

# Risky Driving in Adolescents and Young Adults with Childhood ADHD

Amanda L. Thompson,<sup>1</sup> MS, Brooke S.G. Molina,<sup>1</sup> PhD, William Pelham Jr,<sup>2</sup> PhD, and Elizabeth M. Gnagy,<sup>2</sup> BS

<sup>1</sup>University of Pittsburgh and <sup>2</sup>State University of New York at Buffalo

**Objective** To examine risky driving behaviors and negative driving outcomes in a large sample of adolescents and adults diagnosed in childhood with Attention Deficit Hyperactivity Disorder (ADHD) compared with demographically similar controls without ADHD. **Methods** 355 adolescents and young adults of the Pittsburgh ADHD Longitudinal Study (PALS) ( $n = 203$  probands;  $n = 152$  controls) were administered the Young Adult Driving Questionnaire. Parent and self-report of current ADHD symptoms and conduct problems were tested as potential mediators of the association between childhood ADHD and negative driving outcomes. **Results** ADHD group differences, of small to medium effect size, were found for number of tickets and accidents, and hyperactivity–impulsivity at follow-up emerged as a significant mediator of this association. Current conduct problems were associated with both risky and alcohol-impaired driving. **Conclusions** Childhood ADHD elevates risk for driving-related problems, especially when symptoms persist. Co-occurring conduct problems capture some of this risk.

**Key words** ADHD; conduct problems; driving; hyperactivity; risky behavior.

Motor vehicle accidents are the leading cause of death among American teenagers (National Highway Traffic Safety Administration [NHTSA], 1997). In fact, the rate of automobile crashes is four times higher for 16–19 year olds than for all other ages combined (Williams, 1996). While young people make up only 6.7% of the total driving population in the country, they are involved in 14% of all fatal crashes (NHTSA, 1997). Lack of driving skill and experience, alcohol and/or drug intoxication, and family-related stress are associated with motor vehicle accidents (Brown, Sanders, & Schonberg, 1986). In addition, behavioral and emotional difficulties like low frustration tolerance, aggression, sensation seeking, impulsivity, and high levels of energy also contribute to negative driving outcomes (Donovan, Marlatt, & Salzberg, 1983). Because these characteristics also describe individuals with Attention Deficit Hyperactivity Disorder (ADHD) (Barkley, 2006), adolescents and young adults diagnosed with ADHD should be at an increased risk for automobile accidents and automobile-related injuries and fatalities. They should also be more likely to exhibit risky

driving behavior and to receive more traffic citations than individuals without ADHD.

Previous research does, in fact, support an association between ADHD and certain negative driving-related outcomes. In three separate studies, Barkley and colleagues examined driving-related outcomes in individuals who had been referred to clinics for ADHD as adolescents (Barkley, Guevremont, Anastopoulos, DuPaul, & Shelton, 1993) or as young adults (Barkley, Murphy, DuPaul, & Bush, 2002; Barkley, Murphy, & Kwasnik, 1996). Parent and self-report revealed that individuals with ADHD were more likely than controls to have driven a car without a license, to have had their licenses suspended or revoked, to have had auto crashes, and to have been at fault for these crashes (Barkley et al., 1993, 1996). Significantly more adolescents and young adults with ADHD had received traffic citations, particularly for speeding, and had received multiple citations (upwards of three) (Barkley et al., 1993, 1996). In addition, young adults with ADHD not only reported using safe driving habits (e.g., braking properly at

All correspondence concerning this article should be addressed to Brooke S.G. Molina, 3811 O'Hara St., Pittsburgh, PA 15213. E-mail: molinab@upmc.edu.

*Journal of Pediatric Psychology* 32(7) pp. 745–759, 2007  
doi:10.1093/jpepsy/jsm002

Advance Access publication April 18, 2007

*Journal of Pediatric Psychology* vol. 32 no. 7 © The Author 2007. Published by Oxford University Press on behalf of the Society of Pediatric Psychology. All rights reserved. For permissions, please e-mail: journals.permissions@oxfordjournals.org

intersections, driving within the speed limit) significantly less often than controls, but they also had more crashes, scrapes, and erratic steering in a driving simulator relative to the community controls (Barkley et al., 1996). Finally, poorer performance on measures of driving knowledge and cognitive abilities relevant to driving characterized teens and young adults with ADHD vs. controls (Barkley, Murphy, DuPaul, & Bush 2002).

While the studies conducted by Barkley and colleagues are important, their reliance on small samples of self-referred adolescents and young adults leaves certain questions unanswered. These samples represent a subset of individuals with ADHD who are symptomatic at recruitment. Thus, it is not clear if these findings apply to the larger population of individuals diagnosed with ADHD in childhood, or whether they are specific to individuals whose impairment persists into adolescence and adulthood. In addition, because these studies only examined the driving habits of licensed drivers, an important subgroup of (illegal) drivers were excluded, which may have caused an underestimation of risky driving behaviors within this population. Finally, previous work has provided only minimal consideration of potential mediators of the association between ADHD and negative driving outcomes.

### ***ADHD and Alcohol-Impaired Driving***

To the extent that alcohol consumption is a common contributor to driving error (NHTSA, 1995), alcohol-impaired driving should also be studied specifically as an outcome of ADHD. The limited research investigating rates of drinking-and-driving within the ADHD population has resulted in conflicting findings. Barkley's aforementioned 1993 study found a trend toward more citations in the ADHD group for driving while intoxicated, but his 1996 study failed to find group differences. There are also inconsistencies across studies with regard to risk of later alcohol consumption for children with ADHD, but the findings of some studies suggest concern is warranted (Molina & Pelham, 2003; Molina, Pelham, Marshal, Thompson, & Gnagy, in press; Weiss & Hechtman, 1993). Thus, it is unclear whether or not to expect higher rates of alcohol-impaired driving in adolescents and young adults with childhood ADHD, but the possibility needs further study.

### ***Conduct Problems***

It is well established that children with ADHD display a greater degree of conduct problems including aggression and delinquency than do children without ADHD (Barkley, 2006). Impulsivity, present for many children with ADHD,

may partly explain this comorbidity (Pillow, Pelham, Hoza, Molina, & Stultz, 1998; White et al., 1994). Children with these additional conduct problems have worse long-term adjustment than children with only ADHD (Barkley, Fisher, Edelbrock, & Smallish, 1990; Gittelman, Mannuzza, Shenker, & Bongura, 1985; Jensen, Martin, & Cantwell, 1997; Moffitt, 1990). To the extent that conduct problems are present in late adolescence or in adulthood, this common comorbidity may contribute to, or explain, ADHD risk for driving-related problems. Barkley and colleagues (1993) found that according to their parents, teenagers with ADHD and more comorbid oppositional defiant and conduct disorder (CD) symptoms practiced fewer safe driving behaviors and experienced more negative driving sequelae such as tickets, accidents, and injuries (Barkley et al., 1993). Although not tested as such, this finding suggests that antisocial characteristics may have mediated the association between ADHD and negative driving-related outcomes. Whether the contribution of conduct problems is associated with driving behavior independent of ADHD symptoms (particularly impulsivity) is an unanswered question.

### ***Persistence of Symptoms***

Recent research shows that based on parent report of symptoms and impairment, 66% of children with ADHD continue to experience significant symptomatology in adulthood (Barkley, Fischer, Smallish, & Fletcher, 2002). Symptom persistence, then, measured as parent-reported ADHD symptoms in adolescence and in young adulthood, may explain ADHD/nonADHD group differences in risky driving behaviors. In contrast to antisocial tendencies, which drive decisions to defy social norms, persistence of ADHD symptoms may impair driving for reasons other than planned violation of driving laws. Hyperactivity-impulsivity, for example, may contribute to poor choices while driving such as turning without signaling or pulling into traffic prematurely. Inattention may cause an individual to be less focused on his surroundings, the actions of other drivers on the road, and the posted traffic signs. Barkley's research implies the importance of symptom persistence in predicting driving-related impairment. This prediction is supported by previous findings that ADHD symptom persistence contributes to adverse outcomes, such as substance use (Molina & Pelham, 2003) and peer problems (Bagwell, Molina, Pelham, & Hoza, 2001).

### ***Irritability***

Emotional undercontrol is a well-known associated feature of ADHD (DSM-IV; American Psychological

Association [APA], 1994) that may explain driving-related risk. In non-clinic samples, children low in temperamental, cognitive, and affective regulation are at high risk for later problem behaviors (Eisenberg et al., 1997). In addition, emotional instability, irritability, hostility, and low frustration tolerance all have been found to covary with increased driving risk (Donovan et al., 1983; Donovan, Queisser, Salzberg, & Umlauf, 1985). These dispositional deficits in self-regulation of emotion—above and beyond the core ADHD deficits of attentional and inhibitory control—may also contribute uniquely to risk for later problem behaviors including risky and alcohol-impaired driving in individuals with ADHD. Because problem driving includes a wide range of behaviors that may (alcohol-impaired driving) and may not (risky driving such as speeding) be explained by antisocial tendencies, underlying emotional control (i.e., irritability) may also explain driving risks in individuals with ADHD. Each of these dimensions was examined in the current study.

### Summary

The existing research, largely conducted by Barkley and colleagues, has produced a consistent set of findings that self-referred individuals with ADHD are more prone than their nonADHD peers to receive traffic citations, have their licenses suspended, and be involved in automobile accidents. Due to the nature of the samples, however, it is difficult to know whether these findings generalize to the population of individuals diagnosed with ADHD in childhood, when most individuals are referred for diagnosis and treatment.

The current study provides a comprehensive examination of risky driving behaviors—beyond tickets and accidents and including alcohol-impaired driving—in the Pittsburgh ADHD Longitudinal Study (PALS), which is a large sample of children diagnosed with ADHD followed into adolescence and adulthood and demographically similar controls without ADHD. The PALS data set allows us to determine whether previous findings also apply to individuals diagnosed with ADHD in childhood. It permits us to expand the range of behaviors previously assessed and to test potential mediators (i.e., current ADHD symptoms, conduct problems, and irritability) of the association between ADHD and negative driving outcomes.

### Method

This study utilized a subset of driving individuals ( $n = 355$ ) from the Pittsburgh ADHD Longitudinal

Study (PALS;  $N = 604$ ). In order to provide comprehensive sample information, recruitment procedures and demographics are presented first for the larger sample and then for the subsample.

### Participants in the PALS, $N = 604$

Probands were from the PALS of 364 individuals diagnosed with ADHD in childhood and 240 individuals without ADHD. Probands were diagnosed at the ADD Clinic at the Western Psychiatric Institute and Clinic in Pittsburgh, PA during the years 1987–1996. Age at initial evaluation ranged from 5.0 to 16.92 years, with 90% in their elementary school-aged years (ages 5–12). All participated in the Summer Treatment Program (STP) for children with ADHD (Pelham & Hoza, 1996). Probands were 11–28 years old at their first follow-up interview in the PALS, with the majority (99%) falling between 11 and 25 years of age and an average of 8.3 years having elapsed since the childhood assessment. The PALS is ongoing with interviews being conducted annually.

All probands met diagnostic criteria in childhood for DSM-III-R or DSM-IV ADHD. Diagnoses were made according to well-established assessment and diagnostic procedures. At intake, parents and teachers completed norm-referenced, standardized measures of DSM-III-R or DSM-IV ADHD symptom criteria and additional externalizing behaviors including the Disruptive Behavior Disorders Scale (DBD; Pelham, Gnagy, Greenslade, & Milich, 1992), the Child Behavior Checklist (CBCL; Achenbach, 1991; Achenbach & Edelbrock, 1986), the IOWA/Abbreviated Conners rating scale (Goyette, Conners, & Ulrich, 1978; Loney & Milich, 1982), and the Swanson, Nolan, and Pelham rating scale of ADHD symptoms and associated features (SNAP; Atkins, Pelham, & Licht, 1985). A semi-structured diagnostic interview was administered to parents by PhD level clinicians to evaluate the presence of ADHD, ODD, and CD symptoms, using all of the DSM symptoms. In addition, the interview included queries about other comorbidities to determine whether additional assessment was needed. This interview is available from the third author (WEP). Exclusionary criteria for participation in the follow-up study included a full scale IQ < 80, a history of seizures or other neurological problems, and/or a history of pervasive developmental disorder, schizophrenia, or other psychotic or organic mental disorders. Two PhD-level clinicians independently reviewed all ratings and interviews to confirm the DSM diagnoses. When the two clinicians disagreed, a third

clinician reviewed the file and the majority decision was used.

Two hundred and forty participants without ADHD (controls) were recruited from the Pittsburgh area between 1999 and 2001 for their demographic similarity to the probands at follow-up (e.g., age range between 11 and 25). Most minors were recruited through several large pediatric practices in Allegheny County (40.8% of sample) that serve a population of patients from diverse socio-economic backgrounds. The remaining controls were recruited via advertisements in local newspapers and the university hospital staff newsletter (27.5%), local universities and colleges (20.8%), and other methods (Pittsburgh Public Schools, word of mouth, etc). A telephone screening interview administered to parents of adolescents and young adults gathered basic demographic characteristic, history of diagnosis and treatment for ADHD and other behavior problems, presence of exclusionary criteria as previously listed, and a checklist of ADHD symptoms. Young adults (18+) also provided self-report. ADHD symptoms were counted as present if reported by either the parent or young adult. Individuals who met DSM-III-R criteria for ADHD (eight or more symptoms)—either currently or historically—were excluded. Potential control participants were not excluded on the basis of nonADHD externalizing disorders (i.e., ODD, CD) or internalizing disorders (i.e., anxiety or major depression).

The control participants were selected to ensure that the two groups were equivalent in proportion on several demographic characteristics. As a result, the probands and controls did not differ in age (for ADHD,  $M = 17.74$ ,  $SD = 3.38$ ; for nonADHD,  $M = 17.17$ ,  $SD = 3.16$ ), sex (for ADHD, 89.6% male; for nonADHD, 88.7% male), ethnicity/racial minority (for ADHD, 18.4% were minority, 11.0% were African-American; for nonADHD, 15.4% were minority, 9.2% were African-American), and highest parent education (for ADHD,  $M = 7.14$ ,  $SD = 1.62$ ; for nonADHD,  $M = 7.41$ ,  $SD = 1.65$ , on a scale of 1 (<7th grade education) to 9 (graduate professional training), with 7 = Associate's or 2-year degree. Additional details regarding subject recruitment may be found in Faden et al. (2004) or Molina et al. (in press).

### **Study Subsample, $N = 355$**

From the PALS sample of 604 participants, 597 participants (357 probands, 240 controls) completed the initial screener portion of a questionnaire about driving related outcomes and behaviors (see section, Subsequently "Driving Behavior Questionnaire").

Only participants who reported driving in the past 6 months (legally or illegally) were administered the remaining questionnaire items (355 participants total;  $n = 203$  probands;  $n = 152$  controls) and were included in the principal analyses. Of the 16 young adults who endorsed license suspension or revocation, only two had not driven in the past 6 months (that is, only two were not administered the rest of the measure); the possibility of selecting out those drivers who may exhibit highest levels of the target behaviors, therefore, is unlikely.

Within the study sample, 89% of participants were male and 82% were Caucasian (a percentage roughly reflecting the racial composition of Allegheny County, indicated by 1989 census data to be 11% minority). Annual family income was diverse, ranging from <20 k to >100 k in a roughly rectangular distribution. Median parental household income = \$55,000. Parental education levels ranged from high school to graduate school, with the majority having attained at least partial college or technical training. Importantly, there were no statistically significant differences at  $p < .05$  or less on demographic variables between probands and controls who reported driving in the last six months ( $n = 355$ ).

### **Procedure**

Interviews in adolescence and young adulthood were conducted in the ADD Program offices by post-baccalaureate research staff. In cases where distance prevented participant travel to WPIC, information was collected through a combination of mailed and telephone correspondence; home visits were offered as need dictated. Informed consent was obtained and all participants were assured confidentiality of all disclosed material except in cases of impending danger or harm to self or others. Self-report questionnaires were completed either with pencil and paper or web-based versions on a closed circuit Internet page.

### **Measures**

#### **Driving Behavior Questionnaire**

Driving outcomes were self-reported with The Young Adult Driving Questionnaire (YADQ; Donovan, et al., 1983; Jessor, Donovan, & Costa, 1991). The screener portion of the YADQ includes current license/permit status (yes/no), age of licensure, report of license suspension (yes/no) and revocation (yes/no), and frequency of driving with and without a license over the past 6 months. The remainder of the questionnaire includes items assessing the number of lifetime accidents and citations received, as well as the number of accidents

and citations received while intoxicated. In addition, alcohol-impaired driving is assessed by a four-item subscale (in this sample,  $\alpha = .89$ ) that consists of the frequency (within the past 6 months) of driving after one or two drinks, after three or more drinks, when coordination was knowingly affected, and while drinking. The subscale of risky driving behaviors consists of 24 items ( $\alpha = .92$  in this sample) covering speeding and violations of passing, following, lane-usage, right-of-way, turning, and use of signal (Donovan, 1993). Responses for both of these subscales ranged from “not at all” to “more than ten times per day” in the last 6 months. This measure has been shown to adequately distinguish between individuals arrested for driving while intoxicated, those who had received multiple nonalcohol-related violations, and a representative random sample of the general driving population (Donovan et al., 1985).

### **ADHD Symptomatology, Irritability, and Conduct Problems at Follow-up**

Parent (usually mother) and self-report was used to measure ADHD symptomatology, irritability, and conduct problems at adolescent and young adult follow-up. Consistent with previous studies, the highest item response between parent and self-report was used (Bird, Bould, & Staghezza, 1992; Cohen et al., 1993). The majority of cases (87%) were based on mother and child report; father report was used in 8% of cases. There were 20 young adults for whom parent report was unavailable. As results were not appreciably different when these cases were excluded from analyses, data from these individuals were retained.

Current hyperactive-impulsive symptomatology was measured using parent and self-report on the Eysenck Impulsivity Scale (Eysenck, Easting, & Pearson, 1984; White et al., 1994) and the hyperactivity-impulsivity subscale of the DBD (Pelham et al., 1992), adapted for DSM-IV. The Eysenck Impulsivity Scale includes 23 items, 12 of which assess impulsive behavior with face valid items (e.g., has your son or daughter ever bought things he/she doesn't need? Does your son or daughter ever act without thinking first?, etc.). Item responses are dichotomous (yes/no) and positively coded items (by parent or by self-report) were summed to create an index of the subject's current level of impulsivity ( $\alpha = .87$ , 12 items in this sample). The DBD assessed the occurrence of DSM-IV symptoms for ADHD, ODD, and CD on a 4-point scale (0 = not at all, 3 = very much). In this study, the hyperactivity-impulsivity score was the sum of the nine hyperactivity-impulsivity items ( $\alpha = 91$

this sample). As the correlation between EIS and DBD scales was .67, a single combined hyperactivity-impulsivity score was calculated as the mean of the z-scored EIS and DBD hyperactivity-impulsivity scores. Current inattention symptomatology was measured using parent and self-reports of the inattention subscale of the DBD (e.g., difficulty sustaining attention in tasks or play, does not seem to listen to what is being said, etc.). Responses to nine items were averaged ( $\alpha = .90$ ) to create a mean index of current inattention.

Current irritability was measured with the Caprara Irritability Scale (Caprara et al., 1985), a 30 item 5-point scale with responses ranging from “strongly agree” to “strongly disagree”, administered to parents. Sample items include “My child easily flies off the handle with people who don't want to listen or understand”, and “Sometimes when my child is angry, he/she loses control over his/her actions”. Answers were recoded so that high scores indicate higher levels of irritability. Internal consistency in this sample was excellent,  $\alpha = .91$ . Studies confirm good psychometric properties, reporting a test-retest coefficient of .83 and a split-half consistency of .90 in healthy men and women (Caprara et al., 1985) and even higher coefficients in clinical (Tartar, Blackson, Bringham, Moss, & Caprara, 1995) and other normal samples (Anderson, 1997). Validity for the Caprara Irritability Scale has been established by demonstrating that people with higher irritability scores administer higher shocks on laboratory aggression tasks (Caprara et al., 1986; Parrott & Zeichner, 2001) and rate themselves higher on measures of state hostility (Anderson, 1997).

### **Conduct Problems at Follow-up**

Parent and self-report of conduct problems were measured (e.g., Have you ever stolen from a store? Have you ever been physically cruel to others? Have you ever been arrested?, etc.) using the DBD (Pelham et al., 1992) and the CD module of the Diagnostic Interview Schedule for Children, DSM-IV edition (DISC-IV; Shaffer, Fisher, Lucas, Dulcan, & Schwab-Stone, 2000) for adolescents and the Self-Report of Delinquency measure (SRD; Elliot, Huizinga, & Ageton, 1985; Loeber, Farrington, Stouthamer-Loeber, & VanKammen, 1998) for young adults. The DISC has well-established psychometric properties (Schwab-Stone et al., 1996); agreement between clinician administered DISC diagnoses of CD and diagnoses generated from clinical interview symptom ratings has found to be quite good ( $>.70$ ; Schwab-Stone et al., 1996). Psychometric evaluations of the SRD are described by Loeber et al. (1989) and Elliot et al. (1985). For adolescents, the DISC

was supplemented with SRD items to create a comparable response set across the ages. A continuous measure of current symptoms was created by forming a proportion score from the number of conduct problem behaviors endorsed within the past 12 months over the total possible number of behaviors (23 total behaviors for adolescents and 35 for young adults).

## Results

### Overview of Analytic Plan

First, ADHD group differences in the driving outcome variables (accidents, tickets, etc.) were tested using chi-square and multiple regression, with age and frequency of driving included as covariates where appropriate. Cohen's *ds* (Cohen, 1988) and Odds' ratios are reported as indicators of effect size for continuous and dichotomous outcomes, respectively. Guidelines for interpreting effect sizes were taken from Cohen (1988), with *ds* of .2, .5, and .8 considered to be small, moderate, and large. In a sample size of 355, power to detect small group differences of  $d = .30$  or higher is at least 80 (Cohen, 1988).

Multivariate regression was employed as the general analytic strategy. Prior to all analyses, variables were tested to assess whether they met the assumptions of regression. Examination of residual plots indicated that the assumptions of linearity and homoscedasticity were met. Reliability estimates (Cronbach alphas) were all acceptable ( $>.7$ ). Distribution of variables was inspected graphically (via frequency distributions) and statistically (via skew and kurtosis values). Most variables appeared to be normally distributed and therefore did not require transformation. The risky driving and drunk driving scales, however, were positively skewed (1.5 and 3.0, respectively); these scales, then, were dichotomized (less than once per month/once per month or more)

and re-examined with logistic regression. As results were not appreciably different, scales were retained as continuous variables, and the multiple regression results are presented for ease of interpretation.

Multiple regression was used to test both the association between adolescent functioning at follow-up and driving outcomes and the mediational hypotheses. Table I provides the matrix of zero-order correlations among predictor and outcome variables in the sample of drivers. To reduce nonessential multicollinearity, all continuous predictor variables were centered to zero. None of the variance inflation factors exceeded 3.70, and there were no individual cases that substantially influenced the regression results (per residual diagnostic procedures in Cohen, Cohen, West, & Aiken, 2003 and Fox, 1991).

### ADHD Group Differences in Driving Variables

Table II shows percentages of endorsement and mean values for the individual driving variables. Among individuals of driving age (16 or above,  $n = 412$ ), controls were significantly more likely than probands to be licensed drivers at the time of interview ( $\chi^2 = 34.90$ ,  $df = 1$ ,  $p = .00$ ), but probands were four times more likely than controls to have ever driven without a license or a permit ( $\chi^2 = 20.00$ ,  $df = 1$ ,  $p = .00$ ). In addition, Kaplan–Meier survival analysis confirmed that individuals with childhood ADHD, as a group, received their licenses at significantly older ages than did controls. Although the median survival time (i.e., median age by which license was received) was equivalent for both groups, Median = 16.00 for probands and 16.00 for controls, the mean survival time for controls was younger, 17.52 years, than for probands, 20.51 years (Breslow statistic = 49.71,  $df = 1$ ,  $p = .00$ ), reflecting the fact that proportionally more probands than same-aged controls remained unlicensed by the time of their interview.

**Table I.** Zero Order Correlations of Predictor and Outcome Variables for Mediation Analyses

	1	2	3	4	5	6	7	8	9	10
1. Age	–	.09	.22**	–.05	–.12*	–.14**	–.04	.18**	.20**	.28**
2. Childhood ADHD		–	–.04	.50**	.48**	.31**	.16**	–.10	.04	.15**
3. Frequency of driving			–	–.03	–.07	–.08	–.08	.38**	.21**	.21**
4. Hyperactivity–Impulsivity at follow-up				–	.83**	.65**	.40**	.07	.13*	.16**
5. Inattention at follow-up					–	.60**	.36**	–.02	.08	.03
6. Irritability at follow-up						–	.35**	–.03	.08	.08
7. Conduct problems at follow-up							–	.17**	.25**	.09
8. Risky driving								–	.42**	.41**
9. Alcohol-impaired driving									–	.21**
10. Number of tickets and accidents										–

\* $p < .05$  and \*\* $p < .01$ ;  $n = 347$  participants who have driven in the past 6 months with complete data.

**Table II.** ADHD Group Differences for Driving Variables

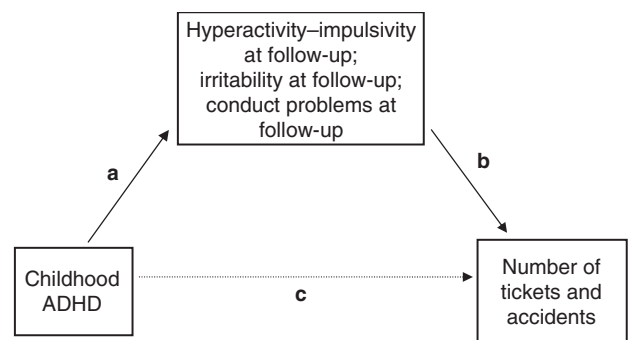
	Controls	Probands	Odds ratio	Cohen's <i>d</i>	<i>p</i> -value
Currently have a license <sup>a</sup>	79.0%	50.0%	.27		.00
Ever driven w/o a license/permit <sup>a</sup>	5.1%	17.6%	3.97		.00
Ever had an accident	44.0%	41.3%	.90		.50
No of accidents in lifetime	.86 (1.25)	1.03 (2.24)		.14	.42
No of accidents last 6 months	.15 (.43)	.29 (.73)		.33	.04
No of accidents after drinking	.03 (.18)	.07 (.51)		.22	.44
Ever received a ticket	36.8%	46.0%	1.46		.20
No of tickets in lifetime	.65 (1.26)	1.22 (2.64)		.45	.03
No of tickets last 6 months	.17 (.41)	.29 (.74)		.29	.05
No of tickets after drinking	.03 (.18)	.04 (.28)		.06	.94
Ever had license suspended	9.3%	14.4%	1.65		.40
No of suspensions	.10 (.32)	.18 (.48)		.25	.15
Ever had to go to traffic school	1.3%	5.7%	4.45		.06
Risky driving	1.36 (1.23)	1.08 (1.37)		.23	.11
Alcohol-impaired driving	.48 (1.22)	.58 (1.29)		.08	.51

<sup>a</sup>Among those of driving age (16 or older), *n* = 412. All other variables are among those who have driven in the past 6 months, *n* = 355. Except for the first two comparisons, all analyses control for age and frequency of driving in the past 6 months. Effect sizes for group differences are included— odds ratios for dichotomous variables and Cohen's *d*s, calculated using the SD of the control group, for continuous variables.

Among participants who reported driving in the past 6 months (and controlling for age and frequency of driving), small to medium sized associations were found between ADHD group and the number of accidents in the last 6 months ( $\beta = .12, p = .04$ ), number of tickets received in lifetime ( $\beta = .11, p = .03$ ), and number of tickets received in the last 6 months ( $\beta = .11, p = .05$ ). Probands were over four times more likely than controls to have gone to traffic school, though this difference only emerged as a trend (Wald  $\chi^2 = 3.43, p = .06$ ), due to modest power (.72). Although the probands reported more license suspensions, the group difference was not statistically significant. No group differences were found for risky driving or alcohol-impaired driving. Most participants (86.4% overall) reported driving after drinking three times or less in the past 6 months; only 3.7% of the entire sample endorsed alcohol-impaired driving as often as once a month or more.

**Mediational Model for Tickets and Accidents**

Because ADHD group differences were found for number of tickets and accidents, the mediational model in Fig. 1 was tested using a series of regression analyses. A single dependent variable was created by summing the raw scores of each participant's reported number of lifetime tickets and past 6-month accidents. First, each of the three hypothesized mediators was tested independently (inattention was not tested as a potential mediator because it was highly correlated with hyperactivity-impulsivity and not correlated with any of the driving variables; Table I). A final model tested all



**Figure 1.** Mediation of the relationship between childhood ADHD and number of tickets and accidents by adolescent symptom reports at follow-up.

mediators simultaneously. Mediation effects were tested statistically by multiplying the unstandardized betas from path a and path b ( $a * b$ , the indirect effect). Approximate *z* scores for each mediated effect were estimated by dividing the product by its standard error ( $SE(ab)$ ) where  $SE(ab)^2 = SE(a)^2 * (b)^2 + SE(b)^2 * (a)^2$ ; *z* scores  $\geq 1.96$  are interpreted as statistically significant mediation (MacKinnon & Dwyer, 1993; MacKinnon, Krull, & Lockwood, 2000).

The zero-order correlations for each of the three hypothesized mediators (Table I) confirmed the significance of path a. The results for Model 1 in Table III, show the statistically significant main effects of childhood ADHD after controlling for age and driving frequency. When added to the regression equation, hyperactivity-impulsivity at follow-up was associated with tickets and accidents, and the childhood ADHD group effect

**Table III.** Mediation Analysis Predicting Number of Tickets and Accidents from Adolescent Symptom Reports at Follow-up

	Model 1 $\beta$ ( $p$ )	Model 2 $\beta$ ( $p$ )	Model 3 $\beta$ ( $p$ )	Model 4 $\beta$ ( $p$ )	Model 5 $\beta$ ( $p$ )
Age at follow-up	.24 (.00)	.23 (.00)	.25 (.00)	.24 (.00)	.25 (.00)
Frequency of driving	.16 (.00)	.15 (.00)	.17 (.00)	.17 (.00)	.16 (.00)
Childhood ADHD	.14 (.01)	.11 (.08)	.12 (.04)	.13 (.01)	.08 (.20)
Hyperactivity-impulsivity at follow-up		.14 (.02)			.10 (.18)
Irritability at follow-up			.09 (.10)		.02 (.77)
Conduct problems at follow-up				.10 (.06)	.06 (.29)
Full model $R^2$ ( $p$ )	.10 (.00)	.14 (.00)	.13 (.00)	.13 (.00)	.14 (.00)

$n=355$  participants with complete data;  $\beta$ =standardized regression coefficient and  $R^2$  is for full model.

**Table IV.** Regression Analyses Predicting Risky Driving from Adolescent Symptom Reports at Follow-Up

	Model 1 $\beta$ ( $p$ )	Model 2 $\beta$ ( $p$ )	Model 3 $\beta$ ( $p$ )	Model 4 $\beta$ ( $p$ )
Age at follow-up	.11 (.04)	.10 (.05)	.11 (.03)	.09 (.07)
Frequency of driving	.37 (.00)	.40 (.00)	.37 (.00)	.38 (.00)
Hyperactivity-impulsivity at follow-up	.11 (.03)			.08 (.25)
Irritability at follow-up		.02 (.66)		-.09 (.18)
Conduct problems at follow-up			.21 (.00)	.20 (.00)
Full model $R^2$ ( $p$ )	.18 (.00)	.16 (.00)	.20 (.00)	.21 (.00)

$n=355$  participants with complete data;  $\beta$ =standardized regression coefficient.

decreased. More hyperactivity-impulsivity at follow-up was associated with more tickets and accidents (Model 2). There were trends for irritability at follow-up, when tested alone in Model 3, and conduct problems at follow-up, when tested alone in Model 4, to be associated with number of tickets and accidents. When the mediators were tested simultaneously in Model 5, none remained significant. Using the unstandardized betas from model (Model 2), the mediation  $z$  score calculated for hyperactivity-impulsivity at follow-up,  $z=2.33$ , indicates that this dimension is a statistically significant mediator of the association between childhood ADHD and later tickets and accidents.

Even though hyperactivity-impulsivity and inattention were highly correlated ( $r=.83$  in Table I), we conducted an additional exploratory regression analysis with both hyperactivity-impulsivity and inattention in one model. None of the prior findings changed, as more hyperactivity-impulsivity at follow-up was associated with more tickets and accidents (age at follow-up  $\beta=.23$ ,  $p=.00$ ; driving frequency  $\beta=.15$ ,  $p=.00$ ; childhood ADHD  $\beta=.11$ ,  $p=.08$ , hyperactivity-impulsivity  $\beta=.36$ ,  $p=.00$ ), but the beta for inattention was negative ( $\beta=-.29$ ,  $p=.00$ ).

### Additional Mediation Hypotheses

We could not test our mediational hypotheses for risky and alcohol-impaired driving because childhood ADHD

diagnosis did not predict these outcomes. However, we were able to test whether hyperactivity-impulsivity, irritability, and conduct problems at follow-up were associated with these two driving outcomes. Results are in Tables IV and V. Hyperactivity-impulsivity at follow-up was significantly associated with risky driving in Model 1. Current conduct problems also emerged as significantly associated with risky driving both when it was tested alone in Model 3 and simultaneously with hyperactivity-impulsivity and irritability in Model 4. For alcohol-impaired driving (Table V), hyperactivity-impulsivity (when tested alone in Model 1), irritability (when tested alone in Model 2), and conduct problems (when tested alone in Model 3) were significant. Only conduct problems at follow-up was statistically significant in Model 4, when hyperactivity-impulsivity, irritability, and conduct problems at follow-up were tested simultaneously.

### Discussion

Our findings suggest a modest yet important level of risk for potentially dangerous and lethal driving outcomes (tickets and accidents) for children with ADHD. This finding serves as a needed replication and extension of Barkley and colleagues' work (1993, 1996), in which they reported higher rates of traffic citations and



**Table V.** Regression Analyses Predicting Alcohol-Impaired Driving from Adolescent Symptom Reports at Follow-Up

	Model 1 $\beta$ ( $p$ )	Model 2 $\beta$ ( $p$ )	Model 3 $\beta$ ( $p$ )	Model 4 $\beta$ ( $p$ )
Age at follow-up	.16 (.00)	.17 (.00)	.17 (.00)	.16 (.00)
Frequency of driving	.18 (.00)	.17 (.00)	.18 (.00)	.19 (.00)
Hyperactivity–impulsivity	.14 (.00)			.02 (.76)
Irritability		.12 (.02)		.02 (.74)
Conduct Problems			.27 (.00)	.26 (.00)
Full model $R^2$ ( $p$ )	.09 (.00)	.08 (.00)	.14 (.00)	.15 (.00)

$n = 355$  participants with complete data;  $\beta$  = standardized regression coefficient.

driving-related accidents with much smaller samples of adolescents and young adults self-referred for ADHD. Thus, our finding of more tickets and accidents among adolescents and young adults diagnosed with ADHD in childhood (compared to same-aged participants without this childhood disorder) suggests generalizability of modest risk to a broader population of individuals with ADHD. This may include youth diagnosed in childhood who often fail to obtain services as adolescents or young adults.

The magnitude of ADHD group difference that we reported for driving-related citations and traffic accidents is smaller than previously reported. In Barkley's 2002 study, the risks for self-reported tickets and accidents were 2.16 and .64, respectively, which are Cohen's  $d$ s calculated by this author. The effect sizes in the present study ranged from .29 to .45. These modest effect sizes may have resulted from dissipation of ADHD symptoms with maturation for a subset of our participants, all of whom were recruited for their diagnosed ADHD in childhood. In contrast, the participants in the Barkley studies were recruited in adolescence (Barkley et al., 1993) or in early adulthood (Barkley et al., 1996, Barkley, Murphy, et al., 2002) on the basis of referral for ADHD treatment at that time. Thus, to the extent that ongoing ADHD symptomatology is associated with driving-related impairment, smaller effect sizes are to be expected with the PALS sample.

Indeed, we proposed a mediational model to test whether symptom persistence and other expected characteristics explained ADHD risk for traffic citations and accidents. As conduct problems did not meet conventional standards of significance in Models 4 & 5, the mediational model with the strongest support indicated the importance of current ADHD symptoms (Model 2). Specifically, current symptoms of hyperactivity and impulsivity as rated by parents and participants together on two measures explained a portion of the childhood ADHD effect on tickets and accidents. This finding underscores the potential importance of this particular

dimension of ADHD symptoms in the regulation of driving behavior. Hyperactivity and impulsivity together may have a proximal impact on risky driving as poor regulation of impulses interferes with an individual's ability to modulate behavior and quickly anticipate the negative consequences of his or her actions (speeding, running a red light, etc.). Similar thinking has been used to explain the association between hyperactivity–impulsivity and substance use among middle schoolers (Molina, Smith, & Pelham, 1999).

We explored the association between inattention symptoms and tickets/accidents controlling for the highly correlated hyperactivity–impulsivity dimension. The results were unanticipated; although hyperactivity–impulsivity results were the same, inattention was inversely associated with tickets/accidents. We speculate that forcing two highly correlated variables to compete for variance in driving behavior may have caused this result. Alternatively, findings may be a result of unstable differences between the groups that are partly a function of reporting bias differences (e.g., group differences in young adult insight, group differences in parental awareness of functioning). Further inquiry with longitudinal analysis (i.e., separating out those participants who are consistently symptomatic over a period of years from those who are not) and additional samples is needed to determine whether these unexpected findings are stable and replicable.

We did not find group differences in self-reported risky driving or alcohol-impaired driving. We surmise that under-reporting by probands is responsible for this result. Previous research has shown that children with ADHD provide inflated estimates of their competence in a variety of domains (Diener & Milich, 1997; Hoza, Pelham, Dobbs, Owens, & Pillow, 2002; Hoza, Waschbusch, Pelham, Molina, & Milich, 2000). Hoza and colleagues (2002), for example, demonstrated that boys with ADHD overestimated their competence more than controls in the scholastic, social, and behavioral domains, relative to teacher ratings. In addition, ADHD boys tended to

overestimate their competence the most in areas of greatest deficit/impairment. To the extent that this “positive illusory bias” (Hoza et al., 2002) persists into adulthood, inflated estimates of performance in another behavioral domain—driving—may account for the low rates of self-reported risky driving by probands in the sample, especially in light of their higher rates of citations and accidents. Indeed, in a recent study (Knouse, Bagwell, Barkley, & Murphy, 2005), adults with ADHD provided similar self-assessment of their driving abilities as a community control group *despite* poorer performance of driving in naturalistic settings and in a virtual-reality driving simulator. Although we expect that reporting of actual driving-related citations and accidents is less affected by positive illusory bias, it may be useful in future research to validate the self-report with actual driving records.

Individuals with more conduct problems, however, did report more risky and alcohol-impaired driving. It is interesting that, despite the fact that CD and Antisocial Personality Disorder occur principally among the probands in the PALS (Molina et al., in press), overall ADHD group differences in these two self-reported driving variables were not found. Perhaps these behaviors, which undoubtedly contribute to driving-related citations and accidents, including above and beyond any contribution by hyperactivity and impulsivity, are less subject to reporting bias (i.e., due to embarrassment from admitting such behaviors) among probands with disregard for the social conventions (and laws) governing driving. It is particularly intriguing that strong associations between conduct problems and risky/alcohol-impaired driving were found even after controlling for hyperactivity–impulsivity. This suggests that other individual difference characteristics typically thought to contribute to CD or antisocial behavior (e.g., callous-unemotional personality traits; Frick, 2006) may contribute to these driving outcomes.

The pattern of associations between hyperactivity–impulsivity, conduct problems, and the three driving-related outcomes (risky driving, alcohol-impaired driving, and tickets/accidents) may reflect two diverging pathways seen in findings from other longitudinal studies of children with ADHD. One putative pathway may be characterized by outcomes typically associated with disregard for social norms, which include substance use disorder, conduct problems, and antisocial personality (e.g., Biederman et al., 1997; Gittleman et al., 1985). The other may be characterized by the persistence of ADHD symptoms and related impairment but not necessarily

antisociality, such as peer rejection (Bagwell et al., 2001), daily cigarette smoking (Burke, Loeber, & Lahey, 2001; Molina & Pelham, 2003), and occupational difficulties (Mannuzza, Klein, Bessler, Malloy, & Hynes, 1997). In the current study, individuals in the proposed antisocial pathway may be prone to alcohol-impaired driving, while individuals in the other pathway may be prone to citations and accidents independent of alcohol use and other conduct problems. Some merging or overlap of these pathways is expected, and risky driving may result for both types of individuals.

Executive functioning deficits that persist beyond childhood may explain driving related impairments for individuals with ADHD (Barkley, Murphy, et al., 2002). Impairments in multiple components of executive functioning (or cognitive control), including visual-spatial working memory, planning, response inhibition or suppression, and activation (Nigg, 2006), likely contribute to risky driving and negative driving outcomes like tickets and accidents. Driving involves the deliberate control of behavior and requires that an individual constantly assess and reassess his spatial environment despite possible interference (e.g., attend to traffic signs and the actions of other drivers; visual-spatial working memory), mentally organize a series of steps in temporal sequence (e.g., mechanical operation of a motor vehicle; planning), quickly interrupt behavior (e.g., stop accelerating) as a context changes (response suppression), and maintain a readiness to respond (e.g., braking quickly at any moment; activation). As impairment in these executive skills also likely contributes to problems with inattention and impulsivity (Nigg, 2006), this pathway may be a particularly important area of future research.

In the end, for one reason or another, it appears that adverse driving outcomes are a possibility for children with ADHD. Presently, is not known whether specialized driver training or medication could decrease this liability. Two studies have shown improved driving performance in a simulator with methylphenidate (Barkley, Murphy, O’Connell, & Connor, 2005; Cox, Merkel, Penberthy, Kovatchev, & Hankin, 2004), so there is some possibility that medication may decrease driving errors, although this association has yet to be demonstrated outside of the laboratory. Unfortunately, previous research has shown poor correspondence between laboratory- or clinic-based measures of response to methylphenidate and actual performance (e.g., classroom behavior and academic performance; Rapport, Chung, Shore, Denney, & Isaacs, 2000). Thus, a study of medication effects on actual driving

behavior outside of the laboratory is needed. Barkley has suggested that interventions directly addressing motivational deficits might be effective (Barkley et al., 1996), such as more immediate cues for behavior while driving or increased insurance penalties (Barkley et al., 1996). Given our finding that disregard for rules (i.e., conduct problems) may be partly associated with these negative driving outcomes, interventions such as these, that extend the principles of behavior management into the driving context, may ultimately be necessary for the subset of individuals with ADHD and antisocial tendencies. Relatedly, it is important to note that the association between childhood ADHD and driving problems is modest in magnitude, and not all children with ADHD will drive in a way that increases their risk for accidents. Further study should focus on identifying additional risk and protective factors within the ADHD population (e.g., various medication types and regimens, parental monitoring, other contextual factors such as passengers in the car) that distinguish the risky drivers from the nonrisky drivers.

### **Limitations of the Current Study and Future Directions**

A limitation of the current study is the sole reliance on self-report of risky and alcohol-impaired driving which may have underestimated these particular behaviors within the proband sample. Although previous research found ADHD-control group differences in both self- and collateral-reported driving habits (e.g., breaking properly at intersections, Barkley et al., 1996), limited insight may have been a factor with some PALS participants. Self-report may not always be the best method of capturing the true variability in risky driving behaviors, especially if highly vulnerable populations (i.e., impulsive) with limited insight are of interest. Although parents are the traditional source for collateral report in studies of ADHD, they may not be optimal reporters of their offspring's risky driving behavior, especially as parental monitoring diminishes over time (Jacobson & Crockett, 2000). Future research would benefit from the addition of collateral reporters who are frequent passengers and around whom the driver is less likely to censor his behavior (such as a close friend or spouse/significant other). Beyond self- and other report of risky driving, driving simulator data has been shown to be useful (Barkley et al., 1996). This strategy removes the need for self-report and may eliminate the biases observed in the present study. At the same time, concerns about the ecological validity of

lab-based measures require that data from such tests be integrated with other sources (Gordon & Barkley, 1998).

Additional limitations pertain to the nature of the sample in this study. First, research suggests that a decline in risky driving and accident involvement typically occurs after age 25, when individuals have transitioned out of adolescence and assumed conventional adult roles (Jessor, Turbin, & Costa, 1997; Williams, 1996). The current study captured driving behaviors in a specific and narrow window of time that is early in the driving career. Thus, the relatively young age of the follow-up sample necessitates re-examining risky driving and alcohol-impaired driving as the majority of the sample ages. Second, it is unknown whether the results of this study would apply to the larger population of children treated for ADHD in nonspecialty settings, such as pediatrician offices. Finally, the small percentage of females in the sample precluded the examination of gender-specific associations with risky and alcohol-impaired driving. This is an important direction for future research since current knowledge of long-term outcomes of childhood ADHD in females is quite limited.

### **Conclusions**

Children with ADHD are at increased risk for driving-related citations and automobile accidents when they have persisting hyperactivity and impulsivity symptoms. The risk is small but important given the potential dangers of these sequelae. Like risky sexual behavior (Flory, Molina, Pelham, Gnagy, & Smith, 2006), substance abuse and dependence (Gittleman et al., 1985; Molina et al., in press; Molina & Pelham, 2003; Weiss & Hechtman, 1993) and cigarette smoking (Burke et al., 2001; Milberger, Biederman, Faraone, Chen, Jones, 1997; Molina et al., 2005), perilous driving may be considered another long-term (negative) outcome for a subset of children with ADHD. Dangerous driving (e.g., speeding, reckless driving, alcohol-impaired driving) is also particularly elevated among young drivers with other violations of conduct (e.g., stealing, lying, property damage). Monitoring of these outcomes jointly among youth with either persisting ADHD or additional behavioral difficulties is warranted. An important question for future research is, whether maturation into middle adulthood will reveal continued or diminished driving risk associated with ADHD.

## Acknowledgments

This study was supported by grant AA11873 from the National Institute of Alcohol Abuse and Alcoholism. Research was also supported in part by AA00202, AA08746, AA12342, AA0626, and grants from the National Institute on Drug Abuse, DA12414, DA05605, the National Institute of Mental Health, MH12010, MH4815, MH47390, MH45576, MH 50467, MH53554, and the National Institute of Environmental Health Sciences, ES0515.

*Conflict of interest:* None declared.

*Received January 5, 2007; revisions received September 13, 2006 and January 5, 2007; accepted January 10, 2007*

## References

- Achenbach, T. M. (1991). *Integrative guide for the 1991 CBCL/4-18, YSR, and TRF profiles*. Burlington, VT: University of Vermont: Department of Psychiatry.
- Achenbach, T. M., & Edelbrock, C. (1986). *Manual for the teacher's report form and teacher version of the child behavior profile*. Burlington, VT: University of Vermont: Department of Psychiatry.
- American Psychiatric Association. (1994). *Diagnostic and statistical manual of mental disorders*. Washington, DC: American Psychiatric Association.
- Anderson, C. (1997). Effects of violent movies and trait hostility on hostile feelings and aggressive thoughts. *Aggressive Behavior, 23*, 161–178.
- Atkins, M. S., Pelham, W. E., & Licht, M. (1985). A comparison of objective classroom measures and teacher ratings of attention deficit disorder. *Journal of Abnormal Child Psychology, 13*, 155–167.
- Bagwell, C. L., Molina, B. S. G., Pelham, W. E., & Hoza, B. (2001). Attention-deficit hyperactivity disorder and problems in peer relations: Predictions from childhood to adolescence. *Journal of the American Academy of Child and Adolescent Psychiatry, 40*, 1285–1292.
- Barkley, R. A. (2006). Attention Deficit Hyperactivity Disorder *A Handbook for diagnosis and Treatment* (3rd ed.), New York: Guilford.
- Barkley, R. A., Fisher, M., Edelbrock, C. S., & Smallish, L. (1990). The adolescent outcome of hyperactive children diagnosed by research criteria: I. An 8-year prospective follow-up study. *Journal of the American Academy of Child and Adolescent Psychiatry, 29*, 546–557.
- Barkley, R., Fischer, M., Smallish, L., & Fletcher, K. (2002). The Persistence of attention deficit hyperactivity disorder into young adulthood as a function of reporting source and definition of disorder. *Journal of Abnormal Psychology, 111*, 279–289.
- Barkley, R. A., Guevremont, D. C., Anastopoulos, A. D., DuPaul, G. J., & Shelton, T. L. (1993). Driving related risks and outcomes of Attention Deficit Hyperactivity Disorder in adolescents and young adults: A 3–5 year follow-up survey. *Pediatrics, 92*, 212–218.
- Barkley, R., Murphy, K., DuPaul, G., & Bush, T. (2002). Driving in young adults with attention deficit hyperactivity disorder: Knowledge, performance, adverse outcomes, and the role of executive functioning. *Journal of International Neuropsychological Society, 8*, 655–672.
- Barkley, R., Murphy, K., & Kwasnik, D. (1996). Motor vehicle driving competencies and risks in teens and young adults with attention deficit hyperactivity disorder. *Pediatrics, 98*, 1089–1095.
- Barkley, R. A., Murphy, K. R., O'Connell, T., & Connor, D. F. (2005). Effects of two doses of methylphenidate on simulator driving performance in adults with attention deficit hyperactivity disorder. *Journal of Safety Research, 36*, 121–131.
- Biederman, J., Wilens, T., Mick, B., Faraone, S. V., Weber, W., Curtis, S., et al. (1997). Is ADHD a risk factor for psychoactive substance use disorders? Findings from a four year prospective follow-up study. *Journal of the American Academy of Child and Adolescent Psychiatry, 36*, 21–29.
- Bird, H., Bould, M., & Staghezza, B. (1992). Aggregating data from multiple informants in child psychiatry epidemiological research. *Journal of the American Academy of Child and Adolescent Psychiatry, 31*, 78–85.
- Brown, R. C., Sanders, J. M., & Schonberg, S. K. (1986). Driving safety and adolescent behavior. *Pediatrics, 77*, 603–607.
- Burke, J. D., Loeber, R., & Lahey, B. B. (2001). Which aspects of ADHD are associated with tobacco use in early adolescence? *Journal of Child Psychology and Psychiatry and Allied Disciplines, 42*, 493–502.
- Caprara, G. V., Cinanni, V., D'Imperio, G., Passerini, S., Renzi, P., & Travaglia, G. (1985). Indicators of impulsive aggression: Present status of research on irritability and emotional susceptibility scales. *Personality and Individual Differences, 6*, 665–674.

- Caprara, G. V., Renzi, P., D'Augello, D., D'Imperio, G., Riellis, I., & Travaglia, G. (1986). Interpolating physical exercise between instigation to aggress and aggression: The role of irritability and emotional susceptibility. *Aggressive Behavior*, *12*, 83–91.
- Cohen, J. (1988). *Statistical power analysis in the behavioral sciences* (2nd ed.). Hillsdale, NJ: Erlbaum.
- Cohen, P., Cohen, J., Kasen, S., et al. (1993). An epidemiological study of disorders in late childhood and adolescence: I. Age and gender specific prevalence. *Journal of Child Psychology and Psychiatry*, *34*, 851–867.
- Cohen, J., Cohen, P., West, S., & Aiken, L. (2003). *Applied Multiple Regression/Correlation Analysis for the behavioral sciences* (3rd ed.), Hillsdale, NJ: Erlbaum.
- Cox, D., Merkel, L. R., Penberthy, J. K., Kovatchev, B., & Hankin, C. S. (2004). Impact of methylphenidate delivery profiles on driving performance of adolescents with attention deficit/hyperactivity disorder: A pilot study. *Journal of the American Academy of Child and Adolescent Psychiatry*, *43*, 269–275.
- Diener, M. B., & Milich, R. (1997). Effects of positive feedback on the social interactions of boys with attention deficit hyperactivity disorder: A test of the self-protective hypothesis. *Journal of Clinical Child Psychology*, *26*, 256–265.
- Donovan, J. (1993). Young adult drinking-driving: Behavioral and psychosocial correlates. *Journal of Studies on Alcohol*, *600*–613.
- Donovan, D. M., Marlatt, G. A., & Salzbeg, P. M. (1983). Drinking behavior, personality factors, and high-risk driving: A review and theoretical formulation. *Journal of Studies on Alcohol*, *44*, 395–428.
- Donovan, D. M., Queisser, H. R., Salzbeg, P. M., & Umlauf, R. L. (1985). Intoxicated and bad drivers: Subgroups within the same population of high-risk men drivers. *Journal of Studies on Alcohol*, *46*, 375–382.
- Eisenberg, N., Fabes, R. A., Shepard, D. A., Murphy, B. C., Guthrie, I. K., Jones, S., et al. (1997). Contemporaneous and longitudinal predication of children's social functioning from regulation and emotionality. *Child Development*, *68*, 642–664.
- Elliott, D. S., Huizinga, D., & Ageton, S. S. (1985). *Explaining delinquency and drug use*. Beverly Hills, CA: Sage.
- Eysenck, S., Easting, G., & Pearson, P. (1984). Age norms for impulsiveness, venturesomeness, and empathy in children. *Personality and Individual Differences*, *5*, 315–321.
- Faden, V. B., Day, N. L., Windle, M., Windle, R., Grube, J. W., Molina, B. S. G., et al. (2004). Collecting longitudinal data through childhood, adolescence, and young adulthood: Methodological challenges. *Alcoholism, Clinical, and Experimental Research*, *28*, 330–340.
- Flory, K., Molina, B. S. G., Pelham, W. E. Jr., Gnagy, E. M., & Smith, B. H. (2006). Childhood ADHD predicts risky sexual behavior in young adulthood. *Journal of Clinical Child and Adolescent Psychology*, *35*, 571–577.
- Fox, J. (1991). *Regression Diagnostics*. Newbury Park: Sage.
- Frick, P. J. (2006). Developmental pathways to conduct disorder. *Child and Adolescent Psychiatric Clinics of North America*, *15*, 311–331.
- Gittelman, R., Mannuzza, S., Shenker, R., & Bongura, N. (1985). Hyperactive boys almost grown up. *Archives of General Psychiatry*, *42*, 937–947.
- Gordon, M., & Barkley, R. A. (1998). Tests and observational measures. In R. A. Barkley (Ed.), *Attention-Deficit hyperactivity disorder: A handbook for diagnosis and treatment* (pp. 294–311). New York: Guilford Press.
- Goyette, C. H., Connors, C. K., & Ulrich, R. F. (1978). Normative data on revised Connors Parent and Teacher Rating Scales. *Journal of Abnormal Child Psychology*, *6*, 221–236.
- Hoza, B., Pelham, W. E., Dobbs, J., Owens, J. S., & Pillow, D. R. (2002). Do boys with attention deficit hyperactivity disorder have positive illusory self-concepts? *Journal of Abnormal Psychology*, *111*, 268–278.
- Hoza, B., Waschbusch, D. A., Pelham, W. E., Molina, B. S. G., & Milich, R. (2000). Attention deficit hyperactivity disorder and control boys' responses to social success and failure. *Child Development*, *71*, 432–446.
- Jacobson, K. C., & Crockett, L. J. (2000). Parental monitoring and adolescent adjustment: An ecological perspective. *Journal of Research on Adolescence*, *10*, 65–97.
- Jensen, P. S., Martin, D., & Cantwell, D. P. (1997). Comorbidity in ADHD: Implications for research, practice, and DSM-V. *Journal of the American Academy of Child and Adolescent Psychiatry*, *36*, 1065–1079.
- Jessor, R., Donovan, J. E., & Costa, F. M. (1991). *Beyond adolescence: Problem behavior and young adult development*. NY: Cambridge University Press.
- Jessor, R., Turbin, M., & Costa, F. (1997). Predicting developmental change in risky driving: The transition

- to young adulthood. *Applied Developmental Science*, 1, 4–16.
- Knouse, L.E., Bagwell, C.L., Barkely, R.A., Murphy, K.R. (2005). Accuracy of self evaluation in adults with ADHD evidence from a driving study. *Journal of Attention Disorders*. Vol 8(4), 221–234.
- Loeber, R., Farrington, D. P., Stouthamer-Loeber, M., & Van Kammen, W. B. (1998). *Antisocial behavior and mental health problems: Explanatory factors in childhood and adolescence*. Mahwah, NJ: Lawrence Erlbaum.
- Loney, J., & Milich, R. (1982). Hyperactivity, inattention, and aggression in clinical practice. In M. Wolraich & D. K. Routh (Eds.), *Advances in developmental and behavioral practices*. Vol. 3 (pp. 113–147). Greenwich, CT: JAI.
- MacKinnon, D., & Dwyer, J. (1993). Estimating mediated effects in prevention studies. *Evaluation Review*, 17, 144–158.
- MacKinnon, D., Krull, J., & Lockwood, C. (2000). Equivalence of the mediation, confounding and suppression effect. *Prevention Science*, 1, 173–181.
- Mannuzza, S., Klein, R., Bessler, A., Malloy, P., & Hynes, M. E. (1997). Educational and occupational outcome of hyperactive boys grown up. *Journal of the American Academy of Child and Adolescent Psychiatry*, 36, 1222–1227.
- Milberger, S., Biederman, J., Faraone, S. V., Chen, L., & Jones, J. (1997). ADHD is associated with early initiation of cigarette smoking in children and adolescents. *Journal of the American Academy of Child and Adolescent Psychiatry*, 36, 37–44.
- Moffitt, T. E. (1990). Juvenile delinquency and attention deficit disorder: Boys' developmental trajectories from age 3 to 15. *Child Development*, 61, 893–910.
- Molina, B. S. G., Marshal, M. P., Pelham, W.E., & Wirth, R. J. (2005). Coping Skills and Parent Support Mediate the Association Between Childhood Attention Deficit/Hyperactivity Disorder and Adolescent Cigarette Use. *Journal of Pediatric Psychology*. Vol 30(4), 345–357.
- Molina, B. S. G., & Pelham, W. E. (2003). Childhood predictors of adolescent substance use in a longitudinal study of children with ADHD. *Journal of Abnormal Psychology*, 112(3), 497–507.
- Molina, B. S. G., Pelham, Jr., W. E., Marshal, M. P., Thompson, A. L., & Gnagy, E. M. (in press). ADHD risk for heavy drinking and alcohol use disorder is age-specific. *Alcoholism: Clinical and Experimental Research*.
- Molina, B. S. G., Smith, B. H., & Pelham, W. E. (1999). Interactive effects of attention deficit hyperactivity disorder and conduct disorder on early adolescent substance use. *Psychology of Addictive Behaviors*, 13, 348–358.
- National Highway Traffic Safety Administration (1995, 1997). *Traffic Safety Facts 1994*. Washington, DC: US Department of Transportation.
- Nigg, J. T. (2006). *What causes ADHD? Understanding what goes wrong and why*. New York: Guilford Press.
- Parrott, D., & Zeichner, A. (2001). Effects of nicotine deprivation and irritability on physical aggression in male smokers. *Psychology of Addictive Behaviors*, 15, 133–139.
- Pelham, W. E., Gnagy, E. M., Greenslade, K. E., & Milich, R. (1992). Teacher ratings of DSM III-R symptoms for the Disruptive Behavior Disorder. *Journal of the American Academy of Child and Adolescent Psychiatry*, 31, 210–218.
- Pelham, W. E., & Hoza, B. (1996). Intensive treatment: A summer treatment program for children with ADHD. In E. Hibbs, & P. Jensen (Eds.), *Psychosocial treatments for child and adolescent disorders: Empirically based strategies for clinical practice* (pp. 311–340). New York: APA Press.
- Pillow, D. R., Pelham, W. E., Hoza, B., Molina, B. S. G., & Stultz, C. H. (1998). Confirmatory factor analysis examining Attention Deficit Hyperactivity Disorder Symptoms and other childhood disruptive behaviors. *Journal of Abnormal Child Psychology*, 26, 293–309.
- Rappaport, M. D., Chung, K. M., Shore, D., Denney, D. B., & Isaacs, P. (2000). Upgrading the science and technology of assessment and diagnosis: Laboratory and clinic-based assessment of children with ADHD. *Journal of Clinical Child Psychology*, 29, 555–568.
- Schwab-Stone, M. E., Shaffer, D., Dulcan, M. K., Jensen, P. S., Fisher, P., et al. (1996). Criterion validity of the NIMH Diagnostic Interview for Children Version 2.3 (DISC 2.3). *Journal of the American Academy of Child and Adolescent Psychiatry*, 35, 878–888.
- Shaffer, D., Fisher, P., Lucas, C. P., Dulcan, M. K., & Schwab-Stone, M. E. (2000). NIMH diagnostic interview schedule for children version IV (NIMH DISC-IV): Description, differences from previous versions, and reliability of some common diagnoses. *Journal of the American Academy of Child and Adolescent Psychiatry*, 39, 28–38.

- Tartar, R., Blackson, T., Bringham, J., Moss, H., & Caprara, G. V. (1995). The association between childhood irritability and liability to substance use in early adolescence: A 2 year follow-up study of boys at risk for substance abuse. *Drug and Alcohol Dependence*, 39, 253–261.
- Weiss, G., & Hectman, L. T. (1993). *Hyperactive children grown up ADHD in children, adolescents, and adults* (2nd ed.), New York: The Guilford Press.
- White, J. L., Moffitt, T. E., Avshalom, C., Bartusch, D. J., Needles, D. J., & Stouthamer-Loeber, M. (1994). Measuring impulsivity and examining its relationship to delinquency. *Journal of Abnormal Psychology*, 103, 192–205.
- Williams, A. F. (1996). Magnitude and characteristics of the young driver crash problem in the United States. In H. Simpson (Ed.), *New to the road: Reducing the risks for young motorists*. Los Angeles: University of California.