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Substance use through adolescence into early adulthood after childhood-diagnosed ADHD: Findings from the MTA longitudinal study

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Abstract

Background—Inconsistent findings exist regarding long-term substance use (SU) risk for children diagnosed with Attention-Deficit/Hyperactivity Disorder (ADHD). The observational follow-up of the Multimodal Treatment Study of Children with ADHD (MTA) provides an opportunity to assess long-term outcomes in a large, diverse sample.

Methods—547 children, mean age 8.5, diagnosed with DSM-IV combined-type ADHD and 258 classmates without ADHD (local normative comparison group; LNCG) completed the Substance Use Questionnaire up to 8 times from mean age 10 to mean age 25.

Results—In adulthood, weekly marijuana use (32.8% ADHD vs. 21.3% LNCG) and daily cigarette smoking (35.9% vs. 17.5%) were more prevalent in the ADHD group than the LNCG.

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The cumulative record also revealed more early substance users in adolescence for ADHD (57.6%) than LNCG (40.3%), including younger first use of alcohol, cigarettes, marijuana, and illicit drug use. Alcohol and non-marijuana illicit drug use escalated slightly faster in the ADHD group in early adolescence. Early SU predicted quicker SU escalation and more SU in adulthood for both groups.

Conclusions—Frequent SU for young adults with childhood ADHD is accompanied by greater initial exposure at a young age and slightly faster progression. Early SU prevention and screening is critical before escalation to intractable levels.

Keywords

Attention deficit disorder; ADHD; Drug abuse; Adolescence

Risk of substance use disorder for children with attention-deficit/hyperactivity disorder (ADHD) has been increasingly studied (e.g., Breyer et al., 2014; Dalsgaard et al., 2014; Hechtman et al., 2016), but important questions remain regarding risk for frequent substance use (SU). Although SU disorder is higher among those with ADHD in childhood (Groenman et al., 2017), reports of SU frequencies known to be associated with negative health outcomes (Terry-McElrath et al., 2017) are rare. A 2011 meta-analysis (Lee et al., 2011) noted few prospective studies of SU generally (vs. SU disorders) and significant heterogeneity in marijuana findings. The observational follow-up of the Multimodal Treatment Study of ADHD (MTA; MTA Cooperative Group, 1999) prospectively assessed SU by children diagnosed with ADHD and a local normative comparison group (LNCG) from mean age 10 into early adulthood (mean age 25). This report capitalizes on this dataset and its strengths (rigorous childhood diagnosis, multisite demographic diversity, narrow age band at recruitment, repeated assessments, and good retention) to clarify 1) the extent to which childhood ADHD elevates risk for SU in early adulthood and 2) the developmental course of SU into adulthood for this vulnerable population.

First, we compare SU rates for the ADHD group and the LNCG during early adulthood when most SU reaches its lifetime maximum (Center for Behavioral Health Statistics and Quality, 2015) and importantly influences health outcomes into later adulthood (Terry-McElrath et al., 2017). We test the hypothesis that childhood ADHD predicts regular SU (e.g., weekly binge drinking and marijuana use) during this critical developmental stage. Second, although polysubstance use is typical among *adolescent* substance users (Palmer et al., 2009) and characterizes the MTA adolescents (Molina et al., 2013), adulthood presents opportunities for substance preference as experience accumulates and social influences change (Monahan et al., 2009). The strong clinical response of ADHD to dopaminergic psychostimulant medication and questions about its precise mechanisms (dela Peña, Gevorkiana, & Shi, 2015) have raised questions about vulnerability to other dopaminergic drugs (Lambert & Hartsough, 1998), including tobacco and cocaine, and concern about abusing prescribed stimulants (McCabe et al., 2017). Additionally, some adults with ADHD report a preference for marijuana (Mitchell et al., 2017), perhaps due to its anxiolytic properties (Bonn-Miller et al., 2007). Hence, we examine adult SU separately by drug class to explore possible increased risk for some but not all substances by early adulthood.

Third, we examine SU onset according to established literature on the developmental course of addiction. Early, frequent, or heavy adolescent SU poses a well-known risk for later SU disorder (Chassin et al., 2002; Chen et al., 2009; Nelson et al., 2015). Several longitudinal studies inconsistently report about early initial use for various substances among adolescents with ADHD (Groenman et al., 2013; Molina & Pelham, 2003; Molina, Pelham, Gnagy, Thompson, & Marshal, 2007; Rhodes et al., 2016; Sibley et al., 2014). A few of these studies reported atypically frequent and/or heavy use (Burke et al., 2001; Molina & Pelham, 2003; Molina et al., 2007; Molina et al., 2013; Sibley et al., 2014). Null group differences may have resulted from focusing categorically on any gateway SU (tobacco, alcohol, marijuana) instead of measuring frequency or quantity (Barkley et al., 1990; Bussing et al., 2010), which may better capture SU disorder risk. In previous MTA reports, we described increased experimentation with gateway substances in late childhood/early adolescence (Molina et al., 2007) and repetitive SU by mid- to late-adolescence for ADHD (Molina et al., 2013). Here, with data collected completely through adolescence into early adulthood, we evaluate the full cumulative record of SU and test the hypothesis that childhood ADHD predicts early and atypically frequent SU in adolescence. The multiple observation points decrease error from single time-point assessments that can underestimate prevalence (Haeny et al., 2014), particularly during adolescence, when SU is episodic.

Finally, rapid escalation from initial experimenting to frequent use is also prognostic of later SU disorder (Chassin et al., 2002; Hussong et al., 2008; Nelson et al., 2015). Some studies report more rapid progression from initial to heavier levels of SU for children with ADHD (Milberger et al., 1997; Sibley et al., 2014; Wilens & Biederman, 2006), which has important intervention implications (Howard et al., 2015). Most studies, however, have limited data to characterize this developmental process. Few studies of SU progression extend through adolescence into adulthood. Diverging trajectories within the peak period of heavy use (age 18–25) also have serious implications for major life outcomes such as unemployment by age 36 (Lee et al., 2015). Adults with a history of ADHD experience difficulties in these life domains (Barkley et al., 2008; Hechtman et al., 2016). Hence, we evaluate whether ADHD predicts faster escalation of SU through adolescence into early adulthood, and whether escalation occurs more rapidly following early SU for individuals with, versus without, childhood ADHD.

We tested the following hypotheses pertinent to ADHD-related SU in adulthood and developmental course:

1. Childhood ADHD predicts elevated SU frequency in early adulthood;
2. ADHD-related risk may be especially pronounced for some substances but not others;
3. SU at an early age—including atypically frequent SU---will be more prevalent in the ADHD group than in the LNCG;
4. Substance use will escalate more quickly for the ADHD group than the LNCG; early substance users with childhood ADHD will escalate most rapidly.

Method

Participants were 579 children diagnosed with DSM-IV ADHD combined type and 258 age- and sex-matched comparison children without ADHD (LNCG). Probands were recruited from seven sites in the US and Canada (see Author Note) when they were 7.0–9.9 (*M*=8.5, *SD*=.80) years old. Sources were schools, primary care and mental health practitioners/ clinics, and family-based referrals (Hinshaw et al., 1997). At each site 95–98 children were randomly assigned to one of four treatment groups: Medication Management, multicomponent Behavior Therapy, the combination, or referral to usual community care. The MTA recruitment strategy, inclusion/exclusion criteria, diagnostic procedures, treatment, and sample demographics are described elsewhere (MTA Cooperative Group, 1999). Informed consent was collected throughout according to the respective IRBs.

ADHD participants were diagnosed prior to randomization and assessed through the 14-month treatment phase and at 2, 3, 6, 8, 10, 12, 14, and 16 years post-baseline. The LNCG was recruited 2 years after ADHD baseline and assessed on the same schedule. For this report, we analyzed SU data from the 2-year (M_{age}=10.4, *Range*=8.2–13.9) through 16-year (M_{age}=25.0, *Range*=21.7–28.6) assessments.

Retention was high. SU data were provided at least once in adulthood (12, 14, and/or 16 years after baseline) by 81.3% of the ADHD group (n=471/579) and 93% of the LNCG (n=240/258). In addition, 95% of ADHD group participants were reassessed at least once between the 2- and 16-year waves and were retained in our analyses (see Table 1 in Swanson et al., 2017 for details). The final sample size was *n*=805 (*n*=547 ADHD, *n*=258 LNCG).

Comparisons between cases with complete versus incomplete data identified covariates to include in our models to satisfy the *missing at random* assumption; this approach provides unbiased point estimates and standard errors when using full information maximum likelihood estimation (Schafer & Graham, 2002). For both ADHD and LNCG (23 and 22 variables tested, respectively), participants with complete data were not significantly different from participants with incomplete data on most baseline sociodemographic variables (e.g., age, parent job loss and marital status, child health, school absences). ADHD cases with incomplete data were more often characterized by male sex, racial or ethnic minority, lower parental incomes, less educated parents, younger biological mothers, fewer fathers with histories of mental health problems, and assignment to MTA treatment involving medication. LNCG cases with incomplete data were more often characterized by male sex, racial or ethnic minority, lower parental incomes, younger mothers, and a history of school expulsion. Models included sex, race/ethnicity, and a household (dis)advantage composite (Molina et al. 2012), as baseline covariates.

Measures

The self-report Substance Use Questionnaire (SUQ; Molina & Pelham, 2003) was adapted for the MTA (Molina et al., 2013). Participants responded to questions about lifetime use (“ever”), age of first use, and recent frequency of use for alcohol, marijuana, cigarettes, and a range of illicit and prescription drugs. At the 2- through 10-year assessments, frequency of use was assessed over the past 6 months, and response options ranged from 1 (*never*) to 9

(*more than twice a week*). Beginning with the 12-year assessment, when all participants were over age 18, frequency was assessed over the past year, and response options ranged from 1 (*not at all*) to 12 (*several times a day or more*). The two frequency response scales were harmonized by prorating the past 6 month responses to a past-year scale, as needed. For example, a substance used "2–3 times" in the past 6 months was prorated to a frequency of 4–6 times in the past year. Other response options (e.g., once a month, once a week) were already on equivalent scales. Honest reporting was facilitated with a Certificate of Confidentiality from the National Institutes of Health.

Substance Use—*Heavy drinking* was the higher score of two items assessing frequency of binge drinking and of drunkenness (How many times did you drink five or more drinks when you were drinking? How many times have you gotten drunk or "very, very high" on alcohol?). *Marijuana use* was assessed with one frequency question. For these variables, the 12-point ordinal scale was recoded to four levels: 0 (*none*), 1 (*less than once per month*), 2 (*at least monthly; less than weekly*), and 3 (*once per week or more*). *Daily smoking* was a binary variable (0=no, 1=yes). For the 2- through 10-year assessments, participants were coded affirmatively if they smoked at least one cigarette per day in response to: "During the past month, how many cigarettes have you smoked on an average day?" For the 12- through 16-year assessments, participants were coded affirmatively if they smoked "once a day" or more often in response to: "In the past year, how often did you smoke cigarettes?" or if they responded "yes" to "Are you currently a daily cigarette smoker?" *Other illicit drug use*. At all assessments, participants reported misuse of prescription medications including stimulants, sedatives, and opioids, and use of heroin, inhalants, hallucinogens, cocaine, and "other substances to get high not mentioned". From the 2- through 10-year assessments, participants also reported use of combinations (e.g., amphetamine and barbiturate combined). Participants' score on a summary illicit drug use variable was their maximum frequency of any illicit drug used (or prescription drug misused). The 12-point ordinal scale was recoded for analysis to three levels: 0 (*none*), 1 (*less than once per month*), and 2 (*once per month or more often*).

Early SU—We identified *early SU*, in relation to published norms (e.g., Chassin et al., 2002; Chen et al., 2009; Nelson et al., 2015; Palmer et al., 2009), using the cumulative reports in the dataset (both prospectively reported and retrospectively recalled, from the assessments 2 to 16 years after baseline). Participants were coded as early substance users if they initiated use of ≥1 substance early for age (Criterion A) ***and*** used ≥1 substance heavily for age (Criterion B). Criteria A and B could be met across different substances. Alcohol criteria were: (A) consumption of a drink (i.e., "not just a sip or taste of someone else's drink") before age 15 and (B) any heavy drinking (as defined above) before age 16. Marijuana criteria were (A) trying marijuana at least once before age 16 and (B) using marijuana more than once before age 17. Cigarette smoking criteria were (A) smoking a cigarette before age 15 and (B) smoking cigarettes "more than a few times" before age 17. For other illicit drugs, any use before age 17 was counted as meeting A or B. Some participants had insufficient data (e.g., withdrew from the study early: n=41 MTA, n=12 LNCG) and were coded as not being early substance users. Results were unchanged when these cases were excluded.

Analytic Plan

Chi-square tests compared percentages of ADHD and LNCG participants who endorsed weekly heavy use of alcohol or marijuana or daily cigarette smoking in adulthood, and monthly use of non-marijuana illicit drugs or prescription drug misuse in adulthood. As in recent reports for other outcomes (Hechtman et al., 2016; Sibley et al., 2017; Swanson et al., 2017), analyses of adult SU involved data from the latest available assessment point in adulthood (12, 14, or 16 years after baseline). Chi-square tests also compared percentages of ADHD and LNCG who endorsed early SU in adolescence.

To test hypotheses about ADHD-versus-LNCG differences in SU escalation, we compared SU growth trajectories using generalized multilevel linear modeling with the PROC GLIMMIX procedure in SAS for categorical outcomes. Preliminary data inspection suggested that increases in SU leveled off in the early twenties. A piecewise linear function of age (e.g., Flora, 2008) incorporated an inflection point at age 21, modeling separate rates of change: (1) through adolescence to age 21 and (2) in adulthood after 21. In a second set of models, we added early SU (no/yes), and interaction with ADHD/LNCG group to test our hypothesis that early SU would more strongly predict escalation for ADHD than LNCG. We centered age in all models at 25—the sample mean age at the final 16-year assessment—giving an intercept at age 25 for main effects. Sex was Male= 0, Female=1; racial/ethnic minority group differences in SU were reflected by three weighted effects codes comparing (1) Black, (2) Hispanic, and (3) Mixed/other to the sample average; effects of childhood household (dis)advantage were accounted for with two weighted effects codes comparing children from two-parent households and a college-educated parent to the sample average (*household advantage*), and children from single-parent households and no college-educated parent to the sample average (*household disadvantage*). The effects of adding CD/ODD in childhood to the models are also reported below. Separate ADHD-only analyses of original treatment group assignment revealed no effects on SU, so we exclude these results from the final models.

Results

Adulthood SU and Adolescent Early Use

Table 1 and Figure 1 show percentages of participants with and without childhood ADHD diagnosis who reported regular SU as adults. The ADHD group and LNCG did not differ in weekly heavy alcohol use or monthly illicit drug use. However, more ADHD than LNCG were weekly marijuana users and daily cigarette smokers. Daily alcohol, daily marijuana, and individual illicit/prescription drugs were explored; cell sizes allowed detection of a significant group difference (ADHD>LNCG) for daily marijuana use. These data revealed that pooling over classes of illicit drugs did not obscure ADHD vs. LNCG differences in usage of specific illicit substances or prescription drug misuse. Importantly, prescription stimulants were misused (more than prescribed or without a prescription), and cocaine used, monthly by only 1.1% of the ADHD group and 1.3% of the LNCG. For stimulant medications, the low rate of misuse was not due to selling it (only 7/474 ADHD and 2/240 LNCG).

Early SU occurred for a greater proportion of the ADHD group (317/547, 57.9%) than the LNCG (108/258, 41.8%), $\chi^2(1)=23.67$, $p<.0001$. We also calculated the percentages reporting *initial* use of each substance type at a young age based on literature-derived cut-offs. For each substance, more in the ADHD group than LNCG started at young ages: alcohol--51.7% of ADHD (n=265/513 with valid alcohol data) versus 43.0% of LNCG (n=107/249; $\chi^2(1)=5.06$, $p=.025$); cigarettes--37.5% of ADHD (n=192/512) versus 19.3% of LNCG (n=48/249; $\chi^2(1)=25.77$, $p<.0001$); marijuana--48.5% of ADHD (n=247/509) versus 34.7% of LNCG (n=86/248; $\chi^2(1)=12.98$, $p=.0003$); other illicit drug use--26.2% of ADHD (n=130/496) versus 13.4% of LNCG (n=33/246; $\chi^2(1)=15.71$, $p<.0001$).

SU Escalation

Table 2, Model 1 and Figure 2, Panels A-D show the results of our growth models comparing SU escalation by childhood ADHD diagnostic group. Although each model predicts up to four levels of use, figures display only the model-implied log odds of attaining the highest categorical level of use for each substance type (to avoid overly-complex figures). We also plot the more interpretable observed proportions.

For Model 1, the log odds of heavy drinking, marijuana use, daily smoking, and illicit drug use significantly increased through adolescence (*Adolescent trajectory*), and declined slightly after age 21 (*Adult trajectory;* illicit–drug decline ns). Partially consistent with use rates in Table 1 for each participant's last adult observation, there were no main effects of ADHD group versus LNCG on heavy drinking or illicit drug use at age 25, suggesting that young adults with and without ADHD histories drink heavily and used non-marijuana illicit drugs (or misused prescriptions) at similar rates. A marginal effect of ADHD group on marijuana use, and a large effect on daily smoking, indicated higher rates of use in young adults with ADHD histories than without. Rates of increase in heavy drinking and illicit drug use to age 21 differed for ADHD versus LNCG (*ADHD/LNCG × Adolescent*). Rates of increase in daily smoking and marijuana use to age 21 were similar across groups. There were no group differences in rates of change (increase or decrease) of any substances after age 21 (*ADHD/LNCG × Adult*). Results remained after adding another covariate that accounted for comorbid childhood conduct or oppositional-defiant disorder (CD/ODD) versus ADHD only, except that children with CD/ODD were more likely to use non-marijuana illicit drugs as adults.

SU Escalation as a Function of Early Use

Table 2, Model 2 and Figure 3, Panels A–D show the results of growth models comparing SU escalation by childhood ADHD diagnostic group, early SU, and their interaction. Early SU was associated with significantly more heavy drinking, marijuana use, daily smoking, and other illicit drug use at age 25 (*Early use vs. Typical* in Table 2). This association did not differ by ADHD/LNCG (*Early use × ADHD/LNCG*) for any substances. Early users increased their SU to age 21 at a significantly faster rate than peers with developmentally typical SU (*Early use × Adolescent;* ns for daily smoking). This effect did not differ by ADHD/LNCG (*Early use × ADHD/LNCG × Adolescent*). After age 21 there were no significant differences in heavy drinking, marijuana, daily smoking, or illicit drug use rates of change for early versus developmentally typical users (*Early use × Adult*). There were no

further differences by ADHD/LNCG for any substances (*Early use × ADHD/LNCG × Adult*). No significant effects of comorbid childhood CD/ODD were found in Model 2.

Baseline Covariate Effects

Table 2 also shows covariate effects which varied slightly between Models 1 and 2; statistically significant Model 2 effects are described here. The odds of heavy drinking were lower among Black participants relative to the sample average at age 25. The odds of daily smoking and any illicit drug use were lower in both Black and Hispanic participants. Household advantage was associated with lower odds of marijuana use and daily smoking at age 25, and household disadvantage was associated with higher odds of daily smoking.

Discussion

Using the prospective longitudinal data of the MTA from childhood to adulthood (mean age 25), we found 1) more regular use of marijuana and cigarettes by adulthood in cases with childhood ADHD diagnosis; 2) no increased risk for use/misuse of other classes of substances including alcohol, cocaine, and prescription stimulants; 3) more early SU in adolescence for the ADHD group than LNCG; 4) slightly faster escalation of SU in adolescence for the ADHD group; and 5) more adult SU of all types (e.g., alcohol, marijuana, etc.) following early SU – regardless of childhood ADHD history. Escalation was unaffected by the inclusion of childhood CD/ODD, but this comorbidity additionally predicted non-marijuana illicit drug use. Collectively, the large size of the MTA sample, research-quality diagnoses of ADHD, multisite design, and prospective assessments make these findings important for clarifying long-term risk for children with ADHD.

SU in Adulthood

We found that 33% of adults with childhood ADHD were weekly marijuana users versus only 21% of the LNCG; the ADHD group had double the LNCG rate for daily marijuana use (22% vs 11%). These findings are especially important given uncertainty of ADHD-related risk for heavy marijuana use in the literature (Lee et al., 2011) and negative health consequences of chronic use, particularly among individuals with psychiatric symptoms (Compton, Volkow, & Lopez, 2017). Adolescents with ADHD have poorer coping skills (Harty, Gnagy, Pelham, & Molina, 2017) and, when combined with increasing marijuana accessibility (Hasin et al., 2017), this may contribute to chronic use and associated negative sequelae. These results amplify concern about ADHD-related risk of cannabis use disorder noted in our recent report (18.9% vs 11.3%; Hechtman et al., 2016[1]) because more MTA adults reported frequent marijuana use than met criteria for disorder. Also shown in recent national surveys of marijuana use (Hasin et al., 2015), we found that weekly marijuana use and cannabis use disorder are not congruent: only half of the weekly users met criteria for cannabis use disorder (54.6% of ADHD and 52.0% of LNCG). Results were similar for daily marijuana use (69% and 66%, respectively). Thus, examining marijuana-use frequency alongside disorder provides a more complete picture than examining either separately.

[1]Reflect corrected rates, previously published erroneously in Hechtman et al. (2016).

Our findings confirm the most consistently reported SU risk associated with ADHD—cigarette smoking—36% of ADHD vs. 18% of LNCG. Similar large group differences were reported in smaller and/or single-site studies (Barkley et al., 2008; Klein et al., 2012; Lambert & Hartsough, 1998; Rhodes et al., 2016). Given the well-established negative health consequences of cigarette smoking (e.g., Lubin & Caporaso, 2013), and that cessation is especially difficult for those with ADHD (Humfleet et al., 2005; Mitchell et al., 2017), the need for improved smoking prevention in ADHD is substantial. Smoking cessation treatments for this population may need to consider multiple factors; despite ADHD-symptom relief by nicotine (Levin et al., 2001), pharmacological treatment of ADHD symptoms does not improve quit rates (Kollins et al., 2012; Winhusen et al., 2010).

ADHD/LNCG group differences were not found for alcohol and illicit drug use. Our assessments in early adulthood, when hazardous consumption peaks in the US (SAMHSA, 2013), maximize power to test hypotheses but may also obscure risk for later, mid-adulthood alcoholism. The few studies that have followed children with ADHD this long have mixed results (Klein et al., 2012; Lambert & Hartsough, 1998; Pedersen et al., 2016). Longitudinal studies of alcohol use into mid-adulthood, including evaluation of psychiatric comorbidity, impairments such as inconsistent parenting, treatment response, and health problems should be conducted before concluding that alcoholism risk is inconsequential for ADHD.

Any concerns about risk of dependency on stimulant-type drugs (Kantak & Dwoskin, 2016; Lambert & Hartsough, 1998) stand in stark contrast to our findings. Despite the vast majority of probands taking stimulants for varying lengths of time (Swanson et al., 2017), we did not find more adults in the ADHD group than the LNCG using stimulant-type illicit drugs (e.g., cocaine) or misusing prescription stimulants (under 2% in both groups for both types of substances). Small numbers of participants reported selling their medication, so diversion did not account for low frequencies of misuse. Fewer than 5% of each group were regularly using any non-marijuana street drug or misusing prescriptions. This figure is comparable for 18- to 25-year-olds nationally (SAMHSA, 2013). Future analyses will examine possible protective effects of prior stimulant medication on later SU; key confounds and moderators will be examined.

SU at an Early Age and Escalation

More ADHD (58%) than LNCG (40%) met criteria for early SU, which extends our prior findings (Molina et al., 2007; 2013) through the complete adolescent phase. Surprisingly, up to 25% of the earliest age reports were from retrospective recall. Thus, aggregating data across prospective and retrospective reports may capture more adolescents with early ages of onset. An important finding is that over half of the children with ADHD suffered a major risk factor (early-age SU) that is well-documented in nonADHD research to predict later drug/alcohol problems (Chassin et al., 2002; Chen et al., 2009; Nelson et al., 2015).

In models examining escalation with age, children with ADHD increased their frequency of alcohol and non-marijuana illicit drug use quicker than children without ADHD. These findings partially align with trajectories of SU for children of alcoholics (e.g., Chassin et al., 2002) and college students (Derefinko et al., 2016). Adolescents with rapid increases in their SU tend to be behaviorally undercontrolled (high externalizing behavior, impulsive,

sensation-seeking) and male. Chassin and colleagues also reported more parental alcoholism, peer drinking, and drug use for adolescents whose binge drinking escalated rapidly. These risk factors, common for children with ADHD (Howard et al., 2015; Molina et al., 2016), likely combine to reinforce SU after initiation.

Early SU predicted quicker increases for alcohol, marijuana, and illicit drug use, and more adult SU for all classes of drug; these effects were not stronger for children with ADHD. This may reflect increased vulnerability for any child who becomes immersed in substance-tolerant environments irrespective of ADHD. Many studies show that early SU is a risk factor for multiple negative outcomes, but these studies have generally not considered ADHD. Importantly, our finding that more children with ADHD were early substance users hints at a possible mediational pathway (e.g., from childhood ADHD to early SU, later heavy SU, and eventually SU disorder in adulthood). Childhood CD/ODD also increased risk of illicit drug use by adulthood; continuing behavior problems may also be explanatory (Howard et al., 2015). We did not directly test these hypotheses due to model complexity but plan to investigate separately. We suggest that screening for, and interventions to prevent, early SU before it escalates to intractable levels is critical for all high-risk adolescents and especially for children with ADHD.

Conclusions

Nearly all of the children with ADHD were treated in childhood. As with ADHD symptoms in adulthood (Swanson et al., 2017) and earlier reports of SU from this sample (Molina et al., 2007; 2013), random assignment to treatment group did not predict adult SU or escalation to it. Only a fleeting effect of intensive behavior therapy was observed when participants were quite young (Molina et al., 2007). Research is needed to identify what interventions, if any, can deflect children with ADHD from these addiction-risk trajectories, particularly given the strong trend to discontinue medication in adolescence (Barkley et al., 2003; Molina et al., 2009).

Frequent marijuana use and daily cigarette smoking stand out as key adult SU outcomes associated with childhood ADHD. Use of any substances at especially early ages predicts these outcomes. This effect was present even after controlling for childhood CD/ODD comorbidity. It is clear from the MTA data that risk for adult SU begins at a young age. Future analyses will consider the contribution of symptom persistence (Hechtman et al., 2016), the parallel unfolding of conduct problems that should exacerbate risk above those occurring in childhood (Howard et al., 2015), extended treatment effects (Swanson et al., 2017), and additional mediators and moderators suggested by the deepening literature on mechanisms of substance abuse risk in ADHD (e.g., Groenman et al., 2015; Molina & Pelham, 2014).

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Abbreviations

LNCG	Local Normative Comparison Group
SU	Substance use

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Key Points

1. By early adulthood, children with ADHD reported more SU than children without ADHD, for regular (weekly and daily) use of marijuana and for daily cigarette smoking.
2. Heavy alcohol use, prescription drug misuse, and other street drug use were not higher in adulthood for the ADHD than nonADHD comparison group.
3. Children with ADHD were more likely to report early use of all substances in adolescence than those without and had slightly faster increases in alcohol and illicit drug use early in adolescence.
4. Early SU, known from nonADHD research to predict SU problems later, forecasts more frequent adult SU and faster progression for both ADHD and comparison groups.
5. Screening and interventions to prevent early SU involvement for children with ADHD should be part of routine clinical practice.

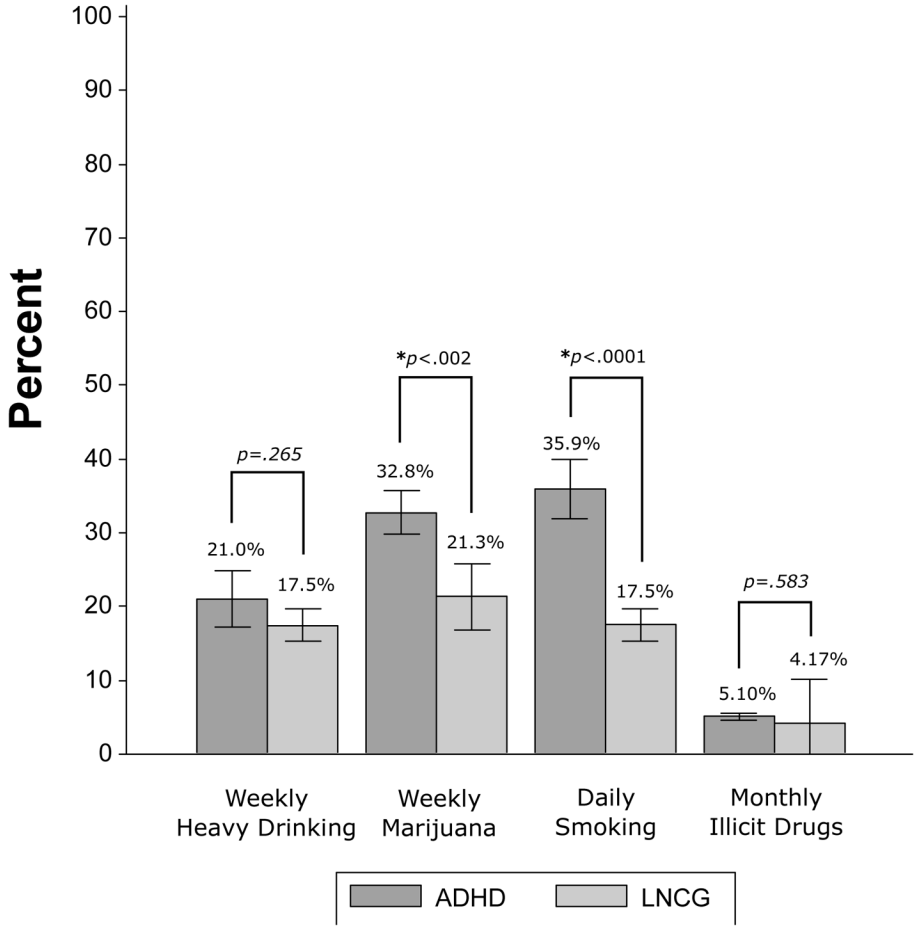

Figure 1.
Regular SU in early adulthood by childhood ADHD/LNCG.

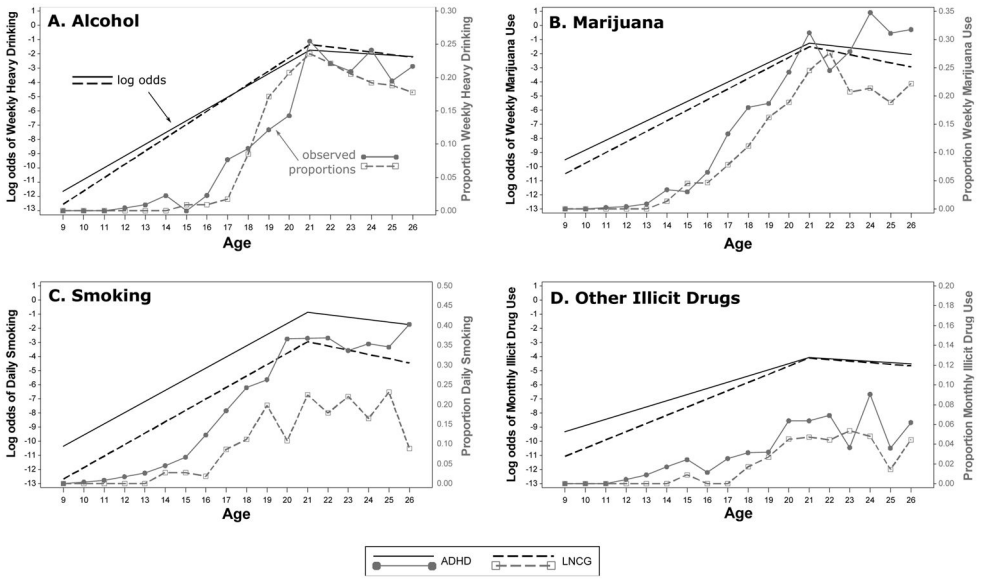

Figure 2.
SU escalation as a function of childhood ADHD/LNCG

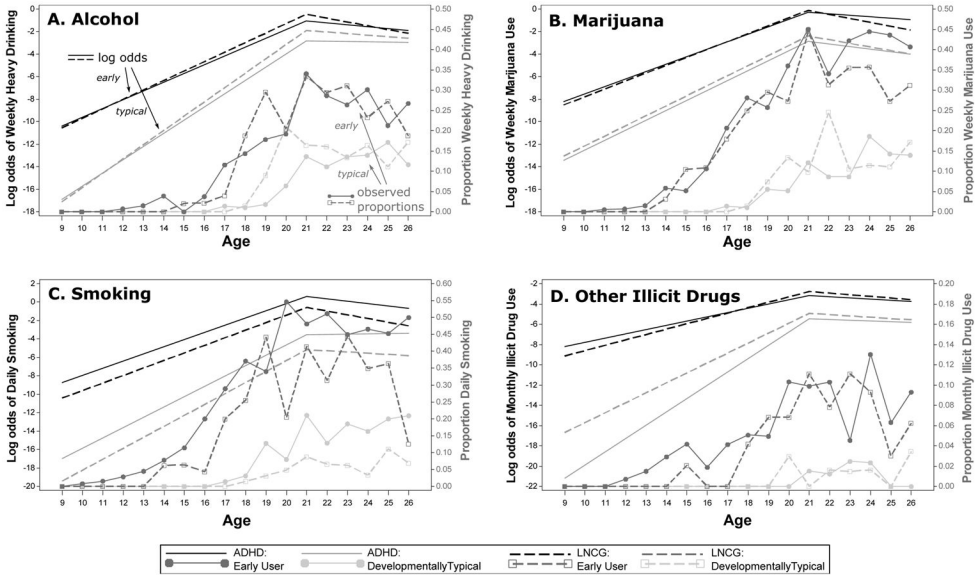

Figure 3.
SU escalation as a function of childhood ADHD/LNCG and early SU

Table 1

Regular SU in early adulthood by childhood diagnostic group (ADHD vs LNCG).

	ADHD		LNCG		χ^2	*p*
	n	%	*n*	%		
Weekly heavy alcohol use	94/447	21.0	41/235	17.5	1.25	.265
Daily heavy alcohol use	9/447	2.0	2/235	0.9		
Weekly marijuana use	152/464	32.8	51/239	21.3	10.02	.002
Daily marijuana use	104/464	22.4	26/239	10.9	13.93	.0002
Daily smoking	168/468	35.9	42/240	17.5	25.74	<.0001
Monthly illicit drug use	24/471	5.1	10/240	4.2	.30	.583
Prescription stimulant misuse *	5/471	1.1	3/240	1.3		
Prescription sedative misuse *	3/471	0.6	3/240	1.3		
Prescription narcotic misuse *	12/471	2.5	3/240	1.3		
Cocaine use	5/468	1.1	3/240	1.3		
Inhalant use	0/468	0.0	0/240	0.0		
Hallucinogen use	1/467	0.2	3/240	1.3		
Other illicit substances	1/468	0.2	0/240	0.0		

Note. Data are from the oldest available observation (*M* age = 24.67 years old, SD =1.37 years). “Daily” = once per day or more frequent; “Weekly” = once per week or more frequent; “Monthly” = once per month or more frequent. Frequencies of use for individual illicit/prescription drugs are provided for descriptive purposes.

* Includes use without a prescription or misuse of one’s own prescription.

Table 2

SU Escalation as a Function of Childhood ADHD/LNCG and Early SU

	Heavy Drinking		Marijuana Use		Daily Smoking		Other Illicit Drug Use	
Predictor Effects	**Model 1 *B(SE)***	**Model 2 *B(SE)***	**Model 1 *B(SE)***	**Model 2 *B(SE)***	**Model 1 *B(SE)***	**Model 2 *B(SE)***	**Model 1 *B(SE)***	**Model 2 *B(SE)***
ADHD (0) vs LNCG (1)	.05 (.23)	.46 (.33)	−.74 (.41)	−.05 (.59)	**−2.59*** (.48)**	**−2.14** (.76)**	−.13 (.31)	.44 (.52)
SU escalation								
Adolescent trajectory (up to age 21)	**.82*** (.03)**	**1.16*** (.08)**	**.69*** (.03)**	**.88*** (.09)**	**.79*** (.05)**	**1.13*** (.18)**	**.44*** (.03)**	**1.27*** (.35)**
Adult trajectory (after age 21)	**−.09* (.04)**	−.02 (.07)	**−.16** (.06)**	**−.22* (.11)**	**−.17** (.06)**	−.01 (.12)	−.09 (.05)	−.11 (.13)
ADHD vs. LNCG differences in change								
ADHD/LNCG × Adolescent	**.12** (.04)**	.09 (.11)	.06 (.05)	.01 (.12)	.02 (.09)	−.02 (.36)	**.14* (.06)**	−.29 (.40)
ADHD/LNCG × Adult	−.09 (.07)	−.12 (.10)	−.13 (.10)	−.13 (.15)	−.13 (.12)	−.06 (.23)	−.02 (.09)	−.03 (.18)
Escalation as a function of early SU in adolescence								
Early use vs. Typical (Early user=1)	-	**1.23*** (.27)**	-	**2.94*** (.50)**	-	**3.13*** (.49)**	-	**2.24*** (.40)**
Early use differences in rates of change								
Early use × Adolescent	-	**−.39*** (.08)**	-	**−.22* (.09)**	-	−.36 (.19)	-	**−.86* (.35)**
Early use × Adult	-	−.15 (.08)	-	.08 (.13)	-	−.23* (.13)	-	−.01 (.14)
Early use differences by group								
Early use × ADHD/LNCG	-	−.54 (.48)	-	−.53 (.81)	-	.26 (.94)	-	−.30 (.63)
Early use × ADHD/LNCG × Adolescent	-	−.03 (.12)	-	.03 (.13)	-	.06 (.34)	-	.40 (.41)
Early use × ADHD/LNCG × Adult	-	−.03 (.14)	-	−.04 (.21)	-	−.11 (.27)	-	−.01 (.21)
Baseline covariate effects								
Sex (Male=0; Female=1)	**−.58** (.20)**	−.33 (.19)	**−.54* (.26)**	−.15 (.23)	−.64 (.42)	−.15 (.39)	−.52 (.27)	−.21 (.25)
Black	**−.82*** (.20)**	**−.85*** (.19)**	.19 (.25)	.24 (.22)	**−1.38*** (.41)**	**−1.28*** (.38)**	**−1.02*** (.28)**	**−.94*** (.26)**
Hispanic	.03 (.30)	−.12 (.28)	−.33 (.38)	−.52 (.34)	−.88 (.63)	**−1.25* (.58)**	**−.86* (.43)**	**−1.04* (.41)**
Mixed/other ethnicity	−.29 (.23)	−.28 (.22)	−.30 (.30)	−.25 (.26)	−.11 (.48)	−.11 (.45)	−.52 (.31)	−.46 (.29)
Household advantage	−.11 (.10)	.01 (.10)	**−.40** (.13)**	**−.23* (.12)**	**−1.30*** (.22)**	**−1.05*** (.20)**	**−.35* (.13)**	−.18 (.12)
Household disadvantage	.21 (.18)	.09(.17)	.25 (.23)	.12 (.20)	**1.15** (.36)**	**.94** (.33)**	.35 (.24)	.22 (.22)

Note. Effects are based on nonlinear piecewise (adolescent; adult) multilevel models of the log odds of each type of substance. In Model 2, *intercepts* (log odds of predicted base rates at age 25 for each categorical threshold) are: Heavy drinking (<monthly=1.10; monthly,<weekly=−1.42; >weekly=−2.93), Marijuana (<monthly=−1.55; monthly,<weekly=−3.19; >weekly=−3.78), Daily smoking (yes=−3.52), Other illicit drugs (<monthly=−3.65, >monthly=−5.85).

* $p<.05$;

** $p<.01$;

*** $p<.001$. Models also control for study site (not shown).