Adolescent Mediators of Unplanned Pregnancy among Women with and without Childhood ADHD

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We aimed to identify adolescent mediators of the significant and sizable link between childhood attention deficit/hyperactivity disorder (ADHD) and later unplanned pregnancy in our prospectively followed, all-female sample. Participants included an ethnically diverse (47% non-White) sample of women with ($n = 140$) and without ($n = 88$) childhood ADHD who were assessed 4 times across childhood, adolescence, and adulthood. Potential mediators were measured via self, parent, and teacher report on questionnaires and interviews and by objective testing. We tested 5 early adolescent variables in three domains (personality, behavioral, and academic) as components of serial mediation pathways from (a) childhood ADHD status to (b) the early adolescent putative mediator to (c) risky sexual behavior in late adolescence and finally to (d) unplanned pregnancy by early adulthood. Of these, academic achievement (indirect effect = .1339, SE = .0721), 95% confidence interval (CI) [.0350, .3225] and substance use frequency (indirect effect = .0211, SE = .0167), 95% CI [.0013, .0711] operated through late-adolescent risky sexual behavior to explain rates of unplanned pregnancy, even adjusting for the effects of age, IQ, and family socioeconomic status (SES). When these 2 indirect effects were entered simultaneously, only the pathway from childhood ADHD to low academic achievement to higher rates of risky sexual behavior to unplanned pregnancy was significant (indirect effect = .0295, SE = .0145), 95% CI [.0056, .0620]. We discuss the significance of these early adolescent mediators, particularly academic engagement, as potential intervention targets intended to reduce rates of later unplanned pregnancies among female individuals with ADHD.

Approximately 85 million unplanned pregnancies occurred throughout the world in 2012 (Sedgh, Singh, & Hussain, 2014), conferring risk for child maltreatment (Guterman, 2015), child behavior problems and later substance abuse (Hayatbakhsh et al., 2011), and even poorer sibling health (Lordan & Frijters, 2013). Unplanned pregnancies are also associated with substantial costs to women in terms of stress and compromised mental health (Abajobir, Maravilla, Alati, & Najman, 2016), as well as huge financial costs, usually in the public sector, which have been estimated to be more than $11 billion per year in the United States alone (Monea & Thomas, 2011; Sonfield, Kost, Gold, & Finer, 2011). In short, unplanned or unintended pregnancies are a substantial public health problem with significant social, health, and economic consequences.

As a consequence, we were concerned by findings from our longitudinal, prospective study of the progression of childhood attention deficit/hyperactivity disorder (ADHD) in girls (Owens, Zalecki, Gillette, & Hinshaw, 2017) indicating that the rate of unplanned pregnancy among girls with childhood ADHD (42.6%) was far higher than among girls without childhood ADHD (10.6%). It is intriguing that this association did not depend on whether clinically significant ADHD symptoms had persisted into adulthood, nor was it a function of SES or other baseline covariates including child IQ and psychiatric comorbidities. Indeed, almost half (48.4%) of the girls whose ADHD desisted by late adolescence reported an unplanned pregnancy by their mid-20s; the rates for girls with either partial or full persistence of ADHD were 39.2% to 40.5%, respectively, statistically indistinguishable from that of the desisters.

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These findings are consonant with the only three other studies, to our knowledge, reporting pregnancy outcomes among children with ADHD followed longitudinally into adulthood. In Flory, Molina, Pelham, Gnagy, and Smith (2006), boys with childhood ADHD were less likely to use birth control and more likely to impregnate a partner by their early 20s than boys without childhood ADHD (25% vs. 4%, respectively), with comorbid conduct problems partially mediating this relation. Similarly, in Barkley, Fischer, Smallish, and Fletcher (2006) a history of childhood ADHD was associated with increased rates of early parenthood (38%) compared to children without ADHD (4%), as well as increased rates of rarely or never using birth control. Although only 19 girls with ADHD were followed up in this study, 13 of them (68%) had become pregnant by early adulthood versus only one in six (17%) of the comparison girls, a significant difference. Meinzer et al. (2017) showed twice the rate of teen pregnancy or pregnancy involvement among youth (mostly boys) with childhood ADHD compared to youth without. Because children with ADHD appear to incur substantial risk for unplanned pregnancy, our aim herein is to identify mediators of unplanned pregnancies among women with and without histories of childhood ADHD.

A conceptual framework regarding ADHD as a failure of self-regulation guided our choice of potential mediators of the relation between childhood ADHD and later unplanned pregnancy. Current theories of ADHD posit that failures or deficits in self-regulation (i.e., organization and execution of one's future-oriented, goal-directed behavior) are central to the ADHD phenotype (Barkley, 2015; Nigg, 2017). Self-regulation deficits and related behaviors (e.g., conduct problems) that are common among youth with ADHD were the focus of our mediational hypotheses. We considered both primary self-regulation problems (e.g., impulsivity) and secondary problems (e.g., substance use, academic underachievement),[1] which we assume would emerge from primary self-regulation deficits.

First, we tested self-reported trait impulsivity as an adolescent mediator of the childhood ADHD/unplanned pregnancy link. Indeed, Nigg (2013) and Flory et al. (2006) suggested impulsivity as a key mechanism related to risky sexual behavior and unwanted pregnancy among individuals with ADHD because it is a central feature of ADHD and because it could predict pregnancy-related risky behaviors, including more frequent casual sex partners or foregoing effective contraception, for which evidence in female individuals also attests (Dir, Coskunpinar, & Cyders, 2014).

Second, we tested behavior problems including hyperactivity/impulsivity, conduct disorder, and substance use because they are prime examples of self-regulation failures posited by our conceptual framework and because Nigg (2013) and Flory et al. (2006) discussed the role that these factors might play in risk for unplanned pregnancies, specifically among individuals with ADHD. Many others have found that adolescent or unplanned pregnancies and related risky behaviors (e.g., multiple partners, inconsistent contraception) are partially attributable to drug use and/or conduct problems (Drescher-Burke, 2014; Kasen, Cohen, & Brook, 1998; Kiene, Barta, Tennen, & Armeli, 2009: Wellings et al., 2013; Yampolskaya, Brown, & Greenbaum, 2002), especially among adults with histories of childhood ADHD (Ramos-Olazagasti et al., 2013; Sarver, McCart, Sheidown, & Letourneau, 2014). In particular, in their study of primarily boys, Meinzer et al. (2017) found that delinquency/substance use accounted for early pregnancy/pregnancy involvement above and beyond ADHD symptom severity, academic performance, and parenting quality during adolescence.

Third, we tested whether academic achievement mediated the relation between ADHD status and unplanned pregnancy via risky sexual behavior. Academic achievement can be thought of a "second order" problem of self-regulation, in the sense that multiple primary self-regulation deficits, including attention regulation, behavioral inhibition, emotion regulation, and effortful control, each contribute to academic achievement. It is well known that early unplanned pregnancies are associated with lower educational attainment, but the direction of the relation is not clear and potentially bidirectional (Schvaneveldt, Miller, Berry, & Lee, 2001). It could be that pregnancies lead to lower school achievement and dropping out, but it is also plausible that girls who are not successful at school are more likely to become pregnant (Gordon, 1996; Olson & Worobey, 1984; Pereira, Canavarron, Cardoso, & Medonca, 2005; Yamaguchi & Kandel, 1987; Yampolskaya et al., 2002). Because low school achievement is a major associated feature of ADHD, academic problems might be a particularly salient mechanism in this population, as noted by Meinzer et al. (2017), who found low adolescent academic performance to mediate the relation between childhood ADHD and early pregnancy. Furthermore, in Owens and Hinshaw (2016a), we found academic achievement and school failure to mediate the relation between childhood neurocognitive vulnerability and adult psychiatric comorbidity, signaling their plausibility as explanatory mechanisms for other undesirable outcomes, including unplanned pregnancies.

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[1] The significant indirect effects for W2 mediators are each positive because for the "beneficial" mediators (e.g., academic achievement), there are two negative coefficients (between diagnostic status and the mediator, and between the mediator and risky sex), which when multiplied produce a positive coefficient. This positive coefficient is then multiplied by another positive coefficient (between risky sex and unplanned pregnancy), resulting in a positive indirect effect. For the "detrimental" mediators (e.g., substance use), all coefficients are positive, also resulting in a positive indirect effect.

In sum, to explain the high rates of unplanned pregnancies among girls with ADHD followed into adulthood, we tested whether five early adolescent personality, behavioral, and academic factors mediated the relation between (a) ADHD diagnostic status during childhood and (b) a history of unplanned pregnancy by adulthood, through their relations with risky sexual behavior in late adolescence. In other words, we used tests of serial mediation to determine whether early adolescent problems with self-regulation across three domains were associated with both childhood ADHD status and late adolescent risky sexual behavior, which then could explain differences in rates of unplanned pregnancy among girls with and without a history of ADHD.

METHOD

Overview of Procedures

We initially recruited girls 6–12 years of age in the San Francisco East Bay area to participate in free 5-week camps during the summers of 1997, 1998, and 1999. The East Bay includes large urban areas as well as semiurban and suburban areas. Girls with and without ADHD were recruited in parallel fashion. Girls with ADHD were reached through medical settings, mental health centers, pediatric practices, local school districts, and newspaper advertisements. Girls without ADHD were recruited through school districts and advertisements.

The summer camps were enrichment (i.e., nontherapeutic) programs designed with emphasis on ecologically valid measures. After extensive diagnostic assessments, 140 girls with ADHD and 88 age- and ethnicity-matched comparison girls were selected, and all participated in the summer camps at Wave 1 (W1). At Wave 2 (W2) and Wave 3 (W3), 5 and 10 years later, respectively, participants and their parents were invited to two half-day clinic-based assessments during which assessors, unaware of diagnostic status, conducted interviews and administered questionnaires and neuropsychological testing. At Wave 4 (W4), 16 years later, we invited participants for a single half-day to full-day clinic-based assessment. With participant consent, parents were contacted and asked to complete questionnaires. When necessary, we performed telephone interviews or home visits. At W1, the incentive for participation was a free 5-week summer camp. At W2 and W3, families were monetarily reimbursed for their time, with separate compensation for girls if they were at least 18 years old. At W4, girls and their parents received separate monetary reimbursements. Informed consent was obtained from all participants, and this study was approved by the Committee for the Protection of Human Subjects at University of California, Berkeley.

Participants

Final study eligibility was contingent on meeting full criteria for ADHD via the parent-administered Diagnostic Interview Schedule for Children (4th ed.; Shaffer, Fisher, Lucas, Dulcan, & Schwab-Stone, 2000). Common comorbidities were allowed. Comparison girls, screened to match the ADHD sample on age and ethnicity, could not meet diagnostic criteria for ADHD. A small number of comparison participants met criteria for internalizing (3.4%) or disruptive behavior disorders (6.8%). Exclusion criteria for both groups were intellectual disability, pervasive developmental disorder, psychosis or overt neurological disorder, English not spoken in the home, and serious medical problems.

The all-female sample was ethnically diverse (53% White, 27% African American, 11% Latina, 9% Asian American). The average level of maternal education was "some college," and the average family income was $50,000 to $60,000, slightly higher than the California median household income in the mid-1990s. Fourteen percent of the sample was receiving some form of public assistance. Mean participant ages were as follows: at W1, 9.6 years (range = 6–12); at W2, 14.2 years (range = 11–18); at W3, 19.6 (range = 17–24), and at W4, 25.6 (range = 21–29). Retention was excellent: 91.6% at W2, 94.7% at W3, and 92.6% at W4. We examined the representativeness of the sample retained at W4, as described in Owens et al. (2017), concluding that the few nonretained participants showed some demographic disadvantage, lower IQs, and greater problematic behavior during childhood according to teachers but not parents.

Measures

Wave 1 covariates

Child Full Scale IQ ($M = 99.7$, $SD = 13.7$) was measured using the third edition of the Wechsler Intelligence Scale for Children (Wechsler, 1991). Maternal education was rated on a scale from 1 (*some high school*) to 6 (*post college*). The mean was 4.7 ($SD = 1.0$), meaning that on average, mothers had completed some college. Family income was rated on a 1-to-9 ordinal scale ($M = 6.2$, $SD = 2.7$), with average household income falling in the $50,000 to $60,000 per year range as just noted. These two scores were standardized and averaged to create our SES covariate. Child age was measured in months.

Wave 2 mediators

Trait impulsivity.   We used the adolescent version of the Big Five Inventory (Robins, John, & Caspi, 1994) to measure trait impulsivity, which reflects a lack of deliberateness (i.e., acting without thinking). Using the author-suggested scoring system, the Cronbach alpha was .64. To

improve psychometric properties, we added two items ("I have trouble waiting for things that I want" and "I often start one thing before I am done with another"), with a resulting Cronbach alpha for all eight items of .69. In our sample, the correlation between this self-reported measure of trait impulsivity and the parent/teacher-reported measure of behavioral impulsivity was $r = .29$.

Behavioral hyperactivity/impulsivity. Behavioral hyperactivity/impulsivity was measured by averaging mother- and teacher-reported scores on the nine-item Hyperactivity/ Impulsivity scale of the Swanson Nolan and Pelham Rating Scale (Swanson, 1992). The Swanson Nolan and Pelham Rating Scale is a dimensionalized checklist of the hyperactivity/impulsivity items specified in the *Diagnostic and Statistical Manual of Mental Disorders* (3rd ed., text rev.; American Psychiatric Association, 1987) and has been used extensively in ADHD assessment and treatment research (e.g., MTA Cooperative Group, 1999). In our sample, the correlation between mother and teacher hyperactivity/impulsivity scores was $r = .50$, $p < .001$.

Conduct problems. Conduct problems were measured by standardizing and averaging two scores: mother's report of Externalizing problems (aggressive and delinquent behavior) on the Child Behavior Checklist (CBCL; Achenbach, 1991), and symptoms of conduct and oppositional defiant disorders from the Diagnostic Interview Schedule for Children (4th ed.; Shaffer et al., 2000), a well-validated and highly structured *Diagnostic and Statistical Manual of Mental Disorders*–based (4th ed.; American Psychiatric Association, 1994) interview. The CBCL is a widely used measure with excellent psychometric properties (Achenbach, 1991). These two scores had a correlation of $r = .56$, $p > .001$.

Substance use. Substance use frequency across the past year was self-reported using the Substance Use Questionnaire (SUQ; Molina & Pelham, 2003). The SUQ is a structured interview adapted from existing measures, including the Health Interview Questionnaire (Jessor, Donovan, & Costa, 1989) and the National Institute on Drug Abuse's National Household Survey of Drug Abuse. The SUQ includes questions regarding current and past quantity and frequency of drug, alcohol, and cigarette use. Kappas for 2-week test–retest reliability for "ever trying" one of five substances averaged .84 (range = .70–.91). For each of 13 substances (alcohol, marijuana, and 11 other illicit drugs such as misused prescription drugs and narcotics), we added the past-year frequency counts, which were each scored on 11-point scales from *never* to *several times per day*. This substance-use frequency variable showed associations of $r = .32$, $p < .001$ and $r = .33$, $p < .001$, respectively, with

the alcohol use disorder and marijuana use disorder symptom counts from the parent-reported Diagnostic Interview Schedule for Children. The same measure of substance use frequency, used for a post hoc analysis, was created from administration of the SUQ at W3.

Academic achievement. Academic achievement was determined by standardizing and averaging scores from the Academic Performance scale of the CBCL and the Word Reading and Math Reasoning subtests of the Wechsler Individual Achievement Test (WIAT; Wechsler, 1992), a psychometrically sound, widely used test. Test–retest reliabilities for the reading and math scores range from .85 to .92 (Wechsler, 1992). Correlations among these scores were as follows: $r = .67$ between WIAT Word Reading and Math Reasoning subtests, $r = .55$ between WIAT Math Reasoning and CBCL Academic Performance scores, and $r = .57$ between the WIAT Word Reading and CBCL Academic Performance scores. The composited academic achievement score used in analyses had a Cronbach alpha of .82.

Deviant peer association. Deviant peer association was measured using the project-developed Social Relationships Interview. As part of this extended interview, girls self-reported the number of friends who engage in any of 15 antisocial activities, including drug use, each on a scale from 1 (*none of them*; meaning, none of my friends do this) to 5 (*all of them*). Examples of antisocial activities ranged from skipping school without an excuse or lying to teachers, to stealing items worth small or large amounts of money, to selling drugs or using a weapon. The Cronbach alpha for this measure in our sample was $r = .93$. The same measure of deviant peer association during late adolescence (W3), used for a post hoc analysis, had a Cronbach alpha in our sample of $r = .82$. These early and late adolescent measures of deviant peer affiliation were correlated: $r = .27$, $p < .001$.

W3 mediator

Risky sexual behavior was operationalized as behavior that could increase the chance of unplanned pregnancy, measured using the following three items from the Health and Sexual Behavior Questionnaire (Flory et al., 2006): age of first intercourse (reverse scored), lifetime number of sexual partners, and rate of contraceptive use on a 0 (*never*) to 4 (*all of the time*) scale (reverse scored). These were standardized and averaged to create the risky sex variable. Correlations among these variables ranged from .28 to .37.

W4 criterion variable

At W4, participants were asked how many times they had been pregnant and whether each pregnancy had been

planned. We dichotomized those scores into *never* and *one or more* unplanned pregnancies. Sixty-one participants reported at least one planned pregnancy. As explained next, for a single analysis (the final mediational test), we trichotomized the score into three categories: *never, once*, or *more than once*. Of the 61 girls who reported an unplanned pregnancy, 38 had had one and 23 had had more than one (the maximum was five).

Data Analytic Plan

Preliminary analyses involved examination of missing data and calculation of descriptive statistics. We then computed a series of *t* tests to examine (a) relations between childhood diagnostic status at W1 and the set of potential mediators at W2, and (b) relations between the set of potential mediators at W2 and our dichotomous measure of unplanned pregnancy at W4. Next, serial mediation of the relation between childhood diagnostic status and unplanned pregnancy by adulthood via each W2 mediator and via W3 risky sexual behavior was tested using a bootstrap method for identifying indirect effects using PROCESS version 2.16 (Hayes, 2013). The bootstrap method is a statistical simulation in which a new mathematical sample is created by randomly sampling observations from the original data with some replacement. Then a point estimate of the indirect effect is generated for each random sampling and repeated 10,000 times, with all point estimates aggregated to arrive at an overall estimate of the indirect effect. For each serial mediation path, we calculated this point estimate of the indirect effect plus the 95% bias-corrected confidence interval (CI) based on the distribution of these effects. We inferred statistical significance if this interval did not contain 0 (see Hayes, 2013). For the final test, in which the significant serial mediation paths were tested against one another in one model, we used PROCESS version 3.0 (Hayes, 2017), because the previous version did not allow the testing of parallel serial mediation pathways in the same model. However, version 3.0 does not allow dichotomous outcome variables in tests of mediation (which version 2.16 did allow). Thus, for this last test we switched to a trichotomized, rather than a dichotomized, measure of unplanned pregnancy, as described earlier.

RESULTS

Preliminary results indicated that rates of missing data were between 0% and 10.5%, with a mean of 5.7% across all variables. Because rates of missing data were low, and because data were not missing at random, we did not impute missing values. For the two variables that had values further than 3 deviations from the mean, those values were transformed to values 3.1, 3.2, and so on, deviations from the mean, maintaining the rank order of variables but reducing skewness. Zero-order correlations among continuous variables are presented in Table 1. Associations between W1 ADHD diagnostic status and the potential mediators, and between mediators and W4 unplanned pregnancy, are presented via *t* tests in Table 2. As can be seen, there were medium to very large, statistically significant positive relations between childhood ADHD status and early adolescent self-reported trait impulsivity ($d = .52$), mother/teacher-rated hyperactivity/impulsivity ($d = 1.17$), and conduct problems ($d = 1.18$). Childhood ADHD and academic achievement were negatively associated, with a very large effect ($d = 1.25$). Also, there were medium-to-large and significant positive relations between unplanned pregnancy and early adolescent mother/teacher-rated hyperactivity/impulsivity ($d = .57$), conduct problems ($d = .61$), and risky sexual behavior ($d = .83$). Unplanned pregnancy was negatively associated with academic achievement, with a large effect ($d = .83$). Regarding baseline covariates, age was unrelated to unplanned pregnancy ($t = -.71$, $p = .478$, $d = .11$), but as expected, family SES ($t = 4.47$, $p < .001$, $d = .68$) and child IQ were related ($t = 4.14$, $p < .001$, $d = .63$).

TABLE 1
Zero-Order Correlations Among Continuous Study Variables

	1. Child Age	2. Child IQ	3. SES	4. Imp (S)	5. HI (M/T)	6. Conduct Problems	7. Substance Use	8. Academic Ach	9. Risky Sex
1		−.19**	−.06	−.01	−.08	.01	.35***	−.22**	.18**
2			.30***	−.10	−.26***	−.27***	−.14	.74***	.04
3				.06	−.18**	−.11*	−.02	.26***	−.07
4					.29***	.32***	.17**	−.16*	.07
5						.67***	.13*	−.45***	.14*
6							.24**	−.46***	.16**
7								−.22**	.12*
8									−.18**

Note: SES = socioeconomic status; Imp = impulsive; S = self; HI = hyperactivity/impulsivity; M/T = average of mother and teacher; Ach = achievement.
*$p < .05$. **$p < .01$. ***$p < .001$.

TABLE 2
Associations Between Mediators and Both Childhood Diagnostic Status and Unplanned Pregnancy

Mediator	Comparison M (SD)	ADHD M (SD)	p	d	No Unplanned Pregnancy M (SD)	Unplanned Pregnancy M (SD)	p	d
Impulsivity (S)	0.41	0.74	< .001	0.52	0.56	0.70	.149	0.23
HI (M/T)	0.13	0.83	< .001	1.17	0.44	0.70	.001	0.57
Conduct Problems	−0.63	0.43	< .001	1.18	−0.16	0.39	< .001	0.61
Substance Use	2.61	8.76	.048	0.29	5.68	7.43	.608	0.08
Academic Achievement	0.67	−0.39	< .001	1.25	0.25	−0.45	< .001	0.83
Risky Sex	−0.16	0.08	.027	0.31	−0.13	0.27	< .001	0.51

Note: ADHD = attention deficit/hyperactivity disorder; S = self-rated; HI = hyperactivity/impulsivity; M/T = average of mother and teacher.

TABLE 3
Adolescent Mediators of Association Between Childhood ADHD
Status and Adult Unplanned Pregnancy

W2 Mediator	W3 Mediator	n	Indirect Effect (SE)	95% CI
Impulsivity – Self	Risky sex	189	.0195 (.0283)	[−.0161, .1074]
HI – M/T	Risky sex	193	.0722 (.0730)	[−.0491, .2477]
Conduct Problems	Risky sex	199	.1107 (.0784)	[−.0071, .3040]
Substance Use	Risky sex	189	.0211 (.0167)	**[.0013, .0711]**
Academic Achievement	Risky sex	193	.1339 (.0721)	**[.0350, .3225]**

Note: In all tests child age, IQ, and family socioeconomic status were covaried. ADHD = attention deficit/hyperactivity disorder; CI = confidence interval; HI = hyperactivity/impulsivity; M/T = average of mother and teacher; Bold = CI does not include zero.

Results of the five serial mediational tests are presented in Table 3. W2 substance use (indirect effect = .0211, *SE* = .0167), 95% CI [.0013, .0711], and W2 academic achievement (indirect effect = .1339, *SE* = .0721), 95% CI [.0350, .3225], each mediated the relation between childhood ADHD status and unplanned pregnancy via W3 risky sexual behavior, covarying W1 child age, IQ, and family SES, with the mediational effect of W2 academic achievement presented in Figure 1. When these two pathways were entered simultaneously in one parallel serial mediation model, with covariation of baseline variables, only the pathway from W1 ADHD to W2 academic achievement to W3 risky sexual behavior to W4 unplanned pregnancy was significant (indirect effect = .0295, *SE* = .0145), 95% CI [.0056, .0620]. A parallel pathway through W2 substance use was not (indirect effect = .0039, *SE* = .0030), 95% CI [−.0002, .0113]. In addition, the CI for the contrast between these two pathways did not include zero, 95% CI [.0031, .0855], suggesting that the mediational path through W2 academic achievement is not only different from zero but also larger than the pathway through W2 substance use, which is not different from zero.

Finally, our identification of substance use as an important early adolescent mediator led to post hoc questions about the role of deviant peers. Thus, we also examined the concurrent W2 (early adolescent) correlation between deviant peer affiliation and substance use (r = .62, p < .001), as well as the correlation between W2 deviant peer affiliation and W3 risky sexual behavior (r = .23, p = .001). Deviant peer affiliation at W3 (late adolescence) was also associated with concurrent substance use (r = .50, p < .001) and risky sexual behavior (r = .36, p < .001). These analyses suggest avenues for future research regarding the role deviant peers might play in the link between adolescent substance use and risky sexual behavior.

DISCUSSION

Our aim was to explain the dramatically different rates of unplanned pregnancy, by early adulthood, for girls with (42.6%) and without (10.6%) childhood ADHD in our 16-year prospective study (Owens et al., 2017), a difference that was significant above and beyond the associations between unplanned pregnancy and family SES and child IQ, age, and psychiatric comorbidities. Of the five serial mediation pathways we tested, two early adolescent variables operated through late adolescent risky sexual behavior to explain differential rates of unplanned pregnancy in girls with and without childhood ADHD: academic achievement and substance use frequency. That is, childhood ADHD status was linked to each of these early adolescent constructs, and each then predicted risky sexual behavior during late adolescence, which was subsequently associated with whether a girl had experienced at least one unplanned pregnancy by early adulthood. These indirect effects were independent of initial child age, IQ, and family SES. Three early adolescent variables were not significant mediators of the ADHD–unplanned pregnancy link (via risky sexual behavior once child age, IQ, and family SES were covaried): self-rated impulsivity, mother/teacher-rated hyperactivity/impulsivity, and conduct problems. In terms of our conceptual model, our findings suggest that more complex behaviors related to the self-regulation deficits that may be at the core of ADHD, rather primary self-regulation challenges such as impulsivity, are
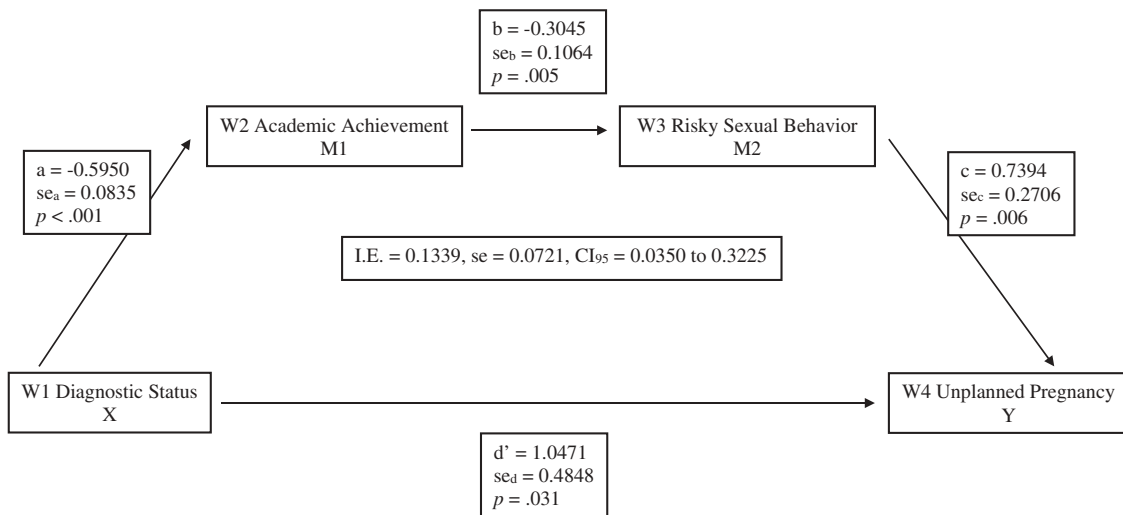
FIGURE 1 Indirect effect of adolescent academic achievement and risky sex. *Note*: I.E. = indirect effect (a × b × c); se = standard error; CI = bias-corrected confidence interval; d' = direct effect. Wave 1 child age, IQ, and family socioeconomic status covaried.

partly responsible for the increased rates of unplanned pregnancy among women with ADHD.

The first significant indirect effect we consider involved early adolescent academic achievement. The initial leg of this serial mediational pathway—that longitudinal relation between childhood ADHD and lower levels of achievement—is extremely well established in the ADHD literature (Owens, Cardoos, & Hinshaw, 2015), as is the negative association we report between school achievement and unplanned pregnancy (Elfenbein & Felice, 2003; Panova, Kulikov, Berchtold, & Suris, 2016; Wellings et al., 2013). However, our findings help to clarify the direction of this relation, because herein, school achievement problems predated and predicted risky sexual behavior and unplanned pregnancies. Others have also found academic problems to predict subsequent risky sexual behavior (Hensel & Sorge, 2014; Wheeler, 2010). In terms of explanations, it is possible that low-achieving girls believe they have "less to lose" by becoming pregnant because they may be unlikely to pursue higher education beyond high school. They may also be unable to fully understand or benefit from sex education, resulting in behaviors that underlie unplanned pregnancies. Regardless, our key finding suggests that academic interventions intended to ensure that girls with ADHD succeed in school compose one possible way to prevent later unwanted pregnancies. This result is consonant with our previous findings suggesting that interventions promoting educational success could be an important strategy for reducing the burden of adult psychopathology and global impairment in this population (Owens & Hinshaw, 2016a, 2016b).

The indirect effect of substance use frequency via risky sexual behavior on unplanned pregnancy is supported by at least one other study showing substance use to mediate the relation between ADHD symptoms and risky sexual behavior (Sarver et al., 2014). Clearly, substance use and risky sexual behavior co-occur during adolescence (e.g., Duncan, Strycker, & Duncan, 1999; Scivoletto et al., 2002; Tapert, Aarons, Sedlar, & Brown, 2001), especially among girls (Connell, Gilreath, & Hansen, 2009; Howard & Wang, 2004). It is also possible that deviant peer affiliation plays a role in this relation. Adolescent girls who more frequently use substances are likely to be socializing with other teens who participate in deviant or risky behaviors, including frequent and unprotected sex (Donovan, Jessor, & Costa, 1988). Supporting this notion are relations in our sample among the proportion of friends engaging in antisocial behavior, adolescent substance use, and risky sexual behavior. Of note, we found no direct relation between childhood diagnostic status and deviant peer association during adolescence, meaning that deviant peers per se do not explain the higher rates of unplanned pregnancies among girls with ADHD. However, of those girls with ADHD who more frequently used substances, deviant peers should be investigated as a correlate of or contributor to risky sexual behavior that results in unplanned pregnancies. Overall, reducing adolescent substance use —in addition to being an important target of intervention in its own right—may also have the benefit of averting unplanned pregnancies.

Of course, these early adolescent mediators are not orthogonal. Our two key mediators were correlated to a small degree, consistent with evidence that substance use is negatively related to academic achievement (e.g., Bryant, Schulenberg, O'Malley, Bachman, & Johnston, 2003; Diego, Field, & Sanders, 2003; Englund & Siebenbruner, 2012). When we tested these mediators simultaneously, only the pathway through academic achievement remained significant. However, as noted by

Hayes (2017), collinearity explains why an indirect effect can be significant when tested on its own but is not when tested simultaneously with other mediators. The interpretation should not be that the now-nonsignificant mediator is of no substantive interest. We therefore conclude that even though only academic achievement survived the statistical competition, substance use may still be an important mechanism by which ADHD is associated with unplanned pregnancy.

Our study is not without limitations. Sampling procedures influence generalizability of findings. Ours was not an exclusively clinic-referred sample, nor was it nationally representative. Although SES varied widely, on average the sample was middle- to upper-middle class. Findings can be generalized to a population of urban and suburban community-referred girls of various ethnicities but not to the population of girls with ADHD as a whole. Relatedly, the very small nonretained subgroup showed some demographic disadvantage, lower IQs, and greater problematic behavior according to teachers but not parents, suggesting that the analyzed sample may be slightly different from the originally recruited one. Moreover, our measurement strategies for some variables (i.e., ADHD status, conduct problems) were stronger than for others. For example, the contraception question in our risky sex variable was not time specified, so we could not capture variations in contraceptive use throughout the long period in which young women were reporting unplanned pregnancies. The trait impulsivity variable had a relatively low internal consistency. Had we been able to measure this variable with more precision, we might have uncovered other significant effects.

Furthermore, effect sizes in mediational analysis is an evolving area of research, and such quantification is not yet available for serial mediation models with dichotomous predictors (Hayes, 2017). We would have liked to indicate the size of the significant effects detected but were not able to do so. We also conducted more than one inferential test that used CIs rather p values to determine significance. Thus, we could not make a post hoc adjustment for Type I error. However, three of our six mediational tests were significant, a higher percentage than would be expected if findings were due to chance. We did not present findings regarding interactions among the mediators, also called *moderated mediation* (i.e., how early adolescent mediators might have moderated the indirect effects of other adolescent mediators), which is an important area for future research. Finally, two of our baseline covariates—family SES and child IQ—were significantly associated with unplanned pregnancy with medium-to-large effects. The causal pathways from these variables to unplanned pregnancy are of interest and could be investigated in a similar manner in subsequent research.

In conclusion, elevated rates of unplanned pregnancy among women with childhood diagnoses of ADHD are due, proximally, to risky sexual behavior that can be partially explained by early adolescent academic achievement and substance use. Thus, each of these is a potential target of early invention to reduce rates of later unplanned pregnancy among girls with childhood ADHD.

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