Adolescent Attention-Deficit/Hyperactivity Disorder: Understanding Teenage Symptom Trajectories

Supplemental Information

In examining the natural history of ADHD we used the terms (ADHD[TI] OR attention deficit hyperactivity disorder[TI]) AND (outcome*[TI] OR traject* [TI] OR persist*[TI] OR course*[TI] OR remission[TI] OR remitted[TI] OR follow-up[TI] OR prospective[TI] OR history[TI]), which returned 631 references. The PRISMA diagrams for searches are given below; a decisions about retention of studies were made by PS. In the search related to the adolescent outcomes of ADHD, we retained only prospective studies that used DSM based diagnostic methods and that focused on observations during adolescence or early adulthood. We further included only the most recent report on cohorts with multiple follow-up reports and did not consider the follow-up of treatment trials with the exception of the Multimodal Treatment of ADHD study (1). The main manuscript considers only studies that focused on adolescence and/or examined symptom trajectories (1-12). Below, we also provide references on recent follow-up studies clinic-based cohorts, in the USA, China and Brazil, not included in the main manuscript (13-17).

The neuroimaging studies were obtained from a search that included the adjunct {+AND (neuroimaging[TI] OR DTI[TI] OR *MRI[TI] * OR neurophys[TI], filtered to the past 10 years). This returned 59 references which were reviewed by PS, which were supplemented by some key references of theoretical importance. All retained references are cited in Table 2 and/or in the main manuscript (and given below as references (17-33).

Fig S1. PRISMA flow diagram for the search used to identify studies of the natural history of ADHD during adolescence

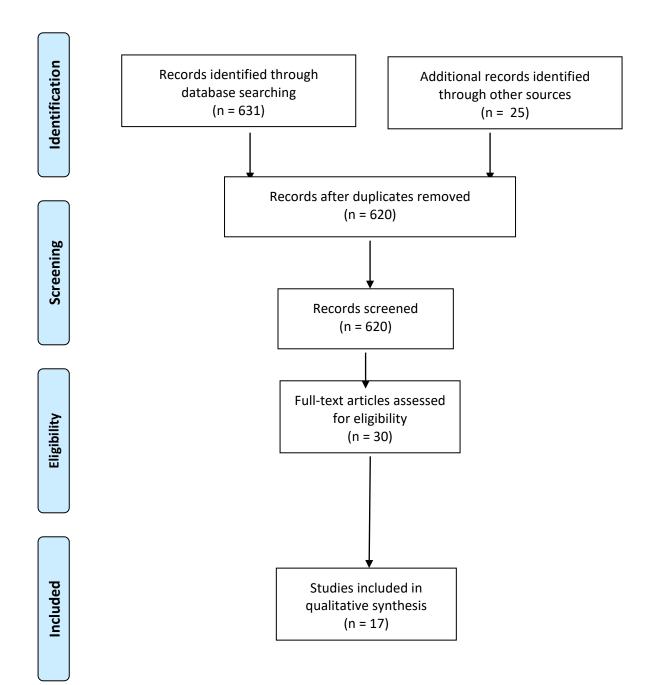
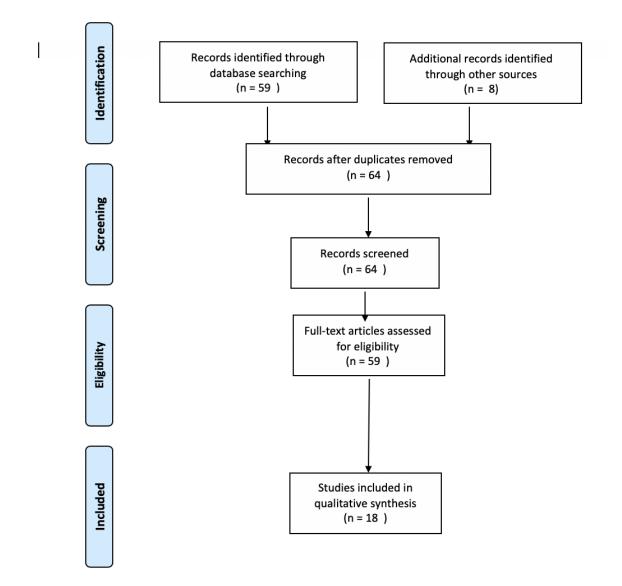


Fig S2. PRISMA flow diagram for the search used to identify neuroimaging studies of the natural history of ADHD during adolescence.



Supplemental References

- 1. Sibley MH, Rohde LA, Swanson JM, Hechtman LT, Molina BS, Mitchell JT, et al. (2017): Lateonset ADHD reconsidered with comprehensive repeated assessments between ages 10 and 25. *American Journal of Psychiatry*.appi. ajp. 2017.17030298.
- 2. Pingault JB, Viding E, Galera C, Greven C, Zheng Y, R. P, et al. (2015): Genetic and environmental influences on the developmental course of attention-deficit/hyperactivity disorder symptoms from childhood to adolescence. *JAMA Psychiatry*. doi:10.1001/jamapsychiatry.2015.0469 T.
- 3. Swanson JM, Hinshaw SP, Arnold LE, Gibbons RD, Marcus S, Hur K, et al. (2007): Secondary evaluations of MTA 36-month outcomes: propensity score and growth mixture model analyses. *Journal of the American Academy of Child & Adolescent Psychiatry*. 46:1003-1014.
- 4. Riglin L, Collishaw S, Thapar AK, Dalsgaard S, Langley K, Smith GD, et al. (2016): Association of genetic risk variants with attention-deficit/hyperactivity disorder trajectories in the general population. *JAMA psychiatry*. 73:1285-1292.
- 5. Tandon M, Tillman R, Agrawal A, Luby J (2016): Trajectories of ADHD severity over 10 years from childhood into adulthood. *ADHD Attention Deficit and Hyperactivity Disorders*. 8:121-130.
- 6. Döpfner M, Hautmann C, Görtz-Dorten A, Klasen F, Ravens-Sieberer U, Group BS (2015): Longterm course of ADHD symptoms from childhood to early adulthood in a community sample. *European Child & Adolescent Psychiatry*. 24:665-673.
- 7. Murray AL, Booth T, Eisner M, Auyeung B, Murray G, Ribeaud D (2019): Sex differences in ADHD trajectories across childhood and adolescence. *Developmental science*. 22:e12721.
- 8. Malone PS, Van Eck K, Flory K, Lamis DA (2010): A mixture-model approach to linking ADHD to adolescent onset of illicit drug use. *Developmental psychology*. 46:1543.
- 9. Larsson H, Dilshad R, Lichtenstein P, Barker ED (2011): Developmental trajectories of DSM-IV symptoms of attention-deficit/hyperactivity disorder: Genetic effects, family risk and associated psychopathology. *Journal of Child Psychology and Psychiatry*. 52:954-963.
- 10. Agnew-Blais JC, Polanczyk GV, Danese A, Wertz J, Moffitt TE, Arseneault L (2016): Evaluation of the persistence, remission, and emergence of attention-deficit/hyperactivity disorder in young adulthood. *JAMA psychiatry*. 73:713-720.
- 11. Lecendreux M, Silverstein M, Konofal E, Cortese S, Faraone SV (2019): A 9-Year Follow-Up of Attention-Deficit/Hyperactivity Disorder in a Population Sample. *J Clin Psychiatry*. 80.
- 12. Caye A, Rocha TB-M, Anselmi L, Murray J, Menezes AM, Barros FC, et al. (2016): Attentiondeficit/hyperactivity disorder trajectories from childhood to young adulthood: evidence from a birth cohort supporting a late-onset syndrome. *JAMA psychiatry*. 73:705-712.
- 13. Cadman T, Findon J, Eklund H, Hayward H, Howley D, Cheung C, et al. (2016): Six-year follow-up study of combined type ADHD from childhood to young adulthood: Predictors of functional impairment and comorbid symptoms. *Eur Psychiatry*. 35:47-54.
- 14. Gao Q, Qian Y, He XX, Sun L, Chang WL, Li YL, et al. (2015): Childhood predictors of persistent ADHD in early adulthood: Results from the first follow-up study in China. *Psychiatry Res.* 230:905-912.

- 15. Palma SM, Natale AC, Calil HM (2015): A 4-Year Follow-Up Study of Attention-Deficit Hyperactivity Symptoms, Comorbidities, and Psychostimulant Use in a Brazilian Sample of Children and Adolescents with Attention-Deficit/Hyperactivity Disorder. *Front Psychiatry*. 6:135.
- 16. Uchida M, Spencer TJ, Faraone SV, Biederman J (2015): Adult outcome of ADHD: an overview of results from the MGH longitudinal family studies of pediatrically and psychiatrically referred youth with and without ADHD of both sexes. *Journal of attention disorders*.1087054715604360.
- 17. Shaw P, Malek M, Watson B, Greenstein D, de Rossi P, Sharp W (2013): Trajectories of Cerebral Cortical Development in Childhood and Adolescence and Adult Attention-Deficit/Hyperactivity Disorder. *Biological Psychiatry*. 74:599-606.
- 18. Michelini G, Jurgiel J, Bakolis I, Cheung CH, Asherson P, Loo SK, et al. (2019): Atypical functional connectivity in adolescents and adults with persistent and remitted ADHD during a cognitive control task. *Translational psychiatry*. 9:1-15.
- 19. Michelini G, Kitsune GL, Cheung CH, Brandeis D, Banaschewski T, Asherson P, et al. (2016): Attention-deficit/hyperactivity disorder remission is linked to better neurophysiological error detection and attention-vigilance processes. *Biological psychiatry*. 80:923-932.
- 20. Cheung CH, Rijsdijk F, McLoughlin G, Brandeis D, Banaschewski T, Asherson P, et al. (2016): Cognitive and neurophysiological markers of ADHD persistence and remission. *The British Journal* of *Psychiatry*. 208:548-555.
- 21. Schulz KP, Li X, Clerkin SM, Fan J, Berwid OG, Newcorn JH, et al. (2017): Prefrontal and parietal correlates of cognitive control related to the adult outcome of attention-deficit/hyperactivity disorder diagnosed in childhood. *Cortex.* 90:1-11.
- 22. Szekely E, Sudre GP, Sharp W, Leibenluft E, Shaw P (2017): Defining the neural substrate of the adult outcome of childhood ADHD: A multimodal neuroimaging study of response inhibition. *American Journal of Psychiatry*. 174:867-876.
- 23. Sudre G, Szekely E, Sharp W, Kasparek S, Shaw P (2017): Multimodal mapping of the brain's functional connectivity and the adult outcome of attention deficit hyperactivity disorder. *Proceedings of the National Academy of Sciences*. 114:11787-11792.
- 24. Francx W, Oldehinkel M, Oosterlaan J, Heslenfeld D, Hartman CA, Hoekstra PJ, et al. (2015): The executive control network and symptomatic improvement in attention-deficit/hyperactivity disorder. *Cortex.* 73:62-72.
- 25. Francx W, Zwiers MP, Mennes M, Oosterlaan J, Heslenfeld D, Hoekstra PJ, et al. (2015): White matter microstructure and developmental improvement of hyperactive/impulsive symptoms in Attention,ÄêDeficit/Hyperactivity Disorder. *Journal of Child Psychology and Psychiatry*.
- 26. Sudre G, Shaw P, Wharton A, Weingart D, Sharp W, Sarlls J (2015): White matter microstructure and the variable adult outcome of childhood Attention Deficit Hyperactivity Disorder. *Neuropsychopharmacology*. 40:746-754.
- 27. Luo Y, Halperin JM, Li X (2020): Anatomical substrates of symptom remission and persistence in young adults with childhood attention deficit/hyperactivity disorder. *European Neuropsychopharmacology*.
- 28. Clerkin SM, Schulz KP, Berwid OG, Fan J, Newcorn JH, Tang CY, et al. (2013): Thalamo-Cortical Activation and Connectivity During Response Preparation in Adults With Persistent and Remitted ADHD. *American Journal of Psychiatry*. 170:1011-1019.

- 29. Muetzel RL, Blanken LM, van der Ende J, El Marroun H, Shaw P, Sudre G, et al. (2018): Tracking brain development and dimensional psychiatric symptoms in children: A longitudinal population-based neuroimaging study. *American Journal of psychiatry*. 175:54-62.
- Mackie S, Shaw P, Lenroot R, Pierson R, Greenstein DK, Nugent TF, 3rd, et al. (2007): Cerebellar development and clinical outcome in attention deficit hyperactivity disorder.[see comment]. *American Journal of Psychiatry*. 164:647-655.
- 31. Whitfield-Gabrieli S, Wendelken C, Nieto-Castañón A, Bailey SK, Anteraper SA, Lee YJ, et al. (2019): Association of Intrinsic Brain Architecture With Changes in Attentional and Mood Symptoms During Development. *JAMA psychiatry*.
- 32. Shaw P, Lerch J, Greenstein D, Sharp W, Clasen L, Evans A, et al. (2006): Longitudinal mapping of cortical thickness and clinical outcome in children and adolescents with attention-deficit/hyperactivity disorder. *Archives of General Psychiatry*. 63:540-549.
- 33. Schneider MF, Krick CM, Retz W, Hengesch G, Retz-Junginger P, Reith W, et al. (2010): Impairment of fronto-striatal and parietal cerebral networks correlates with attention deficit hyperactivity disorder (ADHD) psychopathology in adults: a functional magnetic resonance imaging (fMRI) study. *Psychiatry Research: Neuroimaging.* 183:75-84.