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Attention-Deficit/Hyperactivity Disorder, School Performance and Effect of Medication

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Abstract

Objective: Individuals with Attention-Deficit/Hyperactivity Disorder (ADHD) are at increased risk of poor school performance and pharmacological treatment of ADHD may have beneficial effects on school performance. Conclusions from previous research have been limited by small sample sizes, outcome measures, and treatment follow-up. The current study analyzed school performance in students with ADHD compared to students without ADHD, and the association between pharmacological treatment of ADHD and school performance.

Method: A linkage of Swedish national registers covering 657,720 students graduating from year 9 of compulsory school provided measures of school performance, electronically recorded dispensations of ADHD medication, and potentially confounding background factors such as parental socioeconomic status. Primary measures of school performance included student eligibility to upper secondary school and grade point sum.

Results: ADHD was associated with substantially lower school performance independent of socioeconomic background factors. Treatment with ADHD medication for 3 months was positively associated with all primary outcomes, including a decreased risk of no eligibility to

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Twitter: New study @JAACAP finds positive association between medication for #ADHD and adolescent school performance in Sweden using large population data.

upper secondary school, odds ratio of 0.80, 95% confidence interval (CI) 0.76-0.84, and a higher grade point sum (range 0.0-320.0) of 9.35 points, 95% CI=7.88-10.82; standardized coefficient of 0.20.

Conclusion: ADHD has a substantial negative impact on school performance while pharmacological treatment for ADHD is associated with higher levels in several measures of school performance. Our findings emphasize the importance of detection and treatment of ADHD at an early stage to reduce the negative impact on school performance.

LAY SUMMARY

Attention-Deficit/Hyperactivity Disorder (ADHD) is associated with poor school performance and ADHD medication may improve school performance. Using a register linkage of Swedish students this study finds a positive association between length of medication use prior to graduation and several measures of school performance. Three months of treatment with ADHD medication was associated with an increase in the grade-point average (range 0-20) of 0.49 and treatment over three school years with an increase of 2.38 points. The strength of these associations suggest that ADHD medication may play a role in improving school performance in students with ADHD, but other educational interventions are likely needed to bridge the substantial school performance gap between students affected by ADHD and their unaffected peers.

Keywords

ADHD; school performance; medication; treatment

INTRODUCTION

Approximately 5% of all school-aged children world-wide are diagnosed with Attention-Deficit/Hyperactivity Disorder (ADHD)[1] and the impairments associated with ADHD persist into adulthood in many cases.[2] Research suggests that ADHD is associated with poor school performance, both in childhood and later in life. Children with ADHD are at increased risk of lower scores on reading and arithmetic achievement tests, lower grade point average (GPA), grade repetition and placement in special education classes compared to controls.[3–5] Adolescents with ADHD fail more grades and perform worse on standardized academic achievement tests than matched controls.[6] Although the relationship between ADHD and school performance is well-researched, no study has examined this relationship in a nationwide setting using objectively measured confounders such as parental education.

Randomized controlled trials (RCTs) involving children[7] and adults[8] have shown that ADHD medications have beneficial short-term effects on the core symptoms of ADHD and are associated with improvements in a wide range of cognitive functions in children with ADHD, including complex reaction time, spatial recognition memory reaction time, inhibition, working memory and strategy formation.[9] Research on the short-term effects of ADHD medication on different measures of school performance has found positive effects in several domains. RCTs, usually with a follow-up of 1-7 weeks,[10,11] suggest positive effects on note-taking quality, quiz scores, class work productivity, and disruptive behavior,[12,13] whereas more modest effects have been reported for test scores in reading and mathematics.

[7,14,15] Observational studies exploring short-term effects have found converging evidence.[16,17] One recent study using Swedish register data found that, although of small effect, individuals (mean age 22.2 years) performed better on higher education entrance tests during medicated than unmedicated periods[16] and another study in children using a similar design found that GPA was higher during stimulant adherent periods.[17]

Ideally, the long-term association between ADHD medication and school performance should be examined in large prospective RCTs, but since such trials are problematic (e.g., patients assigned to a long-term untreated control arm may seek out medications elsewhere) and unethical (e.g., withholding treatment with known benefits), future research in this area must rely on findings from observational designs.

Existing observational studies of the long-term association between ADHD medication and school performance have yielded inconsistent results.[18–21] Although improvements in test scores during primary school have been reported,[22,23] the evidence regarding GPA is mixed. A 9-year longitudinal follow-up study of children with ADHD showed an association between ADHD medication and higher GPA[21] and an 8-year follow-up of the Multimodal Treatment Study of Attention Deficit Hyperactivity Disorder (MTA) reported no effects of ADHD medication on GPA.[20] Imperfect assessment (e.g., parent- or self-reported) of long-term medication usage, and small and/or clinically referred samples are essential limitations of the available studies.[18] Another important limitation of the aforementioned observational research is how different measures of school performance influence each other. Standardized tests can be conceptualized as examinations of academic knowledge while school grades, in addition, incorporate broader aspects of school performance such as productivity and classroom behavior.[24] One review reported that the correlation between test scores and grade points is lower in students with ADHD compared to students without ADHD[18], suggesting that teacher assessment differs by ADHD status. The potential role of ADHD medications in this relationship is unknown.

The current study captured the total population of students graduating from compulsory (primary and lower secondary) school in Sweden in 2008-2013, including a large sample of students diagnosed with ADHD. The aims were twofold: First, we investigated the association between ADHD and school performance. Second, we examined how ADHD medication influenced the association between ADHD and school performance in the shorter and longer term.

METHODS

Data sources

We extracted data on school performance from the Swedish National School Register (NSR) for all 657,720 students graduating from year 9 of compulsory school between 2008 and 2013. The NSR contains individual level data on final grades (FGs) from school leaving certificates and grades in standardized tests (subsequently referred to as tests) taken in Swedish, English and mathematics, information about eligibility to upper secondary school (USS), and school of graduation. Using the Longitudinal Integration Database for Health Insurance and Labor Market Studies (LISA) individual completion of USS was obtained.

Individuals were linked to data on dispensed medication, including amphetamine (Anatomical Therapeutic Chemical classification system (ATC) codes: N06BA01, N06BA02), methylphenidate (N06BA04) and atomoxetine (N06BA09), using the Swedish Prescribed Drug Register (July 2005 – December 2013) and diagnosis of ADHD (International Classification of Diseases [ICD] 10: F90), in the National Patient Register (NPR). ADHD cases were defined either by a lifetime in/outpatient primary diagnosis of ADHD or at least one lifetime dispensation of ADHD medication (excluding dispensations indicated for narcolepsy; 93 individuals). Defining ADHD by a dispensed ADHD medication has been used and validated in prior research using Swedish registers.[25] This study was approved by the Regional Ethical Review Board in Stockholm. In Sweden, using de-identified register data in research does not require informed consent from participants.

The Swedish school system

The Swedish primary and lower secondary school is compulsory by law and 9 years in length where each scholastic year starts in mid-August and ends in early June. FGs received upon graduation in the 9th year determines the options available for a student to advance to USS. First, eligibility to any of the national programs in USS requires the student to pass all "core subjects" (Swedish, English and mathematics). Second, eligibility differs between vocational and higher education preparatory programs. In general, preparatory programs require a passing grade in an additional 9 subjects (passing certain subjects is necessary for some of these). Until 2011, vocational eligibility only required passing the core subjects while, 2011 and later, passing an additional 5 subjects was required (in total 8). If the number of applicants to a program exceeds the available slots, these are distributed to the highest achievers using a grade point sum, the *merit value*, constructed by scoring the alphabetical grade in each subject (0-20 points) and summing the student's 16 best-performing subjects (range 0-320).[26] A schematic of the Swedish school system is presented in Figure 1.

In the spring semester of their final year 9, students also take three tests in each of the core subjects. Each student receives a weighted grade in each subject that reflects overall performance on the tests and teachers are supposed to take these results into account when setting FGs at the end of the scholastic year.

The national USS programs are 3 years in length. Ineligible students are admitted to one of the introductory programs that prepare the student for either the labor market or one of the national programs.

Measures of school performance

Primary outcomes of school performance included eligibility for USS and the grade point sum. Eligibility to USS was indicated by eligibility to a vocational program (i.e., the lowest requirement) and was determined using FGs as outlined above. The grade point sum is available in the NSR. For comparison with previous research, we calculated a GPA for each student by dividing the grade point sum by the number of graded subjects (range 0.0-20.0). The grade point sum can complement a GPA as its sensitivity to the number graded subjects differ. For instance, a treatment may increase subject enrollment while leaving the

performance in these subjects unaffected. A measure of teacher assessed school performance (subsequently referred to as teacher assessment) was created by first converting the alphabetical grades as outlined in Figure 1, and subsequently subtracting grade points in weighted tests from the corresponding FG in each of the core subjects (range −20.0-20.0). Since the standardized tests can be considered as a more objective measurement of academic knowledge, this difference can be expected to be more sensitive to behavioral aspects of school performance. As performance in compulsory school determines the options to advance to USS, completion of USS was included in the sensitivity analyses to test whether associations between ADHD, ADHD medication, and performance in compulsory school replicated for USS completion, which was ascertained using LISA and available for students graduating 2008-2010.

Medication for ADHD

We first calculated the number of days of medication usage covered by each dispensation based on the defined daily doses dispensed and the accompanying dosage instruction when available. The extent of treatment was then calculated in months for each individual from the start of grade 7 until graduation (Figure 1) or test while ignoring treatment status during the summer holiday (June 1 to August 15), leading to a treatment range of 0 to 29 months. Details on this procedure are found in online Supplement 1, Figure S1, and Table S1.

Covariates

Information about individual background factors (sex, immigration background, and month of birth) were obtained from the Total Population Register (TPR). Information about comorbid diagnoses of developmental disorder (ICD10: F80-F89) and behavioral disorders (ICD10: F91-98) disorder were obtained from the NPR. Parents were identified through the Multi Generation Register, linked to the TPR for information on immigration status, and linked to LISA for information on disposable income and highest educational attainment in the year of graduation. Parental educational attainment was divided into 4 levels: at most one parent USS, both parents USS, at least one parent with a (3 years or less) university education or at least one parent with 4 years of university education or more. Income was divided into quartiles calculated over the average sum of parental income between the year of the child’s graduation from year 9 and the two preceding years to account for year-to-year fluctuations. When information on parental income and education was missing, information from the year closest to the child’s graduation was used if available.

Analyses

The association between ADHD and school performance—To explore school performance in adolescents with ADHD compared to adolescents without ADHD we used two types of regression models. Logistic regression models were used for the binary outcome eligibility for USS. When school performance was a continuous measure (i.e., the grade point sum, GPA, and teacher assessments) we used linear regression models. To disseminate the influence of potential confounding factors, each association was estimated with and without adjustments for covariates. Individual level covariates included were month of birth (continuous, range 1-12), sex, year of graduation (6 categories), years resident in

Sweden (range 0.0-16.0), age at graduation (<15.5, 15.5 to 16.5, >16.5), indicators (1 when present, 0 otherwise) of diagnosis of developmental and behavioral disorders respectively. Parental background factors included immigration status (no, one, or both parents born abroad), combined educational level, and income quartile. The adjusted model was estimated within school of graduation (i.e. a fixed-effects approach) using robust standard errors clustered on this unit.

The association between ADHD medications and school performance—We estimated the association between medication and school performance by extending the logistic (i.e., for binary outcomes) and linear (i.e., for continuous outcomes) regression models outlined above with treatment exposures. An indicator of ever being treated between the start of grade 7 and test or graduation was used to account for baseline differences between the treated and untreated groups in terms of the outcome. Months on ADHD medication (range 0.0-29.0) prior to test or graduation was entered as a continuous covariate. To account for non-linear effects, a quadratic term of months on ADHD medication was included in the models. When the quadratic term was statistically significant ($p<0.05$) the combined association was reported. Since estimates including non-linear effects differ according to treatment length, the estimates were scaled to 3 and 29 months to reflect treatment periods of 3 months and the entire three school years preceding graduation respectively. The relationship between the grade point sum and ADHD medication was also plotted against treatment length including estimates stratified by treatment length to assess the fit of the association.

Risk differences (RDs) and standardized coefficients (SCs)—To aid the interpretation of estimates in the logistic models, RDs were calculated for point estimates. The RD is the average difference in the probability of the outcome due to a unit change in the exposure (i.e., ADHD status or treatment length) predicted from the fitted model given the underlying covariate data.[27] For continuous outcomes, SCs were calculated by multiplying the point estimate with the standard deviation of the exposure and dividing with the standard deviation of the outcome. A standard deviation increase in the exposure thus increases the outcome with a standardized coefficient (SC) standard deviations. Point estimates of RDs and SCs were provided for estimates mentioned in text, and for all outcomes in supplementary tables.

Sensitivity analyses—The sensitivity analyses focused on the association between ADHD medication and school performance. First, different treatment groups were defined according to the pattern of dispensations and stratifying the analyses on these groups. Similar to previous research[17], continuous treatment was defined as a treatment extent covering the remaining 70 percent of the scholastic months following the student's first observed dispensation of ADHD medication up until the time of the outcome (test or graduation). Discontinuous treatment was defined as a treatment pattern not classifiable as continuous. Further details on the definition of these treatment groups are found in online Supplement 2, Figure S2, and Table S2. Second, we performed analyses excluding cases that did not carry a clinical diagnosis of ADHD, and third, excluding cases that were dispensed an ADHD medication prior to the 3-year period in which medication use was calculated.

Fourth, we used logistic regression models to investigate whether treatment length at graduation was predictive of not completing USS within 3 years among students graduating 2008-2010.

Analyses were conducted using R version 3.4.4 (R core team, Vienna, Austria), package drgee[28] for continuous outcomes and package bife[27] for binary. Routines in bife were also used to calculate RDs.

RESULTS

Descriptives

Of the 657,720 students graduating in 2008 to 2013, 29,128 (4.4%) students had either received a diagnosis of ADHD and/or dispensation of ADHD medication. There were fewer females in the ADHD group (35.8%), than in the student population without ADHD (49.4%). A larger portion of students with ADHD (12.5%) graduated later than expected based on their age, compared to students without ADHD (3.8%). A comorbid diagnosis of developmental disorder was found in 14.9% of the ADHD group compared to 1.2% in the unaffected group and for behavioral disorders 15.5% in the ADHD group compared to 1.9% in the unaffected group. Parents of students with ADHD had fewer years of education and were about 6 percentiles lower in the income distribution than parents of students without ADHD. The share of females was lower in the group treated with ADHD medications prior to graduation (27.9%) than the ADHD group in general. Otherwise the differences in the ADHD group by treatment status were negligible (Table 1).

The association between ADHD and school performance

Students with ADHD were at increased risk of not being eligible to USS, 37.6% compared to 10.7% in the student population unaffected by ADHD; adjusted odds ratio (AOR) 4.70 (95% confidence interval [CI]: 4.56; 4.85); RD=19.9%. The ADHD group received a lower grade point sum (max=320), 136.8 compared to 211.0 points among students unaffected by ADHD; adjusted grade point difference (β_A) −56.40 (−57.47; −55.33); SC=−0.17. ADHD was negatively associated with teacher assessments (i.e., FG minus test) in Swedish and English, but displayed a positive association in mathematics (Table 2). ADHD associated with significantly lower grade points (β_A) in tests and FGs of core subjects (Swedish, English, and mathematics), and other subjects, ranging from −2.32 to −3.99 grade points (see Table S3, available online).

The association between ADHD medication and school performance

One treatment period (i.e., three months) significantly decreased the odds of not being eligible to USS, AOR=0.80 (0.76; 0.84), RD=−1.9%, and was associated with a higher grade point sum of β_A=9.35 (7.88; 10.82) points, SC=0.20. Positive associations were observed between ADHD medication and teacher assessments (i.e., FG minus test) in all core subjects (Table 3). Statistically significant, positive associations between ADHD medication and FGs (β_A range 0.09 to 0.58) were observed for all subjects while the only significant association with tests was found for mathematics and Swedish (see Table S4, available online).

Scaling the adjusted estimates to the maximum treatment length (29 months) amounted to a lower likelihood of not being eligible for USS of AOR=0.50 (0.39; 0.63), RD=−6.0%, and a grade point sum β_A=40.84 (34.49; 47.18) points higher (Table 3). Figure 2 illustrates the association between treatment length and the grade point sum, including the modeled trend, absolute and relative (adjusted) grade points stratified by treatment length. The model displays a close dose-response relationship with the relative grade points when extrapolating the estimated association beyond the 3-month treatment period and indicates that the effect of medication is diminishing over treatment length. This means that according to the model, the estimated difference in grade sum between, for instance, 18 and 21 months of treatment is smaller than the corresponding difference between 3 and 6 months.

Sensitivity analyses

Stratifying the analyses by treatment group (continuous or discontinuous) did not reveal any systematic differences between the groups in terms of school performance (see Table S5, available online). The associations also remained robust to the exclusion of ADHD cases without a clinical diagnosis of ADHD, and cases with a dispensed medication prior to the period over which medication use was calculated (see Table S6–7, available online). Treatment length prior to graduation from compulsory school was predictive of completing USS within 3 years where one treatment period was significantly associated with a reduction in the odds of not completing USS, AOR=0.89 (0.87; 0.91); RD=−1.8% (Table 3).

DISCUSSION

To our knowledge, this is the largest study to examine the associations among ADHD, medication usage, and school performance. We used a population cohort of 657,720 individuals graduating from compulsory school between 2008 and 2013. The main findings were that ADHD has a substantial negative impact on school performance that is independent of several important confounders (e.g., parental education), and that pharmacological treatment for ADHD is associated with an attenuation in this relationship. For instance, we estimated the ADHD associated risk of ineligibility for USS to 19.9 percent and the modeled risk reduction associated with the longest treatment length to −6.0 percent yielding a residual risk of 13.9 percent. Our findings thus highlight the need to detect ADHD at an early stage, and that other non-pharmacological educational interventions are likely needed if school performance in students with ADHD is to be normalized. From an educational policy perspective, it can be proposed that pharmacological treatment should at most be viewed as an aid to facilitate learning, and without the proper educational support for the affected students it appears unlikely that such treatment would translate into large gains in knowledge.

Our finding that pharmacological treatment for ADHD is positively associated with several measures of school performance is consistent with previous observational studies.[17,21,22] The largest previous study (N_{ADHD}=3543) reported an improvement in GPA of 0.11 points during stimulant adherent marking periods (≈78 days).[17] Expressing this effect as a percentage of maximum GPA (4.0) would yield an effect size of 2.7%. The corresponding effect size in our study was 2.1% which indicates a weaker relationship between ADHD

medication and school performance, possibly due to differences in source population (Medicaid claims versus national registers), study question (treatment adherence versus length), and school system as students in Sweden are generally not separated based on abilities (with some exceptions). Other available studies are less comparable due to differences in design, outcome measures, or substantially longer follow-ups than the three years used in our study. Of these, a small study (N_{ADHD}=90) where participants had an average treatment duration of 5.33 years found that medicated individuals had a 0.6 point higher GPA (max=4.0) compared to unmedicated individuals.[21] Concerning standardized tests, one of the larger studies (N_{ADHD}=594) found that ADHD medication was associated with a 2.9 point higher score in mathematics and 5.4 in reading.[22] Other studies have found significant positive correlations in this domain, but do not report effect sizes.[19,20,29] Our findings are inconsistent with two follow-ups of the MTA-study reporting no statistically significant association between past year ADHD medication use and GPA[20], and between 8-year medication use and test scores in mathematics.[19] The differences could be due to several factors. First, it is unclear whether these studies addressed confounding by indication appropriately (i.e., whether ADHD medication was indicative of lower school performance). This is problematic as our results illustrate (Figure 2) that students receiving ADHD medication prior to graduation are performing worse in terms of school performance compared to students treated later or not at all. Thus, not accounting for the baseline differences between treatment groups may bias the estimated effect of ADHD medication on school performance. Second, our results indicate that improvements in school performance diminish with increasing treatment length. It is possible that the additional gains at the 8-year follow-up are too small to detect given the sample size in the MTA-study and the low frequency of treatment naïve individuals.

Our study extends previous research on ADHD, the effect of ADHD medication, and school performance in several ways. First, by estimating how the usage of ADHD medication over several years affects school performance we show how short-term effects potentially translate to long-term effects.

Second, by including a measure of teacher assessment (the grade point difference between FGs and tests) we were able to include a more comprehensive set of school performance measures and thereby explore new aspects of how ADHD, and ADHD medication, is associated with school performance. We found that, after accounting for their test performance, students with ADHD receive a lower FG in Swedish and English, but a higher FG in mathematics, compared to students without ADHD. Consistent with previous research,[18,19] these findings suggest that teacher assessment differs by ADHD status. Furthermore, research using Swedish data has revealed that differences between tests and FGs are systematically related to student background characteristics such as sex and socioeconomic status.[30] Possible explanations for the negative differences (Swedish and English), and positive difference in mathematics, are that the behavioral aspects associated with ADHD, such as classroom productivity and disturbance, are taken into account by teachers as the classroom environment likely differs between languages and mathematics. If, and to what extent, this type of grading behavior exists in other educational systems is an important direction for future research on ADHD and school performance to take.

Third, the positive associations between ADHD medication and teacher assessments coupled with the absent, or small relative to FGs, associations with tests (see Table S4, available online), suggest that the main treatment related improvements are not in terms of subject knowledge as measured by standardized tests. As Swedish and English are subjects that place more focus language related skills (e.g., reading, writing) than mathematics, potentially medication affects these subjects differentially via their respective skill requirements. Such an interpretation is supported by a recent meta-analysis of the effect of methylphenidate on academic performance reporting positive effects on mathematics productivity and accuracy, but only productivity for reading.[31] This highlights the importance in considering the domain (e.g., academic knowledge, classroom behavior and productivity) of school performance when assessing the potential benefits of ADHD medication.

The current study has limitations that need to be highlighted. It is not possible to determine whether students received concurrent non-pharmacological treatment or supportive measures such as teaching in a smaller group setting, help by extra personnel, or if the school specialized in teaching students with ADHD, as this information is not available in the registers. According to a report from 2016, about 5 percent of 7th graders and 8 percent of 9th graders in Sweden receive some form of educational support in compulsory school.[32] The presence of such supportive resources is not necessarily problematic since these interventions are likely to cluster at the school level and are thus accounted for in our analyses. However, if treatment is increasing in schools in which such resources are provided over time, or other unmeasured factors correlated with treatment length are present, our estimates might be positively biased. We do find that the strongest predictor of treatment assignment and length by far is year of graduation, reflecting an increase over time in the utilization of ADHD medication, but that other measured background factors at the individual and parental level are of relatively low importance neither for the extent of treatment nor for initiating treatment earlier or individual treatment pattern (see Table S8, available online). Nonetheless, despite controlling for an important set of confounders, it must be emphasized that the non-randomized design with regards to pharmacological treatment initiation is an inherent limitation of our results that precludes a causal interpretation.

ADHD is associated with substantially lower school performance. Pharmacological treatment of ADHD is associated with higher grades, eligibility for, and completion of, USS. The strength of these associations suggest that interventions targeting school performance should be initiated early, in conjunction with medication when considered appropriate by clinicians and the relevant stakeholders, for closing the school performance gap associated with ADHD. Potential beneficial effects of medication on school performance should be carefully weighed against potential adverse effects of medication, including side-effects (e.g., disturbed sleep, appetite loss), and problems with misuse and diversion.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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CLINICAL GUIDANCE:

- Students with ADHD are at risk for poor school performance.
- Duration of medication use is associated with higher levels of school performance.
- Parents and teachers should be encouraged to monitor school performance in students with ADHD and address difficulties at an early stage.

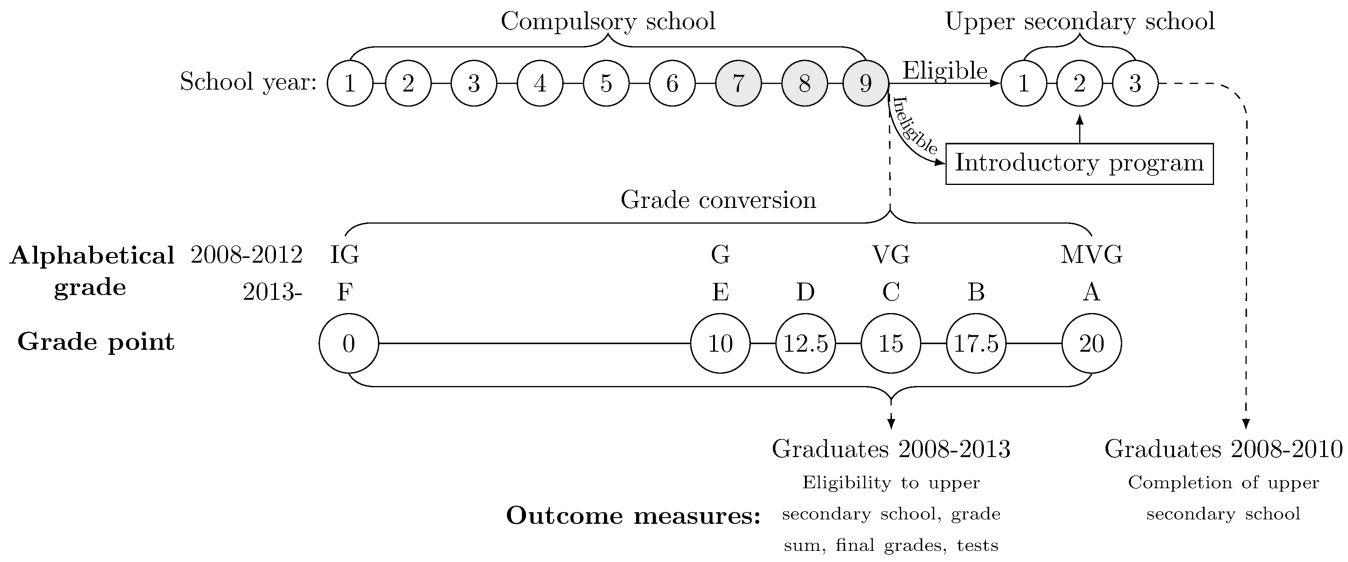

FIGURE 1.

Measurement of Medication Use, Grade Conversion, and Outcome Measures in the Swedish School System from Compulsory to Upper Secondary School

Note: Medication use measured during year 7-9 (shaded circles).

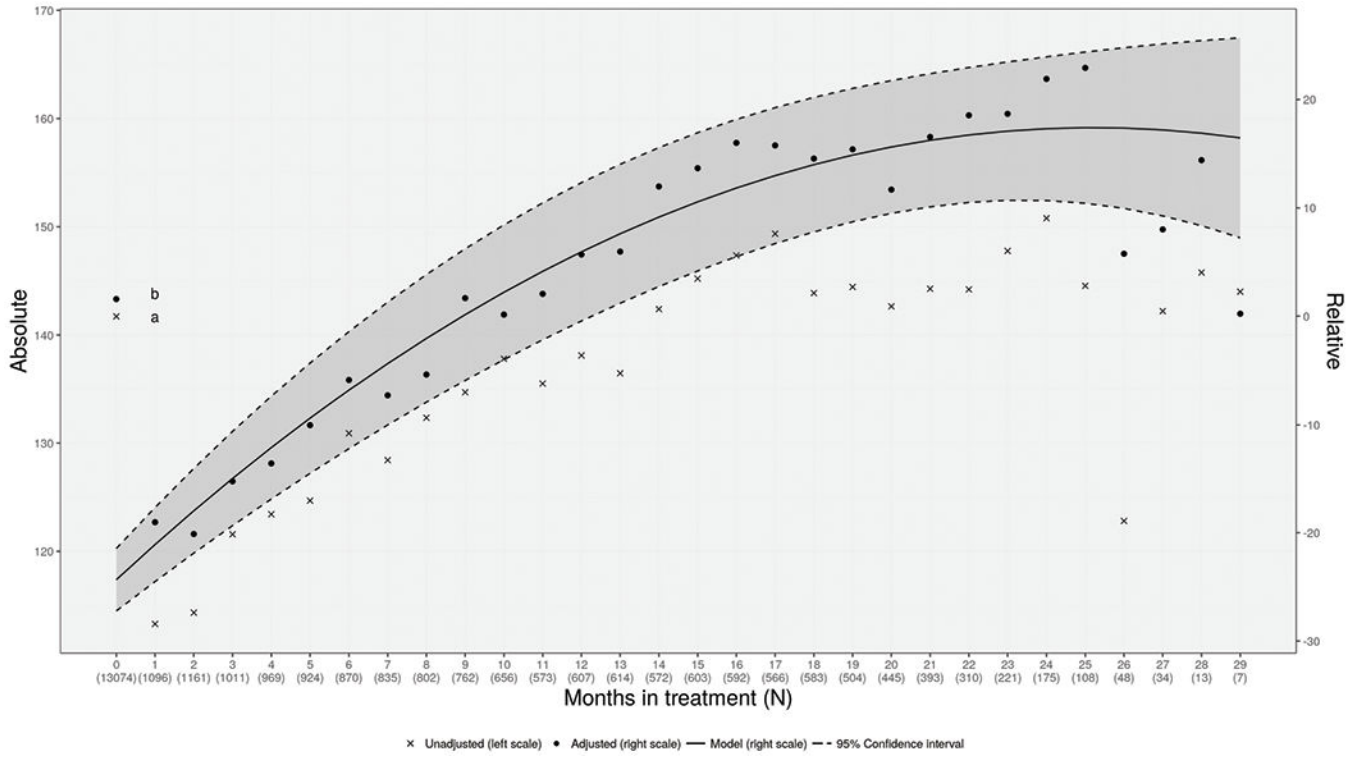

FIGURE 2.

Grade Point Sum by Length of Treatment with Attention-Deficit/Hyperactivity Disorder (ADHD) Medication

Note: See Table 3 for details of the statistical model. Months in treatment (prior to graduation from compulsory school) have been rounded upwards.

Left scale: Crosses represent the means. (a) Students with ADHD not treated prior to graduation.

Right scale: Dots represent the adjusted grade point sum by treatment length relative to students with ADHD not treated prior to graduation. The black line represents the modelled change in grade point sum extrapolated over treatment length. (b) The adjusted grade point sum of students with ADHD not treated prior to graduation relative to those treated prior to graduation

TABLE 1.

Demographic Characteristics of the Student Population Graduating Swedish Compulsory School 2008-2013 by Attention-Deficit/Hyperactivity Disorder (ADHD) and Treatment Status

	Non-ADHD	ADHD	Treated prior to graduation
Total	628,592 (95.6)	29,128 (4.4)	16,054 (55.1)
Individual background			
Female	310,592 (49.4)	10,435 (35.8)	4,485 (27.9)
Age at graduation			
Less than 15.5	50,610 (8.1)	1,925 (6.6)	992 (6.2)
15.5 to 16.5	553,941 (88.1)	23,562 (80.9)	12,701 (79.1)
Greater than 16.5	24,041 (3.8)	3,641 (12.5)	2,362 (14.7)
Birth month[a]	6.2 (3.4)	6.6 (3.4)	6.6 (3.4)
Immigrant	52,576 (8.4)	1,469 (5.0)	821 (5.1)
Years resident in Sweden	15.3 (2.7)	15.8 (1.4)	15.8 (1.4)
Comorbidity			
Behavioral disorder	12,040 (1.9)	4,502 (15.5)	2,699 (16.8)
Developmental disorder	7,387 (1.2)	4,332 (14.9)	2,607 (16.3)
Family background			
Immigrant	135,049 (21.7)	4,471 (15.7)	2,259 (14.4)
One parent born abroad	56,248 (9.0)	2,759 (9.7)	1,465 (9.3)
Both parents born abroad	78,801 (12.7)	1,712 (6.0)	794 (5.1)
Parental income percentile[a]	50.8 (28.9)	45.0 (27.7)	45.3 (27.5)
Missing	6,619 (1.1)	633 (2.2)	388 (2.4)
Parental education			
One parent secondary education	128,695 (20.7)	8,146 (28.6)	4,567 (29.2)
Both parents secondary education	180,397 (29.1)	9,477 (33.3)	5,392 (34.5)
At least one parent tertiary education	217,555 (35.1)	8,087 (28.4)	4,266 (27.3)
At least one parent 4 years of tertiary education or more	93,636 (15.1)	2,758 (9.7)	1,423 (9.1)
Missing	8,309 (1.3)	660 (2.3)	406 (2.5)

Note: N (%) unless specified.

[a]Mean (standard deviation)

TABLE 2.

The Association Between Attention-Deficit/Hyperactivity Disorder (ADHD) and School Performance in the Student Population Graduating Swedish Compulsory School

	ADHD status		Estimated association with ADHD	
	ADHD	Non-ADHD	Unadjusted	Adjusted
Outcome	**N (%)**		**OR (95% CI)**	
Not eligible to USS	10,954 (37.6)	67,505 (10.7)	5.01*** (4.89; 5.14)	4.70*** (4.56; 4.85)
Not completed USS	9,583 (67.8)	74,296 (21.9)	7.50*** (7.23; 7.78)	5.84*** (5.61; 6.08)
	M (SD)		**Grade point β (95% CI)**	
Grade point average	9.0 (4.1)	13.3 (3.8)	−4.30*** (−4.35; −4.25)	−3.29*** (−3.35; −3.23)
Grade point sum	136.8 (71.8)	211.0 (64.7)	−74.21*** (−75.05; −73.37)	−56.40*** (−57.47; −55.33)
Teacher assessment				
Swedish	0.3 (3.4)	0.7 (2.7)	−0.45*** (−0.50; −0.41)	−0.35*** (−0.40; −0.31)
English	−0.3 (2.6)	0.1 (2.2)	−0.33*** (−0.36; −0.29)	−0.25*** (−0.29; −0.21)
Mathematics	1.9 (4.0)	1.6 (3.4)	0.24*** (0.18; 0.29)	0.23*** (0.17; 0.29)

Note: The sample includes all students that graduated compulsory school 2008-2013 unless specified. ADHD status determined by lifetime in-/outpatient diagnosis of ADHD or dispensation of ADHD medication. The adjusted model is estimated within the school unit and standard errors have been clustered on this unit. Covariate adjustments include sex (2 levels), year of graduation (6 levels), parental education (4 levels) and income quartile at graduation (4 levels), parents born abroad (none, one or two), years resident in Sweden (0.0-16.0), month of birth (1-12)), age at graduation (<15.5, 15.5 to 16.5, >16.5), indicators of comorbid developmental and behavioral disorder.

USS: Upper secondary school.

Not eligible to USS: Indicator of being eligible to USS requiring passing Swedish, English, Mathematics for graduates 2008-2010, and for graduates 2011-2013 passing an additional 5 subjects for a vocational program.

Not completed USS: Indicator of having completed USS within 3 years of graduation within the student population graduating compulsory school 2008-2010.

Grade point sum: The sum of grade points in leaving certificates of the student's 16 best performing subjects.

Teacher assessment: Grade point difference between final grade and weighted test.

*: p < 0:05

**: p < 0:01

***: p < 0:001

TABLE 3.

The Association Between Attention-Deficit/Hyperactivity Disorder (ADHD) Medication and School Performance in the Swedish Student Population Graduating Compulsory School

	Treatment status prior to graduation		Effect over one treatment period		Effect over 3 school years	
	Treated	Not treated	Unadjusted	Adjusted	Unadjusted	Adjusted
	N (%)		OR (95 % CI)		OR (95 % CI)	
Not eligible to USS	6,347 (39.5)	4,607 (35.2)	0.82q^{***} (0.78; 0.86)	0.80q^{***} (0.76; 0.84)	0.75q^{**} (0.61; 0.91)	0.50q^{***} (0.39; 0.63)
Not completed USS	3,952 (65.2)	5,631 (69.8)	0.92*** (0.90; 0.94)	0.89*** (0.87; 0.91)	0.43*** (0.34; 0.54)	0.32*** (0.25; 0.42)
	Grade point mean (SD)		Grade point β (95% CI)		Grade point β (95% CI)	
Grade point average	8.7 (4.0)	9.3 (4.1)	0.49q^{***} (0.39; 0.58)	0.49q^{***} (0.40; 0.58)	1.44q^{***} (1.05; 1.82)	2.38q^{***} (2.01; 2.75)
Grade point sum	132.7 (70.4)	141.7 (73.2)	9.61q^{***} (8.07; 11.16)	9.35q^{***} (7.88; 10.82)	26.87q^{***} (20.19; 33.35)	40.84q^{***} (34.49; 47.18)
Teacher assessment						
Swedish	0.3 (3.4)	0.2 (3.3)	0.08*** (0.05; 0.11)	0.10*** (0.07; 0.12)	0.75*** (0.49; 1.02)	0.92*** (0.66; 1.18)
English	−0.2 (2.5)	−0.3 (2.7)	0.02* (0.00; 0.04)	0.04*** (0.02; 0.06)	0.22* (0.03; 0.41)	0.36*** (0.17; 0.54)
Mathematics	1.8 (3.9)	2.0 (4.1)	0.03* (0.00; 0.06)	0.05** (0.02; 0.08)	0.31* (0.00; 0.63)	0.49** (0.18; 0.80)

Note: See Table 2 for general details on outcomes and the models used. Treatment status prior to graduation determined by a dispensation of an ADHD medication prior to graduation from compulsory school. The model includes treatment length in months prior to graduation (max=29), and the estimates have been scaled by 3 and 29 months to reflect the effect of the defined treatment period and treatment from start of grade 7 to graduation at grade 9 respectively. In addition to the covariates specified in Table 3, the model included an indicator of treatment prior to graduation so that the baseline is the average performance in those who were treated prior to graduation.

USS: Upper secondary school.

q – Quadratic term of treatment length included.

*: p < 0:05

**: p < 0:01

***: p < 0:001