This article may not exactly replicate the final version published in the journal. It is not the copy of record.
Dvorsky, M. R., Breaux, R., Langberg, J. M., & Becker, S. P. (2022). Adolescents with ADHD are at increased risk for COVID-19 vaccine hesitancy. *Journal of Psychiatric Research, 152,* 25-30. doi:10.1016/j.jpsychires.2022.06.005. PMID: 35714550

Adolescents with ADHD are at Increased Risk for COVID-19 Vaccine Hesitancy

Melissa R. Dvorsky, PhD[1,2], https://orcid.org/0000-0002-3790-1334

Rosanna Breaux, PhD[3], https://orcid.org/0000-0001-5500-6950

Joshua M. Langberg, PhD[4], https://orcid.org/0000-0003-0169-2793

Stephen P. Becker, PhD[5,6] https://orcid.org/0000-0001-9046-5183

[1] Division of Psychology and Behavioral Health, Children's National Hospital, Washington, DC
[2] Department of Psychiatry & Behavioral Sciences, and Department of Pediatrics, the George Washington University School of Medicine and Health Sciences, Washington, DC
[3] Department of Psychology, Virginia Polytechnic Institute and State University, Blacksburg, VA
[4] Department of Psychology, Virginia Commonwealth University, Richmond, VA
[5] Division of Behavioral Medicine and Clinical Psychology, Cincinnati Children's Hospital Medical Center, Cincinnati, OH
[6] Department of Pediatrics, University of Cincinnati College of Medicine, Cincinnati, OH

Key words: adolescence; attention-deficit/hyperactivity disorder; coronavirus; vaccine hesitancy; vaccination; social determinants

Correspondence: Melissa Dvorsky, Ph.D., Center for Translational Research, Division of Psychology and Behavioral Health, Children's National Hospital, 111 Michigan Ave NW, Washington, DC 20010, USA. E-mail: mdvorsky@childrensnational.org
Conflicts of interest: The authors declare no conflict of interest

Acknowledgement: This research was supported by award number R305A160126 from the Institute of Education Sciences (IES), U.S. Department of Education. When data reported in this study were collected, Stephen Becker was supported by award number K23MH108603 from the National Institute of Mental Health (NIMH). The content is solely the responsibility of the authors and does not necessarily represent the official views of the IES or the NIH.

Abstract

Identifying factors that influence adolescent intentions for COVID-19 vaccination is essential for developing strategic interventions to increase uptake, particularly in subgroups of at-risk adolescents. Attention-deficit/hyperactivity disorder (ADHD) in adolescence is characterized by difficulties regulating attention and behavior, social impairment, and impulsive risk-taking behaviors, which may impact vaccine hesitancy and vaccine uptake. This study examined hesitancy toward COVID-19 vaccines among adolescents with and without ADHD, and explored how ADHD status interacted with malleable social mechanisms and other social determinants of health in predicting vaccine hesitancy. Participants were 196 U.S. adolescents (44.4% male), 45.6% diagnosed with ADHD. Adolescents reported their confidence and willingness toward COVID-19 vaccines from March to May 2021. Adolescents with ADHD reported greater hesitancy and less confidence in COVID-19 vaccine safety compared to adolescents without ADHD ($p < .01$). Only 61.8% of adolescents with ADHD reported vaccine acceptance, compared to 81.3% of adolescents without ADHD. For all adolescents, those who identified as Black or Latinx and with lower family income had greater hesitancy and reduced confidence, whereas greater COVID-19 concerns, media use, and perceived negative impact on relationships was associated with greater vaccination willingness. Social contextual processes significantly interacted with ADHD status such that for adolescents without ADHD, concerns about COVID-19 were associated with increased confidence in vaccine safety. Being noncompliant with social distancing guidelines was associated with greater vaccine hesitancy, only for adolescents with ADHD. A concerted effort is needed to increase trust, confidence, and social relevance among adolescents, especially those with ADHD and from lower socio-economic backgrounds.

Key words: adolescence; attention-deficit/hyperactivity disorder; coronavirus; vaccine hesitancy; vaccination; social determinants

In December 2020, the U.S. Food and Drug Administration (FDA) issued an emergency authorization of COVID-19 vaccines for adolescents ages 16 and up (Ackerson et al., 2021; FDA, 2021). Since then, there has been substantial misinformation and vaccine hesitancy, despite widespread vaccination being critical to mitigating the pandemic. Uncertainty about the safety and efficacy of COVID-19 vaccines has impeded vaccination (Klein et al., 2021; Machingaidz & Wiysonge, 2021), with only 65% of adolescents and young adults indicating willingness to get a COVID-19 vaccine (Afifi et al., 2021), and as of April 20, 2022 only 58.9% of U.S. adolescents aged 12-17 have been fully vaccinated (CDC, 2022). Identifying factors that influence intentions to vaccinate and developing strategic interventions to increase adolescent uptake is essential to achieving "herd immunity" (FDA, 2021). This is particularly important in subgroups of adolescents that are especially likely to be hesitant to be inoculated against COVID-19 (Brandt et al., 2021; Humer et al., 2021).

Individuals with attention-deficit/hyperactivity disorder (ADHD) have been identified as a key research and public health priority during COVID-19, given evidence of increased infection, hospitalization, and mortality (Breaux et al., 2021; Cortese et al., 2020). ADHD is the most common childhood mental health disorder, impacting 11.9% of adolescents (American Psychiatric Association, 2013). Characterized by attention and behavior regulation deficits, ADHD is associated with social impairments, poor planning, impaired decision-making, and impulsive risk-taking behaviors (Becker, 2020). Adolescents with ADHD experience poorer access to and engagement in routine healthcare, particularly among racial/ethnic minorities and low-income families (Coker et al., 2016). The core deficits of ADHD likely impact vaccine hesitancy and, ultimately, vaccine uptake. For example, difficulties with attention regulation could interfere with filtering misinformation about vaccine, and motivational deficits could undermine vaccine willingness and plans to get vaccinated. Further, there is evidence that

ADHD is associated with increased susceptibility to peer influence for risk behavior and maladaptive social perceptions (e.g., viewing risky behavior as normative and socially desirable; Dvorsky & Langberg, 2019; Molina & Pelham, 2014). Similarly, adolescents with ADHD may perceive themselves and their peers as less susceptible to COVID-19, which may impact compliance with social distancing and vaccine hesitancy.

To design effective vaccine promotion interventions, it is important to address factors that influence voluntary vaccination (Paul et al., 2021). This study examined whether adolescents with and without ADHD differed in vaccine hesitancy. Consistent with the Increasing Vaccination Model (IVM; Brewer et al., 2017), and health behavior change principles which emphasize psychosocial processes for influencing vaccine uptake (Brewer & Abad, 2021), we assessed malleable social-contextual predictors including adolescents' concerns about COVID-19, perceived impact on their relationship quality during the pandemic, frequency of media use, and compliance with COVID-19 social distancing guidelines. We also examined key social determinants of health including family income, geographic location, and adolescent race, ethnicity, sex, and grade level.

Method

Participants were 196 adolescents (87 male) ages 16.48-18.72 years ($M \pm SD = 17.53 \pm 0.58$) from two sites in the Southeastern and Midwestern United States. Adolescents were high school students in 11th and 12th grade during the 2020-2021 school year. Adolescents identified as predominantly White (81%), with 9% identifying as biracial/multiracial, 5% identifying as Black, 5% Asian; 5% of the sample identified as Latinx. Participants came from a range of socioeconomic backgrounds (Mincome=$95,612, SD=$34,233), with 21% of

families falling below the 2019 U.S. median household income ($68,703). Approximately half of the sample (*n*=89) was comprehensively diagnosed with ADHD prior to COVID-19.

Procedures

Participants who provided consent to be contacted for future research pre-COVID-19 (*N*=262) were invited to participate in a longitudinal COVID-19 study utilizing online surveys in spring 2020, summer 2020, fall 2020, and spring 2021. 238 participants participated in the COVID-19 study, of which 82.4% (*N*=196) participated in this timepoint (i.e., spring 2021) assessing vaccine hesitancy. These 196 participants did not differ from those who were contacted for possible participation on adolescent sex, race, ethnicity, ADHD symptoms, or family income (*p*s > .10). Additional information regarding the sample/procedures is described in the *Supplemental Materials*.

Measures

Vaccine hesitancy. Vaccine willingness was assessed separately as both (1) *Confidence* (i.e., "I am completely confident COVID-19 vaccines are safe" rated on a 7-point scale from -3=*completely disagree* to +3=*completely agree*), and (2) *intent/willingness* (i.e., "If a vaccine that could prevent COVID-19 were made available to you, would you accept it for yourself?" rated on a 4-point scale from 0=*no*, 1=*maybe*, 2=*yes*, 3=*already vaccinated*). Regression analyses combined "yes" and "already vaccinated" categories to examine predictors of hesitancy.

ADHD status. During the initial in person pre-COVID-19 assessment, all participants underwent a comprehensive ADHD diagnostic evaluation. Adolescents in the ADHD group, met all *DSM-5* criteria for either ADHD combined (22.5%) or predominantly inattentive presentation (77.5%) via parent reported on the

Children's Interview for Psychiatric Syndromes (Weller et al., 2000) diagnostic interview including parent reported ≥6 symptoms of inattention and evidence impairment in home, academic, and/or social settings. Participants were included in the comparison group if parents endorsed <4 symptoms in both domains of ADHD (i.e., inattention, hyperactivity/impulsivity) on the diagnostic interview.

Social-contextual predictors. Social-contextual variables related to COVID-19 were assessed using items from the Coronavirus Health Impact Survey (CRISIS; Nikolaidis et al., 2021) developed by National Institutes of Health investigators/collaborators. Items from the adolescent version assessing concerns about COVID-19, media use, and impact on relationships were utilized in the present study. Concerns about COVID-19 was measured with a mean of five items (i.e., worries about being infected, families/friends being infected, worries about physical or emotional health impacted by COVID-19, and how often reading or talking about COVID-19) rated from 1=*not at all* to 5=*extremely*. Adolescents' perceived impact of the pandemic on relationships was measured with a single-item question: "How has the quality of your relationships with your friends changed?" rated on a 5-point scale from 1=*a lot worse* to 5=*a lot better*. Frequency of media use was assessed with a mean of two items assessing social media and television/other digital media use: "during the past month, how much time per day did you spend a) using social media, and b) watching TV or digital media (e.g., Netflix, YouTube, web surfing)?" rated from 1=*none* to 5=*more than 6 hours*. An additional item was added to assess adolescents' compliance with social distancing guidelines: "during the past month, how often

have you engaged in indoor social gatherings with six or more people that you do not live with (not including going to school)" rated from 1=*not at all* to 5=*almost every day or every day*.

Demographic variables. Key demographic variables (i.e., family income, adolescent ethnicity, sex, age, geographic location) associated with adolescent vaccine hesitation (Humer et al., 2021) and found to predict other immunization programs (Glatman-Freedman & Nichols, 2012) were also examined as predictors. Parents reported on adolescent biological sex (0 = male, 1 = female), and family income. Adolescents self-reported on their racial and ethnic identities. Given that this sample was predominately non-Latinx and White, and the disproportionate impact the COVID-19 pandemic has had on Black and Latinx families, a dichotomous variable was created (0 = adolescent does not identify as Black or Latinx, 1 = adolescent identifies as Black or Latinx).

All data were analyzed using IBM SPSS version 28. Descriptive statistics, independent t-tests and chi-squared tests were examined to assess potential differences in vaccination willingness and confidence/trust for adolescents with and without ADHD. Cohen's *d* was calculated as a measure of effect size, with .3, .5, and .8 representing small, medium, and large effects, respectively (Cohen, 1988). Using multiple regressions models, we examined the main and interactive effects of hypothesized social-contextual processes with ADHD group status (ADHD x predictor) in predicting adolescent vaccine hesitancy. Social determinants of health variables (i.e., ADHD status, family income, adolescent race/ethnicity, sex, grade, geographic location) and malleable social-contextual factors related to COVID-19 were entered simultaneously in Step 1. Once main effects were controlled, we proceeded to test whether

ADHD status demonstrated an interactive effect by adding the interaction between ADHD and each of the hypothesized social-contextual variables in Step 2. Models were re-run with nonsignificant interactions trimmed from the model for parsimony. Potential interactions between ADHD and significant social determinants of health variables (i.e., income, race) were also examined, but were not significant. In the presence of a significant interaction, we plotted the simple slopes for the effects of the predictor on the vaccination outcome for adolescents with and without ADHD.

Results

As indicated in Figure 1, adolescents with ADHD were significantly less likely to report intent to accept the COVID-19 vaccine, than adolescents without ADHD, $\chi^2(3)=10.03$, $p=.018$, $d=.36$. Twenty-five (12.8%) adolescents were already vaccinated (10% of ADHD, 15% of comparison), and 46 (52%) adolescents with ADHD reported "yes" they would accept a vaccine, compared to 71 (66%) adolescents without ADHD. A greater proportion of adolescents with ADHD reported "maybe" (24%) or "no" (15%) intent to accept a vaccine, compared to adolescents without ADHD (9% maybe, 9% no). Confidence in the safety of vaccines was higher in adolescents without ADHD ($M=1.65$) compared to adolescents with ADHD ($M=.95$; $F(1)=7.73$, $p=.006$, $d=.40$.

Correlations among vaccination outcomes and predictors were associated with one another in the expected directions (Table 1). Results of the regression analyses are provided in Table 2. After controlling for other demographic and social-contextual variables, Black/Latinx adolescents and those from lower family incomes reported greater vaccination hesitancy (βs from -.15 to -.19, $p<.05$) and reduced confidence in the safety of vaccines (βs=.24-.33, $p<.003$). Experiencing a negative impact of COVID-19 on relationships (β=-.19, $p=.004$), greater

concerns about COVID-19 (β=.17, *p*=.017), and greater media use (β=.16, *p*=.020) were associated with higher levels of vaccination willingness for all adolescents. There was also a significant interaction between ADHD status and not following social distancing guidelines in predicting vaccination willingness (β=-.44, *p*=.022). A visual plot of this interaction (see Figure 2) demonstrates that frequently engaging in large gatherings over 6 or more indoors (excluding school), was associated with less vaccine willingness only for adolescents with ADHD (*b*=.37, *p*<.001), and not adolescents without ADHD (*b*=-.07, *p*=.472). In the model predicting confidence in the safety of COVID-19 vaccines, ADHD status (β=-.15, *p*=.044) and not following social distancing guidelines (β=-.21, *p*=.005) showed significant main effects. As shown in Figure 3, ADHD status also demonstrated a significant interactive effect with concerns about COVID-19 (β=-.23, *p*=.020), such that increasing concerns about the pandemic were associated with increased confidence in the safety of vaccines for adolescents without ADHD (*b*=.32, *p*<.001), although this was not significant for adolescents with ADHD (*b*=.12, *p*=.255). None of the social determinant constructs significantly interacted with ADHD. Adolescent sex, grade, and geographical location were not associated with vaccine willingness or confidence (*p*s>.05).

Discussion

This study is the first to our knowledge to examine COVID-19 vaccine hesitancy in adolescents with and without ADHD, and to examine potentially malleable social-contextual predictors of vaccine acceptance and confidence. Consistent with recent international studies of youth (Afifi et al., 2021; Brandt et al., 2021; Humer et al., 2021), 72.4% of all adolescents in our sample were willing to get vaccinated

against COVID-19 and of these, 12.7% were at least partially vaccinated. However, adolescents with ADHD were more than twice as likely to report vaccine hesitancy (38.2% hesitant among ADHD vs. 18.7% among comparison adolescents) and less confidence in the safety of the vaccines compared to adolescents without ADHD (Cohen's *d* from .36-.40). Research addressing adolescent COVID-19 vaccination willingness and readiness remains scarce.

Adolescents who came from families with lower income levels or identified as Black and/or Latinx were more likely to be vaccine hesitant and report lower confidence in the safety of COVID-19 vaccines. This is in line with results from Afifi et al. (2021) and Humer et al. (2021), showing lower vaccine acceptance among lower income and racial/ethnic minority adolescents and emerging adults. Although family income and race/ethnicity did not significantly interact with ADHD, a main effect was found for all adolescents. This unfortunately is not surprising given individuals from lower socioeconomic backgrounds and Black and Latinx individuals are disproportionately affected by COVID-19 compounded by vaccination uptake being lower in communities disproportionately affected by COVID-19 (Brewer & Abad, 2021). However, since our sample was predominately non-Latinx/White and from a higher socioeconomic status (i.e., 10.8% identified as Black or Latinx and 21.4% had family incomes below the US median), we may have been underpowered to detect interactive effects

based on these demographic factors. The sample size in the present study may have been underpowered to detect interactions with other variables as well. Additional research with larger samples of youth with/without ADHD including a greater range of diversity among adolescents with regard to race, ethnicity, and socioeconomic status is urgently needed.

Social processes appear particularly relevant for adolescent vaccination. Adolescents who frequently engaged in large social gatherings reported less confidence in the safety of vaccines. Non-compliance to social distancing recommendations was also associated with increased vaccine hesitancy, but only for adolescents with ADHD. For adolescents with and without ADHD, experiencing greater concerns about COVID-19, greater negative impacts on relationships, and greater media use was associated with higher adolescents' vaccine willingness. Findings have important implications for health and mental health providers and educational strategies aimed at promoting COVID-19 vaccinations in adolescents. Consistent with the IVM (Brewer & Abad, 2021), a concerted effort is needed to intervene on adolescents' risk appraisals, vaccine confidence, and motivation, and leverage social mechanisms. Public health interventions tailored for adolescents could leverage social media platforms and brief text messages using visual illustrations/graphics, which have been effective for promoting behavior change with other health outcomes (e.g., physical, mental health; Maher et al., 2014). Social network interventions and peer-delivered approaches targeting perceived social norms and providing opportunities for prosocial behavior may be especially useful for increasing motivation to vaccinate among adolescents with ADHD. Given evidence that motivational interviewing (MI; Miller & Rollnick,

2013) is an important predictor of treatment engagement for adolescents with ADHD (e.g., Sibley et al., 2022), MI approaches may be useful for addressing attitudinal barriers and increasing openness to vaccines.

Mental health providers are uniquely positioned to offer effective communication using strong, presumptive language to address vaccine hesitancy (Olusanva et al., 2021). These efforts should emphasize the personal relevance of COVID-19 (e.g., vaccination being linked to return to social normalcy; Eisenhauer et al., 2021), and increase trust in adolescents who are unwilling or uncertain about the safety of the vaccines (Poland et al., 2021). Adolescents, especially those with ADHD and from lower socio-economic backgrounds and those who identify as Black or Latinx, may benefit from tailored strategies for providing clear communication about the vaccine's efficacy, side effects, and safety. Vaccine uptake, willingness, and confidence is especially low among adolescents with ADHD, perhaps in part due to core symptoms of ADHD and associated impairments likely impacting planning, motivation, and execution of vaccination, risk appraisals and perceived susceptibility to COVID-19. Enhancing opportunities for direct behavior change may be especially important for addressing vaccine uptake in adolescents with ADHD. Specifically, efforts should focus on frequent behavioral nudges via text messages, reminders or prompts, automatic appointments, and presumptive healthcare provider communication, to target core risk mechanisms associated with ADHD.

References

Ackerson, B. K., Sy, L. S., Glenn, S. C., Qian, L., Park, C. H., Riewerts, R. J., & Jacobsen, S. J. (2021). Pediatric Vaccination During the COVID-19 Pandemic. *Pediatrics*, 148(1):e2020047092. doi:10.1542/peds.2020-047092

Afifi, T. O., Salmon, S., Taillieu, T., Stewart-Tufescu, A., Fortier, J., & Driedger, S. M. (2021). Older adolescents and young adults willingness to receive the COVID-19 vaccine: Implications for informing public health strategies. *Vaccine*, *39*(26), 3473-3479. doi: 10.1016/j.vaccine.2021.05.026

American Psychiatric Association. (2013). *Diagnostic and statistical manual of mental disorders* (5th ed.). doi: 10.1176/appi.books.9780890425596

Becker, S. P. (Ed.) (2020). *ADHD in adolescents: Development, assessment, and treatment*. New York. Guilford. https://doi.org/10.1080/07317107.2020.1780820

Becker, S. P., Breaux, R., Cusick, C. N., Dvorsky, M. R., Marsh, N. P., Sciberras, E., & Langberg, J. M. (2020). Remote learning during COVID-19: examining school practices, service continuation, and difficulties for adolescents with and without attention-deficit/hyperactivity disorder. *Journal of Adolescent Health*, *67*(6), 769-777.

Brandt, E. J., Rosenberg, J., Waselewski, M. E., Amaro, X., Wasag, J., & Chang, T. (2021). National Study of Youth Opinions on Vaccination for COVID-19 in the US. *Journal of Adolescent Health*, *68*(5), 869-872. doi:10.1016/j.jadohealth.2021.02.013

Breaux, R., Dvorsky, M. R., & Becker, S. P. (2021). ADHD in COVID-19: Risk, resilience, and the rapid transition to telehealth. *The ADHD Report*, *29*(2), 1-9. doi:10.1521/adhd.2021.29.2.1

Breaux, R., Dvorsky, M. R., Marsh, N. P., Green, C. D., Cash, A. R., Shroff, D. M., ... & Becker, S. P. (2021). Prospective impact of COVID-19 on mental health functioning in

adolescents with and without ADHD: protective role of emotion regulation abilities. *Journal of Child Psychology and Psychiatry*.

Brewer, N. T. & Abad, N. (2021). Ways that mental health professionals can encourage COVID-19 vaccination. *JAMA Psychiatry.* Advanced Online Publication. doi:10.1001/jamapsychiatry.2021.2951

Brewer, N. T., Chapman, G. B., Rothman, A. J., Leask, J., & Kempe, A. (2017). Increasing vaccination: putting psychological science into action. *Psychological Science in the Public Interest, 18*(3), 149-207.

Center for Disease Control and Prevention (2022, April 20). *COVID-19 Vaccination and Case Trends by Age Group*. Data.CDC.gov https://data.cdc.gov/Vaccinations/COVID-19-Vaccination-and-Case-Trends-by-Age-Group-/gxj9-t96f/data

Chu, H., & Liu, S. (2021). Integrating health behavior theories to predict American's intention to receive a COVID-19 vaccine. *Patient Education and Counseling, 104,* 1878-1886. doi:10.1016/j.pec.2021.02.031

Coker, T. R., Elliott, M. N., Toomey, S. L., Schwebel, D. C., Cuccaro, P., Emery, S. T., ... & Schuster, M. A. (2016). Racial and ethnic disparities in ADHD diagnosis and treatment. *Pediatrics*, *138*(3). doi:10.1542/peds.2016-0407

Cortese, S., Asherson, P., Sonuga-Barke, E., Banaschewski, T., Brandeis, D., Buitelaar, J., ... & Simonoff, E. (2020). ADHD management during the COVID-19 pandemic: guidance from the European ADHD Guidelines Group. *The Lancet Child & Adolescent Health*, *4*(6), 412-414.

COVID-19 Vaccines. U.S. Food & Drug Administration website. Updated June 15, 2021. Accessed June 18, 2021. https://www.fda.gov/emergency-preparedness-and-response/coronavirus-disease-2019-covid-19/covid-19-vaccines

Dvorsky, M. R., & Langberg, J. M. (2019). Cigarette and e-cigarette use and social perceptions over the transition to college: The role of ADHD symptoms. *Psychology of Addictive Behaviors*, *33*(3), 318-330.

Eisenhauer, L., Hansen, B. R., & Pandian, V. (2021). Strategies to improve human papillomavirus vaccination rates among adolescents in family practice settings in the United States: A systematic review. *Journal of clinical nursing*, *30*(3-4), 341-356.

Glatman-Freedman, A., & Nichols, K. (2012). The effect of social determinants on immunization programs. *Human vaccines & immunotherapeutics*, *8*(3), 293-301. doi: 10.4161/hv.19003

Humer, E., Jesser, A., Plener, P. L., Probst, T., & Pieh, C. (2021). Education level and COVID-19 vaccination willingness in adolescents. *European Child & Adolescent Psychiatry*, 1-3.

Klein, J. K., Middleman, A. B., & Quinn, J. R. (2021). 10. COVID-19 Impact on Parent/Young Adult Attitudes and Beliefs Toward Vaccines for Adolescents and Young Adults. *Journal of Adolescent Health*, *68*(2), S1-S9.

Machingaidze, S., & Wiysonge, C. S. (2021). Understanding COVID-19 vaccine hesitancy. *Nature Medicine*, *27*(8), 1338-1339. doi: 10.1038/s41591-021-01459-7

Maher, C. A., Lewis, L. K., Ferrar, K., Marshall, S., De Bourdeaudhuij, I., & Vandelanotte, C. (2014). Are health behavior change interventions that use online social networks effective? A systematic review. *Journal of Medical Internet Research*, *16*(2), e40.

Miller, W. R., & Rollnick, S. (2013). *Motivational interviewing: Helping people change*. Guilford press.

Molina, B. S., & Pelham, W. E., Jr. (2014). Attention-deficit/hyperactivity disorder and risk of substance use disorder: Developmental considerations, potential pathways, and opportunities for research. *Annual Review of Clinical Psychology, 10*, 607–639.

Nikolaidis, A., Paksarian, D., Alexander, L., Derosa, J., Dunn, J., Nielson, D. M., ... & Merikangas, K. R. (2021). The Coronavirus Health and Impact Survey (CRISIS) reveals reproducible correlates of pandemic-related mood states across the Atlantic. *Scientific Reports*, *11*(1), 1-13.

Ningsih, O., Eka, A., & Danal, P. (2020). Factors Predicting Adolescents' Compliance on Covid-19 Prevention Protocols. *Indonesian Nursing Journal of Education and Clinic*, *6*(1), 55-63.

O'Leary, S. Middleman, A., & Rockwell, P. (2021). Improving vaccination coverage in children and adolescents: the role of professional societies. *Academic Pediatrics*, *21*(4), S5-S6.

Olusanya, O. A., Bednarczyk, R. A., Davis, R., & Shaban-Nejad, A. (2021). Addressing Parental Vaccine Hesitancy and Other Barriers to Childhood/Adolescent Vaccination Uptake During the Coronavirus (COVID-19) Pandemic. *Frontiers in Immunology*, *12*:663074.

Paul, E., Steptoe, A., & Fancourt, D. (2021). Attitudes towards vaccines and intention to vaccinate against COVID-19: Implications for public health communications. *The Lancet Regional Health-Europe*, *1*, 100012. doi:10.1016/j.lanepe.2020.100

Poland, C. M., Matthews, A. K., & Poland, G. A. (2021). Improving COVID-19 vaccine acceptance: Including insights from human decision-making under conditions of uncertainty and human-centered design. *Vaccine*, *39*(11), 1547-1550.

Sibley, M. H., Coxe, S. J., Stein, M. A., Meinzer, M. C., & Valente, M. J. (2022). Predictors of treatment engagement and outcome among adolescents with attention-deficit/hyperactivity disorder: an integrative data analysis. *Journal of the American Academy of Child & Adolescent Psychiatry*, *61*(1), 66-79.

Weller, E. B., Weller, R. A., Fristad, M. A., Rooney, M. T., & Schecter, J. (2000). Children's interview for psychiatric syndromes (ChIPS). *Journal of the American Academy of Child & Adolescent Psychiatry*, *39*(1), 76-84.

Table 1.

Means and Correlations of Study Variables

	1	2	3	4	5	6	7	8	9	10	11	12
1. Vaccine Willingness	--											
2. Vaccine Confidence	.70***											
3. ADHD Group	-.18**	-.20**										
4. Sex(Male)	.03	.07	-.16*									
5. Race/Ethncity	-.20**	-.22**	.06	.12								
6. Location	.06	.04	-.06	.02	.21**							
7. Grade	.06	.00	.05	.10	.05	.08						
8. Income	.33***	.28***	-.25***	.00	-.23**	.04	-.10					
9. COVID Concerns	.28***	.24***	-.08	.14*	-.04	.09	.10	.07				
10. Relations Impact	-.23***	-.18*	.04	-.05	.07	.03	-.03	.04	-.11			
11. Media Use	.05	.02	.06	.09	.22**	.20**	.07	-.27***	.04	.02		
12. Non-Compliance to social distancing	-.20**	-.26***	-.10	-.01	.03	-.09	.11	-.01	-.29***	.18*	.07	--
Mean	1.61	1.33	.45	.44	.11	.41	11.47	95,612	2.07	2.96	3.05	2.90
SD	.69	1.76	.50	.50	.31	.49	.51	34,233	.77	.60	.67	1.13
Range	0 to 2	-3 to +3	0 to 1	0 to 1	0 to 1	0 to 1	10 to 12	$0 to $125,000	1 to 5	1 to 5	1 to 5	1 to 5

Note. For vaccine willing, 0=no, 1=maybe, 2=yes/already vaccinated. For vaccine confidence, -3=completely disagree, 3=completely agree that vaccines are safe.
*$p < .05$. **$p < .01$. ***$p < .001$.

Table 2.

Effects of ADHD Status and Social Determinants Predicting Adolescent Vaccine Hesitancy and Confidence

	DV: Vaccine Intent/Acceptability					DV: Vaccine Confidence			
	B	*SE*	*β*	*p*		*B*	*SE*	*β*	*p*
Step 1:	$F(10) = 7.067^{***}$, $R^2 = .25$				*Step 1:*	$F(10) = 5.42^{***}$, $R^2 = .24$			
ADHD	-.17	.10	-.12	.07	ADHD	-.49	.19	-.15	.04
Sex (Male)	-.05	.09	-.03	.62	Sex (Male)	.06	.25	.02	.80
Race (Black/Latinx)	-.34	.16	-.15	.03	Race (Black/Latinx)	-1.08	.41	-.19	.01
Location	.03	.09	.02	.80	Location	.02	.24	.06	.40
Grade	.16	.09	.11	.08	Grade	.20	.24	.04	.53
Income	.07	.01	.33	<.001	Income	.12	.04	.24	.002
Concerns about COVID-19	.16	.06	.17	.02	Concerns about COVID-19	.28	.17	.12	.10
Impact on relationships	-.22	.07	-.19	.004	Impact on relationships	-.36	.20	-.12	.07
Media use	.17	.07	.16	.02	Media use	.32	.19	.12	.08
Non-Compliance to social distancing	-.09	.04	-.14	.05	Non-Compliance to social distancing	-.33	.12	-.21	.01
Step 2:	$F(11) = 7.08^{***}$, $R^2 = .27$, $\Delta R^2 = .02^{*}$				*Step 2:*	$F(11) = 5.22^{***}$, $R^2 = .26$, $\Delta R^2 = .03^{*}$			
ADHD x Non-Compliance to social distancing	-.19	.08	-.44	.02	ADHD x Concerns about COVID-19	-.53	.22	-.23	.02

Note. $^{*}p < .05$. $^{**}p < .01$. $^{***}p < .001$.

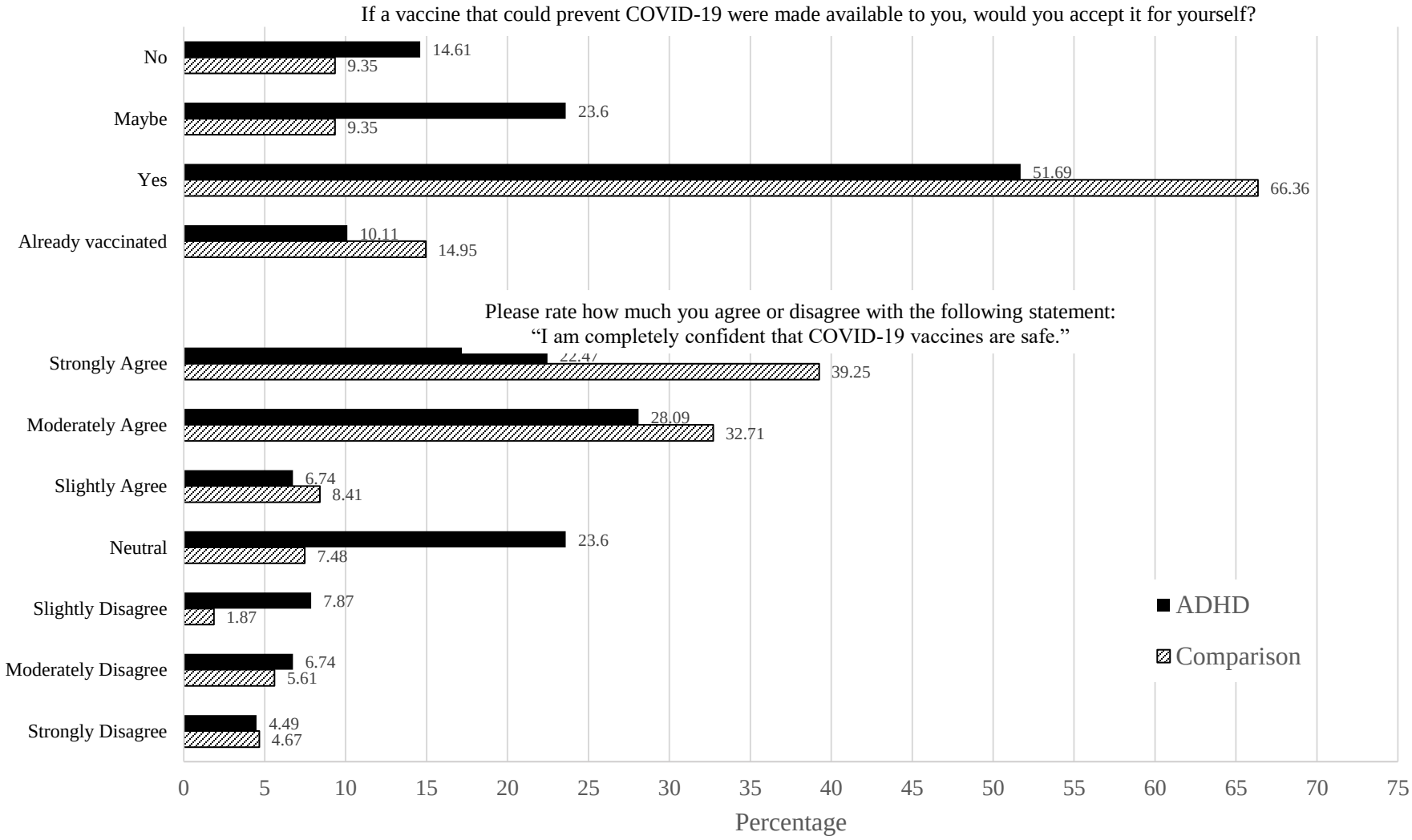

Figure 1. Intent/willingness to vaccinate against COVID-19, $\chi^2(3) = 10.03$, $p = .018$, and confidence towards vaccines, $F(1) = 7.73$, $p = .006$, among adolescents with and without ADHD.

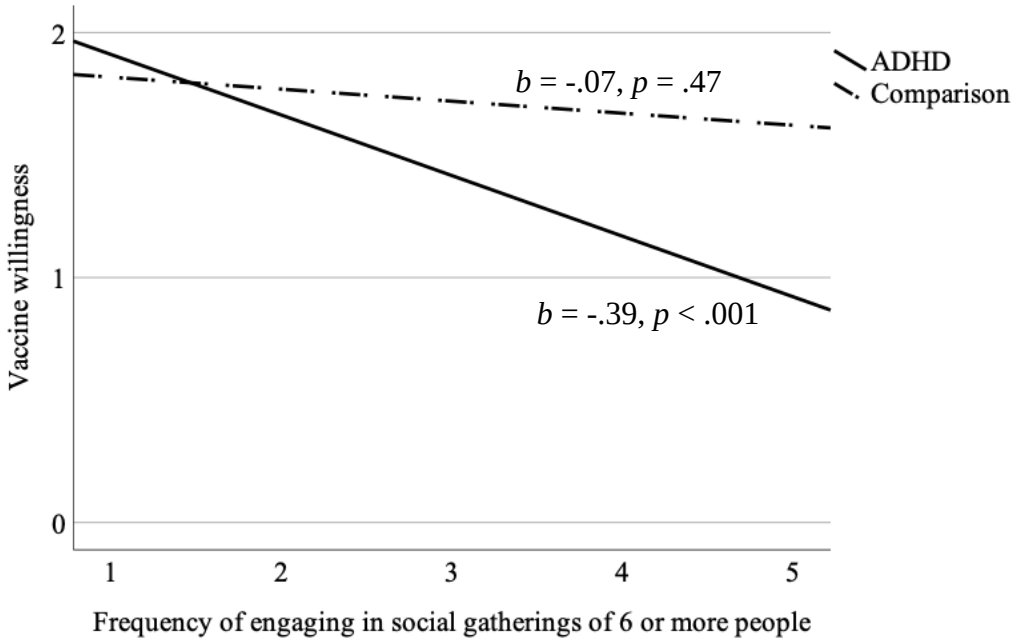

Figure 2. Adolescents' ADHD status moderates the association between engaging in large social gatherings indoors and COVID-19 vaccine willingness.

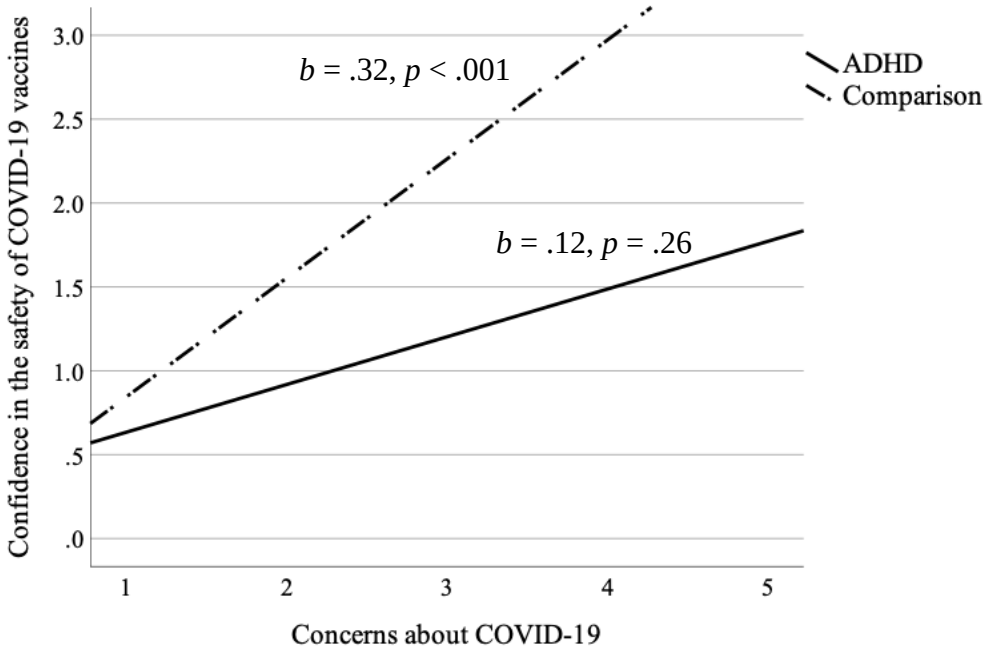

Figure 3. ADHD status moderates the association between adolescents' concerns about COVID-19 and confidence in the safety of the COVID-19 vaccines.

ONLINE ONLY SUPPLEMENTAL MATERIALS

To conserve space in the print version of the journal, these supplemental materials provide additional detail regarding the study methods, sample characteristics, and procedures.

Supplemental Materials Table of Contents

Study Procedures

The study utilizes data collected from a larger prospective longitudinal study evaluating the impact of the COVID-19 pandemic on adolescent functioning. Participants in a larger parent study (Becker et al., 2019) who provided permission for further contact were invited to participate in the current COVID-19 study. At the time of the COVID-19 assessment, participants were in the eleventh (n = 102) or twelfth (n = 93) grade, and one participant was in tenth grade due to being retained a grade. To maintain social distancing and compliance with institutional policies, all measures were collected electronically using Research Electronic Data Capture (REDCap). Adolescents and parents provided consent and assent, respectively, before proceeding to the survey. Adolescents and parents were compensated for participation.

Description of Parent Study Procedures and Inclusion/Exclusion Criteria

For the parent study (N = 302) from which participants in the current COVID-19 study were recruited, adolescents in eighth grade and their parents were originally recruited across two consecutive years for a prospective longitudinal study examining sleep in adolescents with and without ADHD (see Becker et al., 2019 and Breaux et al., 2021, for additional details). Of which, 262 participants provided consent to be contacted for future research pre-COVID-19 (visits between September 2018-February 2020). Of the 262 participants who provided consent to be contacted, 90.8% (N = 238) provided data at a prior COVID-19 timepoint (spring 2020). Data for the current study come from the fourth COVID-19 timepoint (N = 196) which took place in spring 2021 (i.e., March-May 2021; 82.4% retention from the N = 238).

Of the N=238 who were contacted for possible participation, those who participated in this COVID-19 timepoint (N=196) did not differ from the 42 participants who were contacted for possible participation on adolescent sex, race, ethnicity, location, ADHD symptoms, or family

income (*p*s > .10). Of the 196 participants in the current study, 47 resided in Ohio, 67 resided in Kentucky, and 80 resided in Virginia (United States); two additional participants had resided in one of these states when initially recruited for the larger parent study, but had since moved and resided in another state (Michigan, Missouri) during the time point in the current study.

The original parent study and current study were approved by the Cincinnati Children's Hospital Medical Center and Virginia Commonwealth University Institutional Review Boards, and written informed consent and assent were obtained. All potential participants went through the same assessment procedures. Families meeting screening criteria were invited to receive a comprehensive assessment, during which adolescents and their parents were administered study measures. Inclusion criteria included: (1) enrolled in eighth grade; (2) estimated Full Scale IQ ≥ 80 based on *Wechsler Abbreviated Scale of Intelligence, Second Edition* (Wechsler, 2011); and (3) enrolled in regular education classes. Exclusion criteria were: (1) meeting criteria for autism spectrum disorders, bipolar disorder, a dissociative disorder, or a psychotic disorder; (2) previous diagnosis of an organic sleep disorder (e.g., obstructive sleep apnea, narcolepsy, restless leg syndrome, periodic limb movement disorder) according to parent report during the initial phone screen, and (3) not meeting criteria for either the ADHD or comparison groups as described next.

Diagnostic Procedures

During the initial comprehensive assessment completed for the parent study, all potential participants underwent a comprehensive ADHD diagnostic evaluation in accordance with the Fifth Edition of the *Diagnostic and Statistical Manual for Mental Disorders* (DSM-5) criteria. Participants met criteria for ADHD on the basis of the parent version of *Children's Interview for Psychiatric Syndromes* (P-ChIPS; Weller et al., 1999). To be eligible for participation in the ADHD group, adolescents were required to meet all DSM-5 criteria for either the ADHD

Combined Presentation or Predominantly Inattentive Presentation on the P-ChIPS. Specifically, participants were included in the ADHD group if parents reported ≥6 symptoms of inattention at clinically significant levels; presence of ADHD symptoms prior to age 12 years, presence of ADHD symptoms in two or more settings (e.g., home, school), evidence that symptoms contribute to home, academic, and/or social impairment; and symptoms of ADHD were not better explained by another mental disorder. Participants were included in the comparison group if the parent endorsed < 4 symptoms of ADHD in both domains (i.e., inattention, hyperactivity/impulsivity) on the P-ChIPS. Additionally, both parent report on the P-ChIPS and adolescent report on the Children's Interview for Psychiatric Syndromes were used to determine common mental health diagnoses (i.e., mood and anxiety disorders, disruptive behavior disorders, obsessive compulsive disorder). This approach is consistent with recommendations for diagnosing ADHD in adolescence supporting the use of parent, but not adolescent self-report, for the assessment of ADHD (Sibley et al., 2012).

Of the 89 participants in the ADHD group in the present study, 69 (77.5%) met criteria for ADHD predominantly inattentive presentation and 20 (22.5%) met criteria for ADHD combined presentation. These proportions are consistent with epidemiological research findings that approximately 72% of all adolescents with ADHD present with ADHD predominately inattentive presentation and approximately 18% present with ADHD combined presentation (Willcutt, 2012), Participants meeting criteria for ADHD predominantly hyperactive-impulsive presentation (n = 2) in the original parent study were not included given the low prevalence of this presentation during adolescence, and ongoing concerns about the validity of this presentation after early elementary school (Willcutt, 2012; Willcutt et al., 2012). See Becker et al. (2019) for additional sample and diagnostic inclusion procedures.

Demographic Characteristics

Key demographic characteristics and differences between the ADHD and comparison groups are reported in Table S1. Adolescents in the ADHD group did not differ from adolescents in the comparison group on key demographic characteristics including race, ethnicity, grade, location, or cohort (*p*s > .16), with only two exceptions. There was a significantly greater proportion of females in the comparison group (51% female), relative to the ADHD group (36% female), χ^2 = 4.70, *p* = 03, *Cohen's d* = .31, which is consistent with gender differences in prevalence of ADHD in adolescents supported in the larger literature (Willcutt, 2012). Parents of adolescents with ADHD also reported significantly lower family income (*M*=$86,123) relative to parents of adolescents in the comparison group (*M*=$103,504), *t* = 3.65, *p* < .001, *Cohen's d* = .42. Adolescents with ADHD (45%) were also more likely to be taking any psychotropic medication for ADHD, emotional/behavioral concerns, and/or sleep at the spring 2021 COVID-19 timepoint, relative to adolescents in the comparison group (12%), χ^2 = 31.57, *p* < .001, *Cohen's d* = .91. This difference was largely driven by a greater proportion of adolescents taking medication for ADHD in the ADHD group. During the present study COVID-19 timepoint, parents of adolescents with ADHD reported significantly higher severity of ADHD inattentive (*M*=1.22) and hyperactive/impulsive symptoms (*M*=.52) relative to parents of adolescents in the comparison group (Inattention: *M*=.49, *t* = -8.33, *p* < .001, *Cohen's d* = 1.29; Hyperactivity/ impulsivity: *M*=.17, *t* = -5.65, *p* < .001, *Cohen's d* = .89) on the Vanderbilt ADHD Rating Scales (Wolraich et al., 2003). Parents and adolescents self-reported significantly higher severity of internalizing problems on the Revised Children's Anxiety and Depression Scales (Chorpita et al., 2005) in the ADHD group (self-report: *M*=42.67; parent-report: *M*=49.37) relative to parent-

report and adolescent self-report in the comparison group (self-report: *M*=39.59, *t* = -2.86, *p* = .008, *Cohen's d* = .42; parent-report: *M*=44.91, *t* = -1.66, *p* =.02, *Cohen's d* = .24).

References in Supplement

Becker, S. P., Langberg, J. M., Eadeh, H.-M., Isaacson, P. A., & Bourchtein, E. (2019). Sleep and daytime sleepiness in adolescents with and without ADHD: Differences across ratings, daily diary, and actigraphy. Journal of Child Psychology and Psychiatry, 60, 1021-1031. doi:10.1111/JCPP.13061

Breaux, R., Dvorsky, M. R., Marsh, N. P., Green, C. D., Cash, A. R., Shroff, D. M., ... & Becker, S. P. (2021). Prospective impact of COVID-19 on mental health functioning in adolescents with and without ADHD: protective role of emotion regulation abilities. Journal of Child Psychology and Psychiatry.

Chorpita, B. F., Moffitt, C. E., & Gray, J. (2005). Psychometric properties of the Revised Child Anxiety and Depression Scale in a clinical sample. *Behaviour research and therapy*, *43*(3), 309-322. doi:10.1016/j.brat.2004.02.004

Sibley, M. H., Pelham Jr, W. E., Molina, B. S., Gnagy, E. M., Waschbusch, D. A., Garefino, A. C., ... & Karch, K. M. (2012). Diagnosing ADHD in adolescence. *Journal of Consulting and Clinical Psychology*, *80*(1), 139-150.

Wechsler D. *Wechsler Abbreviated Scale of Intelligence - Second Edition (WASI-II).* San Antonio, TX: Pearson; 2011.

Weller, E. B., Weller, R. A., Fristad, M. A., Rooney, M. T., Schecter, J. (2000). Children's Interview for Psychiatric Syndromes (ChIPS). *Journal of the American Academy of Child and Adolescent Psychiatry*, *39*(1), 76-84.

Willcutt, E. G. (2012). The prevalence of DSM-IV attention-deficit/hyperactivity disorder: a meta-analytic review. *Neurotherapeutics*, *9*(3), 490-499.

Willcutt, E. G., Nigg, J. T., Pennington, B. F., Solanto, M. V., Rohde, L. A., Tannock, R., ... & Lahey, B. B. (2012). Validity of DSM-IV attention deficit/hyperactivity disorder symptom dimensions and subtypes. *Journal of abnormal psychology*, *121*(4), 991-1010.

Wolraich, M. L., Lambert, W., Doffing, M. A., Bickman, L., Simmons, T., & Worley, K. (2003). Psychometric properties of the Vanderbilt ADHD diagnostic parent rating scale in a referred population. *Journal of pediatric psychology*, *28*(8), 559-568.

Table S1

Group Comparisons Among Sample Demographic Characteristics

	Total Sample *M(SD)* *N* = 196	ADHD Sample *M(SD)* *N* = 89	Comp Sample *M(SD)* *N* = 107	*t-test* / χ^2	*d*
Sex	.44 (.50)	.36 (.48)	.51 (.50)	$\chi^2 = 4.70$*	.31
Race	.79 (.41)	.82 (.39)	.77 (.43)	$\chi^2 = .85$	.13
Ethnicity	.05 (.22)	.09 (.29)	.07 (.25)	$\chi^2 = 1.00$	.14
Cohort	1.53 (.50)	1.51 (.50)	1.55 (.50)	$\chi^2 = .41$	.09
Site/Location	.41 (.49)	.38 (.49)	.44 (.50)	$\chi^2 = .66$	.11
Grade	11.47 (.51)	11.49 (.53)	11.45 (.50)	$\chi^2 = 1.97$	.09
Medication Status	.28 (.45)	.45 (.50)	.12 (.32)	$\chi^2 = 31.57$***	.91
Income	95,612 (34,233)	86,123 (36,879)	103,504 (29,804)	*t* = 3.65***	.42
PR VADRS Inattention Mean	.82 (.68)	1.22 (.71)	.49 (.43)	*t* = -8.33***	1.29
PR VADRS Hyp/Imp Mean	.33 (.42)	.52 (.51)	.17 (.25)	*t* = -5.65***	.89
SR RCADS Internalizing T score	40.91 (12.18)	42.67 (13.01)	39.59 (11.37)	*t* = -2.86**	.42
PR RCADS Internalizing T score	46.88 (10.75)	49.37 (11.67)	44.91 (9.46)	*t* = -1.66*	.24

Note. Comp = comparison sample. For sex, 0 = male, 1 = female. For race, 0 = non-White, 1 = White. For ethnicity, 0 = not Latinx, 1 = Latinx. For medication status, 0 = no medication, 1 = taking any psychotropic medication for ADHD, emotional/behavioral disorder, and/or sleep. PR = parent-report. SR = adolescent self-report. VADRS = Vanderbilt ADHD Diagnostic Rating Scales item mean from items rated on scale from 0 to 3 (Wolraich et al., 2003). Hyp/Imp = Hyperactivity/Impulsivity. Parent and adolescent report of internalizing is based on the internalizing T score from the Revised Children Anxiety and Depression Scale (RCADS; Chorpita et al., 2005). * $p < .05$, ** $p < .01$ *** $p < .001$.