

RESEARCH ARTICLE

Social gradients in ADHD by household income and maternal education exposure during early childhood: Findings from birth cohort studies across six countries

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Data Availability Statement: Data underlying the results presented in this EPOCH study are available from the primary data sources. Data from the UK Millennium Cohort Study is available in a public open-access repository (<https://cls.ucl.ac.uk/cls-studies/millennium-cohort-study/>). Data from the Longitudinal Study of Australian Children (LSAC) is available in a public, open-access repository (<https://growingupinaustralia.gov.au/data-and-documentation>). Data from the US NLSY-79 is available in a public open-access repository

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Abstract

Objective

This study aimed to examine social gradients in ADHD during late childhood (age 9–11 years) using absolute and relative relationships with socioeconomic status exposure (household income, maternal education) during early childhood (<5 years) in seven cohorts from six industrialised countries (UK, Australia, Canada, The Netherlands, USA, Sweden).

Methods

Secondary analyses were conducted for each birth cohort. Risk ratios, pooled risk estimates, and absolute inequality, measured by the Slope Index of Inequality (SII), were estimated to quantify social gradients in ADHD during late childhood by household income and maternal education measured during early childhood. Estimates were adjusted for child sex, mother age at birth, mother ethnicity, and multiple births.

Findings

All cohorts demonstrated social gradients by household income and maternal education in early childhood, except for maternal education in Quebec. Pooled risk estimates, relating to

(<https://www.nlsinfo.org/content/cohorts/nlsy79-children>). Data from the Rotterdam, Netherlands Generation R are available to request from (<https://generationr.nl/researchers/>); authors do not have permission to share their data. Data from the Sweden Alia Barn I Sydöstra Sverige (ABIS) are available to request from (<http://www.abis-studien.se>); authors do not have permission to share their data. Data from the Quebec Longitudinal Study of Child Development (QLSCD) is available to request from (<https://www.maelstrom-research.org/mica/individual-study/qlscd#>); authors do not have permission to share their data.

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44,925 children, yielded expected gradients (income: low 1.83(CI 1.38,2.41), middle 1.42 (1.13,1.79), high (reference); maternal education: low 2.13(1.39,3.25), middle 1.42 (1.13,1.79)). Estimates of absolute inequality using SII showed that the largest differences in ADHD prevalence between the highest and lowest levels of maternal education were observed in Australia (4% lower) and Sweden (3% lower); for household income, the largest differences were observed in Quebec (6% lower) and Canada (all provinces: 5% lower).

Conclusion

Findings indicate that children in families with high household income or maternal education are less likely to have ADHD at age 9–11. Absolute inequality, in combination with relative inequality, provides a more complete account of the socioeconomic status and ADHD relationship in different high-income countries. While the study design precludes causal inference, the linear relation between early childhood social circumstances and later ADHD suggests a potential role for policies that promote high levels of education, especially among women, and adequate levels of household income over children's early years in reducing risk of later ADHD.

Introduction

Attention-Deficit/Hyperactivity Disorder (ADHD) is amongst the most common mental health disorders in childhood. Early studies of the worldwide prevalence of ADHD reported rates between 8–12% [1]. More recent meta-regressions of over 100 studies spanning the globe estimate that the identified prevalence rates hover around 3.4–5.29% [2, 3]. ADHD can be considered as arising from a range of genetic, neurological, and environmental conditions that can act individually or together [4]. ADHD's heterogenous phenotype is empirically linked to multiple aetiologies including: hereditary polygenic gene variants, neurological factors during brain development, environmental toxin exposure, and early deprivation [5].

ADHD's association with socioeconomic status (SES) has been reported in a systematic review published in 2016 [6]. Russell et al.'s review identified 42 studies, 35 of which reported a significant association of at least one measure of low SES with ADHD. Across multiple dimensions (i.e., maternal education, paternal education, single parent families, occupation, income), lower SES was robustly associated with ADHD. Children from lower SES families were twice as likely (Odds Ratio 1.85 to 2.21) to have ADHD compared to those from high SES families. Further, Russell and colleagues noted this finding appeared to be universal across continents. Population-based cohort studies, which were published since Russell et al.'s systematic review, have reported an association between household income and/or maternal education in early childhood with ADHD during later childhood in four high-income countries: the UK [7–12], Sweden [13, 14], Denmark [15, 16] and Korea [17]. Reported effect sizes for late childhood ADHD were modest, ranging from an adjusted hazard ratio of 2.09 (95% Confidence Interval (CI) 2.00–2.19) [13] to an unadjusted odds ratio of 1.72 (95% CI 0.94–3.18) [8] for low compared with high household income during early childhood, and an unadjusted odds ratio of 1.45 (95% CI 1.21–1.73) [10] for low compared with high maternal education. Furthermore, a social gradient was evident in eight of these cohort studies [7–9, 13–15, 17]. We are not aware of published studies reporting *absolute* measures of inequality in ADHD. Indeed, few studies compare the association of ADHD with SES using compatible measures in more than one country; one cross-sectional study reported on the association in five European countries [18] and one study compared results from a UK and Brazilian birth cohort [10].

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The measurement of ADHD is fundamental when comparing prevalence rates and their determinants across countries. Diagnostic definitions have evolved over time: 'minimal brain dysfunction' and 'organic brain dysfunction' morphed into 'hyperkinetic disorder', 'attention deficit disorder', and 'attention deficit hyperactivity disorder'. ICD and DSM are the two international medical classification systems used globally. The ICD-10 definition of Hyperkinetic Disorders with disturbance of activity and attention (F90.0) [19] differs from the DSM-5 definition of Attention-deficit/Hyperactivity Disorder (314.0X) [20]; ICD-10 yields a lower prevalence rate because of its more stringent criteria requiring symptoms for inattention, hyperactivity, and impulsivity [21]. These differences in definition likely explain differences in prevalence rates between Europe and North America as the ICD-10 definition is more commonly used in Europe and the DSM-5 is more commonly used in the US and the rest of the world. The more recent ICD-11 introduces emerging convergence toward a consensus definition with criteria closely aligned with the DSM-5 [22]. Other diagnostic differences across countries are also relevant, including which health professionals are licensed to diagnose ADHD (e.g., primary care clinicians, pediatricians, general family physicians, psychiatrists, clinical psychologists, social workers, other health professionals), the clinical assessment method used, and the rigor of applying diagnostic criteria. Of particular relevance to this study, ADHD diagnosis may be limited by income, insurance, access to a diagnostic professional, or parental engagement for seeking assessment.

The Elucidating Pathways Of Child Health inequalities (EPOCH) study draws on data from seven birth cohort studies from six countries to explore the pathways from early SES exposure to child health outcomes at age 9–11 years. The EPOCH study, funded by the Canadian Institutes of Health Research (CIHR), was conceived and planned by researchers in the International Network for Research on Inequalities in Child Health (INRICH) [www.inrichnetwork.org]. Researchers reviewed and considered large, population-based birth cohorts from their respective countries that had comparable data aligned with the UNICEF child well-being outcomes. We acknowledge potential bias in selection of participating countries due to data accessibility; however, all included countries are high income with contrasting social policies and distributed along the gradient of country-level measures of income inequality. In addition, the birth cohort enrollments were largely conducted during the same time period (i.e., age 0–1 recruitment years: 1997–2004), with the exception of the US cohort (i.e., recruitment years: 1988–1996). The impact of low socioeconomic status in early childhood on adult health has been extensively studied [23], but less attention has been given to its impact across childhood and adolescence [24]. The EPOCH study aims to address this gap in the literature. This project within the EPOCH study explores pathways to ADHD. The paper aims to examine the relationship of household income and maternal education as separate measures of SES exposure during early childhood to ADHD during late childhood in the different country settings represented by the participating cohorts.

Methods

Data sources

Data were extracted from seven birth cohorts participating in the EPOCH study: UK Millennium Cohort Study (MCS); Alla Barn i Sydöstra Sverige (All Babies in Southeast Sweden, ABIS); Quebec Longitudinal Study of Child Development (QLSCD); Longitudinal Study of Australian Children B cohort (LSAC B); Generation R, Rotterdam, The Netherlands (GenR); National Longitudinal Study of Children and Youth, Canada (NLSCY); and National Longitudinal Study of Youth, USA (US NLSY). Concordia University Human Research Ethics Committee certified the ethical acceptability for EPOCH's secondary data use (#2011028). All

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original birth cohorts complied with the ethical standards of their relevant institutional and/or national committees and with the Helsinki Declaration of 1964, and its later amendments. As part of the original cohort methodology, information summarizing what participation would involve was provided in both oral and written form; explicit informed written consent was obtained for all participants (parents, guardians). Cohort profiles and cohort technical report references are shown in [Table 1](#). All cohorts enrolled population-based samples of children at birth or within the first 2 years of life. The US cohort was based on the 1996 Child Supplement and included children who were born to female participants of the nationally representative 1979 National Longitudinal Survey of Youth (NLSY79). The Southeast Sweden cohort, based on comprehensive medical records and linked to administrative databases, had the lowest attrition rate (3.9%) whereas attrition rates for the remaining cohorts varied between 24.2% (Rotterdam, The Netherlands) and 39.1% (Canada, all provinces). Weights and/or imputation accounting for differential attrition and non-response were applied in all cohorts except South-east Sweden.

ADHD outcome variable

Attention Deficit Hyperactivity Disorder (ADHD) was measured in late childhood. [Table 2](#) shows the measurement specifications for each cohort. All cohorts were based on DSM-IV or ICD-10 criteria. ADHD diagnosis was based on parental report of medical diagnosis or diagnostic criteria for all cohorts, except ABIS, which was derived from Swedish medical records. The Dutch cohort (Netherlands, GenR) used a DSM-oriented symptom scale with a pre-defined clinical cut-point (98th percentile) and the timeframe was limited to past 6 months. The US cohort (US NLSY) recorded 'limiting' hyperkinesis/hyperactivity/attention deficit disorder, whereas all other cohorts recorded 'ADHD ever diagnosed'.

Main independent variables of interest

Household income and maternal education are two of the most common measures of SES in observational studies [\[34\]](#). Household income and maternal education, measured in the first five years of life, were available in all cohorts allowing harmonisation of these key variables. Household income tertiles at birth or within early life with ranges and means in local currency and \$Purchasing Power Parity 2000 (\$PPP) [\[35\]](#) were obtained for each cohort. [Table 3](#) shows differences in income data collection. Four cohorts collected household income net of tax and transfers; the three other cohorts collected gross income. Three cohorts reported equalized income that was derived by dividing household income by a factor calculated based on the number of household members as follows: the first adult member of the household is given an equivalence value of 1.0, the second adult 0.5 and each subsequent person aged 14 and over 0.5, each child aged under 14 adds a value of 0.3 [\[36\]](#). \$PPP ranges for the low income groups vary widely; low income households in the Rotterdam, The Netherlands cohort had the highest purchasing power, while low income households in the UK cohort had the lowest. Maternal education at child's birth or within first year of life was harmonized to high, middle, and low using the International Standard Classification of Education (ISCED): low education = ISCED I-II; middle education = ISCED III-IV; high education = ISCED V-VII [\[37\]](#).

Baseline confounding variables

Cohort surveys defined ethnicity using 'Majority / Minority' or 'Born inside country / Born outside country' designations; Mother Ethnicity was dichotomized using these designations. Aboriginal (Australia) and First Nation (Quebec) mothers were classified as 'Born in country' in these cohorts. Additional confounding variables included maternal age at child's birth, child

sex, and multiple births. The Quebec cohort did not include multiple births as it had singleton births only.

Statistical analyses

We estimated unweighted frequencies for all variables. We estimated unadjusted and adjusted Risk Ratios (RRs) using a generalized linear model with a log link and robust variance estimation (see [S1 Appendix](#) for details of data analysis in each cohort) [38]. The level of significance was set at $p < .05$ (two-tailed) for all analyses. Potential mediators identified in previously published literature (smoking in pregnancy [7], birth weight [10], lone parenthood [39], breast feeding [40], low parental involvement [7], maternal mental health [12]), which are potentially on the pathway between early childhood SES and ADHD in late childhood were excluded from the regression models to avoid overcontrolling for the effect of SES. In cohorts with loss to follow-up, either censoring and/or sample weights were used to adjust for nonresponse and/or make the sample comparable to a reference population. Only the Southeast Sweden cohort did not use sample weights because the cohort did not experience differential attrition due to the use of nationwide health records containing ADHD diagnosis information for all children.

After Risk Ratios were estimated, they were pooled using the Meta for package in R [41]. We estimated the I^2 , which is the percentage heterogeneity in RRs among studies, relative to the total amount of variance. The Slope Index of Inequality (SII) was estimated for each population. SII estimates the absolute advantage of higher income or education, interpreted as the absolute difference in percentage of ADHD from the highest to the lowest level in the social hierarchy. SII is a regression-based index that accounts for the socioeconomic distribution of the population, excluding the size of socioeconomic groups as a source of variability in estimating the magnitude of inequalities in health [42]. Differences in ADHD prevalence between the least and the most advantaged groups were estimated for each cohort by extrapolation from the weighted prevalence estimates for each of the income tertiles and the three levels of maternal education. The SIIs were weighted to adjust for differential loss to follow-up in GenR and to weight back to the population in the NLSCY, MCS, LSAC, QLSCD and USNLSY cohorts. If given a causal interpretation, the SII estimates how much ADHD prevalence would be reduced if income or maternal education were improved in each population. Compared to relative risks, absolute estimates of risk have a different public health utility as they reflect the magnitude of a health outcome within a population; thus, instead of comparing risks among groups, absolute risks convey what percentage of the population is affected. On the other hand, relative risks are multiplicative; they show how much more disadvantaged groups are affected compared to wealthier counterparts. Relative risks convey relative inequality, and therefore, are useful when considering issues of social justice.

Results

Samples for all cohorts were drawn from whole populations and were broadly representative of the target populations ([Table 1](#)). The design of the US cohort resulted in no children born to mothers under the age of 24 years being enrolled, thus excluding at least 5% of the child population [43]. Numbers of children with complete data on exposures in early childhood and ADHD in late childhood are shown in [Table 4](#). Pooled estimates relate to a total of 44,925 children in late childhood. Cohort sample characteristics by unweighted frequencies are shown in [Table 4](#). Prevalence of ADHD ranged from 1.3% in the UK to 7.6% in Quebec. Levels of maternal education at baseline varied widely by cohort: Quebec and UK cohorts have the largest proportion of mothers with low education (28.6% & 20.8%, respectively) and Sweden and

Australia, the smallest (8.4% & 9.0% respectively); the proportion of mothers with high education was larger in Australia (47.8%) and Canada (all provinces, 42%), than in the remaining cohorts. Proportion of mothers from ethnic minority groups or born outside the cohort country was lowest in Southeast Sweden (6.5%) and highest in the US cohort (43.9%); the US cohort (US NLSY) purposely oversampled minority groups (n.b., sample weights applied to inferential statistics adjusted for oversampling). Proportion of mothers below 20 years of age at their child's birth in the Canada cohort (23%) was high and an outlier compared with all other cohorts with proportions less than 10%.

Unadjusted Relative Ratios (i.e., bivariate risk ratios; RRs) of ADHD by income tertiles, the three categories of maternal education, and confounding variables (i.e., child sex, mother age at birth, mother ethnicity, multiple births) are shown in [S1 Table](#). Adjusted RRs, adjusting for all confounding variables, are shown in [Table 5](#). For maternal education categories, social gradients were present in all cohorts, except Quebec. Additionally, confidence intervals around both estimates in the Canada (all provinces) and US cohorts crossed unity (see [Table 5](#)). For household income tertiles, adjusted RRs for ADHD by household income tertiles showed a tendency towards social gradients in all cohorts, except for the Quebec cohort, where the risk was higher for middle than low income; confidence intervals for both estimates crossed unity in the Australian, US, and Canada (all provinces) cohorts.

Pooled estimates were calculated for household income (low: 1.83, 95% CI = 1.38, 2.41; middle: 1.42, 95% CI = 1.13, 1.79) and maternal education (low: 2.13, 95% CI = 1.39, 3.25; middle: 1.42, 95% CI = 1.13, 1.79). Heterogeneity ranged from moderate to high (I^2 middle income 47.9%, middle education 47.9%, low income 51.3%, low education 79.8%). (Forest plots are shown in [Fig 1](#)).

Absolute inequality in ADHD during late childhood across the cohort populations confirms the advantage for children in high income households or those with more highly educated mothers in most cohorts. If we were to assign a causal interpretation to these estimates, the largest potential reduction in ADHD prevalence due to increased maternal education levels would be observed in Australia and Sweden (reduction in ADHD: 4% and 3%, respectively); while improvement in household income would lead to the largest reductions in Quebec and Canada (reduction in ADHD: 6% and 5%, respectively). These findings may seem to contradict the impression given by Relative Risks that the most severe inequalities by income are found in the UK and The Netherlands (RR of low vs high income: 4.2 and 2.19, respectively). However, while the poorest in these countries are at higher risk of ADHD compared to the wealthiest, the lower prevalence of ADHD means lower absolute risk at the population level. On the other hand, income changes would result in larger reductions in Canada where the prevalence of ADHD is higher. It should also be noted that while Relative Risks were adjusted for confounders (child sex, mother age at birth, mother ethnicity, multiple births), the SIIs were not. (SIIs plots are shown in [Fig 2](#)).

Discussion

The objective of the EPOCH study, of which this paper is a part, is to examine the pathways from SES around birth and in the first 5 years of life and a range of child health outcomes at 9–11 years of age in different high income country settings. An essential step in studying these pathways is to demonstrate social gradients in these outcomes in the participating cohorts. Although the study design limits causal inference, the finding of social gradients and the linear relationship by SES measures at baseline with ADHD during late childhood lends support to a possible causal role. To our knowledge, this is the first published paper examining social gradients in ADHD in later childhood, using relative and absolute measures of inequality, by

maternal education and household income in early childhood based on comparable data in cohort studies from different industrialised countries. The findings indicate that high SES exposure during early childhood, measured as maternal education or household income, is associated with lower risk of ADHD later at age 9–11. Pooled estimates showed that low maternal education at baseline was associated with a 113% higher risk of ADHD during late childhood, relative to high maternal education; middle maternal education was associated with a 42% higher risk. The equivalent risk increase for low household income was 83% and for middle household income was 42%, relative to high household income. Absolute inequality in ADHD in late childhood across the cohort populations confirms the advantage for children with more highly educated mothers or in high income households in most cohorts. Absolute inequality differs from relative inequality as it reflects the prevalence of the outcome, while accounting for the proportion of each level of SES in the population. The SII provides an estimate of the difference in ADHD prevalence between the highest and lowest levels of household income and maternal education in the cohort populations. Absolute inequality in ADHD has not previously been reported and, in combination with relative inequality, provides a more complete account of the SES ADHD relationship in different high income countries.

Our findings are compatible with those reported by Russell et al. [6] in their systematic review of the association of low SES with ADHD in childhood and adolescence. In addition, an association of low SES in early childhood with ADHD in later childhood is reported by other cohort studies [8–17] although different SES measures and methods of analysis limit comparison with our findings. Social gradients by household income in early childhood are reported in three studies [8, 9, 13]. The paper comparing UK and Brazilian cohorts reported an association in both cohorts with hyperactivity measured by the Strengths and Difficulties Questionnaire (SDQ) but not with “any ADHD disorder”, defined as ADHD sub-types (hyperactive-impulsive, inattentive and combined), measured by the Development and Well-Being Assessment (DAWBA) set of questions [10]. Three studies [12, 14, 17] found a social gradient in income trajectories in the early life course with increasing risk from never experiencing low income to persistent low income. Three studies [7, 8, 15] reported a social gradient in ADHD in later childhood by maternal education measured in early childhood. A further study [16] reported an association of ADHD with early childhood SES using a measure of low social class combining low parental education, low occupational status, and low income.

Comparison of findings for countries included in our study are consistent with findings from comparable UK and Swedish cohorts [7, 8, 12–14]. An Australian study using the LSAC K cohort (children enrolled at 4 years of age, versus the LSAC B cohort enrolled at birth) reported a social gradient by maternal education, but not by household income [44]. A paper based on the Quebec Longitudinal Study of Kindergarten Children (QLSKC) [45] reported an association of household income with ADHD measured when the child was 6 years old consistent with our findings from the QLSCD; however, in contrast to QLSCD findings of no association with ICESD level of maternal education measured when the child was 6 months of age, they reported an association with parental education based on whether or not the parent had a high school diploma by the age of 30. A 2007 cross-sectional study based on a nationally representative sample of the US child population, reported no association of ADHD with low maternal education, but a clear association with low income consistent with the US NLSY cohort findings, although reporting a higher prevalence rate of 8% [46]. A Dutch case-control study, nested within a cohort study, found no association of ADHD for low parental education during early childhood [47].

Interpretation

The findings of this study are broadly consistent with the conclusion of Russell et al.'s systematic review [6] that the association of ADHD with SES is found in different countries. Despite wide variation in ADHD prevalence, major differences in purchasing power parity and income distribution (see Table 3), and in levels of educational attainment (see Table 4), the findings indicate that, in the rich countries studied, high income or high maternal educational status in early childhood is associated with a lower risk of ADHD at 9–11 years. The pathways by which early childhood household income and maternal education exposure exert their influence on risk of ADHD later during childhood are likely to be complex and have not been fully elucidated. Low household income and/or low maternal education may expose children to established socially-related risk factors for ADHD (e.g., inconsistent parenting, family adversity, maternal anxiety/depression), across the early life course. Further, these children who are exposed to low household income and/or low maternal education at a young age are likely to experience longer periods of exposure to risk factors than their more advantaged peers, thereby increasing inequality in ADHD during later childhood. Alternative explanations, such as bidirectional pathways, where the child's ADHD affects parents' capacity for earning household income, also have been proposed [48]. However, by including income before ADHD diagnosis in our analyses, we have shown that the direction of association flows from income to ADHD and not the other way around. Furthermore, Russell et al. [7], in a large population-based study, found no evidence of income reduction associated with ADHD over the child's first 7 years of life. Another alternative explanation that might result in reverse causation is ADHD symptoms in parents leading to poor economic outcomes in adulthood at the same time as increasing the risk of their children developing ADHD. However, both inherited and non-inherited factors play a role in ADHD and their effects are interdependent [49]. The social gradients observed in our EPOCH study are likely to reflect a linear, dose-response relationship to exposure across income and maternal education categories to socially-related risk factors over the early life course in combination with inherited risk. Low maternal education was associated with a higher risk of ADHD in late childhood than low income in the pooled estimates suggesting that maternal education in early childhood might have more influence than household income on ADHD in late childhood. The absence of a gradient in maternal education in the Quebec cohort combined with the higher likelihood in the middle income group may be partly explained by long delays in the public system to access appropriate psychometric ADHD evaluation such that parents of more favorable socioeconomic status (i.e., more educated, higher income) can opt to pay for private services for testing rendering their children more likely to have an ADHD diagnosis [50].

Strengths and limitations

Harmonization of the SES measures across cohorts is one of the strengths of this study; however, as discussed above, wide variations in income distribution, purchasing power, and distribution of maternal education levels due to social and educational policy differences remain between cohorts. By analysing the effect of household income and maternal education separately, the analysis avoids potential collinearity and allows assessment of whether the effect of these two commonly used SES measures on late childhood ADHD differs. The analysis reduced the likelihood of overcontrolling for SES by excluding socially-related variables which are potential mediators, rather than confounders, of the SES ADHD relationship. All cohorts collected data on household income and maternal education prospectively within the child's first five years of life, ranging from pregnancy to the fifth year. Non-participation and differential attrition were accounted for by weighting and/or imputation in all cohorts except for

Southeast Sweden, which used administrative whole population data rendering weights unnecessary. The longitudinal nature of the analysis combined with the adjustment for differential attrition strengthen the causal interpretation of our estimates.

Several limitations should be taken into account when interpreting findings. Similar to previous worldwide comparisons, prevalence rates of ADHD varied widely [1, 2]. ADHD was based on parental report in all cohorts, except the ABIS cohort. While the use of diagnostic data harmonized across cohorts to address criticisms regarding methodological differences was a study strength, informant bias may have led to overreporting by low SES parents. However, Visser et al. [51] found parent-reported prevalence rates compatible with rates based on administrative data; and, Russell et al. [8] found no evidence of overreporting in disadvantaged groups. Furthermore, others have suggested a socioeconomic gradient exists for ADHD management based on measures of symptom severity and medication use, whereby higher socioeconomic status was associated with superior treatment response and reduction in ADHD symptomatology [52]. Alternatively, financial and insurance limitations on access to diagnostic services in some countries, as discussed above for Quebec, may partially explain variation in prevalence rates as may differences in which professionals are licensed to diagnose in different countries. Teachers are frequently involved in identifying hyperactive children [53] and the extent of their involvement may vary by country. The US prevalence rate is based on a nested question about hyperkineses/hyperactivity/minimal brain dysfunction/ADHD that asked only if the informant identified the child as having a limiting condition; this may have precluded identification of those with inattentive phenotypes or those with ADHD sufficiently managed that did not interfere with daily functioning. Although the pooled estimates for maternal education are consistent with those reported by Russell et al. [6], caution should be employed in interpreting them due to high levels of heterogeneity.

Conclusions

We have shown that children who were in high income households or had more educated mothers in early childhood were at lower risk of ADHD at age 9–11 in different high-income countries. Pooled estimates indicate that risk of ADHD in later childhood is more strongly related to early childhood exposure to maternal education than household income. We have estimated the percentage difference in ADHD prevalence between the highest and lowest levels of income and maternal education in each cohort population using SII, a measure of absolute inequality. In combination with relative inequality, absolute inequality provides a more complete account of the SES-ADHD relationship in the different cohort populations. The findings of this study confirm the association of early childhood SES with ADHD in later childhood; however, the explanation for this relationship remains unclear. Country-level social, economic, and political decisions have a major influence on household incomes during early childhood and maternal education in mothers' own childhood suggesting policies that promote adequate levels of household income over the child's early years and high levels of education, especially among women, have a potential role in reducing the risk of later ADHD and narrowing the social gradient. Health and educational services can contribute by providing support for parents through their children's early years. Future research should examine the mediators and moderators of the SES-ADHD pathway in early childhood to identify possible interventions to minimise risk associated with low income and low maternal education.

Supporting information

S1 Appendix. Details of data analysis & available data files.

(DOCX)

S1 Table. Bivariate analysis of ADHD by household income and maternal education and baseline confounders.

(CSV)

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References

1. Faraone S., Sergeant J., Gillberg C., and Biederman J., "The worldwide prevalence of ADHD: Is it an American condition?," *World Psychiatry*, vol. 2, no. 2, pp. 104–113, 2003. PMID: [16946911](https://pubmed.ncbi.nlm.nih.gov/16946911/)
2. Polanczyk G., de Lima M., Horta B., Biederman J., and Rohde L., "The worldwide prevalence of ADHD: A systematic review and meta-regression analysis," *American Journal of Psychiatry*, vol. 164, no. 6, pp. 942–948, 2007, <https://doi.org/10.1176/ajp.2007.164.6.942> PMID: [17541055](https://pubmed.ncbi.nlm.nih.gov/17541055/)
3. Polanczyk G., Salum G., Sugaya L., Caye A., and Rohde L., "Annual Research Review: A meta-analysis of the worldwide prevalence of mental disorders in children and adolescents," *Journal of Child Psychology and Psychiatry and Allied Disciplines*, vol. 56, pp. 345–365, 2015, <https://doi.org/10.1111/jcpp.12381> PMID: [25649325](https://pubmed.ncbi.nlm.nih.gov/25649325/)
4. Schachar R. and Tannock R., "Syndromes of hyperactivity and attention deficit," in *Child and Adolescent Psychiatry*, Oxford: Blackwell, 2002, pp. 399–418.
5. Bélanger S., Andrews D., Gray C., and Korczak D., "ADHD in children and youth: Part 1—Etiology, diagnosis, & comorbidity," *Paediatrics & Child Health*, vol. 23, no. 7, pp. 447–453, 2018, <https://doi.org/10.1093/pch/pxy109> PMID: [30681669](https://pubmed.ncbi.nlm.nih.gov/30681669/)
6. Russell A., Ford T., Williams R., and Russell G., "The association between socioeconomic disadvantage and Attention Deficit/Hyperactivity Disorder (ADHD): A systematic review," *Child Psychiatry and Human Development*, vol. 47, pp. 440–458, 2016. <https://doi.org/10.1007/s10578-015-0578-3> PMID: [26266467](https://pubmed.ncbi.nlm.nih.gov/26266467/)
7. Russell G., Ford T., Rosenberg R., and Kelly S., "The association of attention deficit hyperactivity disorder with socioeconomic disadvantage: Alternative explanations and evidence," *Child Psychology and Psychiatry*, vol. 55, no. 5, pp. 436–445, 2014. <https://doi.org/10.1111/jcpp.12170> PMID: [24274762](https://pubmed.ncbi.nlm.nih.gov/24274762/)
8. Russell A., Ford T., and Russell G., "Socioeconomic associations with ADHD: Findings from a mediation analysis," *PLoS ONE*, vol. 10, no. 6, pp. 1–16, 2015, <https://doi.org/10.1371/journal.pone.0128248> PMID: [26030626](https://pubmed.ncbi.nlm.nih.gov/26030626/)
9. Russell A., Ford T., and Russell G., "Barriers and predictors of medication use for childhood ADHD: Findings from a UK population-representative cohort," *Social Psychiatry and Psychiatric Epidemiology*, vol. 54, pp. 1555–1564, 2019, <https://doi.org/10.1007/s00127-019-01720-y> PMID: [31073627](https://pubmed.ncbi.nlm.nih.gov/31073627/)
10. Murray E., Pearson R., Fernandes M., Santos I., Barros F., and Victora C., "Are fetal growth impairment and preterm birth causally related to child attention problems and ADHD? Evidence from a comparison between high-income and middle-income cohorts," *Journal of Epidemiology and Community Health*, vol. 70, pp. 704–709, 2016. <https://doi.org/10.1136/jech-2015-206222> PMID: [26767410](https://pubmed.ncbi.nlm.nih.gov/26767410/)
11. Fluori E. and Midhouas E., "Environmental adversity and children's early trajectories of problem behavior: The role of harsh parental discipline," *Journal of Family Psychology*, vol. 31, no. 2, pp. 234–243, 2017. <https://doi.org/10.1037/fam0000258> PMID: [27977229](https://pubmed.ncbi.nlm.nih.gov/27977229/)
12. Fitzsimons E., Goodman A., Kelly E., and Smith J., "Poverty dynamics and parental mental health: Determinants of childhood mental health in the UK," *Social Science and Medicine*, vol. 175, pp. 43–51, 2017, <https://doi.org/10.1016/j.socscimed.2016.12.040> PMID: [28056382](https://pubmed.ncbi.nlm.nih.gov/28056382/)

13. Larsson H., Sariaslan A., Långström N., Onofrio B., and Lichtenstein P., "Family income in early childhood and subsequent Attention-Deficit/Hyperactivity Disorder: A quasi-experimental study," *Journal of Child Psychology and Psychiatry and Allied Disciplines*, vol. 55, no. 5, pp. 428–435, 2014, <https://doi.org/10.1111/jcpp.12140> PMID: 24111650
14. Björkenstam E., Björkenstam C., Jablonska B., and Kosidou K., "Cumulative exposure to childhood, and treated attention deficit/hyperactivity disorder: A cohort study of 543 650 adolescents and young adults in Sweden," *Psychological Medicine*, vol. 48, pp. 498–507, 2018, <https://doi.org/10.1017/S0033291717001933> PMID: 28738913
15. Hegelund E., Flensburg-Madsen T., Vassard D., Niclasent J., and Mortensen E., "Parental socioeconomic position and risk of ADHD in offspring: A cohort study of 9648 individuals in Denmark 1976–2013," *European Child & Adolescent Psychiatry*, vol. 28, pp. 685–693, 2019, <https://doi.org/10.1007/s00787-018-1235-8> PMID: 30311007
16. Ostergaard S., Larsen J., Dalsgaard S., Wilens T., Mortensen P., and Agerbo E., "Predicting ADHD by assessment of Rutter's indicators of adversity in infancy," *PLoS ONE*, 2016, <https://doi.org/10.1371/journal.pone.0157352> PMID: 27355346
17. Choi Y., Choi R., Park S., and Kwon J., "Parental smoking and depression, and attention-deficit hyperactivity disorder in children and adolescents: Koren national health and nutrition examination survey 2005–2014," *Asia-Pacific Psychiatry*, vol. 10, p. e12327, 2018, <https://doi.org/10.1111/appy.12327> PMID: 30088339
18. Kovess K., Keyes K., Hamilton A., Pez O., and Bitfoi A., "Maternal smoking and offspring inattention and hyperactivity: Results from a cross-national European survey," *Child Adolescent Psychiatry*, vol. 24, pp. 919–929, 2015, <https://doi.org/10.1007/s00787-014-0641-9> PMID: 25413602
19. World Health Organization, *The ICD-10 Classification of Mental and Behavioural Disorders: Clinical Descriptions and Diagnostic Guidelines*, 10th ed. Geneva: World Health Organization, 1992.
20. American Psychiatric Association, *Diagnostic and Statistical Manual of Mental Disorders: Diagnostic and Statistical Manual of Mental Disorders*, 5th ed. Arlington, Virginia: American Psychiatric Association, 2013.
21. Moffitt T. and Melchior M., "Why does the worldwide prevalence of childhood attention hyperactivity disorder matter?," *American Journal of Psychiatry*, vol. 164, no. 6, pp. 856–858, 2007. <https://doi.org/10.1176/ajp.2007.164.6.856> PMID: 17541041
22. World Health Organization, *International Statistical Classification of Diseases and Related Health Problems*, 11th ed. World Health Organization, 2020.
23. Galobardes B., Davey Smith G., and Lynch J., "Systematic review of the influence of childhood socioeconomic circumstances on risk for cardiovascular disease in adulthood," *Annals of Epidemiology*, vol. 16, pp. 91–104, 2006. <https://doi.org/10.1016/j.annepidem.2005.06.053> PMID: 16257232
24. Spencer N., Than M., and Séguin L., "Low income / socioeconomic status in early childhood and physical health in later childhood/adolescence: A systematic review," *Maternal Child Health Journal*, vol. 17, no. 3, pp. 424–431, 2013, <https://doi.org/10.1007/s10995-012-1010-2> PMID: 22466716
25. Connelly R. and Platt L., "Cohort profile: UK Millennium cohort study," *International Journal of Epidemiology*, vol. 43, no. 6, pp. 1719–1725, 2014, <https://doi.org/10.1093/ije/dyu001> PMID: 24550246
26. Ludvigsson J., Ludvigsson M., and Sepa A., "Screening for prediabetes in the general child population: Maternal attitude to participation," *Pediatric Diabetes*, vol. 2, no. 4, pp. 170–174, 2001, <https://doi.org/10.1034/j.1399-5448.2001.20405.x> PMID: 15016182
27. Nygren M., Carstensen J., Koch F., Ludvigsson J., and Frostell A., "Experience of a serious life event increases the risk for childhood type I diabetes: The ABIS population-based prospective cohort study," *Diabetologia*, vol. 58, no. 6, pp. 1188–1197, 2015, <https://doi.org/10.1007/s00125-015-3555-2> PMID: 25870022
28. "Direction Santé Québec." [/www.iamillbe.stat.gouv.qc.ca/publications/BabyV2No1.pdf](http://www.iamillbe.stat.gouv.qc.ca/publications/BabyV2No1.pdf).
29. Edwards B., "Growing up in Australia: The longitudinal study of Australian Children," *Family Matters*, vol. 95, pp. 5–14, 2014.
30. Jaddoe V., Mackenbach J., Moll H., Steegers E., Tiemeier H., and Verhulst F., "The Generation R Study: Design and cohort profile," *European Journal of Epidemiology*, vol. 21, pp. 475–484, 2006. <https://doi.org/10.1007/s10654-006-9022-0> PMID: 16826450
31. Jaddoe V. et al., "The Generation R Study: Design and cohort update 2012," *European Journal of Epidemiology*, vol. 27, no. 9, pp. 739–756, 2012, <https://doi.org/10.1007/s10654-012-9735-1> PMID: 23086283
32. US Bureau of Labor Statistics, "National Longitudinal Survey of Youth, Children, and Young Adults 1979." www.nlsinfo.org/content/cohorts/nlsy79-children.

33. Statistics Canada, "Microdata User Guide National Longitudinal Survey of Children and Youth Cycle 6, September 2005—June 2005," Ottawa, 2006.
34. Shavers V., "Measurement of socioeconomic status in health disparities research," *Journal of the National Medical Association*, vol. 99, pp. 1013–1023, 2007. PMID: [17913111](#)
35. OECD, "OECD 2000," *Purchasing Power Parities*, 2000. <https://data.oecd.org/conversion/purchasing-power-parities-ppp.htm>.
36. OECD, "Equivalence Scales," *Equivalence Scales*. [/www.oecd.org/els/soc/OECD-Note-EquivalenceScales.pdf](http://www.oecd.org/els/soc/OECD-Note-EquivalenceScales.pdf).
37. UNESCO, "International Standard Classification Education." <http://uis.unesco.org/en/topic/international-standard-classification-education-isced>.
38. Zou G., "A modified poisson regression approach to prospective studies with binary data," *American Journal of Epidemiology*, vol. 159, no. 7, pp. 702–706, 2004. <https://doi.org/10.1093/aje/kwh090> PMID: [15033648](#)
39. Hjern A., Weitoft G., and Lindblad F., "Social adversity predicts ADHD-medication in school children—A national cohort study," *Acta Paediatrica*, vol. 99, pp. 920–924, 2010. <https://doi.org/10.1111/j.1651-2227.2009.01638.x> PMID: [20002622](#)
40. Foulon S., Pingault J.-B., Larroque B., Melchior M., Falissard B., and Côté S., "Developmental predictors of inattention-hyperactivity from pregnancy to early childhood," *PLoS ONE*, 2015, <https://doi.org/10.1371/journal.pone.0125996> PMID: [25938453](#)
41. Viechtbauer W., "Conducting meta-analyses in R with the metafor package," *Journal of Statistical Software*, vol. 36, no. 3, pp. 1–48, 2010.
42. Health Equity Assessment Toolkit (HEAT), *Software for exploring and comparing health inequalities in countries. Built-in database edition*. Geneva: World Health Organization, 2017.
43. Ventura S., Brady H., and Mathews T., "National and state patterns of teen births in the United States, 1940–2013," *National Vital Statistics Report*, vol. 63, no. 4, Aug. 2014. PMID: [25142408](#)
44. Scriberras E., Koumounne O., and Efron D., "Predictors of parent-reported Attention-Deficit/Hyperactivity Disorder in children aged 6–7 years: A national longitudinal study," *Abnormal Child Psychology*, vol. 39, p. 1025–1034, 2011, <https://doi.org/10.1007/s10802-011-9504-8> PMID: [21468666](#)
45. Carbonneau R., Vitaro F., Brendgen M., and Tremblay R., "The intergenerational association between parents' problem gambling and impulsivity-hyperactivity/inattention behaviors in children," *Journal of Abnormal Child Psychology*, vol. 46, pp. 1203–1215, 2018, <https://doi.org/10.1007/s10802-017-0362-x> PMID: [29101590](#)
46. Razani N., Hilton J., Halpern-Felsher B., Okumura M., Morrell H., and Yen I., "Neighborhood characteristics and ADHD: Results of a national study," *Journal of Attention Disorders*, vol. 19, no. 9, pp. 731–740, 2015. <https://doi.org/10.1177/1087054714542002> PMID: [25028386](#)
47. Noordermeer S., Luman M., Weeda W., Buitelaar J., Richards J., and Hartman C., "Risk factors for comorbid oppositional defiant disorder in attention-deficit/hyperactivity disorder," *European Child & Adolescent Psychiatry*, vol. 26, pp. 1155–1164, 2017, <https://doi.org/10.1007/s00787-017-0972-4> PMID: [28283834](#)
48. Zhao X., Page T., Altszuler A., Pelham W., Kipp H., and Gnagy E., "Family burden of raising a child with ADHD," *Journal of Abnormal Child Psychology*, vol. 47, no. 8, pp. 1327–1338, 2009, <https://doi.org/10.1007/s10802-019-00518-5> PMID: [30796648](#)
49. Thapar A., Cooper M., Eyre O., and Langley K., "What have we learnt about the causes of ADHD?," *Journal of Child Psychology and Psychiatry and Allied Disciplines*, vol. 54, no. 1, pp. 3–16, 2013, <https://doi.org/10.1111/j.1469-7610.2012.02611.x> PMID: [22963644](#)
50. L'Institut national d'excellence en santé et service sociaux (INESSS), "Portrait des service psychosociaux utilisé dans le traitement de trouble de déficit de l'attention avec ou sans hyperactivité (TDAH) chez Québécois de 25 ans ou moins," Sep. 2017. [Online]. Available: www.inesss.qc.ca/fileadmin/doc/INESSS/Rapports/ServicesSociaux/INESSS_Portrait_TDAH_SS.pdf.
51. Visser S., Danielson M., Bitsko R., Perou R., and Blumberg S., "Convergent validity of parent-reported ADHD diagnosis: A cross-study comparison," *JAMA Pediatrics*, vol. 167, no. 7, pp. 674–675, 2013, <https://doi.org/10.1001/jamapediatrics.2013.2364> PMID: [23700143](#)
52. Rieppi R., Greenhill L., Ford R., Chuang S., Wu M., and Davies M., "Socioeconomic status as a moderator of ADHD treatment outcomes.," *Journal of the American Academy of Child and Adolescent Psychiatry*, vol. 41, no. 3, pp. 269–277, 2002. <https://doi.org/10.1097/00004583-200203000-00006> PMID: [11886021](#)
53. Moldavsky M., Groenewald C., Owen V., and Sayal K., "Teachers' recognition of children with ADHD: Role of subtype and gender," *Child and Adolescent Mental Health*, vol. 18, no. 1, pp. 18–23, 2013, <https://doi.org/10.1111/j.1475-3588.2012.00653.x> PMID: [32847261](#)