Journal of Psychiatric Research xxx (2015) 1–8

Contents lists available at ScienceDirect

Journal of Psychiatric Research

journal homepage: www.elsevier.com/locate/psychires

Motor vehicle driving in high incidence psychiatric disability: Comparison of drivers with ADHD, depression, and no known psychopathology

Paula A. Aduen [a, 1], Michael J. Kofler [b, *, 1], Daniel J. Cox [c], Dustin E. Sarver [d], Erin Lunsford [a]

[a] University of Virginia, USA
[b] Florida State University, USA
[c] University of Virginia Health Systems, USA
[d] University of Mississippi Medical Center, USA

ARTICLE INFO

Article history:
Received 17 October 2014
Received in revised form
10 March 2015
Accepted 12 March 2015

Keywords:
ADHD
Depression
Driving
Collisions
Violations
Driving outcomes

ABSTRACT

Although not often discussed in clinical settings, motor vehicle driving is a complex multitasking endeavor during which a momentary attention lapse can have devastating consequences. Previous research suggests that drivers with high incidence psychiatric disabilities such as ADHD contribute disproportionately to collision rates, which in turn portend myriad adverse social, financial, health, mortality, and legal outcomes. However, self-referral bias and the lack of psychiatric comparison groups constrain the generalizability of these findings. The current study addressed these limitations and examined the unique associations among ADHD, Depression, and adverse driving outcomes, independent of self-selection, driving exposure, and referral bias. The Strategic Highway Research Program (SHRP-2) Naturalistic Driving Study comprises U.S. drivers from six sites selected via probability-based sampling. Groups were defined by Barkley ADHD and psychiatric diagnosis questionnaires, and included *ADHD* (n = 275), *Depression* (n = 251), and *Healthy Control* (n = 1828). Primary outcomes included self-reported traffic collisions, moving violations, collision-related injuries, and collision fault (last 3 years). Accounting for demographic differences, ADHD but not Depression portended increased risk for multiple violations (OR = 2.3) and multiple collisions (OR = 2.2). ADHD but not Depression portended increased risk for collision fault (OR = 2.1). Depression but not ADHD predicted increased risk for self-reported injury following collisions (OR = 2.4). ADHD appears uniquely associated with multiple collisions, multiple violations, and collision fault, whereas Depression is uniquely associated with self-reported injury following a collision. Identification of the specific mechanisms underlying this risk will be critical to designing effective interventions to improve long-term functioning for drivers with high incidence psychiatric disability.

The upsurge of research into adult attention-deficit/hyperactivity disorder (ADHD) reflects an improved understanding of the lifetime course of this chronic and potentially impairing neurodevelopmental disorder (Klein et al., 2012; Barkley et al., 2002). Prospective studies reveal that most children with ADHD continue to meet full diagnostic criteria in adolescence (70%–80%) and adulthood (46%–66%) (Mannuzza et al., 1993; Barkley et al., 2002; Biederman et al., 2010). These findings are consistent with epidemiological estimates for childhood (5%) (Polanczyk et al., 2007) relative to adult ADHD (4%) (Faraone et al., 2003), and clearly position ADHD as a high incidence disability throughout the lifespan when considered in the context of the disorder's broad impact on functioning (Wilens et al., 2004).

In childhood, ADHD is associated with impairments in academic, peer, and family functioning (Pelham and Fabiano, 2008; Bagwell et al., 2001). Adult ADHD studies confirm continued impairments in these areas, (Wilens et al., 2004) and have identified two additional areas of concern: occupational functioning, (Barkley and Fischer, 2011) and motor vehicle driving (Jerome et al., 2006;

* Corresponding author. Florida State University, Department of Psychology, 1107 W. Call Street, Tallahassee, FL 32306-4301, USA. Tel.: +1 (850) 645 7423; fax: +1 (850) 644 7739.
E-mail address: kofler@psy.fsu.edu (M.J. Kofler).
[1] Co-first authors of the study.

http://dx.doi.org/10.1016/j.jpsychires.2015.03.009
0022-3956/

Barkley and Cox, 2007). Although not often discussed in the clinical setting, motor vehicle driving is a complex, cognitive-motor-perceptual, multitasking endeavor that involves controlling a multi-ton projectile through time and space while negotiating road, traffic, passenger, and technology demands (Cox et al., 2011). In this context, a momentary attentional lapse can have devastating consequences; U.S. car crashes are associated annually with over 34,000 deaths, 2.3 million non-fatal injuries, and $99 billion in costs. Converging data suggest that drivers with high incidence disabilities such as ADHD disproportionately contribute to automobile collision rates, as well as moving violations and license suspensions/revocations (Cox et al., 2011).

Studies of drivers with ADHD consistently report that they have more citations and collisions, more expensive collisions, and are more likely to be at-fault for collisions, with relative risk ranging from 1.23 to 1.88 across meta-analyses (Cox et al., 2011; Vaa, 2003, 2014). A serious shortcoming of most studies, however, is their reliance on self-selected samples recruited specifically to examine the impact of ADHD on their driving behavior (Cox et al., 2011; Chang et al., 2014). This potential for self-referral bias and associated demand characteristics are significant confounds that constrain the external validity of previous findings. In addition, no study has directly compared drivers with ADHD to drivers with other clinical disorders (e.g., Depression) despite meta-analyses suggesting similar driving risk among drivers with ADHD and Depression (Vaa, 2003). This omission is critical given that drivers with Depression have a relative risk for increased collision rates ranging from 1.10 to 2.55 (Vaa, 2003; Bulmash et al., 2006). Whether ADHD portends increased risk for adverse driving outcomes beyond other high incidence disorders such as Depression remains unknown. Finally, fewer than 50% of previous studies reported annual miles/kilometers driven, despite the known association between exposure and collision/violation risk (Vaa, 2014). Thus, the extent to which previous findings are attributable to participant perception, self-selection processes, comorbidity, exposure, or other high incidence psychopathology remains unknown.

The present study addressed these limitations by examining violations, collisions, collision-related injuries, and collision fault in a large, nationally representative sample of U.S. drivers with (a) ADHD, (b) Depression, and (c) no known psychopathology participating in the Strategic Highway Research Program 2 (SHRP-2) Naturalistic Driving Study. SHRP-2 is a 6-center, prospective, naturalistic driving study (Antin et al., 2011). Importantly, drivers were not selected based on diagnostic status but rather completed diagnostic measures after study enrollment (Antin et al., 2011). Thus, the present study allows us to examine the extent to which two high incidence psychopathologies (ADHD, Depression) are associated with adverse driving outcomes, independent of the potential role of self-selection, demand characteristics, driving exposure, and referral bias.

We hypothesized that drivers with ADHD, (Vaa, 2014) and drivers with depression, (Vassallo et al., 2008; Scott-Parker et al., 2013) would endorse more violations, collisions, collision-related injuries, and collision faults relative to Healthy Controls. No predictions were made regarding the relative risk for drivers with ADHD relative to drivers with Depression given the paucity of research.

1. Method

1.1. Design and overview

The SHRP-2 Naturalistic Driving Study consists of 3,600 drivers from six U.S. sites (New York, Washington, Pennsylvania, Indiana, Florida, and North Carolina). A detailed description of study recruitment, participants, and methodology is provided in Antin et al. (2011). Briefly, participants were selected through a probability-based sampling approach and consented to have their vehicles outfitted with a sophisticated data acquisition system to capture day-to-day driving data continuously for 1–2 years. The current study is based on self-report data collected during the initial evaluation that included driver demographic, driving history, and psychiatric screening questionnaires.

1.2. Measures

1.2.1. Barkley adult ADHD quick screen (BAQS)

The BAQS includes six items assessing self-reported ADHD symptoms on a 4-point Likert scale (0 = Never/Rarely, 1 = Sometimes, 2 = Often, 3 = Very Often); scores are summed across the six items and correlate 0.97 with the full, 18-item DSM-IV symptoms (Barkley et al., 2008). The recommended BAQS cutoff score of 7 correctly identifies 93% of ADHD and 99% and non-ADHD adults (Barkley et al., 2008).

1.2.2. Psychological diagnoses questionnaire

The psychological diagnoses questionnaire instructed participants to indicate if they currently met diagnosis for Depression, Anxiety, Bipolar Disorder, ADHD/ADD/Tourette's, Psychotic or Personality Disorders. Participants selected all diagnoses that were applicable. Drivers who endorsed “ADHD/ADD/Tourette's” were included in the ADHD group unless they met the exclusion criteria below given the rarity of Tourette's Syndrome in adulthood (0.002%–0.04%) (Burd et al., 1989; Apter et al., 1993).

1.2.3. Driving history and demographic questionnaire

The driving history and demographic questionnaire assessed participant age, gender, marital status, and annual miles driven. Participants reported violation and collision frequency over the past 3 years (0, 1, 2 + collisions/violations) as well as crash severity and fault for up to two collisions. Endorsement of violations encompassed both moving and traffic violations.

1.3. Inclusion and exclusion criteria

Participants who did not complete the BAQS or the psychological diagnoses questionnaire (n = 341) were excluded (final N = 3,259; 90.5% of SHRP-2 drivers). Group membership was assigned based on the following criteria. Participants were included in the *ADHD Group* with a positive BAQS screen (7+) and/or self-reported ADHD, alone (n = 229) or comorbid with anxiety (n = 46; total n = 275). Participants with positive BAQS screens who reported other clinical disorders but not ADHD (n = 52) were excluded from the ADHD group as recommended because 83% of mood disorders screen positive on the BAQS (Barkley et al., 2008). Participants were included in the *Depression Group* if they endorsed Depression, alone (n = 170) or comorbid with anxiety (n = 81), but did not self-report ADHD (total n = 251); no BAQS criteria were set for the Depression Group. Individuals with self-reported anxiety were included in the ADHD and Depression groups if they met all other inclusion criteria given anxiety's high comorbidity with both adult ADHD and Depression (Kessler et al., 2006, 2008). Individuals were assigned to the *Healthy Control Group* (no known psychopathology) based on negative BAQS screen (<4) and no self-reported psychological diagnoses (n = 1828). Participants were excluded from all groups if they self-reported personality, psychotic, or bipolar disorders (n = 32). The remaining 821 cases were excluded for failing to meet any group criteria (i.e., no self-reported depression

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and BAQS scores of 4–6 that fell between the Healthy Control maximum and ADHD minimum).

1.4. Analyses

Multinomial logistic regression was used to predict relative risk for collisions, violations, injuries, and collision fault for drivers with ADHD and drivers with Depression relative to each other and to drivers with no known psychopathology (Healthy Controls). Additional multinomial logistic regressions tested for potential additive effects of ADHD + Depression comorbidity on adverse driving outcomes, and examined the dimensional relations between distractibility/restlessness symptoms and adverse driving outcomes. These analyses predicted the maximum likelihood conditional probability of reporting 0, 1, or 2 + collisions; 0, 1, or 2 + violations; collision with injury (yes/no); and collision fault (yes/no) as a function of group membership. Results are expressed as odds ratios (OR); odds ratios with absolute values greater than 1.0 indicate increased (positive values) or decreased (negative values) risk relative to the comparison group.

2. Results

2.1. Preliminary analyses

Data were available for over 99% of the 3,259 cases for all dependent and independent variables (range = 99.1%–99.8%; N = 7 to 31 missing cases) with the exception of self-reported income (16.2% missing; N = 2,731 respondents).[2] Chi-square tests supported a Missing At Random (MAR) assumption; the probability of missing data did not vary significantly as a function of group membership (χ^2 [2] = 1.02; p = .60). The groups differed significantly in age, gender, education, marital status, average annual miles driven (all $p < .002$), and income (p = .03). Bonferroni-corrected post hocs revealed that ADHD drivers were overrepresented in the youngest age groups (ages 16–25) and underrepresented in the oldest age groups (ages 51+). Drivers with ADHD were also less likely to have a high school diploma or college degree, were overrepresented in the extreme income groups (<$29K/year, > $150K/year), and were less likely to be married (all $p < .05$). Drivers with depression were more likely to be female and report driving more than 20,000 miles/year (both $p < .05$). These demographic variables were included as covariates in all subsequent analyses (Table 1). Results are reported both before and after controlling for these factors given that most of these variables are known outcomes of ADHD (Barkley et al., 2002; Mannuzza et al., 1993) and Depression (Harrington et al., 1990; Rao et al., 1999; Fergusson and Woodward, 2002).

2.2. Traffic violations (last 3 years)

As shown in Table 2 and Fig. 1, ADHD and Depression were associated with a 56% and 43% increased risk for a single traffic violation (OR = 1.56, 1.43), respectively. Drivers with ADHD experienced a 222% increased risk for multiple violations (OR = 3.22), relative to a 76% increased risk for drivers with Depression. After correcting for demographic covariates, only drivers with ADHD remained significantly at risk for multiple violations (127% increased risk; OR = 2.27). When compared to Depression, ADHD portended a significant 85% increased risk for multiple violations (OR = 1.85; 95% CI: 0.98–3.55).

2.3. Collisions (last 3 years)

Relative to Healthy Controls, ADHD was associated with an increased risk for a single collision (OR = 1.41) and multiple collisions (OR = 2.63) (Table 2, Fig. 2). The ADHD group's increased risk for multiple collisions remained significant when controlling for demographic factors (OR = 2.21). Depression was also associated with increased risk for multiple collisions (OR = 1.72). The difference in relative risk between ADHD and Depression did not reach significance for single or multiple collisions.

2.4. Injuries from collisions (last 3 years)

Among drivers reporting at least one collision,[3] Depression portended a 125% increased risk for self-reported injury that was robust after accounting for demographic factors (OR = 2.25). ADHD was not associated significantly with increased risk for self-reported injuries from collisions (Table 2, Fig. 3).

2.5. Fault for collisions (last 3 years)

Among drivers reporting at least one collision, ADHD was associated with a 112% increase in self-reported fault (OR = 2.12) relative to Healthy Controls but not relative to drivers with Depression. Depression was not associated with a significant increased risk for self-reported collision fault (Table 2, Fig. 3).[4]

2.6. Dimensional analysis of ADHD symptoms on driving outcomes

The previous analyses were repeated using the full sample to examine the association between ADHD symptom severity and adverse driving outcomes. Results were highly consistent with the categorical analyses and revealed that ADHD symptoms (BAQS total score) portended increased risk for single violations (OR = 1.07; 95% CI = 1.02–1.12), multiple violations (OR = 1.17; 95% CI = 1.10–1.24), single collision (OR = 1.06; 95% CI = 1.01–1.11), multiple collisions (OR = 1.16; 95% CI = 1.08–1.24), and collision fault (OR = 1.09; 95% CI = 1.02–1.17) after controlling for Depression and the demographic variables described above. In contrast, ADHD did not predict self-reported injury following collision and Depression did not interact with ADHD symptoms to predict any outcomes (all 95% CI include 0.0). These results suggest that *each* additional increase in overall ADHD symptom severity portends a 16–17% increased risk for multiple collisions and violations.

3. Discussion

The current study used a large, nationwide sample to examine the relative risk of motor vehicle violations, collisions, collision-

[2] The pattern of results reported below did not change with income excluded from the models; we therefore report results with Income included.

[3] N = 91 drivers with suspected ADHD [33%], 73 drivers with self-reported Depression [29%], and 416 Healthy Control drivers [23%].

[4] Given the independent associations of ADHD and Depression with adverse driving outcomes, we conducted exploratory analyses using 72 identified cases of comorbid ADHD + Depression, defined as cases whom self-reported Depression and either self-reported ADHD (n = 46 originally included in the ADHD group) or met ADHD screening criteria on the BAQS (n = 26 originally included in the Depression group). Controlling for demographics, the relative risks associated with ADHD-only (n = 229) and Depression-only (n = 225) were highly similar to the results presented above. Comorbid ADHD + Depression portended increased risk for multiple collisions (OR = 2.68, 95% CI = 1.14–6.32); however, ADHD + Depression did not differ significantly from the ADHD or Depression only groups on any outcome.

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Table 1
Demographic and other risk factors: Relative risk for self-reported driving violations, collisions, injuries from collisions, and at-fault for collisions (last 3 years).

		Relative risk ratio			
	N	Violations (Last 3 years)	Crashes (Last 3 years)	Injuries from collision	At-fault for collision
Total	1924				
Age					
Ages 16–17	136	2.94*	2.22	−1.67	3.59
Ages 18–20	307	2.34*	1.70*	−1.11	2.60*
Ages 21–25	351	2.35*	1.88*	1.40	3.64*
Ages 26–35	207	1.99*	1.45	1.79	2.20
Ages 36–50	230	1.28	−1.27	1.00	1.59
Ages 51–65	245	−1.15	−1.12	2.20	1.86
Ages 66–75	189	−1.23	−1.22	—	−3.23*
Ages 75+	259	—	—	—	—
Gender					
Male	946	1.10	−1.11	−1.41	1.13
Female	978	—	—	—	—
Education					
Some high school	136	−1.66*	−1.40	1.44	−1.69
H.S. diploma/Some college	725	−1.07	−1.06	1.24	−1.46
College degree or higher	1063	—	—	—	—
Annual income					
Under $29K	389	2.07*	−1.23	−1.43	−1.49
$30K to $39K	283	1.65	−1.10	−1.56	−1.64
$50K to $69K	366	1.47	−1.12	−1.51	−1.68
$70K to $99K	393	1.47	−1.21	−1.40	−1.45
$100K to $149K	325	1.57	−1.18	−1.06	−1.53
$150K or higher	168	—	—	—	—
Marital status					
Not married	1180	1.22	1.03	2.14	−1.20
Married	744	—	—	—	—
Average miles driven/Yr					
<5000 miles/year	221	−1.41	−1.45*	1.23	−1.77
5K–10K	511	−1.23	−1.35	1.19	−1.73
10K–15K	596	1.18	−1.29	−1.37	−1.69
15K–20K	282	1.35	−1.19	−1.32	−1.65
20K–25K	126	1.55	−1.24	−1.25	−1.80
25K–30K	72	1.09	−1.29	1.14	−1.78
>30K miles/year	116	—	—	—	—

*95% confidence interval does not include 1.0 ($p < .05$); The last subgroup for each demographic variance serves as the reference group (indicated by the —). Total N reflects the 81.7% of ADHD, Depression, and Healthy Control (N = 2354) drivers with complete demographic and outcome data.

related injuries, and collision fault associated with ADHD and Depression relative to drivers with no known psychopathology. To our knowledge, this is the first study to compare drivers with multiple forms of high incidence psychopathology while also accounting for known risk factors of increased violation and collision rates. Using the nationally representative SHRP-2 sample of drivers, the present study addressed key limitations in our understanding of adverse driving outcomes for drivers with two forms of high incidence psychopathology. Importantly, drivers were not selected based on ADHD or Depression status but rather completed diagnostic screening measures after study enrollment (Antin et al., 2011). Thus, the present study allowed us to examine the extent to which ADHD and Depression are associated with adverse driving outcomes, independent of the potential role of self-selection bias, demand characteristics, exposure, and referral bias.

Results indicated that both ADHD and Depression portended increased risk for adverse driving outcomes, although the specific pattern of relative risk varied considerably between the diagnostic groups. Specifically, both groups were associated with increased risk for a single collision and single violation relative to drivers with no known psychopathology. However, these relationships were no longer significant after controlling for known demographic correlates of adverse driving outcomes such as younger age, male gender, lower socioeconomic status indicators (SES; education, annual income), unmarried status, and increased driving exposure (i.e., more annual miles driven). Interestingly, however, several of these risk factors are known outcomes of ADHD (Biederman et al., 2010; Kessler et al., 2008; Barkley et al., 2002) and Depression (Harrington et al., 1990; Rao et al., 1999; Fergusson and Woodward, 2002). For example, longitudinal studies consistently implicate ADHD and Depression in decreased academic attainment, lower adult SES, unemployment, and increased interpersonal and marital difficulties (Barkley et al., 2002; Mannuzza et al., 1993; Fergusson and Woodward, 2002; Birmaher et al., 1996). Thus, we hypothesize that the influence of ADHD and Depression on single violation and collision risk may be at least partially indirect, such that these associated functional impairments of both ADHD and Depression may also increase the risk of adverse driving outcomes. Although we were unable to test this hypothesized mediation due to our cross-sectional, nonparametric data, the current findings suggest that future studies would benefit from examining the extent to which ADHD and Depression result in increased collisions and traffic violations directly (e.g., due to shared clinical symptoms), or indirectly through their influence on known correlates of adverse driving outcomes across time (Cox et al., 2012). In addition, the extent to which the similar magnitude risk associated with ADHD and Depression is due to shared mechanisms (e.g., inattention/concentration problems, hyperactivity/psychomotor agitation,

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Table 2
ADHD and Depression: Relative risk for self-reported driving violations, collisions, injuries from collisions, and at-fault for collisions (last 3 years).

	Relative risk ratio			
	Relative to healthy control drivers		Relative to drivers with self-reported depression	
	Raw	Corrected	Raw	Corrected
Violations (last 3 years)				
1 violation				
ADHD	1.56* (1.13, 2.16)	1.33 (0.91, 1.93)	1.09 (0.71, 1.68)	1.01 (0.60, 1.70)
Depression	1.43* (1.02, 1.98)	1.40 (0.97, 2.02)	—	—
2 or more violations				
ADHD	3.22* (2.25, 4.61)	2.27* (1.48, 3.49)	1.83* (1.10, 3.02)	1.85† (0.98, 3.55)
Depression	1.76* (1.15, 2.72)	1.20 (0.70, 2.06)	—	—
Collisions (last 3 years)				
1 collision				
ADHD	1.41* (1.03, 1.93)	1.25 (0.87, 1.78)	1.09 (0.72, 1.66)	1.04 (0.62, 1.75)
Depression	1.29 (0.93, 1.79)	1.24 (0.86, 1.79)	—	—
2 or more collisions				
ADHD	2.63* (1.69, 4.09)	2.21* (1.31, 3.74)	1.53 (0.83, 2.81)	1.59 (0.74, 3.45)
Depression	1.72* (1.02, 2.89)	1.55 (0.85, 2.82)	—	—
Injury from collision				
ADHD	1.55 (0.81, 2.96)	1.67 (0.81, 3.48)	0.65 (0.29, 1.44)	0.63 (0.20, 2.01)
Depression	2.39* (1.27, 4.49)	2.25* (1.05, 4.82)	—	—
At-fault for collision				
ADHD	2.12* (1.34, 3.34)	1.65 (0.98, 2.78)	1.45 (0.78, 2.68)	1.24 (0.52, 2.97)
Depression	1.46 (0.89, 2.40)	1.47 (0.84, 2.60)	—	—

*95% confidence interval does *not* include 1.0 ($p < .05$);†$p = .06$.
Injury and at-fault from collision reflect relative risk among drivers reporting at least 1 collision; Corrected relative risk ratios are corrected values after accounting for known risk factors for adverse driving outcomes (age, gender, education, income, marital status, average annual miles driven).

shared executive dysfunction profiles) (Cox et al., 2012; Bulmash et al., 2006; Harvey et al., 2004; Snyder, 2013), or reflects equifinality secondary to disorder-specific processes (e.g., non-shared clinical symptoms) warrants further scrutiny.

ADHD and Depression were most strongly associated with risk for multiple violations and multiple collisions, although the specific risks varied across disorders. Specifically, ADHD but not Depression was a unique risk factor for multiple motor vehicle violations and collisions after accounting for the demographic factors described above. This increased risk was remarkable, such that drivers with ADHD were 2.3 and 2.2 times more likely to report multiple violations and multiple collisions relative to healthy control drivers, respectively. Furthermore, ADHD was associated with increased risk for multiple violations relative to drivers with Depression (OR = 1.9), whereas this increased risk failed to reach statistical significance for multiple collisions. These results are consistent with previous meta-analytic reviews indicating that ADHD is associated with increased risk for adverse driving outcomes (Vaa, 2014), and extends this literature by indicating that this risk is most pronounced for multiple violations and collisions relative to single incidents.

Furthermore, the current study is the first to demonstrate increased risk for drivers with ADHD relative to drivers with another high incidence psychiatric disability also known to increase

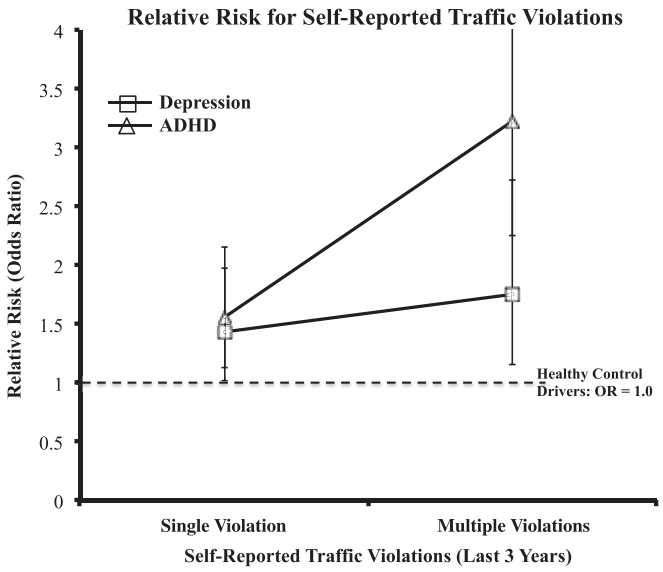

Fig. 1. Relative risk for traffic violations (last 3 years) for drivers with ADHD and Depression. Error bars reflect 95% confidence intervals. OR = odds ratio; an OR of 1.0 indicates no increased risk relative to Healthy Control drivers.

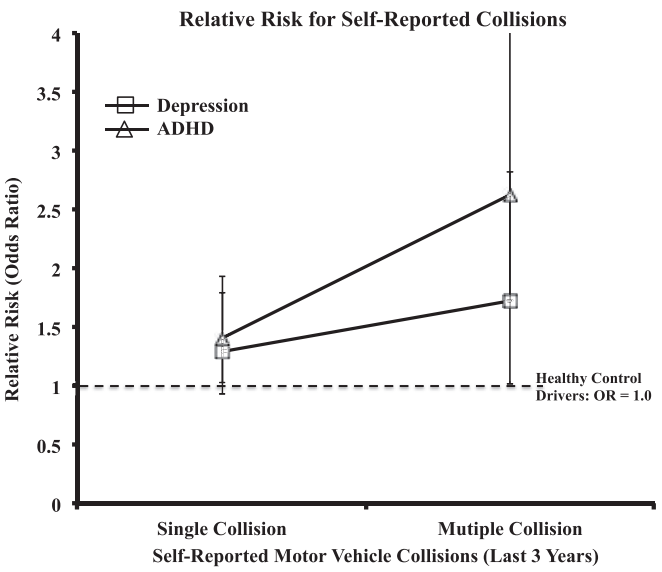

Fig. 2. Relative risk for motor vehicle collisions (last 3 years) for drivers with ADHD and Depression. Error bars reflect 95% confidence intervals. OR = odds ratio; an OR of 1.0 indicates no increased risk relative to Healthy Control drivers.

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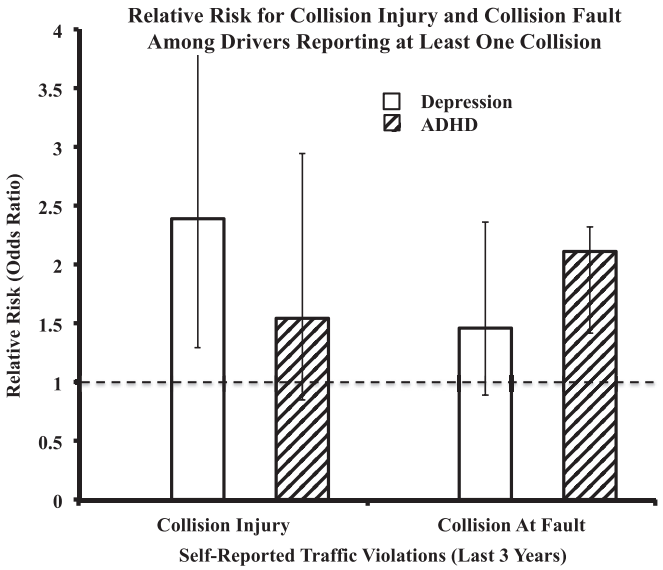

Fig. 3. Relative risk for collision-related injury and collision fault among drivers reporting at least one collision (last 3 years). Error bars reflect 95% CIs. OR = odds ratio; an OR of 1.0 indicates no increased risk relative to Healthy Control drivers.

risk for motor vehicle collisions (Bulmash et al., 2006). Interestingly, this risk was not limited to drivers diagnosed with ADHD; dimensional analyses based on the entire sample suggest that each additional endorsement of distractibility/restlessness is associated with 16% and 17% increased risk for multiple collisions and violations, respectively, that was not moderated by comorbid depression status. These findings are consistent with a growing body of evidence implicating both ADHD and Depression in adverse driving outcomes (Bulmash et al., 2006; Cox et al., 2012), and extend this literature by documenting the overlapping and disorder-specific risks across single and multiple adverse driving events.

Among drivers reporting at least one collision, ADHD and Depression were differentially associated with self-reported risk for collision injury and fault. With regards to collision fault, ADHD but not Depression predicted increased risk. Thus, we hypothesize that disorder-specific mechanisms may account for this finding. It is important to note, however, that this conclusion remains speculative; the current study was based on retrospective self-report, and the resultant nonparametric data limited our ability to examine specific driver behaviors or reasons for collisions. Previous simulator research, however, suggests that drivers with ADHD are more likely to collide with road obstacles compared to healthy control drivers (Biederman et al., 2007). Thus, one explanation may be that these drivers were disproportionately more likely to collide with inanimate objects rather than other vehicles, leaving little doubt regarding collision fault. In contrast, the only on-road study to prospectively record routine driving behavior for drivers with and without ADHD found that driver inattentive behaviors (e.g., eyes off road) tended to immediately precede collisions for drivers with ADHD (Cox et al., 2012). This suggests that inattentive symptoms – a symptom shared between ADHD and Depression – may be a key mechanism linking high incidence disability with collision fault. Alternatively, the findings may reflect the higher base rate of multiple collisions for drivers with ADHD (i.e., more opportunities to have been at-fault for at least one collision). Prospective research using continuous monitoring of routine driving is needed to definitively determine if and why drivers with ADHD are more likely to be at-fault for collisions.

Finally, ADHD was not significantly associated with self-reported injury following collisions. This finding was unexpected given evidence that disruptive behavior disorders are more common among teenage boys hospitalized for road trauma (Redelmeier et al., 2010). Taken together, these results may suggest that (a) the risk for injury is carried by disruptive behavior disorders other than ADHD, similar to findings that the association between ADHD and later substance abuse is attributable to conduct disorder symptoms rather than ADHD symptoms (Fergusson et al., 2007). Alternatively, the association between ADHD and collision injury may be less pronounced when examining risk across the lifespan, or when querying community samples relative to hospital records that include fatalities. In the present study, drivers with self-reported Depression reported being injured during a collision at significantly higher rates relative to healthy control drivers with at least one collision. Potential explanations for this pattern may be an attentional bias toward distress associated with Depression, (Gotlib et al., 2004) such that even minor injuries may take on increased salience in the driver's subjective experience. This increased emotional salience, in turn, is associated with increased rehearsal and consolidation of this aspect of the collision experience into long-term memory (Everaert et al., 2013). Similarly, Depression has been associated with increased rates of somatic symptoms and medical utilization rates (McCauley et al., 1991; Krause et al., 1994) that may further increase the perception and recall of injury for these drivers. Alternatively, it is possible that collision-related injuries predated the onset of depressive symptoms for many of these drivers given the current study's reliance on retrospective reporting and known association between chronic illness/pain and increased risk for depressive disorders (Krause et al., 1994; Fishbain et al., 1997).

3.1. Limitations

The present study is the first to examine adverse driving outcomes for drivers with multiple forms of high incidence psychiatric disability relative to drivers with no known psychopathology, while controlling for known correlates of collisions and risky driving. Despite these methodological refinements, the following caveats must be considered when interpreting the results. The current study relied exclusively on retrospective self-report data, and diagnostic status was based on self-report and responses to a well-validated measure. Thus, the extent to which the findings generalize to adults with clearly defined ADHD and Depression, or correspond to official police, hospital, and/or Department of Motor Vehicles records is unknown, and the rate of ADHD in the overall sample (8.5%) was moderately high relative to other community-based prevalence estimates. Nonetheless, the current study is the first to control for self-selection bias and the overall findings were highly consistent with previous studies using clinically-diagnosed samples. The shortcomings of retrospective self-report data are well-documented (Gearing et al., 2006). We were also unable to examine proximal risk factors for motor vehicle collisions, such as *in situ* driver behavior, and cell phone, medication, and substance use (Cox et al., 2011). Prospective studies are clearly needed to identify the mechanisms by which ADHD, Depression, and other high incidence disabilities lead to the adverse driving outcomes documented in the current study. Finally, the nonparametric, retrospective nature of the data precluded testing hypothesized mediating pathways. Nonetheless, the current findings reinforce previous studies documenting adverse driving outcomes for clinically diagnosed drivers with ADHD and drivers with Depression, and provide important new data suggesting overlapping and unique driving outcomes across these two high incidence clinical disorders.

Please cite this article in press as: Aduen PA, et al., Motor vehicle driving in high incidence psychiatric disability: Comparison of drivers with ADHD, depression, and no known psychopathology, Journal of Psychiatric Research (2015), http://dx.doi.org/10.1016/j.jpsychires.2015.03.009

3.2. Clinical and research implications

Overall, the present results provide evidence that multiple high-incidence psychiatric disabilities – rather than a particular disorder – place drivers at a greater risk for a single violation and collision. However, ADHD and Depression also pose unique driving hazards: ADHD appears to be uniquely associated with multiple violations, multiple collisions, and collision fault, whereas Depression is uniquely associated with self-reported injury following a collision. Prospective, longitudinal studies with clinically defined samples are needed to definitively elucidate the mechanisms and processes linking these high incidence disabilities with adverse driving outcomes. Identification of the specific mechanisms – including both shared symptoms and disorder-specific processes – is critical to designing effective prevention, driver training, and technology-enhanced accommodations to reduce the social, financial, health, mortality, and legal outcomes of motor vehicle collisions for drivers with high incidence disabilities such as ADHD and Depression (Cox et al., 2011). Clinically, consideration of motor vehicle driving risk appears warranted when making treatment determinations and evaluating treatment response. Psychostimulants and manual transmission appear to reduce but not eliminate this risk for drivers with ADHD (Cox et al., 2011), and consideration of the timing of a patient's routine driving (e.g., afternoon/evening vs. late night) appears to be an important consideration when selecting among psychostimulants formulations (Cox et al., 2004).

Role of funding source

Preparation of this manuscript was funded in part by a UVa Curry School of Education Foundation grant (PI: Kofler) from the Galant Family. The sponsor had no role in design and conduct of the study; collection, management, analysis, and interpretation of the data; or preparation, review, or approval of the manuscript. Aduen and Kofler had full access to all of the data in the study and take responsibility for the integrity of the data and the accuracy of the data analysis.

Contributors

All authors contributed substantially to the conceptualization and development of the study.

Conflict of interest

The authors have no conflicts of interest to report.

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