



## Original article

# The economic burden of adult attention deficit hyperactivity disorder: A sibling comparison cost analysis

D. Daley<sup>a,\*</sup>, R.H. Jacobsen<sup>b</sup>, A.-M. Lange<sup>c</sup>, A. Sørensen<sup>d</sup>, J. Walldorf<sup>d</sup>

<sup>a</sup> Division of Psychiatry and Applied Psychology, School of Medicine & Centre for ADHD and Neurodevelopmental Disorders across the Lifespan & NIHR MindTech Health Care Technology Cooperative, Institute of Mental Health, University of Nottingham, Nottingham, United Kingdom

<sup>b</sup> VIVE, The Danish Centre for Applied Social Science, Copenhagen, Denmark

<sup>c</sup> Aarhus University Hospital, Department of Child & Adolescent Psychiatry, Skejby, Denmark

<sup>d</sup> Department of Economics, Copenhagen Business School, Porcelaenshaven, Copenhagen, Denmark

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## ABSTRACT

**Aim:** Attention Deficit Hyperactivity Disorder (ADHD) is a lifespan disorder associated with considerable economic cost. While the economic burden of ADHD has been widely estimated, there is considerable variation in reported costs between studies, which typically focus on health outcomes only, lack adequate control and fail to correct for the influence of genetic and shared environmental factors. The aim of this study is to overcome these limitations to reach a fuller understanding of the economic burden of ADHD. **Method:** Using the Danish National Registers 5269 adults with a diagnosis of ADHD in adulthood who had not received a diagnosis in childhood were identified. Excluding cases with missing data, comorbid diagnoses, and cases without a same sex sibling free of any diagnosed psychiatric diagnoses, a final cohort was formed consisting of 460 sibling dyads. Using a cross-sectional method focusing on the year 2010, cost differences between each adult with ADHD and their sibling were calculated from data retrieved from health, education, crime, employment and social care registers.

**Results:** Adults with ADHD had considerably lower disposable income and paid less tax than their siblings. They also received more state benefits, had higher costs for health, social care, and crime than their siblings. The total average costs difference for the year 2010 was 20,134 euros more than their sibling for each adult with ADHD.

**Conclusion:** ADHD is associated with considerable costs which are borne by both the individual and the state and underlines the need to consider the wider economic impact of ADHD beyond income and healthcare utilisation costs.

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## 1. Introduction

Attention Deficit Hyperactivity Disorder (ADHD) is a lifespan disorder [1] associated with a considerable psychological [2] and cost burden [3] and was included in the global burden of diseases study in 2010, but the limitation of sparse data lead to widespread uncertainty intervals around the burden estimates [4]. The lifetime prevalence of ADHD is now widely acknowledged [5], and while some studies suggest that ADHD in adulthood may be different to ADHD in childhood [6], recent evidence finds little support for late onset adult ADHD [7]. Differences between early and later onset for ADHD may simply reflect different developmental trajectories of environmental exposure and experience [7,8]. Meta-analyses have

demonstrated that the economic burden of ADHD impacts on different outcomes for adults and children, with much greater costs in adulthood than in childhood [9]. For adults, the greatest cost burden is productivity and income losses ((\$87B–\$138B), but for children, the largest cost categories are health care (\$21B–\$44B) and education (\$15B–\$25B) [9]. However, cost estimates vary considerably between studies [10] which cloud the understanding of the true cost burden. Variations can chiefly be attributed to a number of important methodological limitations: i) Few studies examining the costs of ADHD explore costs beyond direct medical expenses [11], ii) Only a minority include costs to the criminal justice system [2] as most are dependent upon reanalysis of existing insurance company databases which usually hold information on health variables only [9], iii) While the few longitudinal studies available are free to explore a wider range of cost outcomes they have very small sample sizes, especially at follow-up [2], and struggle to control for the impact of comorbidity,

\* Corresponding author.

E-mail address: [david.daley@nottingham.ac.uk](mailto:david.daley@nottingham.ac.uk) (D. Daley).

diagnosis and service use on reported costs [12], iv) Most studies utilise poor control or comparison groups, often involving non-affected individuals or heterogeneous clinical groups with potentially overlapping difficulties [13] or national estimates that fail to control for genetic or shared environmental factors between individuals and groups [9]. While the influence of shared environment on the expression of ADHD is controversial [14,15], the influence of shared environment on factors which are known to drive cost differences between individuals such as anti-social behavior [16] and educational attainment [17] have been clearly demonstrated.

The aim of this study is to overcome the limitations of the current literature and to reach a fuller understanding of the social and individual economic impact of ADHD. The study taps into the Danish population based registers [18]. The key focus is to study the costs of untreated ADHD in adults diagnosed with ADHD in adulthood who did not receive a diagnosis in childhood, and where costs are uncontaminated by treatment in childhood. The study investigates the extent to which individuals with undiagnosed ADHD in childhood, adolescence and early adulthood fare differently compared to their same sex siblings without ADHD,

controlling for comorbidity in both groups as comorbidities such as autism, or depression are often associated with considerable economic disadvantage and allows clinicians and policy makers to distinguish the cost of ADHD in adulthood from the costs associated with co-morbidity. The advantage of this sibling-based analysis is that it offers a high level of control for sociodemographic and childhood factors, as siblings share similar genetic and environmental backgrounds which have usually gone unobserved, or undetected, in traditional cost analyses [16,17] Focusing on individuals who received a diagnosis in adulthood but not childhood also removes the need for complex cost corrections to remove the impact of treatment in childhood on costs in adulthood. It also provides healthcare systems with a better estimate of the cost of ADHD uncontaminated by treatment effects.

## 2. Methods

### 2.1. Design

The cross-sectional method was employed to calculate costs for the year 2010 which was the latest year for which full data was

**Table 1**  
Descriptions of ADHD subsamples and differences between study sample and the Danish adult population without psychiatric diagnoses.

Groups	Adults diagnosed with ADHD in adulthood	Adults diagnosed with ADHD in adulthood, with no psychiatric comorbidity	Adults diagnosed with ADHD in adulthood with a same sex sibling without psychiatric disorder	Significance <sup>a</sup>	Adult population without psychiatric disorders
<b>Number of observations</b>	<b>5,269</b>	<b>1,553</b>	<b>460</b>		<b>3,049,195</b>
<b>Demographic background</b>					
Average age in 2010 <sup>b</sup>	30.0	29.2	31.7	***	42.3
Percentage male	63.8	67.2	67.2	***	50.6
Percentage of Danish origin	95.1	95.3	96.1	***	90.8
<b>Labour market and income</b>					
Total annual income in 2010 (€)	23,809	23,870	26,259	**	44,414
Average annual wage income in 2010 (€)	7,312	10,678	12,545	***	33,774
Percentage wage employed in November 2009	25.1	33.8	35.7	***	70.1
<b>Educational attainment</b>					
Percentage achieving primary/elementary education only, as of October 2010	68.8	67.0	62.6	***	24.5
Percentage with tertiary education as of October 2010	5.6	7.3	9.4	***	29.6
<b>Health and health care utilization</b>					
Average Spending on Medicine in 2010 (€)	1,542	1,016	1,138	***	190
Average Number of Primary Care Services in 2010	26.5	21.4	22.0	***	16.7
Average Number of Secondary In-Patient Days in 2010	3.7	2.7	3.5		2.8
<b>Crime, Traffic, and respite care</b>					
Percentage with criminal case in 2001-2010	60.1	54.9	53.9	***	20.6
Percentage who was a victim of a crime in 2001-2010	29.1	21.2	17.4	***	7.6
Percentage who had a Traffic Accident in 2001-2010	8.4	6.6	5.7	***	2.2
Percentage who experienced foster/respite care as a child	14.7	13.4	8.9	***	0.7
<b>Characteristics of parents</b>					
Average Yearly Parental Income until 18th birthday (€)	55,869	57,161	58,575	**	63,587
Percentage of Mothers achieving primary/elementary education, only	44.3	45.2	54.6	***	39.8
Percentage of Fathers achieving only primary/elementary education only	40.0	38.0	40.5	***	29.7
<b>ADHD information</b>					
Median year of diagnosis (50% percentile)	2009	2009	2009		–
Average age at diagnosis	28.1	27.7	30.2		–
Individuals prescribed ADHD medication during 1995-2010 (%)	85.5	85.5	85.2		–

<sup>a</sup> *t*-test for differences in mean between individuals with ADHD and siblings without comorbidity and all Danish Adults. Significance level: 0.10(\*), 0.05(\*\*), 0.01(\*\*\*).

<sup>b</sup> We only explored diagnoses between 1995 and 2010, and while it is very unlikely, we cannot rule out the possibility that some of the included adults with ADHD, or their siblings, received a diagnosis in childhood prior to 1995. However, in the unlikely event that unobserved ADHD diagnosed in childhood and unobserved ADHD diagnosis for siblings occurred, this would imply that our cost estimates are conservative and it would reduce the cost differences between our groups.

available at the time of application to access the data from Statistics Denmark.

## 2.2. Study population

The study population was identified using the unique Danish Civil Registration System (CRS) [19]. The CRS is continuously updated and contains detailed data on all Danish residents. The system includes a personal identification number (PIN) which is also used in every other population-based register in Denmark, thus enabling accurate linkage between registers (e.g., linking siblings).

A total of 5269 individuals with ADHD were identified, who received at least one of five International Classification of Diseases, 10<sup>th</sup> Revision (ICD-10) [20] Hyperkinetic (ADHD) diagnoses (F90.0, F90.1, F90.8, F90.9, F98.8) between 1995 and 2010 and who were between 18 and 50 years of age at the time of diagnosis. Following exclusion of cases with missing values, comorbid diagnoses and cases without a same sex sibling free of any psychiatric diagnosis, the final study population consisted of 460 dyads.

All data was anonymized by and obtained through a strict application procedure overseen by Statistics Denmark. According to Danish legislation, register-based studies involving anonymized data do not require informed consent. We attest that we have obtained appropriate permissions and paid any required fees for use of copyright protected materials.

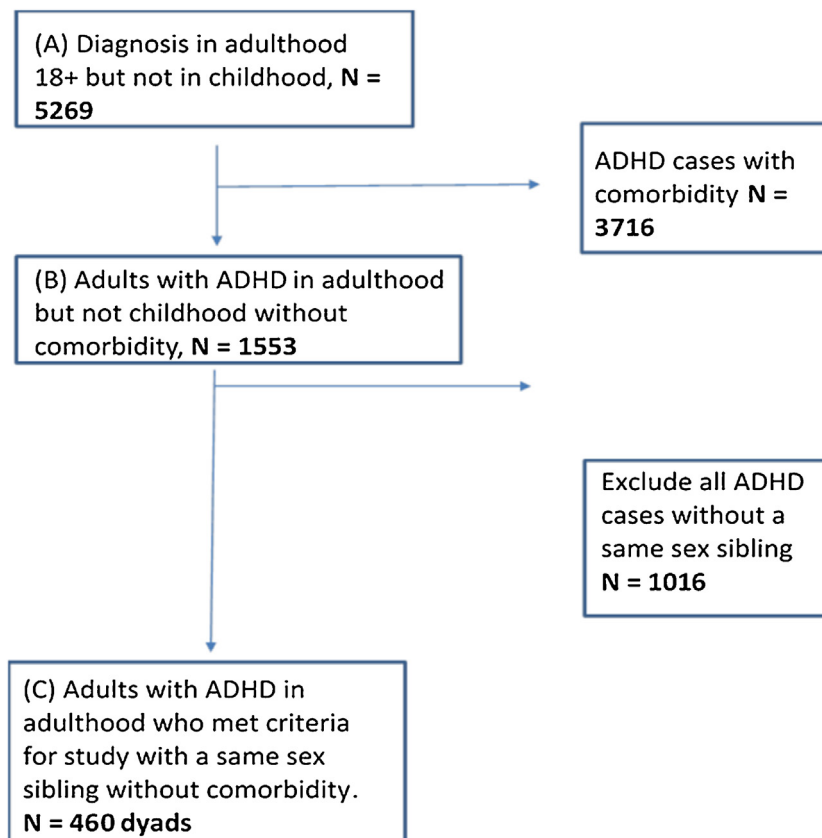
A comparison of the 460 Adults with ADHD and no other psychiatric disorders, against the entire Danish adult population without any registered psychiatric diagnosis is presented in

**Table 1.** This analysis clearly shows significant differences across all categories with the exception of in-patient hospital care which was still higher in the ADHD group. These differences may be due to variations in developmental age, experience or opportunity, and underline the need for the sibling comparison analysis adopted for this study. This comparison was based on estimates of the differences between the Adult ADHD group and their same sex siblings, excluding the influence from comorbidity by removing dyads where individuals with ADHD had a registered co-morbid psychiatric diagnosis, or where the sibling had any registered psychiatric diagnosis. This sibling-based matched control group offers a high level of control for shared genetic and socio-demographic factors, including upbringing [21]. It presents an enhanced econometric method to reduce the risk of unobserved differences in costs between the two groups [14,17,22] (see Fig. 1).

## 2.3. Data sources

We identified adults with a diagnosis of ADHD through the Danish National Patient Register [22] (DNPR) and Danish Psychiatric Central Research Register [23] (DPCR), an electronic register containing information on every psychiatric admission from 1969 onwards as well as outpatient treatment and psychiatric accident and emergency department contacts included from 1995. Psychiatrists in private practice and General

Practitioners (GP's) are not required to register psychiatric patient data in the Danish national registers. Thus, the registers contain psychiatric data on patients referred to and diagnosed in hospital-based in- and outpatient services only. A recent study has



**Fig. 1.** Identification of dyads consisting of Adults with ADHD without psychiatric comorbidity and their siblings without any psychiatric disorder.

Sample defined as A) Adults (18–65) in the Danish population in 2010, diagnosed in adulthood (18–50) from 1995 to 2010 and not in childhood: 5269 B) Adults (18–65) in the Danish population in 2010, diagnosed in adulthood (18–50) and not in childhood with no other psychiatric diagnosis from 1995 to 2010 (no age restriction): 1553 C) Adults (18–65) in the Danish population in 2010, diagnosed in adulthood (18–50) and not in childhood with a same sex (adult) sibling without any psychiatric diagnosis from 1995 to 2010 (no age restriction) or any history of ADHD medication from 1995 to 2010: N=460.

demonstrated that the recorded diagnoses of ADHD in the Danish registers are reliable [24].

We obtained personal information on individuals identified with ADHD and their siblings concerning health-care, educational attainment, labor market performance, crime, traffic accidents, health care, foster care from a record linkage of the following Danish population based registers [18]: *The Danish National Patient Register* [19] including *the Danish Psychiatric Central Register* [23], *The Student Register* [25], *The Danish Central Crime Register* [26], *The Traffic Accident Register*, *The Income Statistics Register* [27], *The Integrated Database for Labor Market Research (IDA)* [28], *The National Sickness Benefit Register* [27], and *the National Prescription Registry* [29].

#### 2.4. Analysis strategy

Cost differences between adults with ADHD and their same sex siblings were estimated using the following strategy. First, the same sex sibling closest in age to the individual with ADHD was selected. Second, the mean outcome measures for the treatment group and the matched sibling control groups were compared. Third, it was determined whether the mean differences were significantly different from zero using t-tests.

Individual or family borne costs of ADHD refer to all costs incurred by individuals including loss of income moderated by gains in income replacement transfers (net income taxes), individual costs of being a victim of a crime, and private costs of prescription medicine. Public or societal costs of ADHD are all costs paid by local or central Government including income transfers, loss of income taxes, cost of crime, education, traffic accidents and

publicly provided health care, including subsidies for prescription medicine. The social costs of ADHD are the total costs and are defined as the sum of both individual/family borne and public/societal costs.

When calculating the costs of ADHD, the prevalence-based method has been used, where costs from individuals from a single year are calculated (in this case 2010). The cross-sectional prevalence based method was employed, as it makes the best use of data [30] and because the group of adults with ADHD, with its relatively small share of individuals above the age of 35, was simply not mature enough to make good life-cycle estimates. The costs reported are interpreted as average yearly costs of ADHD. The monetary cost measures used in the calculations come from a variety of sources. Some are measured directly in monetary terms, for example personal income and tax. Others are measured in shares or crude numbers, for example for GP visits where the number of visits are counted and multiplied by the unit cost to arrive at the economic impact. For foster care costs, we only include costs for those in foster care after the age of 18 years of age. See Daley et al. [31] for more details about cost difference calculations. Throughout this analysis we present our cost results in Euros using a standard exchange rate of 7.45 Danish Kroner to the Euro.

### 3. Results

Table 2 shows the results from the sibling analysis and the unit costs used in the calculation. For almost all the cost elements the difference between the ADHD-groups and the sibling control groups is significantly different from zero. Particularly large

**Table 2**  
Results from sibling comparison and unit cost.

	Average for adults with ADHD	Average for siblings	Significance <sup>a</sup>	Unit cost <sup>b</sup> €
<b>Income and taxes</b>				
Total employment income and public transfers, €	26259.48	38251.75	**	
Income tax payments, €	6887.07	11406.21	**	
<b>Public transfers</b>				
Social security and state benefits €	3113.44	465.75	**	
Early retirement benefits €	1945.28	888.01	**	
Student grants €	721.14	690.40		
Sickness benefits (number of days)	33.58	7.82	**	72
<b>Education</b>				
Secondary and vocational education	12.17%	12.39%		
Higher education	3.48%	6.74%	*	10548
<b>Crime, traffic etc. (occurrences in 2010)</b>				
Percentage who has been victim of a crime	2.83%	1.09%		
Percentage convicted of a crime:				
Violent crimes	5.65%	3.48%		
Burglary, theft and vandalism related crimes	11.96%	1.74%	**	2372
Traffic related crime	10.43%	4.78%	**	1759
Percentage who served time in prison	3.48%	0.87%	*	25696
Percentage who has been in a traffic accident	–	–		
Percentage who has been in adult continuation of foster care <sup>c</sup>	–	–		
<b>Health care utilisation</b>				
<i>Primary health care:</i>				
Number of visits to their General Practitioner	15.47	8.18	**	24.01
Number of specialist appointments	2.49	1.43	**	78.57
Number of visits to a Psychologist	0.25	0.05	**	63.99
Number of other health related visits	3.77	5.41	*	34.34
<i>Secondary health care:</i>				
Inpatients costs	703.93	497.27		
Outpatients costs	1207.44	413.74	**	
<b>Medication:</b>				
Patient costs of prescription medication, €	313.16	68.04	**	
Public subsidy to prescription medication, €	763.72	102.94	**	

Note: 460 siblings matched to their control siblings have been used. Numbers indicate values for 2010 unless otherwise noted. Source: Statistics Denmark.

<sup>a</sup> Significance levels: \* =  $p < 0.05$ , \*\* =  $p < 0.01$ .

<sup>b</sup> Unit cost of relevant, significant outcomes included in the costing analysis are shown.

<sup>c</sup> This estimation only concerns adult continuation of foster care whereas the numbers in Table 1 refer to the costs of childhood foster care.

differences can be seen for receipt of social security benefit and early retirement benefit, but the differences in personal income and the number of GP contacts between Adults with ADHD and their same sex siblings are remarkable.

An examination of Table 3 demonstrates the cost differences for the adult ADHD sample compared against the sibling comparison group. Negative values indicate greater costs for the Adult ADHD group and positive values indicate greater costs for the siblings. A focus on individual costs (which fall to the individual) indicate that adults with ADHD have considerably less disposable income than their siblings, as well as higher personal medication costs. A focus on public/societal costs (which fall to the state) demonstrates that adults with ADHD receive more state income subsidies and pay less tax than their siblings, are associated with higher costs for, crime and medical costs (inpatient, general practice and medication). An examination of the relative costs reveals the striking differences in disposable income between siblings with and without ADHD as well as the fact that cost differences between siblings with and without ADHD for crime related cost were comparable to the cost differences for health care utilization. Total average cost differences between Adults with ADHD and their sibling were 20,135 euros per individual with ADHD, per year. An examination of Fig. 2 presents the same cost differences as easier to access percentage data and highlight the relative differences for individual cost categories between adults with ADHD and their siblings. An examination of Fig. 2 highlights the very high relative cost differences between Adults with ADHD and their siblings, especially for personal income, prescribed medication and social welfare and state benefits.

An examination of Table 4 demonstrates our estimates of the aggregate costs of ADHD in adulthood for five countries. The calculations are carried out by simply taking the individual cost of ADHD and multiplying this by the prevalence rate of ADHD from a recent meta-analysis [32] and by the country's recorded population

in the age group between 18 and 65 years. The aggregate costs presented in Table 4 are crude estimates and vary for four reasons. First, the costs vary across countries due to different demographic profiles within the various adult populations. Second, the costs vary due to the application of different reported prevalence rates. Third, the costs vary as a function of different ways of estimating total costs. Finally the between country comparison calculations based upon two different sources, the Simons et al prevalence rate<sup>32</sup> calculates prevalence rates of ADHD in adulthood that are unable to correct for diagnosis and access to care in childhood. The Daley et al study<sup>31</sup> uses a prevalence rate of ADHD in adulthood, calculated using the prevalence of individuals who received a diagnosis of ADHD in Denmark, after their 18<sup>th</sup> birthday. Overall controlling for differences in prevalence, the cost data presented in Table 4 suggests that adults who do not receive a diagnosis until adult are a more disadvantaged group with higher costs than those who received a diagnosis in childhood and access to care. The results in Table 4 are presented in order to extend our findings to an international context. Doshi et al. [9] estimated the total cost of adult ADHD in the US at a magnitude of USD 105–194 billion. With a pooled prevalence for adult ADHD of 2.5% from a meta-analysis [32] we estimate a total cost of ADHD in the US of 99 billion euros. Using an average USD/EUR exchange rate of 1.27, this aggregate cost amounts to USD 126.2 billion, which is within the range reported by Doshi et al [9], albeit towards the lower end. Our rather lower estimate is possibly due to the fact that we are able to control for a number of family characteristics and exclude the influence of co-morbidity both of which will undoubtedly have elevated previous cost estimates.

#### 4. Discussion

This study has attempted to overcome the problem of unobserved heterogeneity, through conducting a same-sex sibling comparison, thereby estimating the true costs of ADHD as

**Table 3**  
Calculation of cost comparison using similar siblings, € per individual.

	Adults with ADHD	Siblings	Cost Difference €	% <sup>c</sup>
<b>Individual or family borne costs</b>				
<b>Disposable income</b>				
Total work income and public transfers	26,259	38,252	-11,992	-31%
Income tax payment <sup>b</sup>	6,887	11,406	4,519	40%
<b>Other costs to the individual</b>				
Patient cost of prescribed medication	313	68	-245	-360%
Costs of being a victim of a crime			0	N.A.
<b>Total cost to the individual</b>			<b>-7,718</b>	
<b>Public costs</b>				
<b>Public transfers and income tax</b>				
Income replacement transfers	7,476	1,917	-5,559	-290%
Income tax revenue to the state <sup>b</sup>	6,887	11,406	-4,519	-40%
<b>Crime, traffic, foster care and education</b>				
Costs of being in a traffic accident <sup>a</sup>			0	N.A.
Costs of crimes committed (investigation, sentencing)	1,361	349	-1,012	-290%
Education costs (direct costs)	367	711	344	48%
Adult continuation of foster care <sup>a</sup>			0	N.A.
<b>Medical expenses</b>				
Secondary health care	1,207	414	-794	-192%
Primary health care (GP and other primary care)	713	498	-215	-43%
Public subsidy to prescribed medication	764	103	-661	-642%
<b>Total cost to the public sector</b>			<b>-12,416</b>	
<b>TOTAL COST (INDIVIDUAL + PUBLIC)</b>			<b>-20,134</b>	

N.A.: Not applicable.

<sup>a</sup> We found no statistical significant differences for traffic accidents and continuation of foster care.

<sup>b</sup> The "income tax payment" listed under individual of family borne costs is repeated under "income tax revenue to the state" in the public costs part of the table (albeit with opposite signs). The lower "income tax payment" by "Adults with ADHD" reduces costs to the individual by €4,519, whereas the lower "income tax revenue to the state" by "Adults with ADHD" increases the public costs. The reason for this is that while "income tax payment" is a cost for the private individuals they represent a revenue of exactly the same magnitude to the public sector. Thus when aggregating, these two entries representing payment from one part of society to another cancels out and has no impact on the total costs, but needs to be included when looking at either the private individuals or the public sector separately.

<sup>c</sup> The cost difference in percent is calculated in relation to values for "Siblings".

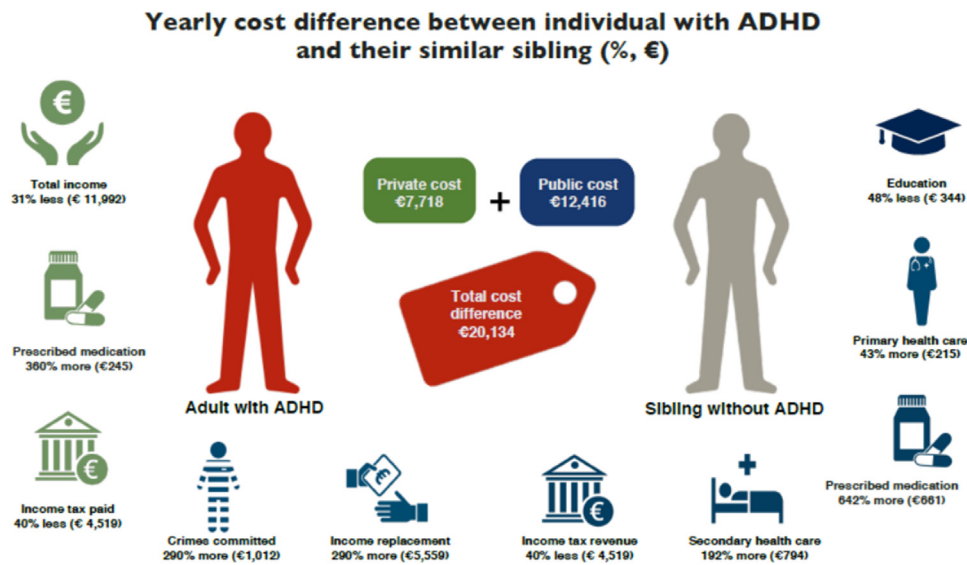


Fig. 2. Infographic demonstrating relative cost differences in percentages between Adults with ADHD and their similar siblings.

Table 4

Total cost to society (social cost) for individuals with ADHD for different countries (million €).

Country	Canada	Denmark	France	Netherlands	United Kingdom	United States
<b>Adult population size (18-65 years) (N)</b>	22,193,298	3,467,888	40,184,477	10,677,769	39,681,768	197,407,194
	<b>Cost estimates based on present sibling-analysis, million €</b>					
<b>ADHD prevalence rate estimates</b>						
Daley et al. (2015) [31]	0.5%	2,439	381	4,417	1,174	4,361
Simon et al (2009) [32]	2.5%	11,171	1,746	20,227	5,375	19,974

accurately as possible. Findings from this study demonstrate that ADHD in adulthood is associated with considerable individual and public costs. Based on comparisons between adults with ADHD and their same-sex siblings, and removing any influence of comorbidity, the study has eliminated many of the shortcomings of previous cost studies. When compared to their siblings, adults with ADHD incurred much higher private and social costs. The results confirm existing findings that the cost burden of ADHD in adulthood in terms of medical costs, productivity and income losses [9] are substantial, but unlike previous studies can be explained by ADHD in the individual rather than other social or environmental explanations. This study also confirmed the additional cost burden of ADHD on medication costs [9], but also on general practice [2], and in and out-patient hospital costs [10]. This study is one of the first to accurately estimate the additional contribution of crime, traffic accidents, and foster care to the overall costs associated with ADHD [9]. Although, our results show no significant difference for traffic and adult continuation of foster care. However, our results clearly demonstrate that costs associated with criminal activity among adults with ADHD were comparable to the costs associated with healthcare utilization and underlines the need to consider the wider economic impact of ADHD.

The value of this study comes from the strength of the methodological approach and the use of the population based Danish Registers which allow for the identification of a large group of individuals with ADHD and a sibling comparison control. The ability to control for demographic differences allows an exploration of the unique costs associated with ADHD with little contamination from un-controlled variables. The study has extended previous findings by investigating a wider range of health and social outcomes and their combined costs to individuals

and society. Despite the many strengths of this study there are important limitations to the analysis i) The Danish registers provide unique opportunities to investigate a comprehensive range of outcomes but are limited to direct, measurable outcomes, such as income and medication costs. Registry studies do not allow the measurement of indirect costs, including the psychological burden, or perceived quality of life related to ADHD. ii) The applied cross-sectional cost analysis may not give a full picture of all costs over time. We have chosen to use a cross-sectional method as this method makes the best use of data and because the age of the group of adults with ADHD is too young to make good life-cycle estimates [30]. This choice implies that the obtained estimates represent a 'snapshot of a moment in time' and may not be a good estimate of costs in future years. iii) Data collected for the Danish registers are not research-led [33], which means that essential information for specific analyses may be missing. iv) While the study design was able to exclude the influence of treatment during childhood on costs, we were not able to control for the impact of treatment during adulthood, which may have lowered the cost estimates. v) Prevalence estimates indicate that clinical practice in Denmark is more conservative in diagnosing ADHD than in the USA [34]. Hence, the diagnosed sample in this study may represent a more severe and impaired group, which in turn may have impacted on the cost estimates. vi) Despite the many advantages of our sibling comparison design, it does exclude families with only one child from the analysis who may be different from families with siblings.

Previous studies have underlined the considerable economic burden associated with ADHD. Yet, individual studies and systematic reviews point out inconsistency in costs associated with ADHD, with considerable variations in estimates. Secondly, several conceptual and methodological weaknesses in the current

literature have been emphasized - especially in relation to the lack of focus on costs to societal systems such as welfare or criminal justice and the lack of adequate comparison groups. This analysis has produced a more accurate methodology and a more confident estimate of the true economic impact of ADHD. In comparison with other previous estimates and controlling for differences in national prevalence of ADHD, this study finds comparable costs, albeit it at the lower end of previous estimates, due no doubt to the ability remove the influence of comorbidity on cost as well as the opportunity to expand the cost estimate parameters to crime, traffic accidents and foster care costs.

These results show the considerable costs associated specifically with ADHD and suggest that greater investment in earlier identification and treatment could be cost effective [35]. As ADHD involves costs in relation to a number of individual outcomes as well as for the public sector, effective strategies should be developed not only in the health sector but also include the education and employment sector to create a comprehensive evidence base for action in practice. The goal would be to facilitate sustainable outcomes for society and for individuals with ADHD.

To conclude, ADHD diagnosed in adulthood presents with substantial costs for the individual and for society. We recommend that future research and health policy address the need for early identification and intervention strategies to mitigate the negative impact of ADHD in order to improve individual lives and reduce the costs associated with the disorder. Effective interventions addressing different areas of personal and social functioning hold the promise to increase opportunities for individuals with ADHD to attain optimal personal and social outcomes.

## 5. Contributors

AS, DD, AML, and RH conceived the study. AS was granted access to the data by Statistics Denmark, JW, AS and RH conducted the analyses. The manuscript was drafted by DD, AML, AS, RH and JW. RH created the tables, AML created the figures. As lead author DD confirms that the results presented in this paper are a fair, accurate and transparent account of the study findings.

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## Declaration of Competing Interest

All authors have completed the ICMJE uniform disclosure from at [www.icmje.org/coidisclosure.pdf](http://www.icmje.org/coidisclosure.pdf) and declare: Dr. Daley reports grants from the Rockwool Foundation during the conduct of the study. Outside the submitted work he reports grants, personal fees and non-financial support from Shire. Personal fees and non-financial support from Medice and Eli Lilly. Non-financial support from QbTech. Book royalties from Jessica Kingsley. Dr. Jacobsen reports grants from Rockwool Foundation, during the conduct of the study; grants from Trygfonden, outside the submitted work. Ms Lange reports grants from The Rockwool Foundation during the conduct of the study. Outside the submitted work, she reports grants from Trygfonden, personal fees and non-financial support from Medice. Dr. Sørensen reports grants from The Rockwool Foundation, during the conduct of the study. Ms Walldorf reports grants from The Rockwool Foundation, during the conduct of the study

## Ethical approval

Ethical approval was not required for this study which was based on anonymised data. Strict approval was granted by Statistics Denmark for the use of the data reported.

## Availability of data

The data for this study was provided by Statistics Denmark under strict time limited control. The authors are not therefore able to share the data, but the data can be accessed via Statistics Denmark

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