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Systematic Literature Review

Economic Burden and Service Utilization of Children With Attention-Deficit/Hyperactivity Disorder: A Systematic Review and Meta-Analysis

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ABSTRACT

Objectives: Attention-deficit/hyperactivity disorder (ADHD) is one of the most common neurodevelopmental disorders in children. This study aims to systematically synthesize the literature on service utilization and costs for children with ADHD.

Methods: The search included 9 databases for peer-reviewed primary studies in English from 2007 to 2023. Two independent reviewers conducted title/abstract and full-text screenings and quality assessment. Meta-analysis was conducted on direct medical costs.

Results: Thirty-two studies were included. Children with ADHD have used more pharmaceuticals, mental health, and special education services than children without ADHD (counterparts). Nevertheless, one study found that children with ADHD were twice as likely to have unmet health needs than their counterparts. Annual health system costs per patient were highly varied and higher in children with ADHD ($722-$11 555) than their counterparts ($179-$3646). From a societal perspective, children with ADHD were associated with higher costs ($162-$18 340) than their counterparts ($0-2540). The overall weighted mean direct medical cost was $5319 for children with ADHD compared with $1152 for their counterparts when all studies with different sample sizes were considered together, with the difference being $4167. Limited literature on productivity losses associated with ADHD reported them as a substantial cost. ADHD in children had a "large" effect on the increment of direct medical costs.

Conclusions: ADHD was associated with increased service utilization and costs. However, unmet health needs or underuse among children with ADHD was also evident. Governments should endeavor to improve access to effective services for children with ADHD to mitigate the impact of ADHD.

Keywords: ADHD, adolescent, children, cost, service use.

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Introduction

Attention-deficit/hyperactivity disorder (ADHD) is defined as a "persistent pattern of inattention and/or hyperactivity-impulsivity that interferes with functioning or development."[1] ADHD is the most common pediatric neurodevelopmental condition, with a 2% to 7% prevalence in children and adolescents globally.[2] ADHD has significant long-term impacts (eg, substance abuse,[3] adverse occupational outcomes,[4] and criminality[5]), with 75% of patients diagnosed in childhood continuing to experience symptoms until late in adulthood.[4] Therefore, it is critical to recognize and treat the condition at the earliest to mitigate these adverse outcomes.[6] ADHD often coexists with other neurodevelopmental and mental health conditions, such as autism, depression, and anxiety.[7] Worldwide recognition of ADHD is increasing in recent times, largely because of changes in approaches to both diagnosis and management.[8]

ADHD creates a substantial social and economic burden nationally, for example, US$14 billion financial and well-being costs in Australia in 2019[9] or US$143 billion to US$266 billion in the United States in 2010.[10] The most recent review in 2021 on the global economic burden of ADHD in children reported annual total cost ranging from US$831 to US$20 538 per person.[11] It has been consistently demonstrated that children with ADHD incur higher medical costs than children without the condition, and this trend continues into adulthood.[12] ADHD in children leads to chronic absenteeism from school[13] and parents taking more time off work or having to change jobs or being fired, reducing income and productivity.[14] The education system is also burdened by costs associated with ADHD because special education schemes and other intervention strategies required for children with ADHD in school are significantly more costly than regular schooling programs.[15] In a broader context, there is evidence that young people with ADHD had more involvement with the criminal justice system, with more police proceedings, charges or convictions in court, and more incarcerations than those without ADHD.[16] Children with ADHD have a twofold likelihood of being arrested when

they become young adults.[17] However, these incurred costs of these involvements were largely unexplored in the current academic literature.

Currently, treatments for ADHD vary globally. Children may be offered either pharmacological or non-pharmacological therapy or a combination of both (ie, multimodal treatment).[18] The main pharmacological treatments are stimulants and nonstimulant medications.[19] Stimulants are the most commonly utilized, improving core ADHD symptoms and executive functioning.[20,21] Nonpharmacological treatment involves psychological, such as behavioral and cognitive, therapy.[19] It is important to note that treatment is often required through into adulthood.[22]

Primary care, mental health, and educational services were reported to be important in the management of ADHD.[23] Chhibber et al[11] synthesized global evidence on the economic burden of ADHD for both children and adults but was cost-focused and did not explore the impact of ADHD on service access and utilization. A comprehensive understanding of service utilization and costs associated with ADHD is important to efficiently and equitably plan services and allocate population health resources for ADHD treatment. The efficient and equitable allocation of resources would potentially minimize the substantial economic and social burden associated with ADHD in the long run.

This study aims to systematically synthesize the literature about the service utilization (health and nonhealth) and costs of ADHD in children globally, including both direct (eg, medical costs) and indirect costs (eg, productivity losses for both parents and children with ADHD). This knowledge will assist future policy decisions relating to population health resource allocation to improve the health and well-being of children with ADHD.

Methods

The systematic review was adhered to the PRISMA 2020 checklist[24] and registered in PROSPERO (CRD42022346675).[25]

Search Strategy

The following databases were searched: Medline, The Cochrane Library, NHS EED, HTA, DARE, EconLit, Embase, PsycINFO, and CINAHL. The research in the topic area has evolved since 2011, and the guidelines have been revised over time, for example, Diagnostic and Statistical Manual (DSM)-5 in 2013 with changes on ADHD diagnostic criteria.[26] Because therapies for ADHD have evolved from 2008 onward,[27] the service utilization and associated costs might have been affected. Therefore, we focused our search over the past 15 years to reflect the contemporary research. The search terms included keywords for ADHD, children, service use, and economic impact (see Appendix 1 in Supplemental Materials found at https://doi.org/10.1016/j.jval.2023.11.002).

Inclusion and Exclusion Criteria

Peer-reviewed primary studies that examined the service utilization or costs of ADHD were included if they (1) targeted children and adolescents (≤18 years old) in any setting (onward, term "children" is used when referring to children and adolescents), (2) were on ADHD reported by parents or a clinical diagnosis, (3) compared findings with a group of children without ADHD (counterparts), (4) were published between January 1, 2007 and April 30, 2022, and (5) were published in English. Studies that did not meet the inclusion criteria and systematic, rapid or scoping reviews, protocols, newsletters, and abstracts were excluded.

Data Screening and Extraction

The search results were exported into EndNote 20[28] and then uploaded to Covidence[29] for screening. Two reviewers independently screened the title and abstracts (M.D. and S.W.A.D.) and then full text. Inter-rater reliability (IRR) between the 2 reviewers was tested using Cohen's Kappa to assess the agreement on the decision whether an article met the selection criteria.[30] Any conflicts were resolved upon discussion among the review team. Two reviewers independently completed the data extraction and cross-checked for accuracy. The extracted data included study aim, method of ADHD diagnosis, type of study, study period, location of study, population, outcome, key results, and the perspective adopted by the study (ie, societal or health system) (Tables 1[31-43] and 2[14,44-61]).

Quality Assessment

Quality assessment was independently completed by 2 reviewers (M.D. and S.W.A.D.) using the National Heart, Lung, and Blood Institute checklists for cohort, cross-sectional and case-control studies.[62] It uses a set of 14 criteria for assessing the study methodology. IRR for the agreement between the 2 raters was performed using Cohen's Kappa on quality indicators of the National Heart, Lung, and Blood Institute checklists. Any discrepancies in the overall quality rating were discussed and resolved upon discussion among the review team. Based on previous literature,[63,64] a score of 1 was given for a "yes" option, and the overall quality of studies was rated as "good," "fair," and "poor" quality if the overall score is ≥6, 4 to 5, and <4 yes, respectively, with a maximum score of 14. When calculating the total score, questions 1 to 5, 9, 11, and 14 were considered for cross-sectional studies, whereas all 14 questions were considered for cohort studies.[62]

Standardizing Costs Across Studies

All costs were converted to annual cost per person. Then, all values were converted to 2023 US dollars using web-based Campbell and Cochrane Economics Method Group and Evidence for Policy and Practice Information Centres' cost converter, which is based on gross domestic product deflator index and purchasing power parities.[65]

Meta-Analysis

Meta-analysis was conducted using MetaXL version 5.3 on Excel (EpiGear International Pty Ltd, Sunrise Beach, Australia; https://www.epigear.com/) for 6 studies that reported mean direct medical cost because it was the only cost item reported consistently. The standardized mean difference (Hedges' g score) was calculated through a more robust inverse variance heterogeneity (IVhet) model.[66] Compared with random effect model, the IVhet model maintains a correct coverage probability and a lower observed variance despite heterogeneity.[66] IVhet model was used over quality effects model because the 6 included studies were rated as same level of quality.[66] Overall weighted mean direct medical cost was calculated for the 6 included studies.

To enable the meta-analysis, relevant statistics were calculated[67] (see Appendix 2 in Supplemental Materials found at https://doi.org/10.1016/j.jval.2023.11.002). The standardized mean difference was used to calculate each study's effect size. Hedges' g is an index of standardized group differences comparable across studies.[68] Positive Hedges' g reflects that childhood ADHD is associated with increased costs. At least 0.80, 0.50, and 0.20 Hedges' g means a large, a moderate, and a small effect, respectively.[69]

Table 1. Service utilization of children living with ADHD.

Study	ADHD sample size; comparison sample size (without ADHD); age; gender in the ADHD sample vs comparison group	Study period; location (whether the sample represents a national population)	ADHD diagnosis; diagnostic tool	Data source	Service type	Service description	Main findings
Studies adopted a health system perspective							
Ames et al[31]	20 615; 20 615; 14-25 years, including 14-17; 4:1 male:female ratio in the ADHD vs not reported for comparison group	2014-2015; USA (from Kaiser Permanente Northern California)	Clinical diagnosis; not reported	KPNCs database	Outpatient care	Annual % of mental health services use compared with comparison group	32% vs 7%
					Inpatient care	Annual % of hospitalization compared with comparison group	4% vs 2%
						Annual % of ED use compared with comparison group	23% vs 13%
					Medication	Annual % of ADHD medications use	27.5% vs 0%
Boulet et al[32]	5972; 82 875; 3-17 years; 73.2% vs 48.8% males in ADHD vs comparison group	1997-2005; USA (National sample)	Parent-reported clinical diagnosis; NHIS	NHIS data	Outpatient care	Annual % of medical specialist use compared with comparison group	24.1% vs 11.1%
						Annual % of mental health services use compared with comparison group	39.4% vs 3.4%
					Inpatient care	Annual % of hospitalization and ED compared with comparison group	9.8% vs 5.5%
					Medication	OR of having a prescription	1.8
					Other	Annual % of special education service use in ADHD cohort compared with comparison group	36.6% vs 1.5%

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Table 1. Continued

Study	ADHD sample size; comparison sample size (without ADHD); age; gender in the ADHD sample vs comparison group	Study period; location (whether the sample represents a national population)	ADHD diagnosis; diagnostic tool	Data source	Service type	Service description	Main findings
Cuffe et al[33]	278; 9423; 4-17 years; 194 vs 4700 males in ADHD vs comparison group	2001; USA (National sample)	Parent reported; DSM IV based SDQ	NHIS data	Outpatient care	Annual % of male and female having seen a medical specialist compared with comparison group	Male: 90.9% vs 85.3% Female: 93.5% vs 85.8%
						Annual % of male and female having seen mental health services compared with comparison group	Male: 45.2% vs 5.4% Female: 44% vs 5%
					Inpatient care	Annual % of male and female hospitalization and ED compared with comparison group	Male: 31.8% vs 19.4% Female: 38.9% vs 17.5%
					Medication	% of male and female that needed prescription medication for at least 3 months	Male: 48% vs 13.7% Female: 40.7% vs 10.9%
Engelhard et al[34]	1175; 20 387; before age 1; 71.1% vs 51.5% males in ADHD vs comparison group	2006-2016; USA (Carolina)	Clinical diagnosis; ICD 10	DUHS database	Outpatient care	OR of medical specialist use compared with comparison group in 12 months	1.7
					Inpatient care	OR of annual hospitalization compared with comparison group	1.6
						OR of annual ED compared with comparison group	1.6
Ford et al[35]	115 in clinical sample, 35 in epidemiological sample; 109 in epidemiological sample; 6-15 years; 80% vs 51% males in ADHD vs comparison group	1999-2004; UK (Cardiff)	Clinical diagnosis; DSM IV or ICD 10	CLASS survey	Outpatient care	Annual % of mental health services use compared with comparison group	91% vs 45%
					Medication	% of ADHD cohort taking medication at any time point	93%

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Table 1. Continued

Study	ADHD sample size; comparison sample size (without ADHD); age; gender in the ADHD sample vs comparison group	Study period; location (whether the sample represents a national population)	ADHD diagnosis; diagnostic tool	Data source	Service type	Service description	Main findings
Laugesen et al[36]	11 360; 521 193; 1-12 years; 79% vs 51% males in ADHD vs comparison group	1995-2014; Denmark (National sample)	Clinical diagnosis; ICD 10	Parental survey	Outpatient care	OR of mental health services use compared with comparison group	52.5
					Inpatient care	OR of hospitalization-based services compared with comparison group	1.8
Lynch et al[37]	1 186 969 total visits; 6843 (ADHD-related); 21 158 (other psychiatric visits); 0-18 years; 71% vs 51% males in ADHD vs comparison group	2011-2012; USA (Florida State)	Clinical diagnosis; ICD 9	State-level claims data	Inpatient care	Number of unavoidable ED visits for ADHD group compared with comparison group with other psychiatric conditions	6843 per year vs 21 158 per year
Park et al[38]	118; 10 838; 7-18 years; 78% vs 53% males in ADHD vs comparison group	2007-2015; Korea (National sample)	Clinical diagnosis; not reported	Parental survey	Outpatient care	% of outpatient clinic visits compared with comparison group	26.6% vs 22.2%
					Other	% of unmet health needs compared with comparison group	19.9% vs 9.6%
Studies adopted a societal perspective							
Classi et al[39]	432; 5464; 6-17 years; 70% vs 49% males in ADHD vs comparison group	2007; USA (National sample)	Parent-reported clinical diagnosis; not reported	NHIS data	Outpatient care	% of ≥6 medical specialist use in past 12 months compared with comparison group	11.1% vs 5.6%
					Inpatient care	% of ≥2 ED visits in past 12 months compared with comparison group	30.9% vs 9.4%
					Other	% of ≥2 weeks of school missed in past 12 months compared with comparison group	8.4% vs 3.6%
Larson et al[40]	5028; 56 752; 6-17 years; gender not reported	2007; USA (National sample)	Parent-reported clinical diagnosis; not reported	NSCH survey	Outpatient care	Odds Ratio of mental health use in past 12 months	11.42
					Other	Odds Ratio of special education use in past 12 months	9.88

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Table 1. Continued

Study	ADHD sample size; comparison sample size (without ADHD); age; gender in the ADHD sample vs comparison group	Study period; location (whether the sample represents a national population)	ADHD diagnosis; diagnostic tool	Data source	Service type	Service description	Main findings
Pastor et al[41]	3504; 35 021; 4-17 years; 70% vs 49% males in ADHD vs comparison group	2010-2013; USA (National sample)	Parent-reported of clinical diagnosis; not reported	NHIS survey	Outpatient care	% of ADHD cohort receiving mental health services	39.8%
					Medication	% of ADHD cohort receiving prescribed medication	56%
					Other	% of ADHD cohort receiving Special education	20.4%
Schieve et al[42]	2901; 35 665; 3-17 years; 70% vs 49% males in ADHD vs comparison group	2006-2010; USA (National sample)	Parent-reported of clinical diagnosis; not reported	NHIS data	Outpatient care	% of medical specialist use in last month compared with comparison group	23.1% vs 12.1%
						% of mental health services use in last month compared with comparison group	37.4% vs 3.6%
					Medication	% of regular (longer than 3 months) prescription medication users compared with comparison group	56.5% vs 9.7%
					Other	% of special education use in last month compared with comparison group	4.8% vs 0.6%
Tremmery et al[43]	45; 93; 9-year-olds; 78% vs 48% males in ADHD vs comparison group	1999-2000; Netherlands (Maastricht)	Clinical diagnosis; DICA - R	Youth healthcare records	Outpatient care	% of medical specialist use compared with comparison group	35.6% vs 4.3%
					Medication	% of stimulant medication use compared with comparison group	22.2% vs 1.1%
					Other	% of special education use in 12 months compared with comparison group	11.1% vs 6.4%

% indicates percentage; ADHD, attention deficit/hyperactivity disorder; CLASS, Cardiff longitudinal ADHD sample study; DSM, diagnostic and statistical manual; DUHS, Duke University Health System; ED, emergency department; ICD, International Classification of Disease; KPNC, Kaiser Permanente Northern California; NHIS, National Health Interview Survey; NSCH, National Survey of Children's Health; OR, odds ratio; SDQ, Strengths and Difficulties Questionnaire; USA, United States of America.

Table 2. Studies assessing costs of children living with ADHD (2023 US$).

Study	ADHD sample size; comparison sample size (without ADHD); age; gender in the ADHD sample vs comparison group	Study period; location (whether the sample represents a national population)	ADHD diagnosis; diagnostic tool	Data source	Cost category	Cost item	Results (US$, 2023)
Studies adopted a health system perspective							
Braun et al[44]	24 820; 124 100; 017 years; 76% males in ADHD group	2008; Germany (National sample)	Clinical diagnosis; ICD 10	Claims data	Direct	Average annual cost per child compared with comparison group	$6433 vs $1631
Guo et al[45]	75 652; 1 390 666; 2-17 years; 73% vs 52% males in ADHD vs comparison group	2013; USA (New York State)	Two or more outpatient claims with ADHD in a fiscal year; ICD 9	Medicaid database	Direct	Average annual cost per child compared with comparison group	$11 555 vs $3646
						Average annual cost per child for psychological services	$3953
					Medication	Average annual cost per child for prescription medication	$3221
Holden et al[46]	2873; 6598; mean age 10.4 years; 85% vs 86% males in ADHD vs comparison group	1998-2010; UK (National sample)	Clinical diagnosis; not reported	CPRD database	Direct	Average annual cost per child compared with comparison group	$2295 vs $561
					Medication	Average annual cost per child for prescription medication	$548 vs $66
Sciberras et al[47]	333; 7226; 4-9 years; 82% vs 51% in ADHD vs comparison group	2004-2012; Australia (National sample)	Parent-reported clinical diagnosis; not reported	Australian Medicare	Direct	Average annual costs per child over a 2-year period for 4-5 years compared with comparison group	$722 vs $205
						Average annual costs per child over a 2-year period for 6-7 years compared with Comparison group	$468 vs $179
						Average annual costs per child over a 2-year period for 8-9 years compared with comparison group	$656 vs $194
Klora et al[48]	7845; 23 535; 0-17 years; 73% males	2006-2008; Germany (National sample)	Clinical diagnosis; ICD 10	Claim data	Direct	Average annual cost per child pre-diagnosis compared with comparison group	$2169 vs $984

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Table 2. Continued

Study	ADHD sample size; comparison sample size (without ADHD); age; gender in the ADHD sample vs comparison group	Study period; location (whether the sample represents a national population)	ADHD diagnosis; diagnostic tool	Data source	Cost category	Cost item	Results (US$, 2023)
						Average annual cost per child post diagnosis compared with comparison group	$3784 vs $927
Libutzki et al[49]	19 830; 605 106; 76% vs 51% males in ADHD vs comparison group	2009-2014; Germany (National sample)	Clinical diagnosis; ICD 10	SHI database	Direct	Average annual cost per child compared with comparison group (0-12 years)	$3192 vs $921
						Average annual cost per child compared with comparison group (13-17 years)	$3321 vs $1122
						Average annual hospital cost per child compared with comparison group (0-12 years)	$1023 vs $172
						Average annual hospital cost per child compared with comparison group (13-17 years)	$1535 vs $418
						Average annual psychiatric cost per child compared with comparison group (0 -12 years)	$468 vs $27
						Average annual psychiatric cost per child compared with comparison group (12-72 years)	$217 vs $17

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Table 2. Continued

Study	ADHD sample size; comparison sample size (without ADHD); age; gender in the ADHD sample vs comparison group	Study period; location (whether the sample represents a national population)	ADHD diagnosis; diagnostic tool	Data source	Cost category	Cost item	Results (US$, 2023)
					Medication	Average annual stimulant medication cost per child compared with comparison group (0-12 years)	$211 vs 0
						Average annual stimulant medication cost per child compared with comparison group (12-17 years)	$327 vs 0
Studies adopted a societal perspective							
Callander et al[50]	194; 4913; 0-11 years; 73% vs 51% males in ADHD vs comparison group	2004-2014; Australia (National sample)	Parent-reported clinical diagnosis; not reported	LSAC parent survey	Productivity losses	% of parents not in the labor force in families with children with ADHD compared with comparison group	2-3 years: mother: 47% vs 39% father: 3% vs 4 10-11 years: mother: 38% vs 20% father: 10% vs 5%
Dunn et al[51]	22; 22; 8-11 years; 77% vs 86% makes in ADHD vs comparison group	2008; USA (Utah)	Parent reported; Connors parent rating scale	Parent survey	Productivity losses	Mean assistance score, self-care score, and family tasks compared with comparison group (Note: lower score indicates less independence)	Assistance score: 77.3 vs 85.7 Self-care: 80.6 vs 88.3 Family tasks: 76.9 vs 83.8
Fleming et al[52]	7413; 758 831; 4-19 years; 85% vs 51% in ADHD vs comparison group	2009-2013; Scotland (National sample)	Medication for ADHD; ICD 10	NHIS data	Productivity loss	Odds Ratio for future unemployment	1.5 (95% CI 1.3-1.6)
Guevara et al[53]	5561; 99 369; 0-18 years; 73% vs 51% in ADHD vs comparison group	1997-2004; USA (National sample)	Parent-reported clinical diagnosis; not reported	NHIS data	Productivity losses	School absences per year	5.2 vs 3.7
Gupte-Singh et al[54]	458; 8650; 3-17 years; 75% vs 50% males in ADHD vs comparison group	2011; USA (National sample)	Clinical diagnosis; ICD 10	Medical Expenditure Panel Survey	Direct + indirect	Annual incremental cost per child compared with comparison group for inpatient visits	$72

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Table 2. Continued

Study	ADHD sample size; comparison sample size (without ADHD); age; gender in the ADHD sample vs comparison group	Study period; location (whether the sample represents a national population)	ADHD diagnosis; diagnostic tool	Data source	Cost category	Cost item	Results (US$, 2023)
						Annual incremental cost per child compared with comparison group for outpatient visits	−$79
						Annual incremental cost per child compared with comparison group for ED visits	−$93
						Annual incremental cost per child compared with comparison group for home healthcare	$86
						Annual incremental indirect cost per child compared with comparison group	$193
						Annual incremental total cost per child compared with comparison group	$1180
Hakkaart-van Roijen et al[55]	65; 47; mean age 10.5 and 7.8 in ADHD and comparison group; 80% vs 36% males in ADHD vs comparison group	2002-2004; Netherlands	Clinical diagnosis; DSM IV	Parent survey	Direct	Average annual cost per child compared with comparison group	$3377 vs $293
					Indirect	Mean number of days missed by mother at work compared with comparison group	17.3 vs 6
Jones et al[56]	61; 350; 12-17 years; 55-65% males in ADHD group for different sites	1997-2004; USA	Clinical diagnosis; DISC IV	Parent survey	Direct + indirect	Average annual cost per child compared with comparison group	$14 529 vs $6054
Le et al[57]	6310 parents and 2967 children; 4-17 years; gender not reported	2013-2014; Australia (National sample)	Clinical diagnosis; DISC IV	Data from MBS and PBS	Direct + indirect	Average annual cost per child of MHS compared with comparison group	$451 vs $298

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Table 2. Continued

Study	ADHD sample size; comparison sample size (without ADHD); age; gender in the ADHD sample vs comparison group	Study period; location (whether the sample represents a national population)	ADHD diagnosis; diagnostic tool	Data source	Cost category	Cost item	Results (US$, 2023)
						Average annual cost per child of general health services compared with comparison group	$330 vs $233
					Medication	Average annual cost per child for medications compared with comparison group	$545 vs $144
Schein et al[58]	4 512 083; 5-17 years (in which 2 856 780 [5-11 years] and 1 655 303 [12-17 years]); no data	2017- 2018; USA (National sample)	Clinical diagnosis; ICD 9	Medicaid data and insurance plains	Direct + indirect	Average annual excess cost per child (5-11 years)	$7682
						Average annual excess cost per adolescent (12-17 years)	$9434
Sciberras et al[59]	3.2% (n = 814 500) of 2019 Australian population; all ages including 4.1% of them 0-14 years; gender not reported	2019, Australia (National sample)	Australian Twin Registry; DSM IV	ABS, PBS, MBS NHMRC database	Direct + indirect	Average annual hospital cost per child	$135
						Average annual out of hospital cost per child	$259
						Overall burden (ie, social and economic cost) for the year 2018-19 for the total Australian population	$14 billion
						Overall burden (ie, social and economic cost) for the year 2018-19 per person	$17 007
Zhao et al[14]	56; 30; 14-17 years; 77% vs 70% in ADHD vs comparison group	1998-2010; USA (Pittsburgh)	Clinical diagnosis; DSM III- R	Parental survey for burden, direct costs taken from database	Direct + indirect	Average annual cost per child compared with comparison group	$18 340 vs $3474
						Average annual indirect cost per child compared with comparison group	$16 660 vs $2540
Li et al[60]	4530; 20 185; 3-12 years; male:female ratio 3:1	2008-2012; Taiwan (National sample)	Clinical diagnosis; ICD 9	Taiwan health database	Direct	Average annual rehabilitation facility cost per child compared with comparison group	$1701 vs $980

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Table 2. Continued

Study	ADHD sample size; comparison sample size (without ADHD); age; gender in the ADHD sample vs comparison group	Study period; location (whether the sample represents a national population)	ADHD diagnosis; diagnostic tool	Data source	Cost category	Cost item	Results (US$, 2023)
Marks et al[61]	109; 97; 3-5 years; 74% vs 72% in ADHD vs comparison group	2008-2009; USA (community sample)	Parent reported; ADHD rating scale IV, K-SADS	Parent survey	Direct	Average annual cost per child for OT compared with comparison group	$466 vs $52
						Average annual cost per child for PT compared with comparison group	$207 vs $52
						Average annual cost per child for ST compared with comparison group	$569 vs $155
						Average annual cost per child for SPED compared with comparison group	$2587 vs $595
						Average annual cost per child compared with comparison group	$4140 vs $983

ABS indicates Australian Bureau of Statistics; ADHD, attention deficit/hyperactivity disorder; AUD, Australian Dollar; CPRD, Clinical Practice Research Datalink; DISC, Diagnostic Interview Schedule for Children; DSM, Diagnostic and Statistics Manual; ICD, International Classification of Diseases; K-SADS, Kiddie Schedule for Affective Disorders and Schizophrenia; LSAC, Longitudinal Study of Australian Children; MBS, Medicare benefits schedule; MHS, Mental Health Services; NHMRC, National Health and Medical Research Council; NTD, New Taiwan Dollar; OR, odds ratio; OT, occupational therapy, PBS, pharmaceutical benefits schedule; PT, physical therapy, SHI, Germany Statutory Health Insurance; ST, speech therapy, SPED, special education services; USA, United States of America; USD, US Dollar; years, years old.

Homogeneity was assessed using the Cochran's Q test and I^2. Cochran's Q measures the variation in effect sizes, with $P < .10$ representing heterogeneity.[70] However, the true variation in heterogeneity is not reflected in Cochran's Q test.[71] I^2 test assesses the percentage of true variation of studies where I^2 at least 75%, 50%, and 25% are considered high, moderate, and low heterogeneity.[71] The Luis Furuya-Kanamori (LFK) index was used to assess publication bias, based on the Doi plot. An LFK index less than 1, from 1 to 2 and >2 indicates no asymmetry, a minor asymmetry, and a major asymmetry.[72]

Results

Search Results

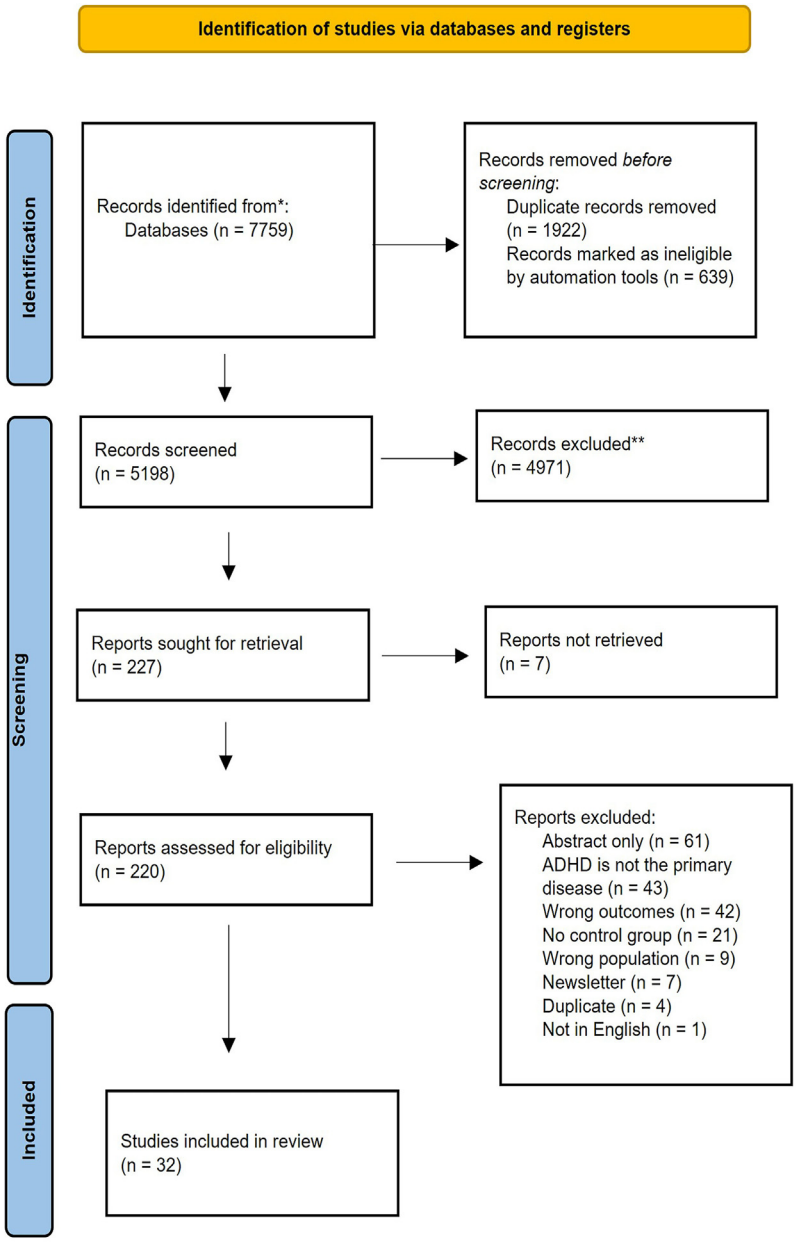
Of 7759 records identified from search, 5198 underwent title and abstract screening after removing duplicates. Full-text screening included 226 records. Thirty-two studies were included in the final synthesis (Fig. 1). IRR testing resulted in a weak to moderate level of agreement between the 2 reviewers for title and abstract (0.49 Kappa value, 96% proportion agreement) and full-text screening (0.61 Kappa value, 82% proportion agreement), on the decision based on the selection criteria.

Study Characteristics

Of 32 studies, the majority were cohort design (66%) and were from the United States (53%). The quality assessment found that all articles were "good" in quality, with IRR between the 2 reviewers in the range of strong (0.83) to almost perfect (1.00) (see Appendices 3 and 4 in Supplemental Materials found at https://doi.org/10.1016/j.jval.2023.11.002). Thirteen studies explored service utilization.[31-43] Fifteen investigated the associated cost.[14,44-49,54-61] Four reported on productivity losses.[50-53] Fourteen considered costs from a health system perspective,[31-38,44-49] whereas the other 18 considered a societal perspective.[14,39-43,50-61]

The studies varied in their diagnostic criteria for ADHD. Eighteen used clinical diagnosis by a physician using various

Figure 1. PRISMA diagram describing flow of search process.



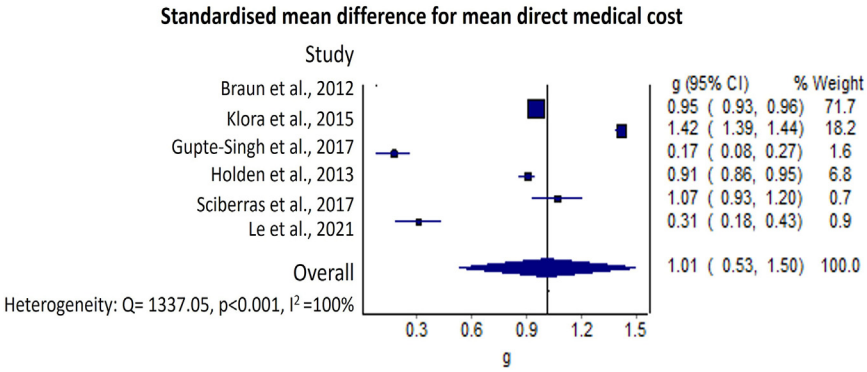
* Medline, The Cochrane Library, NHS EED, HTA, DARE, EconLit, Embase, PsycINFO, and CINAHL

** No automated tool was used to exclude records. Two independent reviewers excluded irrelevant studies via Covidence.

Newsletters are used by various institutions to connect with current, future and past members to convey information and/or research – however these are widely considered grey literature and are not included in the review if they appear in the search.

ADHD indicates attention-deficit/hyperactivity disorder; PRISMA, preferred reporting items for systematic reviews and meta-analyses.

Figure 2. Meta-analysis findings on standardized mean difference for direct medical cost. The blue square of the forest plot resembles the weight of the sample and the lines extending from the box is the confidence intervals, in which the chance of having the true effect in the population.[73] The diamond and the line across the diamond shows the overall pooled effect. Braun et al (2012) study had the largest weight to the pooled estimate, which reduces the uncertainty or imprecision of the pooled effect estimate. [74]



diagnostic approaches (eg, the DSM of Mental Disorders [DSM III or IV]).[14,34-38,43,44,46,48,49,54-60] Eleven studies used parental reporting,[32,33,39-42,47,50,51,53,61] (in which 8 used parent-report of clinical diagnosis and 3 used parent-completed tool, such as DSM IV or Strengths and Difficulties Questionnaire), and 3 used administrative databases, such as outpatient claims and medication prescriptions.[31,45,52] Notably, not all studies included the full age range from 0 to 18 years. The age groups varied: 22 studies targeted age 0 to 18 years,[32,33,35,37-42,44-46,48-50,52,54,55,57,58] whereas others focused on smaller age ranges, for example, 1 to 12 years,[34,36] 14 to 17 years,[14,31] and 3 to 4 years.[61]

Key Findings

Outpatient care/mental health services use

Twelve studies reported on outpatient service use, in which all reported greater utilization for children with ADHD than their counterparts. In a 12-month period, mental health services were utilized by 32% to 91% of children with ADHD[31-33,35,41,42] compared with 3.40% to 45% of their counterparts.[31-33,35,42,43] Children with ADHD had between 11.40 and 52.50 higher odds of using a mental health service than those without ADHD.[36,40] Children with ADHD were also more likely to use other outpatient services such as medical specialists, with 23.10% to 93.50%[32,33,38,42,43] compared with their counterparts 4.30% to 85.80%.[32,33,38,42,43]

Inpatient care services use

Seven studies reported on inpatient service use. Children with ADHD were more likely to be admitted to hospital than their counterparts (odds ratio 1.60-1.80).[34,36] Emergency department visits were also higher in children with ADHD compared with their counterparts, with annual utilization rates 23% to 38.90% compared with 13% to 17.50%.[31,33]

Medication use

Seven studies reported on medication use. Medication use was much higher in children with ADHD compared with their counterparts, with 22% to 93%[31,33,35,41-43] of children with ADHD using ADHD or prescribed medication annually, compared with 0% to 14% of their counterparts.[31,33,35,41-43] Moreover, children with ADHD used more medications overall than children without ADHD. For example, a large sample size study (41 230 participants) reported any medication use was higher in children with ADHD than their counterparts (93.14% vs 48.34%)[31]

Special education services use

Special education service utilization was reported to be higher in children with ADHD, with 4.80% to 36.62%[32,41-43] and an odd ratio of 9.91[51] compared with their counterparts.

Inequity in service access/utilization

Seven studies examined sociodemographic variables and reported differences in service use or unmet needs, with 1 study indicating that children with ADHD were more than twice as likely to have unmet health needs compared with their counterparts, 19.88% compared with 9.64%.[38] Another study reported that parents of children with ADHD could not afford required medications and mental healthcare/counselling, (15.50% and 4.85%, respectively).[42] Two studies found that male children with ADHD had more visits to hospitals/EDs and specialist services (general surgery) than female children.[34,37] For those families with children with ADHD, younger children, children living in metropolitan areas, or having health insurance, higher family income, and divorced or single parents had higher service utilization.[33,34,36,37,41]

Two studies reported conflicting results on the association between parental education and health service use. Cuffe et al[33] found that parental higher education were associated with increased specialist healthcare services use, such as mental healthcare professional visits among children with ADHD (ie, psychologist, clinical social worker, psychiatric nurse, and psychiatrist). Laugesen et al[36], however, reported that there were no significant differences in psychiatric service use among various levels of parental education. Parents with no or limited education used more non-specialist medical services for their children with ADHD than parents with high educational levels.[36]

Direct costs

The included studies consistently reported higher direct costs of children with ADHD than their counterparts. Annual direct costs per patient from a health system perspective ranged from $722 to $11 555 for children with ADHD, whereas it was $179 to $3646 for their counterparts across studies.[44-49] From the societal perspective, the cost per person varied from $162 to $18 340 for

those with ADHD compared with $0 to $2540 for their counterparts.[14,54-58,60,61] Weighted mean direct medical cost was $5319 for children with ADHD compared with $1152 for their counterparts when all studies with different sample sizes were considered together.

The direct costs associated with ADHD were mainly related to use of primary care, medications, mental health services, hospitalizations, home care, and other specialist services/remedies (eg, speech therapy and physical/occupational therapy) (Table 1[31-43]). Medications were a major cost as a primary treatment, with a variety of medications, such as stimulants, antipsychotics, antidepressants, and any other required medications. Annual costs for prescribed medications ranged from $211 to $3221[45,49,54,57] compared with those without ADHD, whose costs ranged from $0 to $144.[46,49,57]

Indirect costs

Indirect costs can be incurred by both caregivers and children with ADHD. Indirect costs were considered a major component of the total economic costs associated with ADHD,[14] representing over 90% of total family costs when included in total cost estimates. These costs were borne from income loss because of missing work, getting fired, additional childcare services and parental mental health issues, or sick leave payments. There were only 4 studies on productivity losses associated with ADHD. One study found that parents of children with ADHD were more likely to be unemployed than parents of children without ADHD.[50] Children living with ADHD had 1.39 odds[52] compared with those without ADHD for unemployment after leaving school. Further, children with ADHD had more school absences per year (eg, 5.20 compared with 3.71).[53] One study found children with ADHD needed more assistance with household tasks than children without ADHD.[51] Overall burden (ie, social and economic cost) of living with ADHD in Australia was estimated at $18 470 per person with ADHD in which productivity losses (eg, absenteeism, presenteeism, and premature mortality) accounted for the majority (81%) followed by deadweight losses (ie, lost taxation revenue) and health system costs.[59]

Meta-Analysis

The pooled effect size (standardized mean difference/Hedges' g) of ADHD for direct medical costs from the 6 studies[41,44-46,48,59] was large (Hedges' g 1.01, 95% CI 0.53-1.50). This large effect shows that ADHD in children was associated with increased costs to the healthcare system compared with those without ADHD. The I^2 test of 100% ($I^2 > 75\%$) indicated a high heterogeneity across studies (Fig. 2). The sample sizes and mean cost variations are illustrated in Appendix 5 of Supplemental Materials found at https://doi.org/10.1016/j.jval.2023.11.002.

Sensitivity analysis and publication bias

The sensitivity analysis was conducted by removing each study. Similar to Forest plot, this showed that the Braun et al[44] had the biggest influence on the pooled estimate. However, the differences between the pooled estimate with all studies included and the estimates with exclusion of each study were not statistically significant. The standardized mean difference ranged from 0.92 (95% CI 0.46-1.38) to 1.17 (95% CI 0.49-1.87) (see Appendix 6 in Supplemental Materials found at https://doi.org/10.1016/j.jval.2023.11.002). The LFK showed a major asymmetry due to publication bias (see Appendix 7 in Supplemental Materials found at https://doi.org/10.1016/j.jval.2023.11.002 for Doi plot). Therefore, the pooled cost estimates should be treated cautiously because studies that show high effect on cost/service utilization might be more likely to get published than those with lower effects, causing publication bias.

Discussion

This review is a comprehensive synthesis of the recent literature on service utilization and costs incurred from ADHD in children and adolescents. Our review showed higher healthcare usage, especially of mental health services, by children with ADHD than children without ADHD across all outpatient, inpatient, and pharmaceutical services. Our meta-analysis confirmed the large effect of ADHD on medical healthcare costs, which is only a proportion of the total cost burden. We also found very limited research on productivity losses which were reported to be the main cost attributed to indirect costs.

All types of services use are higher in children with ADHD than those without ADHD. This aligns with the broader literature on ADHD and its impact on functioning and well-being.[75] Children with ADHD are more likely to have emotional and behavioral problems, anxiety and depression,[76] and somatic health problems[77] and are thus likely to access more health services, especially mental health services, than their counterparts.

Conversely, consistent with the literature,[78] we also found evidence of underutilization of mental health services and unmet health needs in children with ADHD, although this finding came from only 1 study. There is evidence from the literature that parental barriers, such as individual factors (beliefs, lack of knowledge, and health), community factors (cultural differences and poverty), and interpersonal factors (social support or networks), all prevent parents from seeking mental health services for their children with ADHD.[79] This is consistent with our study findings in which there were differences in service use across various sociodemographic characteristics. This inequity can be further worsened by barriers that health professionals face to support patients with ADHD, such as lack of knowledge/training on ADHD, stigma and misconceptions, constraints in resources, and communication difficulties across multidisciplinary care (ie, general practitioners, specialists, teachers, and parents).[80-82] Addressing these barriers will contribute to bridge the gap in unmet needs of access to services, and integrated care models could play a considerable role.[83]

Findings on the large effects of ADHD on the reported medical costs from our meta-analysis confirms the substantial economic costs associated with ADHD in broader literature.[59,84,85] Our review and meta-analysis advanced the previous systematic review in the current literature by providing the first quantitative summary of the direct medical costs associated with ADHD and with the inclusion of the most contemporary evidence, with the targeted population being children and adolescents. The meta-analysis found a high heterogeneity, which may reflect the difference in healthcare costs of ADHD across different countries, for example, studies from Europe, United States, and Australia. However, when considering countries health systems' contexts, for example, with universal or non-universal healthcare system, a particular pattern of medical costs across these health systems is inconclusive because of insufficient number of studies for each healthcare system. For example, there was only 1 study from United States with a nonuniversal healthcare system, which was suitable for the meta-analysis (see Appendix 5 in Supplemental Materials found at https://doi.org/10.1016/j.jval.2023.11.002). Another possible reason for high heterogeneity is the various sample sizes of the included studies.

Our review also found that indirect costs were reported as significant and mainly attributed to productivity losses by parents

and caregivers. This could be because of various reasons, such as increased responsibilities, leading to missed work and absenteeism.[86] Although the studies have considered confounding factors such as other cooccurring conditions of the child, there is no specific consideration of parental ADHD condition, which could have an impact on their productivity losses. Future research needs to incorporate parental health status when considering productivity losses. Evidence on productivity loss is scarce, although ADHD has a huge impact on both caregivers and children's productivity.[59]

Strengths and Limitations

Strengths of our study include a comprehensive search that comprises both service utilization and costs associated with ADHD and the first meta-analysis on healthcare costs of ADHD. Most included studies (Tables 1[31-43] and 2[14,44-46,50-61]) have large sample sizes, enhancing the overall strength of the review. As a limitation, we did not include "productivity," "labor," and "unmet needs" as search terms. The limited studies reporting the unmet needs of ADHD services highlights the gap in the current literature in this area.

We also limited the search to capture the contemporary literature in service use and costs over the past 15 years because of the rapid changes of healthcare system policy and ADHD diagnosis and treatment across countries. Therefore, the excluded (earlier) literature may have included different results, which would have changed our conclusions. We focused on English publications, because of limitations in translation; thus, non-English publications were excluded. We found very limited literature from low- and middle-income countries (ie, only 1 study from Taiwan), and outpatient costs reported in most studies did not consider out-of-pocket (OOP) expenses incurred by patients. Moreover, we were only able to conduct a meta-analysis on direct medical costs, which is a small proportion of the overall cost burden, because of the vast differences in cost reporting methods of other cost categories. Additionally, the high heterogeneity in direct medical costs among studies limits the interpretability of our findings. Subgroup analysis by child age could not be conducted in meta-analysis because there were only 6 studies among which no significant variation in the age groups was reported. The age groups across the 4 studies included in the meta-analysis ranged from 0 to 17 years old (1 included 3 to 17 years group), whereas only 1 study reported findings from 4 to 9 years old.

Implications and Future Research Directions

Sciberras et al[47] suggested that higher Medicare (Australia's universal health insurance) service use can be associated with higher OOP costs to families who receive these services. The lack of evidence on OOP costs is also evidenced in the previous systematic review on the costs of ADHD on both children and adults.[11] Therefore, the reported outpatient costs are only a fraction of the expected total costs because of ADHD. The costs of ADHD could be underestimated to the extent that OOP costs are an additional burden on families. Future research would need to collect OOP costs associated with ADHD service use and to include these costs in estimating the overall costs associated with ADHD.

Our review also highlights a gap in the literature on the costs of educational services for children with ADHD. Given that the impact of ADHD on academic achievement has been well documented, accessing and utilizing special education services would help improve children's academic performance. Future research would be needed to estimate the costs of education services so that efficient and effective population health resources can be planned to support these children. Moreover, the limited evidence on productivity losses and the significant impact of ADHD on productivity highlights the need for more research in this area. Interventions to mitigate the impact of ADHD on productivity losses should be implemented.

High unmet needs in medical services for children with ADHD found in this review highlights the need for stronger support for these children. Specifically, strategies to address the barriers to both service access and service provision should be planned and implemented. Addressing the need for service access and service provision would contribute to improve the functionality affected by the child's ADHD and their overall quality of life, reduce productivity losses, and minimize the substantial economic burden associated with ADHD.

Conclusion

This study found that ADHD in children/adolescents results in increased service use and substantial direct and indirect costs, although evidence of indirect and OOP costs was very limited. Despite the high service utilization among children with ADHD, we found unmet needs for health and education services for these children. Strategies to bridge the gap in service access and service provision for children with ADHD are needed to address the unmet needs for services and to alleviate the productivity losses from children and their families. Future research should focus on a systematic approach to collecting OOP costs and productivity costs to obtain a comprehensive picture of the cost of ADHD in children/adolescents.

Author Disclosures

The authors reported no conflicts of interest.

Supplemental Material

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