Traumatic brain injury, driver aggression and motor vehicle collisions in Canadian adults

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Objective: This study examines the associations between lifetime traumatic brain injury (TBI), driver aggression, and motor vehicle collisions among a population sample of adults who reside in the province of Ontario, Canada.

Method: A cross-sectional sample of 3,993 Ontario adults, aged 18 to 97 were surveyed by telephone in 2011 and 2012 as part of Centre for Addiction and Mental Health’s ongoing representative survey of adult mental health and substance use in Canada. TBI was defined as trauma to the head that resulted in loss of consciousness for at least five minutes or overnight hospitalization.

Results: An estimated 91% (95% CI: 90.0, 91.9) of individuals in this sample held a valid Ontario driver’s licence at the time of testing. Among those, 16.7% reported a history of lifetime TBI and 83.3% reported no TBI. The prevalence of TBI was higher among men than women. Relative to licenced adults without TBI, adults with a history of TBI had significantly higher odds of engaging in serious driver aggression in the past 12 months, such as making threats to hurt another driver, passenger or their vehicle (AOR=4.39). These individuals also reported significantly higher odds (AOR=1.74) of being involved in a motor vehicle collision that resulted in hurting themselves, their passenger(s) or their vehicle.

Conclusion: This is the first population-based study to demonstrate a relationship between a history of TBI and higher rates of serious driver aggression and collision involvement. Given the large proportion of adult drivers with a history of TBI, these individuals may account for a disproportion burden of all traffic safety problems.
Whether the increased road safety risk of adults with a history of TBI is reflective of neurocognitive deficits or is merely evidence of a cluster of unsafe activities produced by a higher risk lifestyles requires further research attention.

KEYWORDS: traumatic brain injury, concussions, driver aggression, adults, motor vehicle collision
1. INTRODUCTION

Driver aggression has been linked to collisions, injuries and deaths across the world (Hemenway et al., 2006; Joint, 1995; Mann et al., 2007a; 2007b; Sagar et al., 2013; Smart and Mann, 2002; Wells-Parker et al., 2002). Collisions are a leading cause of serious injury and death fatalities (Peden et al., 2004). Drivers can be victims, perpetrators of driver aggression, or both (Smart et al., 2003). Understanding the factors associated with both driver aggression and collisions, and the pathways between them, would contribute significantly to prevention of both.

Being a perpetrator of driver aggression is more common among drivers who are victims of driver aggression themselves (Asbridge et al., 2003). Drivers who have been victims and perpetrators of driver aggression are more likely to report being involved in a collision in the past 12 months (Mann et al., 2007a; 2007b). Driver anger has been reported to be associated with many risky behaviours ranging from loss of control of the vehicle, dangerous and reckless driving, causing traffic collisions, vengeful and retaliatory aggression, lapses in concentration while driving, and close calls that could have led to serious motor vehicle collisions (Deffenbacher et al., 2003; Deffenbacher et al., 2001; Hennessy and Wiesenthal, 2004). While driver aggression is observed in all age groups, younger drivers are more likely to be perpetrators (Wickens et al., 2011), while males and females show similar rates of driver aggression after controlling for demographic factors (Hennessy et al., 2004; Wickens et al., 2012; 2013). Driver aggression is more commonly experienced in urban centres with higher population density (Smart et al., 2003). Individuals who report driving more kilometres and those...
who drive high performance vehicles also report more driver aggression (Smart et al., 2004).

Driver aggression and collision risk are affected by psychiatric factors. Individuals who experience psychological distress are more likely to report perpetration of both mild and more serious forms of driver aggression (Fong et al., 2001; Smart et al., 2003). Specific psychiatric disorders have been linked to serious driver aggression, including Intermittent Explosive Disorder and Borderline Personality Disorder (Galovski et al., 2002; Sansone et al., 2010). Depression and other psychiatric disorders have been linked to increased collision risk (Mann et al., 2010a; Wickens et al., 2013). Individuals who are heavy or problem users of alcohol, or who use illicit drugs, are also more likely to report driver aggression (Butters et al., 2005 and 2006; Mann et al., 2004; Yu et al., 2004). The link between alcohol and collision risk is well established in the literature (Borkenstein et al., 1964). Many other psychoactive substances also have been demonstrated to increase collision risk (Asbridge et al., 2014; Callaghan et al., 2013; Li et al., 2013; Mann et al., 2007b; Mann et al., 2010b).

Traumatic brain injury (TBI) occurs when a sudden hit or blow to the head, or when an object piercing the skull and entering brain tissue, causes trauma and damages the brain (Nortje and Menon, 2004). TBI is a form of injury that is on the rise and can have significant neuropsychiatric consequences, and is a leading cause of injury-related disability and death (Centres for Disease Control, 2010; Gilchrist, 2011). Concussions are a subset of more mild or moderate forms of TBI. All forms of TBI are associated with important clinical outcomes. Depending on severity and brain impact location a brain injury can reduce reaction time, concentration, visual performance, auditory sensitivity,
spatial temporal performance, and hand-eye coordination (Eby and Molnar, 2010). Motor vehicle collisions are among the leading causes of TBI (Centres for Disease Control, 2010). For example, Cassidy et al. (2014) recently observed that 24% of injuries sustained in collisions were TBIs. Since TBI can affect cognitive and psychomotor skills, a serious TBI may permanently affect driver behaviour and even preclude driving (D’apolito et al., 2013). Patients with TBI often report developing emotional problems and aggressive tendencies (Baguley et al., 2006; Kim et al., 2007). Population based studies of adolescents have found significant associations between having had a history of TBI and current risk conduct behaviours (e.g., stealing more than $50, carrying a weapon on school property, selling illegal drugs, setting fire), including mental health issues, and bullying (Ilie et al., 2014). A few studies have examined the effects of TBI on driving in small clinical samples. The results are mixed, with some, but not all studies, suggesting a significant association between a history of TBI and driving-related problems and risk behaviours, including increased risk of collisions and driver aggression (c.f., D’apolito et al., 2013; Ilie et al., 2014; Pietrapiana et al., 2005; Schultheis et al., 2002).

Recent research suggests that a relatively large proportion of individuals in the population report a history of TBI in their lifetime, and that many TBIs go unreported to a medical professional, especially milder forms of the injury (Cassidy et al., 2004). For example, Ilie et al. (2013; 2014a) found that 14.6% of a large representative population sample of Ontario students in grades 7-12 reported a history of head injuries that resulted in at least 5 minutes of unconsciousness, or at least one overnight in the hospital, in their lifetime (but not in the past 12 months) and 5.6% had experienced an injury like this in
the past year. This is not surprising since higher annual estimates among teens have been reported by CDCP (6.5%; ages 10-19) in the US. According to the CDCP report, sports related head injuries among teens, based on hospitalized records alone, have increased by 60% between 2001 and 2009 and similar to even higher increases were reported in New Zealand (Halstead, 2011; McKinlay et al., 2008; Rusnak, 2013). Individuals who had experienced these injuries were also more likely to report substance use, suicidality, and increased aggression, such as bullying and other violent and delinquent behaviours (Ilie et al., 2013, and 2014a,b). Associations between a history of TBI and current substance use, and a variety of risk behaviours, have also been reported among Australian adults by other investigators examining adult community samples in Australia (Anstey et al., 2004).

While clinical studies have shown that more serious cases of brain injury affect driving behaviour and further risk of collisions, no studies have yet examined the association between a history of TBI, driver aggression and collision risk in population samples. In this work we examine the association between self-reported history of TBI, driver aggression and collision risk in a large representative sample of the driving licenced adults living in Ontario, Canada.

2. METHODS

Our data were derived from the 2011 and 2012 cycles of the Centre for Addiction and Mental Health’s (CAMH) Monitor, a cross-sectional telephone survey of Ontario adults aged 18 years or older, and administered by the Institute for Social Research at York University. Excluded from selection were adults who were phoneless,
institutionalized, and unable to speak English. The design employed a stratified, two-stage-probability sample drawn quarterly through random digit dialing of listed and unlisted landline and mobile telephone numbers. Each calendar year, the four quarterly non-overlapping samples are combined to provide a single annual dataset. Although 3,039 adults (response-rate: 51%) completed the survey in 2011 and 3,030 adults (response-rate: 51%) completed the survey in 2012, only 3,993 (1,999 and 1,994 respondents, from 2011 and 2012 respectively) were asked the TBI question and of those only 3,626 adults also held a valid Ontario driving licence. Our analysis is based on this later figure. Two versions of the survey were administered in this period. The version of the survey that administered the TBI question (Panel B) included 150 questions in total and averaged 23 minutes to complete. Interviews were distributed across a six-day week (Fridays excluded) and time of day. A complete description of the survey, its items, methods of administration and discussion of potential non-response bias is available on the Monitor’s webpage (Ialomiteanu et al., 2011 and 2013). The study was approved by the Research Ethics Committees of CAMH and York University.

2.1 Measures

2.1.1 Traumatic Brain Injury

Head injuries sustained in one’s lifetime were assessed by a single question prefixed as follows: We are interested in any head injuries that resulted in you being unconscious (knocked out) for at least 5 minutes, or you had to stay in the hospital for at least one night because of it. Respondents were then asked: How many times, if ever in your life, have you had this type of head injury? Responses were recoded to create a binary
lifetime TBI measure (yes=1; no=0). Similar questions assessing TBI have been previously validated (Anstey et al., 2004; Ilie et al., 2013; 2014; Tait et al., 2010).

While respondents were normal adults, able to participate in regular adult activities, we cannot rule out the possibility of cognitive impairments affecting responses of TBI-injured adults. Of relevance here, we found that adults who reported a history of TBI were no more likely than adults without a history of TBI to assess questionnaire difficulty completion as “difficult” (10.2%; 95%CI: 6.8%, 15.0% versus 6.7%; 95%CI: 5.4%, 8.2%), Second-order Rao-Scott adjusted chi-square $X^2(1,1966)=5.04, P > 0.05$.

2.1.2 Past 12 months aggressive driving behaviour

Two variables were assessed. Participants were first asked “During the past 12 months, either as a driver or a passenger, how many times have you shouted, cursed, or made rude gestures at a driver or passenger in another vehicle?” Participants were subsequently asked “Still thinking about the past 12 months, how many times have you threatened to hurt a driver or passenger in another vehicle, or threatened to damage their vehicle?” For both questions responses were binary coded (never=0; 1 or more=1).

2.1.3 Driving collisions

Participants were asked “During the past 12 months, how often, if at all, were you involved in an accident or collision involving any kind of damage or injury to you or another person or vehicle while you were driving?” For both questions responses were binary coded (never=0; 1 or more=1).

2.2 Participants’ characteristics

2.2.1 Sex
Sex was coded 1 for men, 2 for women. 41.4% of the participants in this sample were men.

2.2.2 Age

Age was recoded into 5 categories (18-29 years=1; 30-39 years=2; 40-49 years=3; 50-64 years=4; 65 years or older=5). The mean age of licenced drivers was 53.67 years (range: 18-97; SD=16.67).

2.2.3 Household income

Household income was recoded into 4 categories [less than $30,000=1; between $30,000 and $49,999.99=2; between $50,000 and $79,999.99=3; more than $80,000=4; not stated (refused or don’t know)=5]. Category 5 was treated as missing data and was not included in the analyses.

2.2.4 Education

Highest level of education was recoded into 4 categories (less than high school=1; completed high school=2; some post-secondary, college or university=3; university degree=4).

2.2 Analysis

To accommodate the complex survey data, variances were estimated using Taylor Series Linearization available in the Complex Sample module in SPSS V20.0. The final analyses were based on a design with 12 strata (region), and 3,626 adults (only adults who answered the TBI question and held a valid Ontario driving licence were included in the analysis). Logistic regression assessed the association between lifetime TBI status (acquired vs. not-acquired) and the four outcomes, while holding constant age, sex, family income, and education. The choice of these controls followed suggestions from
the literature that point out to the importance of controlling for these variables in research measuring violence or various forms of aggression among adults (Ellis, Beaver, & Wright, 2009). To assess gender differences in TBI, a two-way TBI × sex interaction was added to each of the three models listed in Table 2, separately, and assessed with the likelihood test.

3. RESULTS

In this population sample of the Ontario adult drivers, 5,476 or 91% (95% CI: 90.0, 91.9) reported having a driver’s licence. Among these adult drivers, 16.7% (95% CI: 15.2, 18.4) reported at least one TBI in their lifetime, while 83.3% (95% CI: 81.6, 84.8) reported they never had a TBI. Male drivers who reported a history of TBI had net odds nearly 2 times higher (OR=1.94; 95% CI: 1.54, 2.45) than female drivers. Among all reported collisions 25.6% (18.2, 34.6) were associated with a history of traumatic brain injury. Table 1 presents the demographic characteristics, aggressive driving behaviour, and collision involvement among drivers who report a history of TBI versus those who do not. Adults reporting at least one TBI in their lifetime tended to be younger than those not reporting TBI. Among those reporting at least one TBI in their lifetime, 23.2% (95% CI: 18.0, 29.3) were in the youngest age group (18-29) compared to 17.1% (95% CI: 15.0,19.4) of those not reporting a TBI, while 12.8% (95% CI: 10.4, 15.6) of those reporting a TBI were in the oldest age group (aged 65 and above) compared to 17.3% (95% CI: 16.0, 18.7) of those not reporting a TBI, $X^2(4)=10.62$, $P < 0.05$. Males were significantly more likely to report TBI than females, and constituted 62.1% (95% CI: 56.9, 67.0) of the TBI sample while females constituted 37.9% (95% CI: 33.0, 43.1),
The largest family income group among respondents both with and without TBI was $80,000 and above, followed by those reporting family income in the $50,000-$79,000, in the $30,000-$49,000, and less than $30,000 ranges, $X^2(3)=1.56, P > 0.05$. The largest proportions in both groups reported some post-secondary education, followed by those reporting university education, completing high school, and less than high school, $X^2(3)=4.21, P>0.05$.

Table 2 shows results of logistic regression analyses fitting the TBI status of adults who held a driver's licence at the time of testing on aggressive driving behaviour and driving collisions that resulted in harm to either the driver, the passenger, their vehicle or all three. Ontario adult drivers who reported a history of TBI in their lifetime had higher odds of reporting milder and more serious forms of driver aggression, as well as being involved in a collision that resulted in damage to the individual, the passenger, or the vehicle (ORs=1.34, 4.83, and 1.73, respectively). After adjusting for the influence of age, sex, family income and education, the impact of TBI on milder forms of driver aggression was no longer significant. However, those with TBI had significantly higher odds of reporting more serious forms of driver aggression (AOR=4.39) and reporting being involved in a collision as a driver (AOR=1.74) than those who did not report TBI. Comparison of the log-likelihood ratios for models with and without the interactions between TBI and sex did not show discernible improvement. Thus, the associations presented in Table 2 did not vary between men and women among adults with TBI.

4. DISCUSSION
Previous studies have hinted at an important link between a history of TBI and subsequent driver aggression and increased collision risk. Our results provide confirmation of both associations. Drivers who reported lifetime TBI were more likely to engage in serious aggressive driving in the preceding 12 months, an association that remained significant even after controlling for demographic factors. Milder forms of aggressive driving also emerged (driver aggression expressed through rude gestures, verbal messages, or both, aimed at a driver or passenger in another vehicle in the past 12 months), but controlling for age, sex, family income, and education rendered the association insignificant. These results are consistent with previous studies that point to a link between a history of TBI and increased milder and more severe forms of driver aggression (D'apolito et al., 2013; Hannold et al., 2013). They also are consistent with previous literature suggesting that milder forms of aggression may be the result of demographic characteristics such as family income, education, sex or age (Ellis, Beaver, & Wright, 2009). These results may be useful to driving licensing policy makers in their assessments of factors that may reduce number of fatalities associated with traffic collisions and guide future research as numbers of fatalities and victims from driving collisions remain high. The Canadian Motor Vehicle Traffic Collision Statistics indicate that the number of motor vehicle fatalities in 2012 was 2,077 (up 2.7% since 2011) and that the rate of the number of victims was 6.0 (up 0.2 from 2011) per 100,000 (Canadian Motor Vehicle Traffic Collisions Statistics, 2012). Detailed statistics on the number of brain related disease, disorders, and injuries are, however, not available and require further research.

Equally important to point out is that this study is the first...
population-based study to assess the relationship between TBI and collision risk. Our results show that lifetime TBI is associated with 75% higher odds of past-year self-reported collision involvement, even after controlling for demographic factors. That increased collision risk is associated with a history of TBI has only been previously reported in small clinical samples among individuals that had a history of more severe forms of TBI (D’apolito et al., 2013). Our study extends this evidence by examining this relationship in a large population-based sample of adult drivers and among drivers who report having had a history of TBIs that includes all levels of severity including milder and moderate forms of TBI. Furthermore, data presented here captures hospitalized as well as non-hospitalized cases of TBI. It is also worth noting that TBI-associated collisions may constitute a substantial proportion of collisions in the population. Indeed, a large proportion of the population reports these injuries (17% in this sample) and most instances of TBI are not reported to health services (Cassidy et al., 2004). It is worth noting, since most instances of TBI are not reported to health services (Cassidy et al., 2004), and since a large proportion of the population report these injuries (17% in this sample), that TBI-associated collisions may constitute a substantial proportion of collisions in the population. Currently, most individuals with brain injuries, ranging from mild to severe, return to driving with no formal evaluations of their fitness to drive following the injury (Fisk et al., 1998; Pidikiti and Novack, 1991; van Zomeren et al., 1987). Most individuals with brain injuries ranging from mild to severe return to driving, many with no formal evaluations of their fitness to drive following the injury (Fisk et al., 1998; Pidikiti and Novack, 1991; van Zomeren et al., 1987). In light of the results we report here, suggesting screening for fitness to drive post TBI is justified.
Assessing the efficacy and effectiveness of introducing such screening for TBI survivors receiving treatment and rehabilitation represents an area for further study. Clearly, there are important and possibly reciprocal links between TBI and motor vehicle collisions (Cassidy et al., 2014), of which greater attention is warranted. Injury prevention strategies could go a long way in reducing motor vehicle collisions and road aggression if initiatives by various levels of socialization within our society, public health and schools are taken, given that the history of TBI may have occurred early in one’s life.

The link between history of TBI and increased collision risk observed in these data may result from one or more of several pathways. First, TBI may alter behaviour and influence driving skills in ways that increase collision risk. Several studies have identified links between TBI and driving performance deficits that may include slow reaction time (Stock and Gaillard, 1986), reduced visuomotor coordination (van Zomeren et al., 1988) or skills related to the ability to perceive and judge pertinent stimuli (Sivak et al., 1981). Neuropsychological tests have been correlated with driving measures for individuals who have suffered a TBI and may be good predictors of driving performance (Sivak et al., 1981). Second, TBI may increase aggressive behaviors (Baguley et al., 2006; Ilie et al., 2014; Kim et al., 2007), which can lead to increased collisions (Mann et al., 2007b). In support of this suggestion, we also observe that TBI is associated with increased driver aggression, particularly more serious forms of aggression. Third, the effects of TBI on collision risk may occur as a result of TBI’s effects on other risk-enhancing behaviours. For example, TBI may increase use of alcohol and other drugs (Ilie et al., 2013; in press; Tait et al., 2010), which themselves are known to increase
collision risk (Asbridge et al., 2012 and 2014; Callaghan et al., 2013; Li et al., 2013; 
Mann et al., 2007b; Mann et al., 2010a; 2010b). It is important that clinicians and 
stitutions that govern driving licenses regulations adopt a logical sequence for the 
agement of drivers with a history of traumatic brain injury to reduce further 
ccidences of fatalities and injury to self and others. Fourth, the relationship between TBI 
and collisions may be spurious and result from the influence of some other common 
derlying factors. For example, individuals with higher risk-taking propensities may 
experience both increased likelihood of TBI and collision involvement. Understanding 
the nature of the relationship between TBI and collisions is important for prevention 
purposes, and more research on this issue is necessary.

Several limitations must be considered when interpreting the results of this study. 
First, although population surveys are particularly useful for estimating the prevalence of 
a health condition in a large population of adults and for identifying associated risk 
factors and at-risk subtypes, possible bias related to self-report procedures may limit such 
results. Evaluation of self-report methods for collecting information on driving measures 
and substance use suggest, however, that although surveys tend to underestimate true 
measures, they are still regarded as valid ways to estimate such measures in the 
population (Boufous et al., 2010; Turner et al., 1992). Similarly, while the response rate 
for the survey is considered good (Aday, 1996), we cannot be certain that non-
respondents would have answered survey questions in the same way. Driving exposure 
was not controlled for in the analyses, and may have potentially confounded the results. 
Future studies should consider including this control in their analyses. Adjusting for age, 
sex, family income and education, however, did render a previously significant
association between TBI and milder forms of driver aggression (when no controls were applied), insignificant. Indeed previous literature recommends these adjustments to inquiries about human aggression as many studies find aggressive acts to be the result of frustrations associated with one’s role in the society (e.g., male, female), financial or marital problems, lack of education or age (Ellis, Beaver, & Wright, 2009). Finally, because of the cross-sectional design used we cannot establish casual order among the variables examined.

In summary, the results of this study are of substantial interest in our efforts to reduce collision risk and improve road safety. First, the study provides preliminary population-level data on potentially important relationships among TBI, driver aggression and collision involvement. These relationships may be seen among those experiencing less serious forms of TBI than considered in previous research, and because a large proportion of the population have experienced these injuries they may account for a substantial but previously unrecognized number of collisions and incidents of driver aggression. As well, these results suggest the importance of considering road safety issues in dealing with individuals who have experienced these injuries. They also point to the need to introduce improved screening and rehabilitation services of drivers who had a TBI, with the aim of assessing fitness to drive and other related cognitive skills. Clearly, such interventions, even as applied to those individuals who have survived a severe head injury, are not observed consistently. Assessing the efficacy and effectiveness of introducing such screening for TBI victims receiving treatment and rehabilitation represents an area for further study. In view of the possible significance of these relationships, research to replicate these findings and to understand the causal
pathways involved is needed. Traumatic brain injury is a leading cause of death among adolescents and adults in the western world, and head trauma is placing a significant burden on the health systems of the developing world. The use of motor vehicles for transportation is also on the growth worldwide. With population growth, overcrowding, and urbanization, driving has become an increasing challenge, and the number of hours on the road while commuting is on an upward trend. The recognition of increased prevalence rates of TBI in the population, coupled with an acknowledgement that reduced attention to driving rules threaten to become the norm, will contribute to create pressure at various levels of our society to engage in preventive efforts. Traumatic brain injuries are not inherited; they are preventable. Therefore, the most significant impact on reducing the worldwide burden of traumatic brain injuries and motor vehicle aggression and fatalities will come from injury prevention programs organized at societal and governmental levels.

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the collection, management, analysis and interpretation of the data, or the preparation,
review or approval of the manuscript.

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Table 1. Demographic characteristics, self-reported aggressive driving behaviours and collision involvement in Ontario adults with a valid driver’s licence who reported a history of TBI (n=575) or never had a TBI (n=3,051).

<table>
<thead>
<tr>
<th>Age</th>
<th>Adults with a history of TBI</th>
<th>Adults without TBI</th>
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</thead>
<tbody>
<tr>
<td>18-29</td>
<td>23.2</td>
<td>17.1</td>
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<td></td>
<td>(18.0, 29.3)</td>
<td>(15.00, 19.4)</td>
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<tr>
<td>30-39</td>
<td>16.2</td>
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<td></td>
<td>(12.8, 20.4)</td>
<td>(16.5, 20.1)</td>
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<tr>
<td>40-49</td>
<td>20.3</td>
<td>20.5</td>
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<td></td>
<td>(16.7, 24.4)</td>
<td>(18.7, 22.3)</td>
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<td>50-64</td>
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<td></td>
<td>(23.5, 32.0)</td>
<td>(25.2, 28.8)</td>
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<td></td>
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<td>(16.0, 18.7)</td>
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<tr>
<td>Mean age (SE)</td>
<td>45.0 years (SE=.94)</td>
<td>47.32 years (SE=.40)</td>
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<tr>
<td>Sex</td>
<td>X^2(1)=31.19***</td>
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<td>Male</td>
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<td></td>
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<td>Female</td>
<td>37.9</td>
<td>54.2</td>
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<td></td>
<td>(33.0, 43.1)</td>
<td>(52.0, 56.5)</td>
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<tr>
<td>Family income</td>
<td>X^2(3)=1.56, ns</td>
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<td>&lt; $30,000</td>
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<td>(5.5, 10.2)</td>
<td>(7.7, 10.5)</td>
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<tr>
<td>Income Level</td>
<td>Adults with a history of TBI</td>
<td>Adults without TBI</td>
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<td></td>
<td>% (95%CI)</td>
<td>% (95%CI)</td>
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<tr>
<td>$30,000-$49,000</td>
<td>14.4 (11.3, 18.3)</td>
<td>13.4 (11.9, 15.1)</td>
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<td>$50,000-$79,000</td>
<td>24.9 (20.3, 30.0)</td>
<td>23.3 (21.3, 25.5)</td>
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<tr>
<td>$80,000+</td>
<td>53.1 (47.6, 58.6)</td>
<td>54.2 (51.8, 56.7)</td>
</tr>
</tbody>
</table>

Education

<table>
<thead>
<tr>
<th>Level</th>
<th>Adults with a history of TBI</th>
<th>Adults without TBI</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; High school</td>
<td>8.1 (5.9, 11.2)</td>
<td>7.8 (6.8, 9.0)</td>
</tr>
<tr>
<td>Completed high school</td>
<td>23.5 (19.2, 28.5)</td>
<td>19.2 (17.6, 21.0)</td>
</tr>
<tr>
<td>Some post secondary</td>
<td>36.6 (31.6, 41.8)</td>
<td>36.9 (34.8, 39.1)</td>
</tr>
<tr>
<td>University Degree</td>
<td>31.8 (27.2, 36.7)</td>
<td>36.0 (33.9, 38.2)</td>
</tr>
</tbody>
</table>

Driver aggression expressed though rude gestures, verbal messages (or both) aimed at a driver or passenger in another vehicle in the past 12 months

<table>
<thead>
<tr>
<th>Type of aggression</th>
<th>Adults with a history of TBI</th>
<th>Adults without TBI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Expressed driver aggression</td>
<td>49.1 (43.9, 54.4)</td>
<td>42.0 (39.7, 44.2)</td>
</tr>
<tr>
<td>Did not express driver aggression</td>
<td>50.9 (45.6, 56.1)</td>
<td>58.0 (55.8, 60.3)</td>
</tr>
</tbody>
</table>

Serious driver aggression expressed through threats to a driver or passenger in another vehicle or driver’s vehicle in the past 12 months

<table>
<thead>
<tr>
<th>Type of aggression</th>
<th>Adults with a history of TBI</th>
<th>Adults without TBI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Expressed driver aggression</td>
<td>49.1 (43.9, 54.4)</td>
<td>42.0 (39.7, 44.2)</td>
</tr>
<tr>
<td>Did not express driver aggression</td>
<td>50.9 (45.6, 56.1)</td>
<td>58.0 (55.8, 60.3)</td>
</tr>
</tbody>
</table>

\( X^2(3)=4.21, \text{ns} \)

\( X^2(1)=6.07^* \)

\( X^2(1)=12.66^{***} \)
<table>
<thead>
<tr>
<th></th>
<th>Adults with a history of TBI</th>
<th>Adults without TBI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Expressed serious driver aggression</td>
<td>3.9 (2.0, 7.3)</td>
<td>0.8 (0.5, 1.4)</td>
</tr>
<tr>
<td>Did not express serious driver aggression</td>
<td>96.1 (92.7, 98.0)</td>
<td>99.2 (98.6, 99.5)</td>
</tr>
<tr>
<td>Involved in collision as a driver resulting in damage to self, another person or vehicle damage in the past 12 months</td>
<td>X²(1)=5.60*</td>
<td></td>
</tr>
<tr>
<td>Reported collisions</td>
<td>9.1 (6.3, 13.0)</td>
<td>5.4 (4.4, 6.7)</td>
</tr>
<tr>
<td>Did not report collisions</td>
<td>90.9 (87.0, 93.7)</td>
<td>94.6 (93.3, 95.6)</td>
</tr>
</tbody>
</table>

Notes: *** p < 0.001; ** p < 0.01, * p < 0.05 , ns – not statistically significant, p > 0.05
Table 2. Logistic regression analyses predicting self-reported aggressive driving behaviours and motor vehicle collisions by Ontario adults with a valid driver’s licence who reported a history of TBI (n=575) compared to those not reporting TBI (n=3,051).

<table>
<thead>
<tr>
<th>Behaviour</th>
<th>Odds Ratio (95% CI)</th>
<th>Adjusted Odds Ratio (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Driver aggression expressed though rude gestures, verbal messages (or both) aimed at a driver or passenger in another vehicle in the past 12 months</td>
<td>1.34* (1.06, 1.68)</td>
<td>1.27 (.98, 1.65)</td>
</tr>
<tr>
<td>Serious driver aggression expressed through threats to a driver or passenger in another vehicle or driver’s vehicle in the past 12 months</td>
<td>4.83*** (2.03, 11.52)</td>
<td>4.39** (1.87, 10.29)</td>
</tr>
<tr>
<td>Involved in collisions as a driver resulting in damage to self, another person or vehicle damage in the past 12 months</td>
<td>1.73* (1.10, 2.73)</td>
<td>1.74* (1.06, 2.87)</td>
</tr>
</tbody>
</table>

Notes: Unadjusted odds ratios (OR) and Adjusted odds ratios (AOR) were calculated using logistic regression. AOR were evaluated while holding fixed values of age, sex, family income, and education;*** p < 0.001; ** p < 0.01, * p < 0.05