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SYMPTOM DIMENSIONS OF ATTENTION DEFICIT HYPERACTIVITY DISORDER AND NICOTINE WITHDRAWAL SYMPTOMS

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Abstract

Research suggests that Attention Deficit Hyperactivity Disorder (ADHD) and nicotine withdrawal symptoms are related; however, it is unknown how this relationship extends across ADHD symptom gradations, differs between inattention and hyperactivity-impulsivity symptom types, and generalizes to a national sample. This study examined cross-sectional associations between childhood ADHD symptom indexes (total, inattention, and hyperactivity-impulsivity) and lifetime DSM-IV nicotine withdrawal symptoms. Results showed that each ADHD symptom index associated with almost every withdrawal symptom ($P < .01$). After controlling for hyperactivity-impulsivity and inattention symptom overlap, inattention (but not hyperactivity-impulsivity) retained incremental associations with most withdrawal symptoms. These findings are relevant for understanding mechanisms of ADHD and smoking comorbidity.

Keywords

Inattention; hyperactivity-impulsivity; smoking; relapse prevention; comorbidity

INTRODUCTION

The relationship between attention deficit hyperactivity disorder (ADHD) and tobacco use has been well documented. Extant research indicates that individuals with ADHD exhibit higher rates of smoking,^{1–3} earlier age of smoking initiation,^{4–6} and increased likelihood of regular smoking^{1,5,7} compared with individuals not diagnosed with ADHD. Furthermore, ADHD may increase the risk for persistent smoking and poorer smoking cessation outcomes.^{2,8}

The etiological factors underpinning the relationship between ADHD and persistent and heavy smoking are not entirely clear. One promising hypothesis is that ADHD may be associated with a greater likelihood of nicotine withdrawal symptoms during abstinence, which could contribute to regular and persistent smoking in those with ADHD. Withdrawal symptoms may be important to the tobacco dependence process because the motivation to suppress withdrawal symptoms could maintain day-to-day smoking among individuals not attempting to quit⁹ and may potentially contribute to relapse following a cessation attempt.¹⁰

Prior research on the link between ADHD and nicotine withdrawal symptoms is sparse. McClernon et al.¹¹ examined the effects of experimentally induced overnight smoking abstinence on self-report measures of mood and withdrawal severity and on performance-based cognitive tasks designed to measure attention and behavior inhibition in those with and without current ADHD. They found no difference on self-report measures of mood and withdrawal symptom severity during abstinence between the 2 groups; however, abstinence did significantly decrease performance on 1 of their cognitive tasks for individuals with ADHD compared with controls—the number of commission errors (a measure of response inhibition) and reaction time variability (a measure of attentional control). A separate study comparing rates of retrospectively reported withdrawal symptoms in 3 groups of daily smokers—individuals with no ADHD, individuals with childhood only ADHD, and individuals with adult persisting ADHD—and found that withdrawal symptoms did not differ significantly between those with childhood only and adult persisting ADHD; however, compared with participants with no ADHD, those with childhood only or adult persisting ADHD reported higher prevalence of certain withdrawal symptoms (e.g., insomnia, irritability, difficulty concentration) but not others (i.e., decreased heart rate, anxiety).¹² In a study that followed individuals with more than 12 days of tobacco abstinence, those with ADHD experienced greater increases across a wide range of withdrawal symptoms including negative affect, somatic symptoms, (lower) arousal, habit withdrawal, and craving compared with controls, primarily in the first few days of abstinence.¹³ Moreover, these increases occurred independently from increases in ADHD symptoms, indicating that relationships between ADHD and withdrawal symptoms may not purely be a result of symptomatic overlap and/or an exacerbated expression of ADHD symptoms (see Gray et al.¹⁴).

These findings seem to suggest that ADHD may influence the withdrawal experience. However, ADHD was characterized as a single entity in prior work, even though ADHD symptomatology has commonly been separated into 2 dimensions: inattentive symptoms (e.g., often does not seem to listen when spoken to directly, often has difficulty organizing tasks and activities, is often easily distracted by extraneous stimuli) and hyperactive-impulsive symptoms (e.g., often fidgets with hands or feet or squirms in seat, often interrupts or intrudes on others).¹⁵ Although hyperactivity-impulsivity and inattention symptom dimensions typically show correlations with one another,^{16–18} these constructs are psychometrically distinct,^{19,20} exhibit differences in patterns of clinical and psychiatric correlates,²¹ and have disparate genetic influences.²² Furthermore, there is some evidence that hyperactivity-impulsivity and inattention demonstrate differential patterns of associations with different types of smoking characteristics.^{3,16,18,23–29} For example, Lerman et al.³⁰ found that the urge to smoke to minimize withdrawal symptoms was related to inattention symptoms but not to hyperactivity-impulsivity symptoms. To the best of our knowledge, no studies have disentangled the relative associations of inattention and hyperactivity-impulsivity symptoms to nicotine withdrawal.

In addition, existing reports of nicotine withdrawal conceptualized ADHD only from a categorical standpoint (presence vs. absence of diagnosis), which leaves it unclear whether there is a clinically important variation with nicotine withdrawal above and below the diagnostic thresholds of ADHD. ADHD symptoms appear to correspond with a dimensional (rather than taxonic) underlying structure,^{31,32} and prior research suggests a linear relationship between increasing levels of ADHD symptoms and certain smoking variables.^{26,33,34} Also, prior studies of ADHD and withdrawal have used clinical samples,^{11–13} which raises the possibility that these findings may not be entirely representative of the general population.

The current study addresses these questions using the National Epidemiologic Survey on Alcohol and Related Conditions (NE-SARC), a large population-based sample of U.S. adults. This study examined cross-sectional associations of 3 retrospectively measured ADHD symptom indexes—overall, inattention, and hyperactivity-impulsivity symptoms—and DSM-IV nicotine withdrawal symptoms in a general population sample with varying levels of ADHD symptomatology. Of particular interest was the extent to which hyperactivity-impulsivity and inattention symptom dimensions evidenced: associations with disparate types of withdrawal symptoms and composite withdrawal and incremental associations to withdrawal symptoms and composite withdrawal after controlling for their covariance. Although not our primary objective, we also investigated whether sex moderated any of the ADHD-withdrawal symptom relations because studies have indicated that women with ADHD may primarily be responsible for the association between ADHD status and greater abstinence effects,¹³ as well as whether having the number of symptoms required for a clinical ADHD diagnosis (i.e., 6 hyperactivity-impulsivity or inattention symptoms) moderated any of the ADHD-withdrawal symptom relationships.

METHODS

Participants

Participants were respondents in the NESARC, which assessed the prevalence of substance use, psychiatric disorders, psychosocial features, and other clinical characteristics in the U.S. adult population at 2 time points. At the wave 1 (2001–2002) survey, 43,093 individuals completed the in-person interview, and 34,653 of these individuals subsequently completed the wave 2 (2004–2005) survey. Participants were all noninstitutionalized civilians, aged 18 years and older, residing in the United States. Young adults aged 18–24 years were oversampled by a 2.25 to 1 ratio. African Americans and Hispanic Americans were also oversampled, and each group accounted for approximately 20% of the sample. To account for oversampling, the data had accompanying weights so adjustment was representative of the 2000 U.S. Census results. Additional details of the sampling, purpose of the survey, and weighting procedures have been published elsewhere.^{35,36} Of the 34,653 individuals who responded to both surveys, only those who had ever smoked more than 100 cigarettes by wave 2 and had ADHD and covariate data (see Measures section) were included in the final sample for analyses in the current report ($n = 14,744$; 43.9%).

Procedure

The U.S. Census Bureau selected 1 adult from each participating household. The response rate for wave 1 was 81%. After efforts were made to reinterview all participants, excluding individuals who were not eligible (e.g., those who were deceased), the response rate for wave 2 was 86.7%. The cumulative response rate across both waves was 70.2%. After obtaining informed consent, interviewers conducted face-to-face interviews of the Alcohol Use Disorder and Associated Disabilities Interview Schedule (AUDADIS-IV).³⁷ The protocol was reviewed and approved by the U.S. Census Bureau and the U.S. Office of Management.

Measures

The AUDADIS-IV gathers information on demographic characteristics, substance use patterns, DSM-IV criteria for psychiatric and substance use disorders, and other clinical characteristics. Previous analyses have shown adequate psychometric properties for mental disorder diagnoses and other information yielded from the AUDADIS-IV.^{37–39}

ADHD—The ADHD module of the AUDADIS-IV has evidenced acceptable psychometric properties for both the dimensional scale and the dichotomous diagnosis.³⁹ At wave 2 only,

participants were asked whether they experienced any of a list of 20 ADHD symptoms before the age of 18 years (yes/no). Although the DSM-IV requires ADHD symptoms to be present prior to age 7 years to meet diagnostic criteria, the age cutoff of 18 years is sufficient for the purpose of our analyses because we are investigating the relationship between childhood ADHD symptoms, independent of clinical ADHD status, and nicotine withdrawal symptoms. Furthermore, research suggests that ADHD symptoms that onset during the entire childhood years are clinically meaningful^{40,41} and therefore may affect smoking-related measures.

The list of 20 symptoms included dichotomous (present vs. absent) measures of 9 inattention items each reflecting a different symptom (e.g., “did you frequently lose things like assignments or books or other things you needed?” and “did you dislike, avoid, or put off doing things that required a lot of concentration?”) and 11 hyperactivity-impulsivity items reflecting 9 hyperactivity-impulsivity symptoms (e.g., “did you usually fidget or squirm a lot when you were sitting down?” and “did you often blurt out answers to other people’s questions ever before they were finished talking?”) based on DSM-IV criteria. The AUDADIS-IV divided 2 of the DSM-IV hyperactivity-impulsivity symptoms—often interrupts or intrudes on others (e.g., butts into conversations or games) and often excessively runs about or climbs when and where it is not appropriate (adolescents or adults may feel very restless)—into 2 separate questions (e.g., “often blurt out answers to other people’s questions even before they were finished talking” and “often interrupt or butt in to other people’s conversations without being asked to do so.”). Thus, we collapsed these items so that a response was considered positive if they endorsed either AUDADIS-IV symptom question reflective of the DSM-IV symptom, for a total of 9 hyperactivity-impulsivity symptoms. Although the dichotomous nature (presence vs. absence) of the ADHD symptoms in the AUDADIS-IV is limited in that the severity of each symptom is not assessed, dichotomous measures of ADHD symptoms have been successfully used in previous research to assess both childhood (prior to age 12 years) and current ADHD symptoms in adults.⁴² Participants who answered “unknown” were categorized as missing for that symptom, and those who had missing information across all symptoms were excluded from analyses. Participants received 3 scores based on symptom count indexes: number of total ADHD symptoms endorsed, number of inattention symptoms endorsed, and number of hyperactivity-impulsivity symptoms endorsed.

Nicotine Withdrawal Symptoms—Participants were asked whether they had ever experienced (yes/no) each DSM-IV nicotine withdrawal symptom (see Table 2 for a list of symptoms assessed). The nicotine withdrawal module was administered at both waves, and responses were combined across waves in analyses. If participants endorsed the withdrawal symptom at either wave, they were coded positive for that symptom. Participants also received a composite withdrawal score based on total number of withdrawal symptoms endorsed.

Covariates

Smoking Characteristics—Smoking covariates included age of first full cigarette, quantity of cigarettes usually smoked per day (higher value across waves), and lifetime DSM-IV nicotine dependence to determine whether ADHD–withdrawal associations were explained by the possibility that individuals with ADHD may be heavier and more chronic, dependent smokers.

Axis-I Disorders—Lifetime non-nicotine substance use disorder, mood disorder (major depression, dysthymia, [hypo]mania), anxiety disorder (panic disorder, agoraphobia, social phobia, specific phobia, specific phobia, generalized anxiety disorder, posttraumatic stress

disorder), and conduct disorder were categorized based on DSM-IV criteria. We included these covariates because ADHD and nicotine withdrawal are both associated with these disorders;^{43–49} therefore, these variables could account for ADHD–withdrawal associations.

Data Analysis

For preliminary analyses, we examined descriptive characteristics of ADHD symptoms, smoking characteristics, and withdrawal symptoms; calculated correlations between total ADHD symptoms, inattention symptoms, and hyperactivity-impulsivity symptoms; and calculated Cronbach's alpha coefficients for each ADHD symptom index. To reduce positive skewness, hyperactivity-impulsivity and inattention symptom counts were square root transformed and then standardized (mean = 0, standard deviation [SD] = 1) to aid interpretation of the odds ratios.

Because the timing of onset and offset of individual ADHD and nicotine withdrawal symptoms were not assessed in the AUDADIS-IV, the primary analyses focused on lifetime cross-sectional associations between ADHD and withdrawal symptoms. Specifically, we used logistic regression models to test the associations of total, inattention, and hyperactivity-impulsivity symptoms to the presence (vs. absence) of each withdrawal symptom and total withdrawal symptom score. We examined each withdrawal symptom separately because of evidence that ADHD is more robustly associated with some withdrawal symptoms than others.^{12,14}

For each withdrawal outcome, 4 types of models were calculated: a univariate model that included total ADHD symptoms as the sole predictor; a univariate model that included inattention symptoms as the sole predictor; a univariate model that included hyperactivity-impulsivity symptoms as the sole predictor; and a combined model that included inattention and hyperactivity-impulsivity symptoms as simultaneous predictors to examine their unique associations with withdrawal symptoms after controlling for their covariance. All models adjusted for demographic characteristics (sex, marital status, age, ethnicity/race, education, income), lifetime non-nicotine substance use disorders, lifetime psychiatric diagnoses (mood disorder, anxiety disorder, conduct disorder), and smoking characteristics (lifetime nicotine dependence diagnosis, age of first full cigarette, average number of cigarettes smoked during period of heaviest smoking).

Lastly, because previous work has found gender differences in abstinence effects among those with ADHD,¹³ we examined whether sex moderated the relationships between ADHD symptoms and withdrawal symptoms in single-predictor models. We also investigated whether meeting the number of symptoms necessary for a clinical diagnosis of ADHD moderated ADHD–withdrawal symptom relationships in single-predictor models. To do this, we included moderators of: ≥ 6 inattention or hyperactivity-impulsivity symptoms versus <6 inattention or hyperactivity-impulsivity symptoms for associations between total ADHD symptoms and withdrawal symptoms, ≥ 6 inattention symptoms vs. <6 inattention symptoms for inattention symptom relations, and ≥ 6 hyperactivity-impulsivity symptoms vs. <6 hyperactivity-impulsivity symptoms for hyperactivity-impulsivity symptom relations.

All analyses were performed in SAS using the PROC SURVEY procedures⁵⁰ to account for the complex sampling methodology of the NESARC and to use the recommended sampling weights to approximate the U.S. population.³⁶ Primary results of logistic regressions are reported as odds ratios (ORs) and standardized beta weights (β s). Significance was set at $P < 0.01$ (2-tailed) to decrease the probability of type 1 errors associated with multiple comparisons while not severely limiting statistical power, as used in previous studies.^{51,52}

RESULTS

Preliminary Analyses of Descriptive Characteristics

ADHD Characteristics—The mean \pm SD of ADHD symptom indexes (non-transformed) were as follows: total number of overall symptoms (2.74 ± 3.75), inattention symptoms (1.14 ± 2.06), and hyperactivity-impulsivity symptoms (1.60 ± 2.16). The distribution of total inattention symptoms ($\% \pm$ standard error [SE]) was as follows: 0 symptoms ($63.9\% \pm 0.48$), 1 ($12.2\% \pm 0.33$), 2 ($6.6\% \pm 0.24$), 3 ($4.7\% \pm 0.23$), 4 ($3.4\% \pm 0.18$), 5 ($2.7\% \pm 0.16$), 6 ($2.0\% \pm 0.14$), 7 ($1.8\% \pm 0.13$), 8 ($1.6\% \pm 0.13$), and 9 ($1.1\% \pm 0.10$). For hyperactivity-impulsivity symptoms, the distribution was: 0 ($46.2\% \pm 0.5$), 1 ($17.9\% \pm 0.38$), 2 ($11.3\% \pm 0.32$), 3 ($7.3\% \pm 0.26$), 4 ($5.5\% \pm 0.23$), 5 ($3.9\% \pm 0.18$), 6 ($3.0\% \pm 0.17$), 7 ($2.0\% \pm 0.51$), 8 ($1.5\% \pm 0.12$), and 9 ($1.4\% \pm 0.12$). Thus, there was adequate variability within each symptom index.

Smoking Characteristics

The mean age of first full cigarette smoked was 17.02 years (SD = 6.26 years). The average number of cigarettes smoked per day during time of heaviest use was 17.24 (SD = 12.58), and 7,169 ($49.8\% \pm 0.50$) participants met criteria for lifetime nicotine dependence.

Nicotine Withdrawal Symptoms

Presence of withdrawal symptoms ($\% \pm$ SE) among the sample was as follows: depressed mood ($18.5\% \pm 0.39$), sleep difficulties ($16.6\% \pm 0.38$), poor concentration ($19.3\% \pm 0.40$), weight gain ($49.0\% \pm 0.49$), anger ($43.6\% \pm 0.49$), anxiety ($39.7\% \pm 0.49$), slower heartbeat ($7.0\% \pm 0.26$), and restlessness ($32.2\% \pm 0.47$). The distribution of total number of withdrawal symptoms ($\% \pm$ SE) in the sample was: 0 symptoms ($33.5\% \pm 0.47$), 1 ($16.9\% \pm 0.37$), 2 ($10.6\% \pm 0.31$), 3 ($8.9\% \pm 0.29$), 4 ($9.2\% \pm 0.29$), 5 ($8.4\% \pm 0.29$), 6 ($6.4\% \pm 0.25$), 7 ($4.5\% \pm 0.21$), and 8 ($1.6\% \pm 0.13$).

Correlations Between ADHD Symptom Variables

As illustrated in Table 1, the 3 ADHD symptom indexes evidenced adequate internal consistency. The correlation between inattention and hyperactivity-impulsivity was moderate, indicating that the 2 indexes were likely assessing related but non-redundant constructs.

Primary Analyses

Individual Models—In the individual models, all 3 ADHD symptom indexes were significantly associated with increased odds of experiencing each type of withdrawal symptom, as well as composite withdrawal, except for the associations of hyperactivity-impulsivity to withdrawal-related depressed mood and difficulty concentrating (Table 2).

Combined Models—After adjusting for the other ADHD symptom index, inattention retained significant associations with each withdrawal symptom, except for sleep difficulties and weight gain/increased hunger (Table 2). By contrast, all hyperactivity-impulsivity-withdrawal associations, with the exception of reduced heartbeat, were no longer significant.

Because withdrawal symptom assessment was not specific to cigarette use in the AUDADIS-IV (i.e., withdrawal symptom questions were for all forms of tobacco use), we reran analyses excluding anyone who was a lifetime user of other tobacco products (i.e., cigars, pipe, smokeless tobacco). Odds ratios yielded little, if any, substantive change (results available upon request to the first author [KJA]).

Moderation Analyses

Sex—Results indicated minimal sex differences across ADHD–withdrawal symptom relationships. The only relationship sex significantly moderated was between total ADHD symptoms and reduced heart rate (Wald = 6.74, $P = 0.009$), wherein women demonstrated a significant relationship ($OR = 1.40$, $P < 0.0001$) and men had a non-significant relationship ($P > 0.01$).

ADHD Symptom Threshold—ADHD symptom threshold status (≥ 6 hyperactivity-impulsivity or inattention symptoms vs. < 6 hyperactivity-impulsivity and inattention symptoms) significantly moderated a small number of the ADHD–withdrawal symptom associations. Having 6 or more inattention symptoms compared with less than 6 inattention symptoms significantly moderated the relationship between total inattention symptoms and sleep difficulties (Wald = 9.82, $P = 0.002$), heartbeat more slowly than usual (Wald = 7.08, $P = 0.008$), and total withdrawal ($\beta = .05$, $P = 0.001$). In all instances, meeting symptom threshold resulted in a stronger relationship between inattention and withdrawal symptoms. Symptom threshold status did not significantly moderate any hyperactivity-impulsivity or total ADHD symptom associations with withdrawal symptoms.

DISCUSSION

This cross-sectional study of U.S. adults found that total number of overall ADHD symptoms endorsed was significantly associated with presence of each individual withdrawal symptom, which generally coheres with past work. In a previous laboratory study, McClernon et al.¹¹ found no effects of experimentally induced overnight smoking abstinence on self-report measures of mood and withdrawal severity between adult smokers with current ADHD ($n = 12$) versus those without current ADHD ($n = 14$); however, participants with ADHD were more sensitive to the effect of abstinence on a performance-based cognitive measure than participants without ADHD. Two other studies with larger samples ($n = 40$, $n = 282$) have found associations between ADHD diagnostic status and self-reported nicotine withdrawal symptoms.^{12,13} The current study extends these findings to a quantitative measure of ADHD symptomatology, which allowed for investigation of the influence of a range of symptom scores on the withdrawal experience, demonstrated these relationships in a representative population-based sample, and indicated that ADHD symptom–withdrawal associations are incremental to demographic variables, substance use and psychiatric disorders, and smoking characteristics.

An important focus of this study was to distinguish between inattention and hyperactivity-impulsivity symptom indexes. Without accounting for the associations between inattention and hyperactivity-impulsivity, both dimensions were significantly associated with a greater likelihood of experiencing almost every type of nicotine withdrawal symptom, as well as a composite withdrawal. However, when hyperactivity-impulsivity and inattention symptoms were simultaneously added as predictors to examine their unique variance, these constructs demonstrated differential patterns of associations. Associations between hyperactivity-impulsivity and every withdrawal symptom, except for slower heartbeat, were not significant when accounting for the overlap between the 2 symptom indexes and covariates. In contrast, inattention symptoms retained significant associations to the affective symptoms, reduced heart rate, and concentration problems in combined adjusted models over and above hyperactivity-impulsivity and other cofactors. Taken together, these findings suggest that common variance across inattention and hyperactivity-impulsivity symptom dimensions contribute to ADHD's link with nicotine withdrawal, and inattention uniquely associates with several withdrawal symptoms over and above its covariance with hyperactivity-impulsivity and other potential confounds. These findings add to a growing

literature suggesting differential relations of inattention and hyperactivity-impulsivity levels to smoking variables other than nicotine withdrawal^{3,16,18,23–28} and suggest that different aspects of the ADHD syndrome may play unique roles in the nicotine dependence process.

There are several explanations for these findings. Because smoking may alleviate attentive deficits for people with ADHD,^{53–56} those with more inattention (vs. hyperactivity-impulsivity) symptoms may have a greater urge to smoke to minimize withdrawal symptoms³⁰ or may use nicotine to suppress their symptoms.^{11,57,58} In lieu of this, one explanation may be that those with increasing levels of inattention symptoms are not experiencing actual withdrawal but instead may be experiencing only an exacerbation of their ADHD symptoms that share similarities with certain withdrawal symptoms.¹⁴ Although the cross-sectional nature of this study precludes causal interpretations, concentration deficits in smokers with inattention symptoms may be unmasked during abstinence due to the absence of acute attention-enhancing effects of nicotine,^{59–61} which could account for the current pattern of findings. However, it does not seem that this explanation addresses the entire scope of findings. Inattention exhibited incremental relations across a range of withdrawal symptoms, including many that do not overlap with symptom criteria for ADHD (e.g., feel depressed, nervous/anxious, heartbeat more slowly than normal), as well as with total withdrawal.

Somewhat consistent with prior work,¹³ we found that women with increasing levels of ADHD symptoms may be more likely to experience withdrawal effects compared with men; however, we only found this for the relationship between total ADHD symptoms and reduced heartbeat. Otherwise, sex did not influence any of the ADHD–withdrawal symptom relationships. Future research should continue to investigate and clarify how sex influences the association between ADHD symptoms and withdrawal symptoms. Similar to sex, we found that the ADHD symptom threshold status moderated only a small number of relationships between ADHD symptoms and withdrawal symptoms. Specifically, individuals with 6 or more inattention symptoms showed a stronger relationship between total inattention symptoms and sleep difficulties, reduced heartbeat, and total withdrawal compared with those with less than 6 inattention symptoms. These findings suggest that having the number of inattention symptoms required for a clinical diagnosis may drive a few of the inattention–withdrawal symptom relationships; however, it does not seem that this characteristic was responsible for the majority of findings, which highlights the importance of examining the influence of the entire ADHD symptom spectrum on withdrawal outcomes.

There are several limitations that should be considered when interpreting the current study. First, ADHD and nicotine withdrawal symptoms were measured via retrospective self-report. Because retrospective reports are subject to recall bias, these reports are not as accurate as reports from prospective studies. Although the psychometric properties of self-report retrospective measures of ADHD symptoms have been proven to be adequate,^{62–64} more research is needed that prospectively examines associations of nicotine withdrawal with both self-report and behavioral measures of attention and inhibition. Relatedly, although the ADHD module of the AUDADIS-IV has demonstrated good test-retest reliability and excellent internal consistency,³⁹ further research is needed to assess validity indicators of this scale, especially because studies have shown that adults may underreport their childhood ADHD symptoms.⁶⁵ Second, reports of childhood ADHD symptom presence did not include information from other informants. Because a diagnosis of childhood ADHD relies on parents and teachers as the primary sources of information and because adults may have difficulty accurately recalling and evaluating their childhood symptoms,⁶⁶ researchers and clinicians typically substantiate and supplement self-reports of childhood symptoms with parent and teacher reports.⁶⁷ Although it has been shown that adults can give a true assessment of their childhood ADHD symptoms,⁶² because parent,

teacher, and self-reports of childhood symptoms often differ in degree and severity,⁶⁸ information from multiple sources is optimal to provide the most accurate account of childhood ADHD symptoms.^{66,67} Third, because the onset and offset of individual withdrawal symptoms were not assessed in the NESARC, we were unable to evaluate the order of onset and relative timing of ADHD and withdrawal and, therefore, relied on a cross-sectional analysis of lifetime symptoms. Accordingly, causal or temporal inferences cannot be concluded on the basis of this design. Moreover, because the average age of first cigarette was prior to the age 18 years and because there are similarities between ADHD symptoms and withdrawal symptoms, individuals experiencing certain withdrawal symptoms (e.g., difficulty concentrating, restlessness) before age 18 years may have mistakenly reported these symptoms as both withdrawal and ADHD symptoms, thereby inflating these relationships. Fourth, ADHD symptom assessment was limited to symptoms prior to age 18 years. Although research has shown no differences in withdrawal symptoms between childhood only and adult persisting ADHD,¹² it would have been preferable to differentiate ADHD chronicity as previous and current symptoms may represent important different phenotypes. Fifth, the ADHD symptom count scores we used are limited because they do not take into account the severity or frequency of each individual symptom and, therefore, may not entirely capture the underlying continuum of ADHD symptom severity. Similarly, the NESARC assessed only presence versus absence of DSM-IV nicotine withdrawal symptoms. However, individual nicotine withdrawal symptoms reflect a continuum of severity⁶⁸ and extend beyond DSM-IV based symptoms (e.g., craving, diminished positive affect, cognitive performance).⁶⁹ Thus, future research using continuous measures that span multiple signs and symptoms of withdrawal is warranted. Last, because smoking was assessed at both waves whereas ADHD was only assessed at wave 2, the 2 measures may have different psychometric properties because multiple measurements were used for withdrawal symptoms but not for ADHD symptoms.

These findings and future research on this topic are of clinical importance because this information may help to explain certain smoking cessation patterns found among those with high levels of inattention and hyperactivity-impulsivity.³⁰ Thus, smokers with ADHD symptoms—particularly those with high levels of inattention—may benefit from treatment targeting withdrawal during a cessation attempt to improve their short-term quality of life and potentially to aid in cessation outcomes.

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TABLE 1Intercorrelations and Cronbach Alpha Coefficients of ADHD Symptom Indexes^a

ADHD Symptom indexes	ADHD-HI symptoms ^b	ADHD-IN symptoms ^c	Total ADHD symptoms ^d
ADHD-HI symptoms	(.84)	.57	.91
ADHD-IN symptoms		(.87)	.83
Total ADHD symptoms			(.90)

ADHD = attention deficit hyperactivity disorder; HI = hyperactive-impulsive; IN = inattentive.

^a All correlations were significant at $P < .0001$. Cronbach alpha coefficients are on the diagonal.

^b Total number of hyperactive-impulsive symptoms endorsed (out of 9 possible symptoms).

^c Total number of inattentive symptoms endorsed (out of 9 possible symptoms).

^d Total number of ADHD symptoms endorsed (out of 18 possible symptoms).

TABLE 2

Odds Ratios (95% Confidence Intervals)/Standardized Beta Weights for Associations Between ADHD Symptom Indexes and Nicotine Withdrawal Symptoms

Outcome	Predictor Total ADHD symptoms Single model OR/ β (99% CI)	ADHD-IN symptoms model OR/ β (99% CI)	Single model OR/ β (99% CI)	Combined model OR/ β (99% CI)	ADHD-IN symptoms Single model OR/ β (99% CI)	Combined model OR/ β (99% CI)
Withdrawal symptoms						
Feel depressed	1.10 [*] (1.02–1.19)	1.14 ^{***} (1.06–1.22)	1.16 ^{***} (1.07–1.26)	1.16 ^{***} (1.07–1.26)	NS	NS
Have difficulty falling or staying asleep	1.11 ^{**} (1.02–1.19)	1.09 [*] (1.01–1.17)	NS	NS	1.09 [*] (1.01–1.18)	NS
Have difficulty concentrating	1.13 ^{***} (1.04–1.21)	1.16 ^{***} (1.08–1.25)	1.18 ^{***} (1.08–1.29)	1.18 ^{***} (1.08–1.29)	NS	NS
Eat more than usual or gain weight	1.11 ^{***} (1.04–1.18)	1.10 ^{***} (1.04–1.16)	NS	NS	1.09 ^{**} (1.02–1.15)	NS
Become easily irritated, angry, or frustrated	1.13 ^{***} (1.06–1.21)	1.13 ^{***} (1.06–1.21)	1.10 ^{**} (1.02–1.19)	1.10 ^{**} (1.02–1.19)	1.11 ^{***} (1.04–1.18)	NS
Feel anxious or nervous	1.15 ^{***} (1.07–1.22)	1.14 ^{***} (1.07–1.22)	1.11 ^{**} (1.03–1.20)	1.11 ^{**} (1.03–1.20)	1.11 ^{***} (1.04–1.18)	NS
Heartbeat more slowly than usual	1.27 ^{***} (1.14–1.42)	1.23 ^{***} (1.11–1.36)	1.15 [*] (1.02–1.29)	1.15 [*] (1.02–1.29)	1.23 ^{***} (1.11–1.37)	1.14 [*] (1.01–1.29)
Feel more restless than usual	1.15 ^{***} (1.08–1.23)	1.13 ^{***} (1.06–1.20)	1.09 [*] (1.01–1.18)	1.09 [*] (1.01–1.18)	1.11 ^{***} (1.04–1.19)	NS
Total withdrawal	0.06 ^{***}	0.06 ^{***}	0.05 ^{***}	0.05 ^{***}	0.05 ^{***}	NS

OR = odds ratio, CI = confidence interval, β = standardized beta weights, ADHD = Attention Deficit Hyperactivity Disorder.

ORs illustrate the increase in odds of endorsing the outcome variable associated with each increase in one standard deviation in the index symptom domain.

Total ADHD Symptoms = total number of ADHD symptoms endorsed (out of 18 possible symptoms).

ADHD-IN Symptoms = total number of ADHD inattentive symptoms endorsed (out of 9 possible symptoms).

ADHD-HI Symptoms = total number of hyperactive-impulsive symptoms endorsed (out of 9 possible symptoms).

Total Withdrawal = total number of withdrawal symptoms endorsed (out of 8 possible symptoms).

All models adjusted for sex, marital status, age, ethnicity/race, income, education, any substance use disorder (alcohol included), lifetime mood disorder, lifetime anxiety disorder, conduct disorder, lifetime nicotine dependence, quantity of cigarettes usually smoked per day, and age of first full cigarette. Single model includes respective ADHD symptom index as the sole predictor. Combined model includes both ADHD-IN and ADHD-HI symptom scores as simultaneous predictors. Ns for withdrawal symptoms range from 14,311 to 14,717 as a result of missing data for those symptoms. NS = non-significant.

* $p < .01$;

** $p < .001$;

*** $p < .0001$