extraction, and the last stage was data synthesis. The population, intervention (exposure), comparator, and outcome (PICO) format of the present study was any age, individuals with ADHD, individuals without ADHD, and TDIs, respectively.

Eligibility Criteria

This present review was conducted to cover research published between January 1, 1995, and November 1, 2023, concerning the population of all groups. It included cross-sectional and longitudinal case-control studies that reported dental trauma among patients with ADHD. Two exclusion criteria were employed in this review. First, studies that were not written in English were excluded. Second, studies not associated with TDIs or ADHD were also excluded from the review.

Search Strategy

The systematic search among Cochrane, PubMed, EMBASE, Scopus, and Web of Science databases from their date of inception was conducted using the keywords and the Medical Subject Heading (MeSH) vocabularies as follows: dental trauma, traumatic dental injuries, permanent tooth, overjet, tooth injuries, attention-deficit/hyperactivity disorder, ADHD, children, disabled persons. The Boolean operators "AND" / "OR" were used. The MeSH synonyms and both associated and free terms were also included.

The JBI reporting guidelines for Systematic Reviews and Meta-Analyses were used. The search strategy employed medical subject headings and free text search terms. Limitations were set so that only studies published in English involving human participants were considered.

Two reviewers (Alzahrani A.A.H. and Bhat N.) independently searched all sources to reduce the selection bias. Titles and abstracts of obtained studies were independently screened and assessed through the search for their inclusion. A total of 1,674 included studies were retrieved for the review at this stage; 1,644 duplicated articles were removed, revealing 30 eligible titles and abstracts. The reviewers then met, and after discussion, articles were included. There were no disagreements between the reviewers regarding the included studies. However, if any disagreement occurs, it will be resolved by a further expert reviewer. After evaluating the titles and abstracts, an additional 18 irrelevant articles were excluded for not covering either ADHD or TDIs, revealing an inclusion of 12 studies[8,9,12-21] (Figure 1) in this review. The process of searching the literature and identifying the relevant studies based on PRISMA guidelines is illustrated in Figure 1.

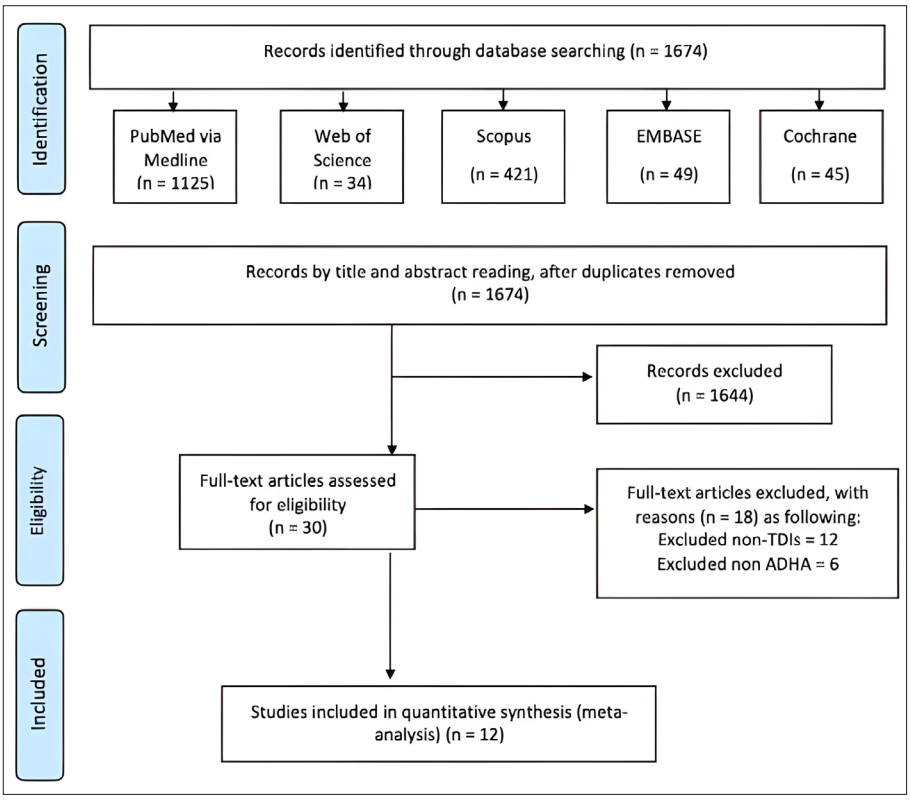

Figure 1. Literature search and identification of relevant studies.

Risk of Bias in Individual Studies

All the studies underwent validity assessment and data extraction. The year, study design, study setting, sample size, age, gender, prevalence, and mean±standard deviation were recorded on the proposed data collection form. The data extraction forms were tested on multiple papers and revised as needed before implementation. Moreover, the risk of bias was evaluated with the tool of the Joanna Briggs Institute (JBI) of the University of Adelaide for analytical cross-sectional and prevalence studies as described in Tables I and II. The risk of bias in the included studies was independently evaluated. If any disagreement between reviewers took place, it was proposed that a discussion with a third reviewer be held. However, there were no disagreements between the reviewers regarding the included studies.

Summary Measures and Synthesis of Results

A narrative synthesis of the findings from the included studies, with respect to the target population characteristics and type of outcome, was assessed, and summaries of intervention effects for each included study were provided by calculating risk ratios (for dichotomous outcomes). The primary outcome assessed was the prevalence of TDIs.

Statistical Analysis

The RevMan tool (version 5.4, the Cochrane Collaboration, United Kingdom) was used for meta-analysis, and a forest plot was generated. The results using a fixed-effects meta-analysis, with standardized continuous outcomes and risk ratios for binary outcomes, and 95% confidence intervals and two-sided *p*-values for each outcome were calculated with statistical significance at values lower than 0.05. Heterogeneity was assessed using both the χ^2 test and the I^2 statistic.

Results

The systematic review and meta-analysis employed a comprehensive approach to assess the risk of bias in both analytical cross-sectional and prevalence studies, utilizing the Joanna Briggs Institute (JBI) criteria. The analysis, presented in Table I, focused on various analytical cross-sectional studies spanning different geographical locations and demographic groups. Notably, the studies conducted by Blomqvist et al[16], Sabuncuoglu et al[8], Bimstein et al[17], Katz-Sagi et al[18], Altun et al[12], Kohlboeck et al[19], Mota-Veloso et al[15], Chau et al[14], Al-Batayneh et al[9], and Begnini et al[21] consistently demonstrated a low risk of bias. These studies adhered to essential criteria such as well-defined sample frames, adequate sample sizes, detailed descriptions of subjects and settings, valid exposure measurements, identification and measurement of the condition, consideration of confounding factors, and appropriate statistical analyses.

Table II delves into the evaluation of prevalence studies by Avsar et al[13] and Staberg et al[20]. Both studies exhibited a low risk of bias, reflecting their methodological robustness. Key considerations, including appropriate sample frames, sampling methods, adequate sample sizes, detailed descriptions of subjects and settings, comprehensive data analysis coverage, valid methods for condition identification, reliable condition measurements, appropriate statistical analyses, and adequate response rates, were met (Figures 2 and 3).

Table III provides an overview of all included studies, encompassing various analytical cross-sectional and prevalence studies across different countries. Katz-Sagi et al[18] in Israel reported a TMD prevalence of 29.1% in cases (ages 5 to 12 years) and 4.5% in controls. Altun et al[12] in Turkey reported prevalence rates of 17.5% in cases and 16.5% in controls (ages 7 to 15 years). Kohlboeck et al[19] in Germany found a prevalence of 17% in cases (ages 10 to 12 years). Mota-Veloso et al[15] in Brazil reported a TMD prevalence of 68.2% in cases and 44.7% in controls (ages 7 to 15 years). Chau et al[14] in Hong Kong reported prevalence rates of 29% in cases (ages 12 to 17 years) and 16.1% in controls. Al-Batayneh et al[9] in Jordan found prevalence rates of 9.6% in cases and 4.1% in controls (ages 6 to 12 years). Begnini et al[21] in Brazil reported a TMD prevalence of 14% in cases and 8% in controls (ages 7 to 14 years).

These findings collectively enrich our understanding of temporomandibular disorders in pediatric populations, considering variations in demographics, geographical locations, and methodological approaches. The robustness of the findings is underscored by the consistently low risk of bias across the evaluated studies.

Discussion

One of the most common oral disorders in children is TDIs. Research[16-22] has shown that the prevalence of TDIs in children and ado-

Table I. The JBI risk of bias evaluation for analytical cross-sectional included studies.

Analytical cross-sectional study	Blomqvist et al[16]	Sabuncuoglu et al[8]	Bimstein et al[17]	Katz-Sagi et al[18]	Altun et al[12]	Kohlboeck et al[19]	Mota-Veloso et al[15]	Chau et al[14]	Al-Batayneh et al[9]	Begnini et al[21]
Were the criteria for inclusion in the sample clearly defined?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Were the study subjects and the setting described in detail?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Was the exposure measured in a valid and reliable way?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Were objective, standard criteria used for measurement of the condition?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Were confounding factors identified?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Were strategies to deal with confounding factors stated?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Were the outcomes measured in a valid and reliable way?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Was appropriate statistical analysis used?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Table II. The JBI risk of bias evaluation for prevalence included studies.

Prevalence study	Avsar et al[13] (2009)	Staberg et al[20] (2014)
Was the sample frame appropriate to address the target population?	Yes	Yes
Were study participants sampled in an appropriate way?	Yes	Yes
Was the sample size adequate?	Yes	Yes
Were the study subjects and the setting described in detail?	Yes	Yes
Was the data analysis conducted with sufficient coverage of the identified sample?	Yes	Yes
Were valid methods used for the identification of the condition?	Yes	Yes
Was the condition measured in a standard, reliable way for all participants?	Yes	Yes
Was there appropriate statistical analysis?	Yes	Yes
Was the response rate adequate, and if not, was the low response rate managed appropriately?	Yes	Yes

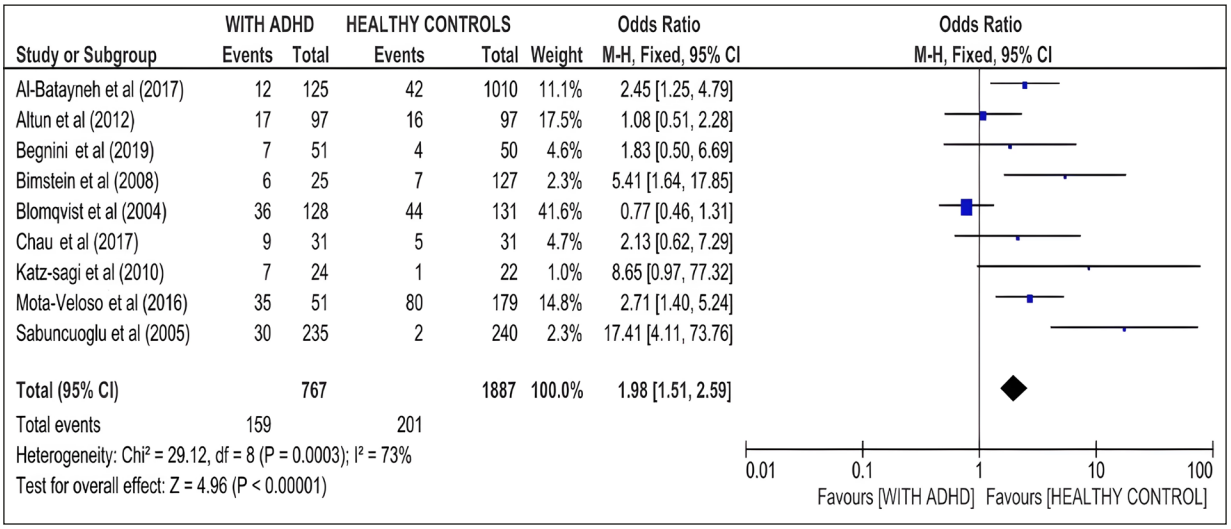

Figure 2. Forest plot of the ADHD studies associated with TDIs compared to healthy individuals.

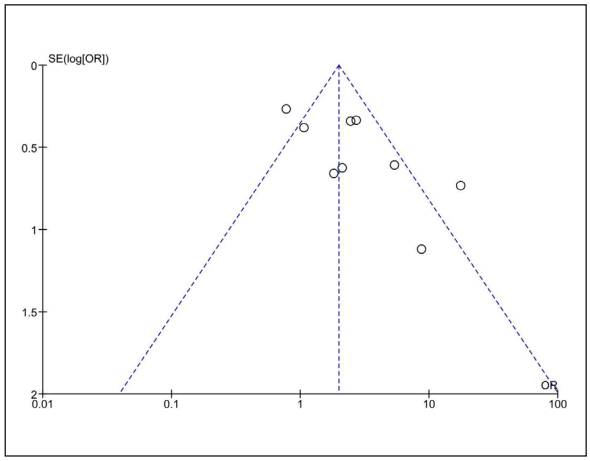

Figure 3. Funnel plot represents homogeneity of the TDIs and ADHA.

lescents is a major dental public health issue. Antecedent tooth fractures have functional, aesthetic, and emotional effects. The sequelae of the traumatized tooth are pulp necrosis or canal obliteration, root resorption, tooth discoloration, marginal alveolar bone loss, and/or abscess formation.

ADHD is considered the most common developmental psychiatric disorder, often associated with significant comorbidities such as learning disorders, conduct disorders, and mood disorders, and may persist into adulthood, often with poor outcomes. The oral health in children with ADHD is compromised as they are unable to effectively conduct routine activities such as teeth brushing, which may contribute to poor oral hygiene practices[18]. Furthermore, their routine

Table III. Characteristics of all included studies.

Study design	Author (year)	Study setting	Age		TDI Prevalence	
			Case	Control	Case	Control
Analytical cross sectional	Blomqvist et al[16] (2004)	United states	N = 128 (1 to 10 years)	N = 131 (1 to 10 years)	36 (28%)	44 (34%)
Analytical cross sectional	Sabuncuoglu et al[8] (2005)	Turkey	N = 235 (8 to 17 years)	N = 240 (8 to 17 years)	30 (12.8%)	2 (0.8%)
Analytical cross sectional	Bimstein et al[17] (2008)	United states	N = 25 (90.4 ± 39.6 months)	N = 127 (88.2 ± 43.6 months)	6 (26%)	7 (6%)
Prevalence	Avsar et al[13] (2009)	Turkey	N = 247 (7 to 16 years)	No controls	78 (31.6%)	NA
Analytical cross sectional	Katz-Sagi et al[18] (2010)	Israel	N = 24 (5 to 12 years)	N = 22 (5 to 12 years)	7 (29.1%)	1 (4.5%)
Analytical cross sectional	Altun et al[12] (2012)	Turkey	N = 97 (7 to 15 years)	N = 97 (7 to 15 years)	17 (17.5 %)	16 (16.5 %)
Analytical cross sectional	Kohlboeck et al[19] (2013)	Germany	N = 161 (10 to 12 years)	N = 965 (10 to 12 years)	21 (17)	NA
Prevalence	Staberg et al[20] (2014)	Sweden	N = 31 (5 to 19 years)	NA	14 (42%)	NA
Analytical cross sectional	Mota-Veloso et al[15] (2016)	Brazil	N = 51 (7 to 15 years	N = 179 (7 to 15 years	35 (68.2%)	80 (44.7%)
Analytical cross sectional	Chau et al[14] (2017)	Hong Kong	N = 31 (12 to 17 years)	N = 31 (12 to 17 years)	9 (29%)	5 (16.1%)
Analytical cross sectional	Al-Batayneh et al[9] (2017)	Jordan	N = 125 (6 to 12 years)	N = 1010 (6 to 12 years)	12 (9.6%)	42 (4.1%)
Analytical cross sectional	Begnini et al[21] (2019)	Brazil	N = 51 (7 to 14 years)	N = 50 (7 to 14 years)	7 (14%)	4 (8%)

Traumatic dental injury (TDI), not applicable (NA).

medications affect the nutrition and hunger of children, which may contribute to the worsening of oral health.

TDIs among ADHD individuals accentuate the already deteriorated quality of life of this population. Due to subjective experience of shame, ADHD children with injured teeth may avoid laughing and smiling. Children's psychological well-being is negatively impacted by facial and dental trauma, as well as subsequent therapy efforts[23-26]. It is fundamental to keep in mind that not all children with ADHD develop TDIs, and not all children with TDIs have ADHD. When bringing theoretical evidence to clinical settings on an individual basis, caution is recommended.

Based on the main results in this review, there is a strong belief that a relationship exists. The odd ratio with a 95% confidence interval of 1.98 (1.51-2.59) of TDI among ADHD was seen as compared to healthy control groups (I^2 = 73%, p = 0.00001); this is similar to the findings of Chau et al[6] where meta-analysis of 5 studies confirmed that children with ADHD had 1.5 higher odds in experiencing dental trauma than non-ADHD controls[6]. In a review by Silveira et al[27], the ADHD group was included in seven studies with heterogeneity (I^2 = 79%, $p < 0.05$); individuals with ADHD had a higher risk of TDIs [2.67 (1.22, 5.87), p = 0.01][27]. These findings emphasize the nature of the functional impairments of ADHD, which could disrupt motor coordination and peer connections.

The ADHD group is hyperactive, unable to stay focused and pay attention, and has difficulties in managing behavior. Socially friendly school surroundings can have a greater effect in reducing TDIs. Effective education for parents and schoolteachers can be provided to fill in gaps in knowledge for the prevention of TDIs. Colorful and stimulating educational materials should be used to provide simple instruction with several time repetitions to improve their focus, attention, and behavior[25,26,28-30].

Like any other research, the present systematic review has some limitations. Analytical cross-study designs were included in the present research, and the removal of French periodicals may possibly have contributed to publication bias[31]; however, various databases were screened to mitigate the effect. A further limitation of the present review was that it was difficult to compare data from different combinations of dentition stages due to the small sample sizes and variety of ages from 90 months to 17 years old. Additionally, a confirmed medical diagnosis of ADHD was not shown in several of the studies. Alternatively, few authors documented the use of ADHD medication, screening surveys, and behavioral rating scales to detect hyperactive or inattentive patients. Despite those limitations, this study provides insights into the association between TDIs and ADHD individuals. It confirmed that ADHD individuals were almost twice as exposed to TDIs compared to healthy individuals. The implication of this study may also be highlighted. For improved comparison of findings, standardized indices assessing TDIs may be considerably advocated. It may also be suggested that further research should use standardized methodology for a better understanding of the oral health conditions of ADHD patients. Not only will this assist dental practitioners in better managing these patients' oral health, but it will also be beneficial to the public's health. This is especially true for ADHD individuals, who are currently underrepresented in the literature. The identification of the prevalence of dental disease range may have consequences for future restorative needs.

Conclusions

A meta-analysis of clinical data found that children with ADHD have a considerably increased risk of TDIs as compared to the healthy control group. The present study of scientific evidence may provide awareness regarding the prevention of TDIs among this vulnerable group. Dental public health advocators may pay great attention to the high prevalence of TDIs, particularly among those who have disabilities such as ADHD and other special needs. Focusing on developing preventive strategies and carrying out oral health needs assessment for the studied population may also be recommended.

Authors' Contributions

A.A.H. Alzahrani takes full responsibility for the conception, design, data collection, analysis, interpretation, drafting, and writing of the manuscript.

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Ethics Approval and Informed Consent

Not applicable due to the design of the study.

Conflicts of Interest

The author has no conflicts of interest to declare.

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Data Availability

Data available for research purposes upon request from Dr. Alzahrani through email: aahalzahrani@bu.edu.sa.

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