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Attention Deficit Hyperactivity Disorder symptoms and smoking trajectories: Race and gender differences

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ABSTRACT

Purpose: This study examined the influence of Attention Deficit Hyperactivity Disorder (ADHD) symptoms severity and directionality (hyperactive-impulsive symptoms relative to inattentive symptoms) on trajectories of the probability of current (past month) smoking and the number of cigarettes smoked from age 13 to 32. Racial and gender differences in the relationship of ADHD symptoms and smoking trajectories were also assessed.
Methods: A subsample of 9719 youth (54.5% female) was drawn from the National Longitudinal Study of Adolescent to Adult Health (Add Health). Cohort sequential design and zero-inflated Poisson (ZIP) latent growth modeling were used to estimate the relationship between ADHD directionality and severity on smoking development.
Results: ADHD severity's effect on the likelihood of ever smoking cigarettes at the intercept (age 13) had a greater impact on White males than other groups. ADHD severity also had a stronger influence on the initial number of cigarettes smoked at age 13 among Hispanic participants. The relationships between ADHD directionality (hyperactive-impulsive symptoms relative to inattentive symptoms) and a higher number of cigarettes smoked at the intercept were stronger among Hispanic males than others. Gender differences manifested only among Whites.
Conclusion: ADHD severity and directionality had unique effects on smoking trajectories. Our results also highlight that the risk of ADHD symptoms may differ by race and gender.
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1. Introduction

Individuals diagnosed with Attention Deficit Hyperactivity Disorder (ADHD) smoke more cigarettes than those without ADHD (Gudjonsson et al., 2012). ADHD symptoms below the threshold for clinical diagnosis, also, adversely influence smoking outcomes (Chang et al., 2012; Kollins et al., 2005; Tercyak et al., 2002). The relative contributions of the different ADHD symptom domains (Hyperactive-Impulsive [HI] vs. Inattention [IN]) have been of interest in several studies (Fuemmeler et al., 2007; Kollins et al., 2005; McClernon et al., 2008; Polanczyk et al., 2010; Ranby et al., 2012; Van Voorhees et al., 2012; Willoughby et al., 2009). Some studies have shown IN symptoms are more predictive of smoking outcomes (e.g., Tercyak et al., 2002; Aytaclar et al., 1999; Burke et al., 2001; Molina and Pelham, 2003) than HI; whereas others report HI symptoms are the stronger predictor (e.g., Kollins et al., 2005). Drawing comparisons across studies is difficult given the differences in methods used to assess ADHD symptoms, age of participants, and the smoking behavior. Continued work is needed to better understand the relative role of HI and IN symptoms on smoking behavior over the course of development.

Race and gender are highly relevant to smoking behavior. Previous studies show that Whites are more likely to become regular or heavy smokers than Blacks (White et al., 2004), whereas Blacks are more likely to continue smoking into adulthood (Kandel et al., 2011). While most studies of smoking focus on Whites and Blacks, Chen and Jacobson (2012) examined the developmental pattern of cigarette smoking among Hispanic, White, and Black adolescents. They documented that Hispanic youth experienced higher rates of smoking during early adolescence compared to

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White and Black youth, White youth reported increased cigarette use during adolescence, and Black youth showed higher levels of smoking than White youth after entering adulthood. With regard to gender, males smoke significantly more than females during adolescence and adulthood though some exceptions have been noted (Kivinieme et al., 2011; Substance Abuse and Mental Health Services Administration, 2012). For example, Chen and Jacobson (2012) showed that females smoked more than males in early adolescence, but males smoked more than females from middle adolescence to adulthood, suggesting that the relation between gender and smoking varies across development. Despite documented differences in smoking behavior by race and gender, little is known about whether gender and race modify the association between ADHD and smoking outcomes.

Utilizing Add Health data, this study extended previous work that only either (a) looked at the relationships between ADHD symptoms and smoking outcomes with gender and ethnicity being controlled (e.g., Fuemmeler et al., 2007), or (b) focused primary on the impact of gender and ethnicity on smoking trajectories (e.g., Chen and Jacobson, 2012). The current study differs from previous studies by investigating the unique contribution of HI and IN symptoms on smoking trajectories from early adolescence to adulthood as a function of race and gender. A clearer understanding of how race and gender influence the relationship between ADHD symptoms and smoking over development has the potential to elucidate the etiology of smoking, and inform treatment and prevention approaches. This study (a) examined the overall severity and directionality (HI vs. IN) of ADHD symptoms in predicting smoking from ages 13 to 32, and (b) assessed whether race and gender differentially influenced the association between ADHD symptoms and smoking.

2. Methods

2.1. Participants

Data were drawn from 14,779 Add Health participants (53.2% female) interviewed from Waves I to IV. Respondents completed in-home surveys during the 1994–1995 school year (Wave I) and three additional times: Wave II during 1996, Wave III during 2001–2002, and Wave IV during 2008–2009. The participants' mean ages for each of the four waves were 15.65 ($SD = 1.75$), 16.22 ($SD = 1.64$), 22.96 ($SD = 1.77$), and 28.9 ($SD = 1.76$), respectively. Study design and data collection have been described elsewhere (see Harris et al., 2009; Resnick et al., 1997). Due to missing data on the covariates and indicators of ADHD symptoms, and restricting the sample to Whites, Hispanics, and Blacks by excluding small racial groups including "Asians" ($n = 936$), "Native Americans" ($n = 263$), and "Other" ($n = 130$), our analysis sample was further reduced to 9719 participants.

2.2. Measures

2.2.1. Smoking status. At all waves, participants reported their smoking status using a computer-aided survey instrument. Participants who had never smoked or who had not smoked during the prior 30 days were coded as having smoked 0 cigarettes in the past 30 days (non-current users). The smoking status of current users was coded by their responses regarding to the number of cigarette smoked per day on the days they smoked in the past 30 days.

2.2.2. ADHD symptoms. At Wave III, participants retrospectively reported on the DSM-IV ADHD symptoms that they experienced between ages 5 and 12. Responses were on a 4-point scale: (1) "never or rarely," (2) "sometimes," (3) "often," or (4) "very often." A symptom was considered present (coded as 1) if it was experienced "often" or "very often," whereas a symptom was considered non-present (coded as 0) if it was experienced "never or rarely" or "sometimes." One DSM-IV HI ADHD symptom, "Often interrupts or intrudes on others," was not available in the dataset. Accordingly, eight HI symptoms and nine IN symptoms were available for analysis and resulted in uneven number of items for the HI and IN domains. Therefore, HI and IN latent factor scores were created, representing a continuous score of the levels of symptoms endorsed.

2.2.3. Gender and race. Male was coded as "1" and female as "2". Based on participants' response of their race, mutual exclusive groups were created for White, Hispanic, and Black.

2.2.4. Covariates. Since educational level and conduct problems have been shown to be associated with both ADHD and smoking outcomes (Armstrong and Costello, 2002; Eiraldi et al., 1997), these variables were included as covariates. Parents'/caregivers' education level was coded categorically as less than high school, high school or equivalent, some college, or college degree or beyond. Conduct Problems (CP) was assessed at Wave I by asking participants whether they have engaged in 13 conduct-related problem behaviors (e.g., fighting, property damage, lying to parents or guardians). Depending on the question, responses ranged from 0 (never) to 3 (5 or more times). The 13 items were dichotomized into 0 (never) and 1 (one or more); the sum score served as the CP measure. A reliability coefficient (KR20) for CP symptoms was 0.71, suggesting the CP measure in this study is adequate and the measure has been used in previously published studies with the Add Health database (e.g., Fuemmeler et al., 2013; Kollins et al., 2005; McClernon et al., 2008; Miles et al., 2002).

2.3. Analytic procedure

Analyses were conducted using *Mplus* version 7.11 (Muthén and Muthén, 1998–2012). We incorporated survey design effects and survey weights into the analysis. We also employed a cohort-sequential design in which age, rather than wave, equaled the unit of time (see Bollen and Curran, 2006; Duncan et al., 2006, 2007). The cohort-sequential approach results in substantial missing data by design; *Mplus* employs an expectation maximization (EM) algorithm to limit potential biases in such designs (Duncan et al., 2006).

To model smoking, we used latent growth modeling (LGM) along with zero-inflated Poisson (ZIP). LGM–ZIP allows for estimating growth components including the average level of a parameter at starting point (i.e., intercept), the increase (or decrease) rate over time (i.e., linear trend), and deceleration (or acceleration) in the rate of the linear trend (i.e., quadratic trend) for binary (probability of current smoking) and count (number of cigarettes smoked) trajectories. These growth components were further regressed on covariates to determine the association that a particular covariate has with each growth component.

Because HI and IN symptoms are highly correlated, putting these domains in the same model may distort the interpretation of the results. We adopted a procedure proposed by Essex et al. (2006) for dealing with highly correlated domains. Specifically, this procedure bifurcates what the correlated factors have in common [severity = (HI + IN)/2], from what distinguishes them [directionality = (HI − IN)/2]. Accordingly, the effect of severity on smoking would be the non-specific effect of ADHD symptoms. The effect of directionality would be the specific effect of one domain relative to the other, in this case, HI symptoms relative to IN symptoms.

Subsequent to fitting unadjusted growth curves, the estimated smoking trajectories (i.e., probability of current smoking and the number of cigarettes smoked) were regressed on ADHD severity and directionality, along with gender and racial groups. A multigroup approach was applied to estimate the relationship between ADHD symptoms and smoking trajectories, stratified by racial and gender groups. Invariance of the effects of ADHD symptoms on smoking trajectories across gender and race were tested using a series of Wald's Chi-square test to examine whether significant differences exist (a) among racial groups within the same gender or (b) between genders within the same racial groups.

3. Results

3.1. Sample characteristics

Around half of the participants were female (54.5%). The racial groups included Whites (60.9%), Blacks (22.5%), and Hispanics (16.5%). Approximately 24% of the participants' primary caregivers had earned college degrees. The percentage of participants reporting six or more HI symptoms (2.9%), six or more IN symptoms (2.5%), or six or more of both HI and IN symptoms (2.2%) are similar with previous research (e.g., Tercyak et al., 2002). Figs. 1 and 2 show the estimated smoking trajectories over development by race and gender groups.

3.2. ADHD symptoms and smoking trajectories

Table 1 shows the results of smoking trajectories (i.e., use vs. non-use and number of cigarettes smoked) regressed on ADHD scores (i.e., severity and directionality) after controlling for gender, race, conduct problems, and primary caregiver's educational level. The adjusted slope for the binary trajectory was $\beta = 4.41$ ($SE = .48$) suggesting that the probability of current smoking increased with age. The negative value for the quadratic ($\beta = -3.84$, $SE = .64$)

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