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ADHD and relative risk of accidents in road traffic: A meta-analysis

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ABSTRACT

The present meta-analysis is based on 16 studies comprising 32 results. These studies provide sufficient data to estimate relative accident risks of drivers with ADHD. The overall estimate of relative risk for drivers with ADHD is 1.36 (95% CI: 1.18; 1.57) without control for exposure, 1.29 (1.12; 1.49) when correcting for publication bias, and 1.23 (1.04; 1.46) when controlling for exposure. A relative risk (RR) of 1.23 is exactly the same as found for drivers with cardiovascular diseases. The long-lasting assertion that "ADHD-drivers have an almost fourfold risk of accident compared to non-ADHD-drivers", which originated from Barkley et al.'s study of 1993, is rebutted. That estimate was associated with comorbid Oppositional Defiant Disorder (ODD) and/or Conduct Disorder (CD), not with ADHD, but the assertion has incorrectly been maintained for two decades. The present study provides some support for the hypothesis that the relative accident risk of ADHD-drivers with comorbid ODD, CD and/or other conduct problems, is higher than that of ADHD-drivers without these comorbidities. The estimated RRs were 1.86 (1.27; 2.75) in a sample of ADHD-drivers in which a majority had comorbid ODD and/or CD compared to 1.31 (0.96; 1.81) in a sample of ADHD-drivers with no comorbidity. Given that ADHD-drivers most often seem to drive more than controls, and the fact that a majority of the present studies lack information about exposure, it seems more probable that the true RR is lower rather than higher than 1.23. Also the assertion that ADHD-drivers violate traffic laws more often than other drivers should be modified: ADHD-drivers do have more speeding violations, but no more drunk or reckless driving citations than drivers without ADHD. All accident studies included in the meta-analysis fail to acknowledge the distinction between deliberate violations and driving errors. The former are known to be associated with accidents, the latter are not. A hypothesis that ADHD-drivers speed more frequently than controls because it stimulates attention and reaction time is suggested.

1. Introduction

Attention Deficit Hyperactivity Disorder (ADHD) is a cerebral dysfunction which involves problems with concentration and impulse control in about one half of adults who were diagnosed with ADHD as child. In the 1970s, there was a huge increase in the research on hyperactivity among children (Zeiner, 2000). A group lead by the neuropsychologist Virginia Douglas had a big impact on the understanding of hyperactivity and attention deficit (Douglas, 1983). Douglas' main idea was that hyperactivity was not the paramount problem, but rather a consequence of attention difficulties and impulsivity. The hypothesis was that a deficit in attention leads to a state of hyperactivity. This understanding was the base when the ADHD-diagnosis in the *Diagnostic and Statistical Manual of Mental Disorders* (DSM) was elaborated. A list of 14 symptoms of hyperactivity, impulsivity and concentration problems was agreed and a minimum of 8 symptoms had to be met if a diagnosis of ADHD should be set. In the 1987-revision of DSM (DSM-IV) the notation *attention deficit/hyperactivity disorder* was introduced and the ADHD-group is now divided in three subgroups: Those predominantly hyperactive, those predominantly with attention problems, and those who have both symptoms. The most correct notation is then AD/HD, but the more commonly used ADHD-notation is used throughout the present study.

1.1. ADHD and road safety

Previous studies of drivers with ADHD have indicated that ADHD-drivers had more risky behavior, more traffic violations, and that they may have a higher risk of being involved in accidents compared to drivers without ADHD. The first study to link the group of hyperactive drivers to road safety was done by Weiss et al. (1979). The most influential study, however, and the one which really put ADHD and road safety on the agenda, was Barkley et al. by concluding that drivers with ADHD had three to four times more accidents compared to drivers without ADHD (Barkley et al., 1993). This level of accident risk is very high compared to the known relative accident risks of other medical conditions. Estimates of relative risks

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(RR) by meta-analysis of the main categories of health-related risk factors addressed by Annex III of the European Community's Council Directive on driving licenses (CD 91/439/EEC) found that all categories fell in the range of 1.09 (vision impairment) and 2.00 (alcoholism). Mental disorders, which also belong to the ten main categories, had an RR of 1.72 (Vaa, 2003). Two previous meta-analysis have estimated relative risks of drivers with ADHD: Vaa's study of 2003 estimated an RR of 1.54 and a later meta-analysis by Jerome et al. (2006) found an RR of 1.88, both considerably lower than Barkley et al.'s estimate of 1993.

One major problem when estimating accident risks is the lack of adequate control for exposure. It is very important to control for exposure not least because ADHD-drivers tend to drive more than drivers without ADHD. Hence, more accidents among ADHD-drivers could be a function of increased mileage in the ADHD-group. Some studies also show that drivers with ADHD violate traffic laws more often than drivers without ADHD, by receiving more fines for speeding (Barkley et al., 1993, 1996, 2002; Lambert, 1995; Murphy and Barkley, 1996). Again, it could be a function of more driving among ADHD-drivers, but it can also be that drivers with ADHD actually drive faster than non-ADHD controls. One should, however, be reluctant to associate the label "traffic violations" with ADHD-drivers in a generic, indiscriminant way because it may comprise acts and behaviors which are unrelated to traffic accidents. Few claim that failure to appear in court, receipt of parking tickets, or "non-moving violations" in general, correlate with accidents in road traffic. Speeding violations and drunk driving, however, are significantly associated with the frequency of accidents in the sense that increases in these violations types increase the number of accidents (Elvik et al., 2009).

The diagnosis of ADHD is sometimes accompanied by the diagnoses of Oppositional Defiant Disorder (ODD) and Conduct Disorder (CD), often described as comorbidity or comorbid states (Barkley et al., 1993, 2002; Beck et al., 1996; Murphy and Barkley, 1996; Woodward et al., 2000; Richards et al., 2002; Fried et al., 2006; Thompson et al., 2007). It is, however, unclear if, or how, these states may contribute to road accidents involving drivers with ADHD.

A large number of studies addressing ADHD-drivers and issues of road safety employ driving simulators, for example Barkley et al. (1996, 2002), Laberge et al. (2005), Reimer et al. (2005, 2007, 2010), Clancy et al. (2006), Fischer et al. (2007). Obviously, simulator studies have limitations compared to studies based on data from real traffic. One research issue would be to discuss the ecologically validity of simulation studies.

Some studies address medical treatment of ADHD-drivers and effects on driving behavior. Driving contexts vary between real traffic (Lambert, 1995; Cox et al., 2000, 2012) and experiments in driving simulators (Cox et al., 2000, 2004, 2006; Barkley et al., 2005, 2007; Kay et al., 2009; Sobanski et al., 2012; Biederman et al., 2012).

1.2. Research questions

As indicated, the issue of road safety and drivers with ADHD has been studied from several different angles. The following research questions are prioritized:

1. The main objective of the present study is to estimate the relative accident risk by meta-analysis of all available accident studies with ADHD-drivers.
2. Control for exposure and publication bias is requisite for a best estimate of the relative risk.
3. The impact of comorbidities such as Oppositional Defiant Disorder (ODD) and Conduct Disorder (CD), on accidents is unclear and should be clarified.
4. Traffic violations may contribute to accidents. Most studies report violations of traffic law. Data on traffic violations should, however, be scrutinized in order to clarify how violations done by ADHD-drivers may differ from violations done by non-ADHD controls.
5. The picture of violations may reveal a pattern that tells why ADHD-drivers are different from controls. If so, how do ADHD-drivers differ from controls?
6. The number of simulator studies on ADHD-issues is large. It is necessary to make some appraisals of this group of studies, such as categorizing according to theme, quality, study design, possible bias and ecological validity. Such appraisals seem required, not least because some studies seem to contribute more to stigmatization of ADHD-drivers than uncovering problem issues about ADHD-drivers and road safety.
7. Some studies address the use of methylphenidate and other substances. A final issue in this context is therefore whether medication improves driver behavior and/or reduces the number of accidents.

These seven research questions are appraised as the prime issues regarding the study of drivers with ADHD and their behavior in road traffic.

1.3. Empirical studies of ADHD, driver behavior and accidents

An extensive literature search was performed by the author on three occasions: In 2003 as part of EU-project IMMORTAL, in 2008 as part of a ADHD-study commissioned by Swedish Public Roads Administration, and as part of the present study. The literature can be assigned to three study categories: (1) Experiments in driving simulators, (2) Studies on the effects of medication, (3) Studies of behavior and accidents in real traffic.

1.3.1. Driving simulator studies

Eighteen studies were identified: Barkley et al. (1996, 2002, 2005, 2006, 2007), Cox et al. (2000, 2004, 2006, 2012), Reimer et al. (2005, 2007, 2010), Laberge et al. (2005), Fischer et al. (2007), Weafer et al. (2008), Kay et al. (2009), Sobanski et al. (2012), and Biederman et al. (2012). This group of studies is very heterogeneous. They vary in themes, quality, research designs, bias, from non-blind observer-ratings of driving skills to randomized, double-blind, placebo-controlled studies of driver behavior. A serious objection is that many studies lack ecological validity. "Crashes" and "collisions" in a simulator can never replace accidents in real traffic in a valid way. Strict confinement to specific "treatments" in a simulator is questionable when specific conditions might be escaped or compensated for in real traffic. A separate, extensive, in-depth scrutiny of simulator studies addressing issues of ADHD-drivers seems justified as the appraisal of this kind of studies must be rather general and limited in the present context.

1.3.2. Studies of the outcome of medical treatment of drivers with ADHD

Fourteen studies which evaluate the effect of medication were identified: Cox et al. (2000, 2004, 2006, 2012), Barkley et al. (2005, 2006, 2007), Barkley and Cox (2007), Verster et al. (2008), Kay et al. (2009), Reimer et al. (2010), Sobanski et al. (2012), Biederman et al. (2012). The medications considered were the stimulant (OROS) methylphenidate, mixed amphetamine salts, lisdexamfetamine dimesylate), and non-stimulants (atomoxetine) (Cox et al., 2000, 2012; Barkley and Cox, 2007; Kay et al., 2009; Sobanski et al., 2012; Biederman et al., 2012). Several studies are conducted in a driving simulator, entailing questions as to ecological validity, but some studies have research designs of a quality that enhance validity, some are performed in real traffic (Verster et al., 2008; Cox et al., 2012; Sobanski et al., 2012).