REVIEW

Economic Impact of Childhood and Adult Attention-Deficit/Hyperactivity Disorder in the United States

Jalpa A. Doshi, Ph.D., Paul Hodgkins, Ph.D., Jennifer Kahle, Ph.D., Vanja Sikirica, Pharm.D., Michael J. Cangelosi, M.P.H., Juliana Setyawan, Pharm.D., M. Haim Erder, Ph.D., Peter J. Neumann, Sc.D.

Objective: Attention-deficit/hyperactivity disorder (ADHD) is one of the most prevalent mental disorders in children in the United States and often persists into adulthood with associated symptomatology and impairments. This article comprehensively reviews studies reporting ADHD-related incremental (excess) costs for children/adolescents and adults and presents estimates of annual national incremental costs of ADHD. **Method:** A systematic search for primary United States-based studies published from January 1, 1990 through June 30, 2011 on costs of children/adolescents and adults with ADHD and their family members was conducted. Only studies in which mean annual incremental costs per individual with ADHD above non-ADHD controls were reported or could be derived were included. Per-person incremental costs were adjusted to 2010 U.S. dollars and converted to annual national incremental costs of ADHD based on 2010 U.S. Census population estimates, ADHD prevalence rates, number of household members, and employment rates by age group. **Results:** Nineteen studies met the inclusion criteria. Overall national annual incremental costs of ADHD ranged from $143 to $266 billion (B). Most of these costs were incurred by adults ($105B–$194B) compared with children/adolescents ($38B–$72B). For adults, the largest cost category was productivity and income losses ($87B–$138B). For children, the largest cost categories were health care ($21B–$44B) and education ($15B–$25B). Spillover costs borne by the family members of individuals with ADHD were also substantial ($33B–$43B). **Conclusion:** Despite a wide range in the magnitude of the cost estimates, this study indicates that ADHD has a substantial economic impact in the United States. Implications of these findings and future directions for research are discussed. J. Am. Acad. Child Adolesc. Psychiatry, 2012;51(10):990–1002. **Key Words:** ADHD, cost of illness, societal costs, children, adults

Attention-deficit/hyperactivity disorder (ADHD) is defined by the *DSM-IV-TR* as a persistent set of inattentive, hyperactive, and impulsive symptoms that impairs function in at least two settings (e.g., home, work, and/or school).[1] It has been reported to be one of the most prevalent mental disorders in children in the United States,[2] with a current prevalence rate of 5.5% to 9.3%[3] in children and adolescents 4 to 17 years old. Children and adolescents with this disorder experience educational difficulties,[4] problems with self-esteem,[5] significantly impaired family and peer relationships,[6] and an overall decrease in quality of life.[7]

Although traditionally thought of as a condition of childhood, ADHD often persists into adulthood with associated symptomatology and impairments. Prevalence rates in U.S. adults 18 to 44 years old are reported to be 4.4%[8] and highlight the chronicity of this disorder. ADHD-related impairments may underlie subsequent problems in adulthood such as occupational dif-

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Supplemental material cited in this article is available online.

ficulties, criminal activity, substance abuse problems, and traffic accidents and citations.[9] Moreover, the difficulties faced by children and adults with ADHD may have spillover effects and can negatively affect the health and work productivity of family members.[10]

Although hundreds of studies have reported on the negative outcomes of ADHD in childhood and adulthood in areas such as health, education, occupation, and antisocial behavior, few have monetized these outcomes to provide an estimate of the economic impact of ADHD in the different sectors of society. For instance, the two most recent systematic reviews of the economic costs of ADHD found only 12 to 13 original research studies addressing this topic[11,12] compared with 351 original research studies found in a recent review of long-term outcomes of ADHD.[9] A comprehensive understanding of the incremental costs of ADHD (i.e., excess costs over and above those of individuals without ADHD) from a societal perspective is important to inform, plan, and justify policies and interventions to help alleviate the numerous negative consequences associated with this disorder. In addition to being dated, prior systematic reviews of the economic impact of ADHD have been limited in scope, examining a restricted population or a few sectors of the economy.[11-13] Pelham et al.[12] (2007) only reviewed costs in children and adolescents with ADHD. Leibson and Long[13] (2003) considered only health care costs. Matza et al.[11] (2005) examined children and adults and additional cost sectors besides health care, but studies of education costs were not available. Furthermore, results reported across the reviewed studies were not consolidated to present an overall estimate of incremental costs of individuals with ADHD at the national level.

The present study uses a societal perspective, comprehensively reviews studies reporting ADHD-related incremental costs for children/adolescents and adults, and computes estimates of overall annual national incremental costs of ADHD in the United States. Estimates are also stratified by age group, cost sectors, and patient versus family member.

METHOD

A systematic review was conducted using guidelines from the Cochrane Handbook for Systematic Reviews of Interventions.[14] Four large databases (MEDLINE, EMBASE, ERIC, and PsycINFO) were searched for articles published from January 1, 1990 through June 30, 2011 using the following abstracted search strategy: (*terms describing ADHD*) AND ((*terms describing cost analysis or economic impact*) OR (*terms describing areas of cost due to ADHD*)). An extensive list of terms describing cost areas of interest was used to identify studies on health care resource use, productivity losses, accidents, education, substance abuse, and criminal behavior (Table S1, available online). Studies were also identified by examining the reference lists of prior publications and by follow-up directly with the study authors. This identification method deviated from strict Cochrane guidelines but was in line with international systematic review guidelines.[15]

A primary screen retained all articles published in English and classified as original research studies of human participants conducted in the United States that included a study group of participants with ADHD and monetized ADHD-related outcomes. In a final screen, the full text of the articles were reviewed to exclude studies in which mean annual incremental costs of individuals with ADHD compared with a control group of patients without ADHD were not reported (or could not be derived).[16-18] Studies using specific disease groups (e.g., asthma or depression) as the only control group were excluded.[19,20] Studies not reporting mean costs (e.g., only median costs reported[21]) and studies from which it was not possible to separately estimate contributions from different cost categories (e.g., combined costs of health care and productivity losses[22]) were also excluded.

Study characteristics and cost measurements were extracted and tabulated for the included studies. For one study,[23] numeric data underlying the published graphs were obtained from the study author. A few calculations and adjustments were made on the data reported in the studies. Per-person annual costs were computed by dividing the aggregate annual national costs by the estimated size of the population in one study.[24] Weighted average estimates for the overall population were calculated for two studies that reported only cost estimates stratified by patient gender.[10,25] Costs were annualized for three studies estimating costs over 1 month or multiple years.[23,26,27] All cost estimates across the included studies were inflated to 2010 U.S. dollars using the consumer price index from the U.S. Bureau of Labor Statistics.[28] The medical care component of the consumer price index was used to inflate reported health care cost estimates.

For the national incremental cost calculations, the studies were compiled by age group (children/adolescents versus adults) and cost category (health care, productivity and income losses, education, and justice system). The health care and productivity cost categories were separated into subcategories of costs incurred by patients with ADHD versus those by family members of patients with ADHD. Except for the minimal requirements that each study had to meet for inclusion

in the review as outlined earlier in the selection criteria, this review did not identify and adjust for differential quality of studies. The number of studies in each age group and cost category combination was too small, often only a single study, to permit such an approach. Instead, for each age group and cost category, the lowest and highest reported incremental cost estimates across all included studies were identified. For the cost categories with a sufficient number of studies, namely those examining costs related to health care in children/adolescents (n = 9) and adults (n = 6) with ADHD and productivity losses in adults with ADHD (n = 7), reported adjusted estimates were used to identify the range of incremental cost estimates. For all remaining cost categories, the number of relevant studies was three or fewer and, hence, estimates adjusted by regression or matched controls or unadjusted estimates were used to identify the range. The range of per-person incremental cost estimates within each age group and cost category were then converted to a range of annual national incremental costs of ADHD using 2010 U.S. Census population estimates, ADHD prevalence rates, number of household members, and employment rates by age group as described below.[29,30]

First, the national counts of individuals with ADHD within each age group and cost category in the United States were estimated as the product of the nationwide U.S. population count reported by the 2010 U.S. Census[31] corresponding to the age range of the patients with ADHD across the studies specifically examining that age group (i.e., children/adolescents or adults) and cost category and the ADHD prevalence rate corresponding most closely to this age range. For children/adolescents, prevalence rates of current ADHD diagnosis reported by the Centers for Disease Control and Prevention were used.[3] For adults, a published and commonly cited rate of 4.4% in 18 to 44 year olds[8] was applied given that the Centers for Disease Control and Prevention has not reported ADHD prevalence rates in adults. For the category of productivity (i.e., absenteeism and low productivity while at work, referred to as "presenteeism" in some studies) costs in adult patients with ADHD, which is applicable only to employed patients, an employment rate of 67.6% was applied, assuming employment rates similar to those in the general 18- to 64-year-old population reported by the 2010 U.S. Bureau of Labor Statistics.[32]

Second, the national counts of family members of individuals with ADHD who would be affected under each of the subcategories of health care and productivity costs in family members of patients with ADHD was estimated. For the subcategory of health care costs among family members of the patients with ADHD, the national count of patients with ADHD was multiplied by 2.92 to compute the total number of family members (adults and children) affected by ADHD. This figure obtained from the 2010 U.S. Census[33] represents the average size of the U.S. household less one (representing the one patient with ADHD in the household.) For the subcategory of productivity costs among adult family members of children/adolescents with ADHD, the national count of patients with ADHD was multiplied by 2.0, which represents the average number of adult household members in the United States in 2010. Similarly, for the subcategory of productivity costs among adult family members of adults with ADHD, the national count of patients with ADHD was multiplied by 1.0. For the two categories related to productivity costs, the same employment rate of 67.6% was applied.[32]

Third, the range of national incremental costs of ADHD was estimated by multiplying the lowest and highest reported per-person incremental cost estimates for each age group and cost category by the corresponding national counts of individuals. Overall national incremental costs of ADHD in 2010 were computed by summing the costs across age groups and categories. The estimates were also stratified by age group, cost sectors, and patient versus family member.

RESULTS

The initial literature search identified 4,580 citations. After the screening process, only 19 studies met all inclusion criteria (Figure S1, available online). Table 1[10,23-27,34-45] lists the key characteristics of these 19 studies. Eleven studies examined costs incurred by children with ADHD or their family members and 10 studies examined costs incurred by adults with ADHD or their family members (two studies examined children/adolescents and adults). Most studies evaluated health care costs (n = 13). Nine studies examined costs related to income and productivity losses. Only three studies examined education costs and two studies examined justice system costs. None of the studies meeting the inclusion criteria evaluated costs related to traffic accidents or substance abuse problems.

Table 2[3,8,10,23-26,31,33-37,41-46] presents the analysis resulting in the range of national incremental costs of ADHD under each combination of cost category and age group of interest. The range of ages considered across all studies was 0 to 64 years old, including individuals with ADHD and their family members. In the health care cost category, wide ranges of per-person incremental cost estimates were reported across the studies evaluating children/adolescents ($621 to $2,720) and adults ($137 to $4,100) with ADHD. This variability was a function of the characteristics

TABLE 1 Key Characteristics of Studies Meeting Inclusion Criteria

Study	Design, Setting, and Sample Size	Year of Data Collection	Identification of ADHD Patients	Age Group (and Age Range Considered) of Patients with ADHD	Cost Categories Evaluated	Regression Adjustment or Matched Controls
Guevara et al., 2001[37]	retrospective analysis of Group Health Cooperative of Puget Sound HMO data (n = 14,960)	1997	*ICD-9* 314.xx or ≥1 prescription for a stimulant	children/adolescents (3–17 yo)	health care (patient)	regression and matched controls
Chan et al., 2002[38]	cross-sectional analysis of Medical Expenditure Panel Survey (n = 5,439)	1996	*ICD-9-CM* 314.xx or ≥2 prescriptions for neurostimulant	children/adolescents (5–20 yo)	health care (patient)	regression
Burd et al., 2003[39]	retrospective analysis of North Dakota Department of Health claims (n = 129,138)	1996–1997	*ICD-9* diagnosis of 314.00, 314.01, 314.8, 314.9	children/adolescents (0–21 yo)	health care (patient)	none
Mandell et al., 2003[27]	retrospective analysis of pediatric Medicaid patients in Philadelphia, PA (n = 76,662)	1993–1996	≥2 claims associated with *ICD-9* 314.xx or parental report of symptoms at diagnostic interview	children/adolescents (3–15 yo)	health care (patient)	regression
Swensen et al., 2003[25]	retrospective analysis of a random sample of health plan enrollees of a large Fortune 100 company (n = 2,172)	1998	*ICD-9* 314.0x with ≥1 ADHD medical or disability claim	children/adolescents (0–18 yo)	health care (patient), health care (family), productivity (family)	matched controls
Swensen et al., 2004[40]	retrospective analysis of a random sample of health plan enrollees of a large Fortune 100 company (n = 2,616)	1998	*ICD-9* 314.0x with ≥1 ADHD medical or disability claim	children/adolescents (0–18 yo) and adults (18–64 yo)	health care (patient), productivity (patient)	matched controls
Birnbaum et al., 2005[10]	retrospective analysis of health plan enrollees in 1 large company and associated disability data (n = 9,822)	1998	*ICD-9-CM* 314.0x with ≥1 ADHD medical claim	children/adolescents (7–18 yo) and adults (19–44 yo)	health care (patient), health care (family), productivity (patient), productivity (family)	matched controls

TABLE 1 Continued

Study	Design, Setting, and Sample Size	Year of Data Collection	Identification of ADHD Patients	Age Group (and Age Range Considered) of Patients with ADHD	Cost Categories Evaluated	Regression Adjustment or Matched Controls
Kessler et al., 2005[41]	retrospective analysis of 2 large health care claims and employer-reported productivity databases (n = 2,399)	2001–2003	*ICD-9-CM* 314.0, 314.00, or 314.01 with ≥1 evaluation or claim for ADHD diagnosis	adults (18–44 yo)	productivity (patient)	regression
Secnik et al., 2005[42]	retrospective analysis of claims from six Fortune 200 employers (n = 4,504)	1999–2001	*ICD-9* 314.00 or 314.01	adults (18–64 yo)	health care (patient) productivity (patient)	regression and matched controls
Biederman and Faraone, 2006[34]	cross-sectional analysis using nationwide, random, telephone-administered survey (n = 1,001)	2003	self-report of prior adult diagnosis	adults (18–64 yo)	income losses due to unemployment and wage differences (patient)	regression
Fischer and Barkley, 2006[26]	patients receiving psychology service within Milwaukee Children's Hospital (n = 223)	1992–1996	*DSM-III-R*	adults (19–25 yo)	income losses due to wage differences (patient)	regression
Ray et al., 2006[43]	Kaiser Permanente (Northern CA) HMO (n = 11,356)	1996–2004	*DSM-IV, ICD-9-CM* 314.0	children/adolescents (2–10 yo)	health care (patient)	regression and matched controls
Fishman et al., 2007[44]	group health coop and group health options members in WA and ID (n = 249,874)	2001	*ICD-9-CM* 314.xx and ≥1 AD[H]D inpatient or outpatient encounter	adults (≥18 yo)	health care (patient)	regression
Fletcher and Wolfe, 2009[24]	nationally representative sample during school years 1994–1995, 1995–1996, and 2001–2002 (n = 13,572)	1994–2002	*DSM-IV* (inattentive, hyperactive, and combined subtypes included)	adults (18–28 yo)	justice system (patient)	regression

TABLE 1 Continued

Study	Design, Setting, and Sample Size	Year of Data Collection	Identification of ADHD Patients	Age Group (and Age Range Considered) of Patients with ADHD	Cost Categories Evaluated	Regression Adjustment or Matched Controls
Jones and Foster, 2009[23]	longitudinal analysis of a cohort of kindergartners from Durham, NC; Nashville, TN; Seattle, WA; and central PA (n = 650)	1997–2004	parental self-report of child's symptoms on the Diagnostic Interview Schedule for Children (identified hyperactivity/impulsivity or inattention)	children/adolescents (12–17 yo)	health care (patient), education (patient), justice system (patient)	regression
Kessler et al., 2009[41]	large U.S. manufacturing firm (n = 8,563)	2005–2006	*DSM-IV* criteria for adult ADHD	adults (40–51 yo IQR)	health care (patient), productivity (patient)	regression
Marks et al., 2009[35]	68 preschools within greater New York City area (n = 206)	2004–2005	*DSM-IV* criteria for pediatric ADHD	children/adolescents (3–4 yo)	education (patient)	regression
Hodgkins et al., 2011[45]	2 large health care claims and productivity databases, 100 large employers throughout US (n = 127,008)	2006	*ICD-9* 314.0, 314.00, or 314.01 with ≥1 evaluation or claim of ADHD diagnosis with continued treatment	adults (18–64 yo)	health care (patient), productivity (patient)	regression and matched controls
Robb et al., 2011[36]	Western Psychiatric Institute and Clinic, Pittsburgh, PA (n = 604)	1999–2008	*DSM-III-R* or *DSM-IV*, childhood diagnosis	children/adolescents (5–18 yo)	education (patient)	none

Note: ADHD = attention deficit/hyperactivity disorder; CA = California; DSM-III-R = Diagnostic and Statistical Manual of Mental Disorders—3rd Edition (Revised); DSM-IV = Diagnostic and Statistical Manual of Mental Disorders—4th Edition; HMO = health maintenance organization; ICD-9 = International Classification of Diseases, Ninth Edition; ICD-9-CM = International Classification of Diseases, Ninth Edition, Clinical Modification; IQR = interquartile range; ID = Idaho; NC = North Carolina; PA = Pennsylvania; TN = Tennessee; US = United States; WA = Washington; yo = years old.

TABLE 2 National Incremental Costs of Attention-Deficit/Hyperactivity Disorder (ADHD) by Cost Category and Age Group

Cost Category	Age Group of Patients with ADHD	Number of Studies	Age Range across Studies	Population corresponding to Age Range[31,33]	ADHD Prevalence for Age Range	Other Multipliers[a]	Population Incurring Cost	Per-Person Incremental Cost, 2010 U.S. Dollars	National Incremental Cost, 2010 U.S. Dollars (Billions)
Health care									
Health care (patient)	children and adolescents	9	0–21	92,140,979	7.2%[3]	—	6,634,150	$621[37]–$2,720[23]	$4.12–$18.04
Health care (patient)	adults	6	18–64	194,296,087	4.4%[8]	—	8,549,028	$137[(NS)46]–$4,100[42]	$1.17–$35.05
Health care (family)	children and adolescents	2	0–18	74,181,467	7.2%[3]	2.92	15,595,912	$1,088[10]–$1,658[25]	$16.97–$25.86
Health care (family)	adults	1	19–44	108,305,787	4.4%[8]	2.92	13,915,128	$1,051[10]	$14.62
								subtotal	$37B–94B
Productivity and income losses									
Income losses (lower wages)	adults	1	19–25	30,433,583	4.4%[8]	—	1,339,078	$(3,744)[26]	$(5.01)
Income losses (unemployment and lower wages)	adults	1	18–64	194,296,087	4.4%[8]	—	8,549,028	$10,532[34]–$12,189[34]	$90.04–$104.20
Productivity losses (patient)	adults	6	18–64	194,296,087	4.4%[8]	67.6%	5,779,143	$209[45]–$6,699[41]	$1.21–$38.71
Productivity losses (family)	children and adolescents	2	0–18	74,181,467	7.2%[3]	2.0, 67.6%	7,221,121	$142[10]–$339[25]	$1.03–$2.45
Productivity losses (family)	adults	1	19–44	108,305,787	4.4%[8]	1.0, 67.6%	3,221,447	$174[10]	$0.56
								subtotal	$88B–$141B
Education	children	1	3–4	8,182,210	5.5%[3]	—	450,022	$12,447[35]	$5.60
	children and adolescents	2	5–18	58,480,960	7.2%[3]	—	4,210,629	$2,222[23]–$4,690[36]	$9.36–$19.75
								subtotal	$15B–$25B
Justice system	adolescents	1	13–17	21,238,249	9.3%[3]	—	1,975,157	$267[(NS)23]	$0.53
	adults	1	18–28	47,550,861	4.4%[8]	—	2,092,238	$1,204[24]–$2,742[24]	$2.52–$5.74
								subtotal	$3B–$6B
								total	$143B–$266B

Note: B = billions; NS = difference was not statistically significant in the original study.
[a]Figures used in "Other Multipliers" are described in the Method section.

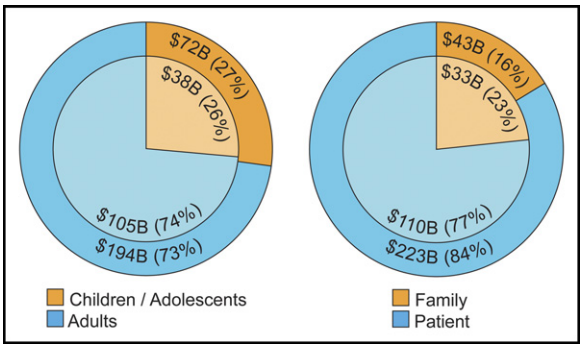
of the studies including setting, design, and cost components included. Conversely, for health care costs incurred by family members of patients with ADHD, there was little variability in these estimates, given that there were only one or two relevant studies. The estimates across the 13 studies evaluating health care costs translate into annual national incremental costs ranging from approximately $37 billion (B) to $94B among individuals with ADHD and their families.

For costs due to income losses, two studies examined costs to patients with ADHD owing to lower wages and/or unemployment. One study found that young adults (19-25 years) with current or childhood ADHD had a significantly higher incremental mean annual salary ($3,744) than non-ADHD controls, likely because a significantly smaller proportion was enrolled in college and thus more likely employed.[26] The second study reported that the annual household income was lower by $10,532 to $12,189 per adult with ADHD when examined across the entire typical working age range of 18 to 64 years.[34]

Productivity losses for adults with ADHD owing to absenteeism, poor performance while at work, disability payments, and/or worker's compensation ranged from $209 to $6,699 annually per 18- to 64-year-old employee across six studies. Although the cost components included across these studies varied, poor performance while at work was clearly the major driver of costs to employers. Per-person incremental cost estimates were smaller in magnitude for productivity losses for family members of children/adolescents ($142 to $339) and adults ($174) with ADHD across the one or two relevant studies. The estimates across the nine studies on income and productivity losses translated to annual national incremental costs ranging from approximately $88B to $141B.

For the category of education costs, one study reported the annual ADHD-related incremental costs of education in 3 to 4 year olds at $12,447 per student and included costs related to special education, occupational, speech, and physical therapy.[35] The annual incremental costs in 5 to 18 year olds ranged from $2,222 to $4,690 per student across two studies; the former estimate included costs related to special education, grade retention, and school counseling,[23] whereas the latter included costs related to special education, grade retention, and disciplinary incidents.[36] The estimates across the three studies on education costs translated to annual national incremental costs ranging from approximately $15B to $25B in 3 to 18 year olds.

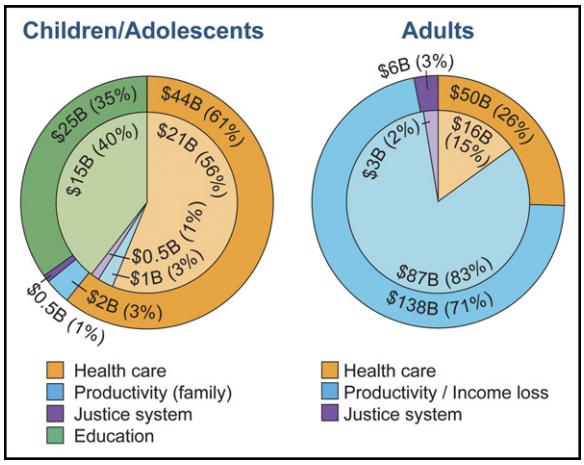
FIGURE 1 Annual national incremental costs of attention-deficit/hyperactivity disorder (ADHD) (in billions) by population groups. Note: The inner circle represents the lower end of the range of costs ($143B). The outer circle represents the higher end of the range of costs ($266B).



For justice system costs, two studies reported costs related to criminal offenses by individuals with ADHD. The per-person annual incremental costs of detention center and arrest expenditures derived from one study of 13- to 17-year-old adolescents with ADHD was $267.[23] Another study of 18- to 28-year-old young adults reported annual incremental costs ranging from $1,204 to $2,742 to the victim and society owing to burglary, robbery, larceny, arrests/convictions, and selling of drugs.[24] The estimates across these two studies translated to annual national incremental costs ranging from approximately $3B to $6B in 13 to 28 year olds.

Summing the estimates across the various cost categories resulted in overall national incremental costs of ADHD ranging from $143B to $266B in 2010. Figure 1 (left) highlights that $105B to $194B (73%−74%) of these overall costs were attributable to adults with ADHD or to adult family members of patients with ADHD. Spillover costs borne by the family of children and adults with ADHD ranged from $33B to $43B (16%−23%; Figure 1 [right]). For adults with ADHD, the largest cost component was productivity and income losses ($87B−$138B, 71%−83%; Figure 2 [left]). For children with ADHD, the largest cost components were health care ($21B−$44B, 56%−61%) and the educational sector ($15B−$25B, 35%−40%; Figure 2 [right]).

FIGURE 2 Annual national incremental costs of attention-deficit/hyperactivity disorder (ADHD) (in billions) by cost sectors within age groups. Note: The inner circle represents the lower end of the range of costs. The outer circle represents the higher end of the range of costs.



DISCUSSION

This review included 19 studies examining the incremental costs of ADHD in the United States. Recognizing the variance introduced by heterogeneous methodologies across these studies, the range of costs rather than point estimates was calculated. Despite a wide range in the annual national incremental costs computed in the present analysis (overall $143B−$266B), the lower end estimate alone indicates that ADHD has a substantial economic impact in the United States. Although large in magnitude, these results may be an underestimate of the true societal costs of ADHD in the nation for several reasons. First, there were no studies identified in the literature reporting analyzable cost information within the cost categories of substance abuse and traffic accidents, and patients with ADHD have been shown to have a higher risk of these problems.[47-51] Second, within the remaining cost categories, some included studies did not capture all relevant cost components within that sector wherein individuals with ADHD or their families may have incurred higher costs. Third, within cost categories of the justice system, education, and health care and productivity losses of family members of adult patients with ADHD, only studies for a restricted age group were found and thus the national incremental cost estimates do not include costs incurred by individuals with ADHD beyond that limited age range. Fourth, within the cost category of education, the period, study samples, and cost components in the included studies may have underrepresented the increased use of special educational services by children with ADHD under the Individuals with Disabilities with Education Act and Section 504 of the Rehabilitation Act.

Although these limitations point to an underestimation of the cost figures, a few caveats that may influence the present computed estimates in either direction also deserve mention. First, because studies varied in whether and how they controlled for comorbidities commonly associated with ADHD (i.e., anxiety, depression, mania, and oppositional-defiant disorder[52]), estimates of the cost of "pure" ADHD in the absence of comorbidities were not derivable for every study and thus the costs of ADHD alone may have been overestimated. Nevertheless, the early age of onset of ADHD makes the majority of these comorbidities secondary in terms of temporality. To the extent that ADHD affects the risk, persistence, or severity of these comorbidities, the costs associated with these comorbidities may be considered long-term indirect effects associated with ADHD and thus appropriately considered costs of patients with ADHD.[53,46] Thus, use of adjusted estimates, where available, from studies that controlled for such comorbidities may have indeed resulted in an underestimate of the true costs associated with ADHD. Second, most of the included studies did not provide sufficient information on the prevalence and length of treatment for ADHD in their study subjects. The economic burden of ADHD may be higher or lower based on treatment status. Third, the present results reflect clinical practice in the settings and time observed within the included studies. For example, several studies predated the emergence of newer ADHD treatments or increased off-label usage, which may have resulted in the true costs associated with ADHD being overestimated (if such new treatments and/or usage save costs) or underestimated (if such new treatments and/or usage do not offset all their additional costs). Furthermore, the prevalence of ADHD has been reported to be increasing over time.[3] It is unclear whether this is because the incidence of ADHD itself has increased or if the recognition and diagnosis of ADHD has increased over time in the U.S. population.[3] If the former, then the total incremental costs associated with ADHD in the United States

may have also increased over time (because the population with ADHD times the mean incremental costs equals the total incremental costs). If the latter, then the incremental costs of ADHD may be lower than estimated to the extent that previously undiagnosed patients had less severe ADHD (and, hence, went unrecognized) or higher than estimated if these patients indeed had more severe ADHD (because their ADHD was not recognized and treated early on). Fourth, the prevalence of ADHD has been reported to vary considerably across the United States. The present study estimated the average economic impact of ADHD at the national level; however, the costs in individual states (and counties) may be higher or lower.

Nevertheless, the present results underscore that the economic cost of ADHD is substantial. The magnitude of this burden can be put into perspective by comparing it with the burden imposed by other chronic conditions, although such comparisons should be made with caution because methodologies differ across studies and other studies do not always include all costs outside the health sector. Greenberg et al.[54] estimated that major depression costs $83.1B annually (~$124B in 2010 U.S. dollars). Wittchen[55] estimated that generalized anxiety disorder costs range from $42B to $47B (~$139B−$155.5B in 2010 U.S. dollars). Weiss and Sullivan[56] estimated the total societal cost of asthma as $12.7B (~$20.4B in 2010 U.S. dollars).

Several noteworthy findings of this study have important clinical and policy implications. Unlike many other conditions, health care costs constitute only one fourth to one third of the overall incremental costs associated with ADHD. The remainder of the costs occurred in non-health care sectors. Thus, the decreases in the cost burden of ADHD owing to additional investments in improving the diagnosis and management of this condition are not all accrued by the third-party payer or health insurer, thus decreasing their incentive to bear the entire cost of such investments. Given the substantial societal costs of ADHD incurred in the workforce, education, and justice system sectors, it is necessary to develop public policies to lessen the burden associated with this condition.

The present results are also the first to highlight the magnitude of the large share of costs associated with ADHD as it progresses into adulthood. Notably, the national incremental costs for adults were almost three times higher than those for children and adolescents. This is due to a combination of a larger absolute number of adults than children and adolescents and the differences in cost sectors wherein the costs are incurred by these groups. The latter point suggests that a "one size fits all" approach to decreasing the burden of ADHD is unlikely to be successful and one should consider the age group and cost sector and target policies or initiatives accordingly.

Workforce productivity costs in adults with ADHD are the single largest contributor to the economic burden associated with the condition, amounting to $87B to $138B and accounting for more than 70% to 80% of the overall adult ADHD costs. The vast majority of these costs were attributable to income losses owing to lack of full time employment and/or lower wages when employed, as estimated by Biederman and Faraone.[34] The same study also reported that individuals with ADHD were significantly more likely to report poorer grades in high school, less likely to graduate from high school or college, or less likely to have completed a postgraduate degree compared with control subjects.[34] This implies that the lack of an early or accurate diagnosis of ADHD or medical treatment and educational interventions during childhood or adolescence extracts a substantial economic burden in adulthood. Appropriate policies or interventions need to be targeted in childhood/adolescence to increase the potential for improving educational milestones and decreasing workforce productivity losses in adulthood.

The remainder of the workforce productivity costs were largely incurred owing to decreased productivity at work in employed adults with ADHD compared with healthy controls without ADHD. Despite the substantial toll of ADHD on the workplace, some private insurers do not cover any costs for ADHD treatments for adult patients.[57] Such policies create barriers to care and may decrease workplace productivity. Ideally, policies should be created that incentivize third-party payers to consider all types of economic costs of adult ADHD when evaluating the cost-effectiveness of coverage and treatments. Self-insured employers in particular should consider these various economic effects, because increases in health care costs that effectively diagnose and treat ADHD may decrease losses in worker productivity. Because most economic costs are incurred by adults with ADHD within the workplace, efforts to decrease the overall economic burden of ADHD should focus within this area. Opportunities to create partnerships between payers, employers, and patients would be an

effective first step and would better align all parties toward the goal of reducing ADHD burden.

The study is also the first to highlight that family spillover costs are a substantial proportion of total ADHD costs (16%–23%). The vast majority of these costs (~95%) are incurred within the health care system and point to the larger potential benefits of improved diagnosis and management of ADHD. Swensen et al.[25] suggested these family members use more office services, outpatient services, and mental-disorder-specific care. Further, the symptomatology associated with improperly treated ADHD can carry an emotional burden to the patient[7,58] and the patient's family[59] beyond the economic burden described here.

Educational costs amounting to $15B to $25B were a large contributor of incremental costs in children/adolescence after health care-related costs. Although these amounts are likely underestimates for the reasons noted earlier, the vast majority of the incremental costs of education identified in the included studies were still due to special education. Thus, research is clearly needed to examine whether early diagnosis and evidence-based medication and behavioral treatments in childhood decrease the future need for special education services and downstream costs. Moreover, research to identify appropriate interventions within the educational settings could provide an evidence base to better understand whether such programs save or increase costs in children and adolescents with ADHD, and if such programs do increase costs, whether the benefits to education produce downstream savings through adult ADHD worker productivity and/or salary gains. Research to provide educators and parents the information to better identify early signs of ADHD would be helpful to limiting the impact of the illness in early life and possible future life trajectory.

Future research should also focus on better understanding the ADHD costs and the costs and benefits of interventions in targeted age groups and cost sectors. Specifically, research is needed to better understand the economic impact of ADHD in unstudied or understudied areas such as substance abuse, traffic accidents, and justice system use. In addition, studies using more recent data are needed to capture costs in light of the increasing prevalence and/or diagnosis of ADHD over time[3] and current ADHD treatment patterns including the increasing use of newer ADHD medications, adjunctive therapy, and off-label prescribing. Further research is also needed to understand how the early diagnosis and treatment of ADHD can ameliorate these costs and inform future policies and interventions.

In conclusion, this comprehensive review points to the large economic burden of ADHD in the United States and to the multifaceted nature of ADHD costs. Given the substantial societal costs of ADHD, public policy to address the burden of the condition is warranted. Moreover, further research to better understand ADHD costs and the costs and benefits of interventions is warranted. Programs to facilitate collaboration among payers, patients, employers, and educational institutions may provide opportunities to create strategies to consider the societal impact of ADHD and strategies to mitigate its burden. &

CG Clinical Guidance

- Overall, the national annual incremental costs of ADHD were substantial, ranging from $143B to $266B. Patients with ADHD and families of patients with ADHD incurred costs associated with ADHD.
- The present results highlight the societal costs of ADHD as it progresses into adulthood. Most of these costs were incurred by adults ($105B–$194B) compared with children/adolescents ($38B–$72B).
- The societal costs of ADHD were multifaceted, including four major cost categories: health care, education, productivity, and justice system costs. For adults, the largest cost category was productivity and income losses ($87B–$138B). For children, the largest cost categories were health care ($21B–$44B) and education ($15B–$25B).
- Given the substantial and multifaceted societal costs of ADHD, the development of public policies to address the burden of the condition is warranted.

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Dr. Doshi is with the Perelman School of Medicine, University of Pennsylvania. Drs. Hodgkins, Sikirica, Erder, and Setyawan are with Global Health Economics and Outcomes Research, Shire Development LLC. Dr. Kahle is with BPS International. Dr. Neumann and Mr. Cangelosi are with the Center for the Evaluation of Value and Risk in Health, Tufts Medical Center.

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Correspondence to Jalpa A. Doshi, Ph.D., University of Pennsylvania, Blockley Hall, Room 1222, 423 Guardian Drive, Philadelphia, PA 19104-6021; e-mail: jdoshi@mail.med.upenn.edu

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REFERENCES

1. American Psychiatric Association. Diagnostic and Statistical Manual of Mental Disorders. 4th ed; text revision ed. Washington, DC: American Psychiatric Association; 2000.
2. O'Connell ME, Boat T, Warner KE. National Research Council (US) and Institute of Medicine (US) Committee on the Prevention of Mental Disorders and Substance Abuse Among Children, Youth and Young Adults. Preventing Mental, Emotional, and Behavioral Disorders Among Young People: Progress and Possibilities. Washington, DC: National Academy of Sciences; 2009.
3. US Centers for Disease Control. Increasing prevalence of parent-reported attention-deficit/hyperactivity disorder among children—United States, 2003 and 2007. MMWR Morb Mortal Wkly Rep. 2010;59:1439-1443.
4. Loe M, Feldman HM. Academic and educational outcomes of children with ADHD. Ambul Pediatr. 2007;7:82-90.
5. Biederman J, Faraone SV, Spencer TJ, Mick E, Monuteaux MC, Aleardi M. Functional impairments in adults with self-reports of diagnosed ADHD: a controlled study of 1001 adults in the community. J Clin Psychiatry. 2006;67:524-540.
6. Hoza B. Peer functioning in children with ADHD. Ambul Pediatr. 2007;7:101-106.
7. Coghill D. The impact of medications on quality of life in attention-deficit hyperactivity disorder: a systematic review. CNS Drugs. 2010;24:843-866.
8. Kessler RC, Adler L, Barkley R, *et al.* The prevalence and correlates of adult ADHD in the United States: results from the National Comorbidity Survey Replication. Am J Psychiatry. 2006; 163:716-723.
9. Hodgkins P, Arnold LE, Shaw M, *et al.* A systematic review of global publication trends regarding long-term outcomes of ADHD. Front Psychiatry. 2011;2:84.
10. Birnbaum HG, Kessler RC, Lowe SW, *et al.* Costs of attention deficit-hyperactivity disorder (ADHD) in the US: excess costs of persons with ADHD and their family members in 2000. Curr Med Res Opin. 2005;21:195-206.
11. Matza LS, Paramore C, Prasad M. A review of the economic burden of ADHD. Cost Eff Resour Alloc. 2005;3:5-13.
12. Pelham WE, Foster EM, Robb JA. The economic impact of attention-deficit/hyperactivity disorder in children and adolescents. J Pediatr Psychol. 2007;32:711-727.
13. Leibson CL, Long KH. Economic implications of attention-deficit hyperactivity disorder for healthcare systems. Pharmacoeconomics. 2003;21:1239-1262.
14. Higgins JPT, Green S. Cochrane Handbook for Systematic Reviews of Interventions Version 5.0.2. Baltimore, MD: The Cochrane Collaboration; 2009.
15. Centre for Reviews and Dissemination. Systematic Reviews: CRD's Guidance for Undertaking Reviews in Health Care. 16. York, UK: University of York; 2009.
16. Barkley RA, Murphy KR, Dupaul GI, Bush T. Driving in young adults with attention deficit hyperactivity disorder: knowledge, performance, adverse outcomes, and the role of executive functioning. J Int Neuropsychol Soc. 2002;8:655-672.
17. Meyers J, Classi P, Wietecha L, Candrilli S. Economic burden and comorbidities of attention-deficit/hyperactivity disorder among pediatric patients hospitalized in the United States. Child Adolesc Psychiatry Ment Health. 2010;4:31.
18. Forness S, Kavale K. Impact of ADHD on school systems. In: Jensen P, Cooper J, eds. Attention Deficit Hyperactivity Disorder. Kingston, NJ: Civic Research Institute; 2002:21-30.
19. Kelleher KJ, Childs GE, Harman JS. Healthcare cost for children with attention-deficit/hyperactivity disorder. Econ Neurosci. 2001;3:60-63.
20. Hinnenthal JA, Perwien AR, Sterling KL. A comparison of service use and costs among adults with ADHD and adults with other chronic diseases. Psychiatr Serv. 2005;56:1593-1599.
21. Leibson CL, Katusic SK, Barbaresi WJ, Ransom J, O'Brien PC. Use and costs of medical care for children and adolescents with and without attention-deficit/hyperactivity disorder. JAMA. 2001; 285:60-66.
22. Kleinman NL, Durkin M, Melkonian A, Markosyan K. Incremental employee health benefit costs, absence days, and turnover among employees with ADHD and among employees with children with ADHD. J Occup Environ Med. 2009;51:1247-1255.
23. Jones DE, Foster EM. Service use patterns for adolescents with ADHD and comorbid conduct disorder. J Behav Health Serv Res. 2009;36:436-449.
24. Fletcher J, Wolfe B. Long-term consequences of childhood ADHD on criminal activities. J Ment Health Policy Econ. 2009;12:119-138.
25. Swensen AR, Birnbaum HG, Secnik K, Marynchenko M, Greenberg P, Claxton A. Attention-deficit/hyperactivity disorder: increased costs for patients and their families. J Am Acad Child Adolesc Psychiatry. 2003;42:1415-1423.
26. Fischer M, Barkley R. Young adult outcomes of children with hyperactivity: leisure, financial, and social activities. Int J Disabil Dev Educ. 2006;53:229-245.
27. Mandell DS, Guevara JP, Rostain AL, Hadley TR. Economic grand rounds: medical expenditures among children with psychiatric disorders in a Medicaid population. Psychiatr Serv. 2003;54:465-467.
28. US Department of Labor. Consumer price index. ftp://ftp.bls.gov/pub/special.requests/cpi/cpiai.txt. Accessed November 16, 2011.
29. American Diabetes Association. Economic costs of diabetes in the U.S. in 2007. Diabetes Care. 2008;31:596-615.
30. Choi BK, Pak AW. A method for comparing and combining cost-of-illness studies: an example from cardiovascular disease. Chronic Dis Can. 2002;23:47-57.
31. US Census Bureau. 2010 Census summary file 1: QT-P1 age groups and sex: 2010. US Census Bureau; 2010. http://factfinder2.census.gov/faces/tableservices/jsf/pages/productview.xhtml?pid=DEC_10_SF1_QTP2&prod. Accessed on October 8, 2011.
32. US Bureau of Labor Statistics. Employment status of the civilian noninstitutional population by age, sex, and race; 2010. http://bls.gov/opub/ee/2011/cps/annavg3_2010.pdf. Accessed on October 27, 2010.
33. US Census Bureau. AVG3. Average number of people per family household with own children under 18, by race and Hispanic origin, marital status, age, and education of householder: 2010; 2010. http://factfinder2.census.gov/faces/tableservices/jsf/pages/productview.xhtml?pid=DEC_10_SF1_QTP11&prod. Accessed on October 28, 2011.
34. Biederman J, Faraone SV. The effects of attention-deficit/hyperactivity disorder on employment and household income. Med Gen Med. 2006;8:12.

35. Marks DJ, Mlodnicka A, Bernstein M, Chacko A, Rose S, Halperin JM. Profiles of service utilization and the resultant economic impact in preschoolers with attention deficit/hyperactivity disorder. J Pediatr Psychol. 2009;34:681-689.
36. Robb J, Sibley M, Pelham W, *et al.* The estimated annual cost of ADHD to the US education system. School Mental Health. 2011;3:169-177.
37. Guevara J, Lozano P, Wickizer T, Mell L, Gephart H. Utilization and cost of health care services for children with attention-deficit/hyperactivity disorder. Pediatrics. 2001;108:71-78.
38. Chan E, Zhan C, Homer CJ. Health care use and costs for children with attention-deficit/hyperactivity disorder: national estimates from the medical expenditure panel survey. Arch Pediatr Adolesc Med. 2002;156:504-511.
39. Burd L, Klug MG, Coumbe MJ, Kerbeshian J. Children and adolescents with attention deficit-hyperactivity disorder: 1. Prevalence and cost of care. J Child Neurol. 2003;18:555-561.
40. Swensen A, Birnbaum HG, Ben Hamadi R, Greenberg P, Cremieux PY, Secnik K. Incidence and costs of accidents among attention-deficit/hyperactivity disorder patients. J Adolesc Health. 2004;35:346-349.
41. Kessler RC, Adler L, Ames M, *et al.* The prevalence and effects of adult attention deficit/hyperactivity disorder on work performance in a nationally representative sample of workers. J Occup Environ Med. 2005;47:565-572.
42. Secnik K, Swensen A, Lage MJ. Comorbidities and costs of adult patients diagnosed with attention-deficit hyperactivity disorder. Pharmacoeconomics. 2005;23:93-102.
43. Ray GT, Levine P, Croen LA, Bokhari FA, Hu TW, Habel LA. Attention-deficit/hyperactivity disorder in children: excess costs before and after initial diagnosis and treatment cost differences by ethnicity. Arch Pediatr Adolesc Med. 2006;160:1063-1069.
44. Fishman PA, Stang PE, Hogue SL. Impact of comorbid attention deficit disorder on the direct medical costs of treating adults with depression in managed care. J Clin Psychiatry. 2007;68:248-253.
45. Hodgkins P, Montejano L, Sasane R, Huse D. Cost of illness and comorbidities in adults diagnosed with attention-deficit/hyperactivity disorder: a retrospective analysis [published online April 14, 2011]. Prim Care Companion CNS Disord. 2011;13. doi: 10.4088.
46. Kessler RC, Lane M, Stang PE, Van Brunt DL. The prevalence and workplace costs of adult attention deficit hyperactivity disorder in a large manufacturing firm. Psychol Med. 2009;39:137-147.
47. Thompson AL, Molina BS, Pelham W Jr, Gnagy EM. Risky driving in adolescents and young adults with childhood ADHD. J Pediatr Psychol. 2007;32:745-759.
48. Molina BS, Hinshaw SP, Swanson JM, *et al.* The MTA at 8 years: prospective follow-up of children treated for combined-type ADHD in a multisite study. J Am Acad Child Adolesc Psychiatry. 2009;48:484-500.
49. Tarter RE, Kirisci L, Feske U, Vanyukov M. Modeling the pathways linking childhood hyperactivity and substance use disorder in young adulthood. Psychol Addict Behav. 2007;21:266-271.
50. Mannuzza S, Klein RG, Moulton JL III. Young adult outcome of children with "situational" hyperactivity: a prospective, controlled follow-up study. J Abnorm Child Psychol. 2002;30:191-198.
51. Hinshaw SP, Owens EB, Sami N, Fargeon S. Prospective follow-up of girls with attention-deficit/hyperactivity disorder into adolescence: evidence for continuing cross-domain impairment. J Consult Clin Psychol. 2006;74:489-499.
52. Spencer TJ, Biederman J, Mick E. Attention-deficit/hyperactivity disorder: diagnosis, lifespan, comorbidities, and neurobiology. Ambul Pediatr. 2007;7:73-81.
53. Burd L, Klug MG, Coumbe MJ, Kerbeshian J. The attention-deficit hyperactivity disorder paradox: 2. Phenotypic variability in prevalence and cost of comorbidity. J Child Neurol. 2003;18:653-660.
54. Greenberg PE, Kessler RC, Birnbaum HG, *et al.* The economic burden of depression in the United States: how did it change between 1990 and 2000? J Clin Psychiatry. 2003;64:1465-1475.
55. Wittchen HU. Generalized anxiety disorder: prevalence, burden, and cost to society. Depress Anxiety. 2002;16:162-171.
56. Weiss KB, Sullivan SD. The health economics of asthma and rhinitis. I. Assessing the economic impact. J Allergy Clin Immunol. 2001;107:3-8.
57. Aldridge AP, Kroutil LA, Cowell AJ, Reeves DB, Van Brunt DL. Medication costs to private insurers of diversion of medications for attention-deficit hyperactivity disorder. Pharmacoeconomics. 2011;29:621-635.
58. Danckaerts M, Sonuga-Barke EJ, Banaschewski T, *et al.* The quality of life of children with attention deficit/hyperactivity disorder: a systematic review. Eur Child Adolesc Psychiatry. 2010;19:83-105.
59. Angold A, Messer SC, Stangl D, Farmer EM, Costello EJ, Burns BJ. Perceived parental burden and service use for child and adolescent psychiatric disorders. Am J Public Health. 1998;88:75-80.

Table S1Search Terms

Outcomes of Interest	Search Terms to Capture Outcomes
ADHD subjects in all countries	ADHD or ADD or attention deficit or hyperkine* or TDAH or DAH or DAA
Cost analysis or economic impact	cost* or burden or econom* or expen* or budget or financ* or pharmacoeconom*
Productivity losses	productiv* or absen* or presen* or inefficien* or efficien* or work performance or job performance or work loss or lost work or human capital or income or employ* or unemploy* or socioeconomic status or SES or occupational scale or public assistance or disability benefit* or *term disability or workm?ns comp* or workers comp*
General services use	resource use or resource utili* or service*
Health care use	care or physician visit* or doctor visit* or physician encounter* or doctor encounter* or outpatient visit* or inpatient visit* or inpatient admission* or emergency or hospital* or day case or *care
Accidents	accident* or injur* or casualty or traffic behave* or traffic violation
Education	special education or special need* or Section 504 or IDEA or education plan or school psych* or remedial education or special class*
Drug abuse	drug rehab* or Substance-Related Disorders/epidemiology/psychology/rehabilitation or treatment seek* or seeking treatment or substance abuse treatment facilit* or substance abuse program or (illicit drug or substance abuse or substance-related disorders and treatment)
Criminal behavior	justice system or juvenile or incarcerat* or delinquen* or institution* or prison* or offender pathway or criminal behavior

Note: ADD = attention-deficit disorder; ADHD = attention deficit/hyperactivity disorder; DAA = déficit de l'attention/activité in French or déficit de atención y actividad in Spanish; DAH = déficit de l'attention/hyperactivité in French or déficit de atención con hiperactividad in Spanish; IDEA = Individuals with Disabilities Education Act; TDAH = trouble déficit de l'attention/hyperactivité in French or trastorno por déficit de atención con hiperactividad in Spanish.

Figure S1Consort diagram of articles meeting inclusion criteria. Note: ADHD = attention deficit/hyperactivity disorder.