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Adolescents with ADHD are at increased risk for COVID-19 vaccine hesitancy

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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.

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; Machingaidze and 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., 2021a,b; Cortese et al., 2020). ADHD is the most

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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 and Langberg, 2019; Molina and 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 and 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.

1. 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.

1.1. 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 ($ps > .10$). Additional information regarding the sample/procedures is described in the *Supplemental Materials*.

1.2. 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 and 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 0.3, 0.5, and 0.8 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.

2. Results

As indicated in Fig. 1, adolescents with ADHD were significantly less likely to report intent to accept the COVID-19 vaccine, than adolescents without ADHD, $\chi^2(3) = 10.03, p = .018, d = 0.36$. 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 ($M = 0.95; F(1) = 7.73, p = .006, d = 0.40$).

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 (β s from -0.15 to $-0.19, p < .05$) and reduced confidence in the safety of vaccines (β s = $0.24-0.33, p < .003$). Experiencing a negative impact of COVID-19 on relationships ($\beta = -0.19, p = .004$), greater concerns about COVID-19 ($\beta = 0.17, p = .017$), and greater media use ($\beta = 0.16, p = .020$) 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 ($\beta = -0.44, p = .022$). A visual plot of this interaction (see Fig. 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 ($b = 0.37, p < .001$), and not adolescents without ADHD ($b = -0.07, p = .472$). In the model predicting

confidence in the safety of COVID-19 vaccines, ADHD status ($\beta = -0.15, p = .044$) and not following social distancing guidelines ($\beta = -0.21, p = .005$) showed significant main effects. As shown in Fig. 3, ADHD status also demonstrated a significant interactive effect with concerns about COVID-19 ($\beta = -0.23, p = .020$), such that increasing concerns about the pandemic were associated with increased confidence in the safety of vaccines for adolescents without ADHD ($b = 0.32, p < .001$), although this was not significant for adolescents with ADHD ($b = 0.12, p = .255$). None of the social determinant constructs significantly interacted with ADHD. Adolescent sex, grade, and geographical location were not associated with vaccine willingness or confidence ($ps > .05$).

3. 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 0.36 to 0.40). 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

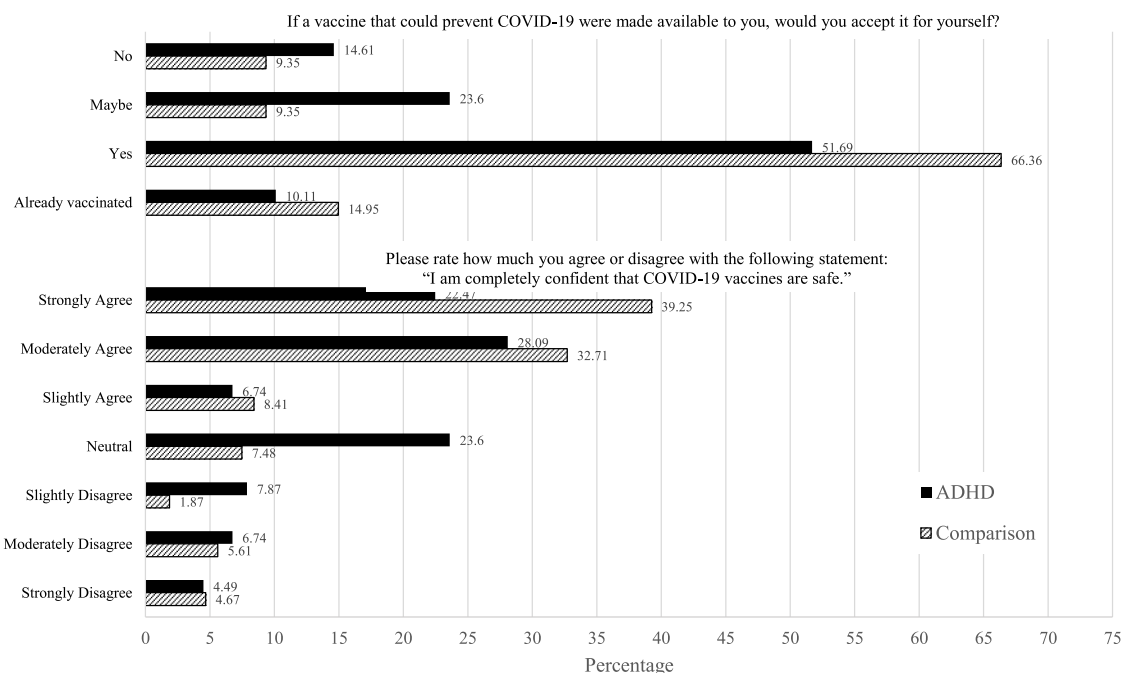


Fig. 1. Intent/willingness to vaccinate against COVID-19, $\chi^2(3) = 10.03, p = .018$, and confidence towards vaccines, $F(1) = 7.73, p = .006$, among adolescents with and without ADHD.

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

Note. * $p < .05$. ** $p < .01$. *** $p < .001$.

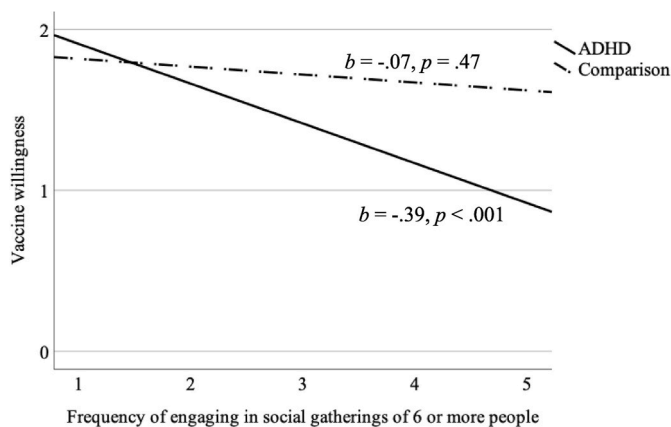


Fig. 2. Adolescents' ADHD status moderates the association between engaging in large social gatherings indoors and COVID-19 vaccine willingness.

COVID-19 compounded by vaccination uptake being lower in communities disproportionately affected by COVID-19 (Brewer and 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

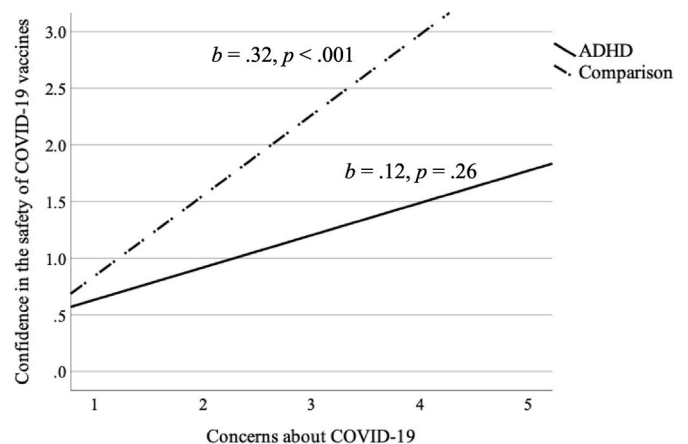


Fig. 3. ADHD status moderates the association between adolescents' concerns about COVID-19 and confidence in the safety of the COVID-19 vaccines.

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 and 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 and 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 (O'Leary et al., 2021; Olusanya 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 (Ningsih et al., 2020; 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.

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Research involving human participants

All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments and comparable ethical standards.

Informed consent

Written informed consent was obtained from the parents and written assent was obtained for adolescents under age 11, informed consent was obtained from adolescents ages 18 and up.

Author contributions

Melissa Dvorsky: Conceptualization, Methodology, Investigation, Software, Data Curation, Formal analysis, Writing – Original Draft preparation. Rosanna Breaux: Software, Investigation, Data Curation, Writing – Review & Editing, Project administration, Funding acquisition. Joshua Langberg: Investigation, Writing – Review & Editing, Funding acquisition. Stephen Becker: Investigation, Writing – Review & Editing, Project administration, Funding acquisition.

Declaration of competing interest

The authors declare no conflict of interest.

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Appendix A. Supplementary data

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