

## Association between drink driving and severity of crash injuries to road users

### 酒後駕駛與道路使用者撞傷嚴重程度間的關係

KL Tsui 徐國樑, NN Sze 施能藝, FL So 蘇鳳玲, SC Wong 黃仕進

**Objective:** To determine the association between alcohol impairment in drivers and risk of severe injury in other road users in Hong Kong. **Method:** The Road Casualty Injury Information System (RoCIS) was set up by linking a regional hospital injury registry to the police traffic injury database. Based on the year 2004 linked dataset, a specific model namely the External Casualty Model (ECM) was designed to measure the association between severe injury outcome of other (non-driver) road user casualties (as stratified by ISS groups [ISS <9 or ISS ≥9]) and the level of alcohol impairment (as measured by breath alcohol concentration [BAC <22 µg/100 ml or BAC ≥22 µg/100 ml]) in drivers involving in the crash, controlling for the driver's demographics (age and sex) and behaviour (as measured by driving-offence points [DOP]) and another attribute (day of week of crash). Binary logistic regression was used in the analysis. **Results:** Out of 1818 matched RoCIS cases in the year 2004, 439 ECM records were available for analysis. Alcohol impaired drivers led to a significantly higher risk of severe injury to other road users (OR=4.2, 95%CI=1.21, 14.36, p=0.02). Crashes on weekdays seemingly led to a lower severe injury risk (OR=0.57, p=0.08) than crashes on weekends. DOP of drivers did not predict a higher severe injury risk to other road users. **Conclusions:** Alcohol impairment on driver increases the risk of severe injury to other road users by four times. Road safety education campaign should stress on this adverse impact of drink driving on innocent people. (*Hong Kong j.emerg.med.* 2010;17:34-39)

**目的：**確定香港受酒精影響之駕駛者與其他道路使用者嚴重受傷的風險之間的關係。**方法：**道路傷者資料系統（RoCIS）由連接一區域性醫院的創傷登記冊至警察交通受傷數據庫而建成。基於在2004年連接的數據集，設計一特定模式，即「在外傷者模式」（ECM），去量度涉及撞擊的駕駛者受酒精影響的水平（以量度呼吸酒精濃度<22 µg/100 ml或≥22 µg/100 ml區分）及其他受傷的道路使用者（非駕駛者）嚴重受傷後果（以傷勢嚴重性得分組別ISS<9或≥9分類）之間的關係，比對駕駛者的人口統計

Correspondence to:

Tsui Kwok Leung, FRCS, FHKCEM, FHKAM(Emergency Medicine)  
Tuen Mun Hospital, Accident and Emergency Department, Tsing  
Chun Koon Road, Tuen Mun, N.T., Hong Kong  
Email: kl12judy@yahoo.com.hk

So Fung Ling, RN, MSN

Delft University of Technology, Department of Transport  
Planning, Faculty of Civil Engineering and Geosciences, Delft,  
the Netherlands  
Sze Nang Ngai, PhD

The University of Hong Kong, Department of Civil Engineering,  
Pokfulam Road, Pokfulam, Hong Kong  
Wong Sze Chun, PhD, FCILT, FHKIE

數據（年齡及性別），行為（以駕駛犯錯分數[DOP]來量度）及其他特性（撞擊的星期天）。使用二元邏輯斯諦回歸法分析。**結果：**在2004年的1818個RoCIS配對個案中，439ECM的記錄可用以分析。受酒精影響的駕駛者引致其他道路使用者嚴重受傷的風險顯著較高（機會率 = 4.2，95% 置信區間 = 1.21，14.36， $p=0.02$ ）。週一至週五的碰撞似乎較週末的碰撞引致較低嚴重受傷的風險（機會率 = 0.57， $p=0.08$ ）。駕駛者的DOP不能預測其他道路使用者嚴重受傷較高的風險。**結論：**受酒精影響的駕駛者增加其他道路使用者4倍嚴重受傷的風險。道路安全教育活動應強調酒後駕駛對無辜人士這些不良的影響。

**Keywords:** Alcohol drinking, automobile driving, ethanol, traffic accidents, wounds and injuries

**關鍵詞：**飲酒、駕駛汽車、酒精、交通意外、傷口與創傷

## Introduction

It is well known that alcohol use is one of the most important personal risk factors that will increase the risk of a wide range of different injuries, including motor vehicle crashes. Extensive research has been conducted to measure the association between alcohol consumption and a driver's injury severity, although conflicting results emerged. It is still uncertain whether alcohol has an effect on the degree or outcome of injury after controlling the severity of impact. Some studies suggested that casualty injury severity in traffic crashes would increase with the degree of alcohol intoxication,<sup>1-3</sup> but others indicated that alcohol would not adversely affect the degree of injury and the clinical outcome.<sup>4,5</sup> The inconsistency of these findings could be attributed to differences in the selection of the study population.<sup>6</sup>

Most of the previous researches were addressing the crash risk and injury consequences of alcohol on impaired drivers. Rarely has a study explicitly evaluated the effects of drink driving on other road user groups, including passengers, pedestrians and cyclists. In this study, we took advantage of the comprehensive crash information from a newly established registry in Hong Kong, namely the Road Casualty Information System (RoCIS),<sup>7</sup> to evaluate the relationship between injury outcome and alcohol intoxication. Rather than measuring the injury outcome in the impaired driver, our emphasis was on the other road users involved in the same crash. A specific model, namely the External Casualty Model (ECM) was designed to measure the injury impact of alcohol on this specific group of

victims. This study attempted to measure the impact of driver's alcohol impairment on the probability of severe injury in external casualties, controlling for driver's attributes and other demographics.

## Methodology

### *The RoCIS*

In the year 2003, a working group was formed by clinicians of the Tuen Mun Hospital and representatives from the Transport Department of the Hong Kong Government and the Hong Kong Police Force (HKPF) to explore ways to establish a comprehensive road traffic casualty database at the hospitals that would be linked to the Traffic Accident Database System (TRADS) collected by the police. The result is a new surveillance system for road traffic injuries, namely the Road Casualty Information System (RoCIS) which was launched in the year 2004. RoCIS aims for a better understanding of the relationships among traumatic injuries, crash mechanisms, human behaviour, traffic, and environmental attributes, and subsequently, better planning for medical care. This study was based on the RoCIS data of the year 2004.

### *ECM and data*

In the ECM, for each successfully linked casualty drivers captured in the RoCIS, we created one record to contain information on the degree of alcohol impairment in driver (as measured by breath alcohol concentration [BAC] which was obtained from breath test using a screening or evidential device by the HKPF at scene), driver's demographics (age and sex), driver's

behaviour (as measured by annual average driving-offence points [DOPs] in the past two years prior to the crash), day of the week of the crash (weekday or weekend) as well as injury severity of external casualties (as measured by ISS).

Not all of the variables captured in the RoCIS were incorporated into the ECM because of the deficiency in association measures that resulted from the inference between highly correlated independent variables. Some variables were removed from analysis. For example, information on driving experience and the time of day were not incorporated, because driving experience was highly correlated with driver's age, and the time of day was highly correlated with alcohol impairment.

Driver's BAC <22 µg/100 ml (which is the legal limit in Hong Kong) was taken as the stratification point for alcohol impairment. The dependent variable of the proposed model was injury outcome, for which external casualties with an ISS <9 would be regarded as slightly injured, whereas those with an ISS ≥9 would be regarded as severely injured. All fatal external casualties would be ascribed as severely injured. If there were more than one external casualty in the crash, the highest ISS recorded would be ascribed as the injury outcome of that specific ECM record. A stratification point of an ISS of 9 for serious injury was applied because this stratification was shown to have the least discordance with the police classification of severe injury in a prior study.<sup>8</sup>

### Statistical analysis

We used binary logistic regression analysis to evaluate the association of different attributes to severe injury risk. Significance level was taken at p=0.05. The goodness-of-fit of the proposed model was examined by log likelihood ratio test. The statistical package employed was NLOGIT 3.0.

### Results

In the year 2004, the RoCIS captured the information of 3034 road traffic injury casualties who received treatment in the emergency department of Tuen Mun Hospital. Out of these 3034 cases, 1818 (59.9%) were successfully matched with TRADS. The remaining 1216 (40.1%) unmatched cases represented those casualties who did not report to the police and thus had no record in TRADS. From the 1818 matched cases in the RoCIS, 789 ECM records were successfully created. A total of 439 (55.6%) valid observations were included for subsequent analysis, after eliminating those non-motorized vehicle crashes (51, 6.5%) and those with missing information on alcohol impairment (279, 35.4%) or driver characteristics (20, 2.5%). Table 1 shows the characteristics of the 439 valid observations. Thirteen (3.0%) drivers had alcohol impairment with a BAC that exceeded the legal limit of 22 µg/100 ml. In addition, 45 (10.3%) were cases of severe injuries (including fatal ones), using an ISS equal to 9 as the stratification point.

**Table 1.** Summary of variables for the External Casualty Model

|   | Count (%)   | Mean (SD)     | Minimum | Maximum |
|---|-------------|---------------|---------|---------|
| Number of observation=439               |             |               |         |         |
| Injury Severity Score (ISS)             |             | 3.67 (9.17)   | 1       | 75      |
| Breath alcohol content (BAC, µg/100 ml) |             | 1.84 (10.59)  | 0       | 92      |
| Driver's age                            |             | 38.80 (11.62) | 18      | 77      |
| Annual average DOPs in past two years   |             | 1.32 (2.03)   | 0       | 13      |
| *ISS ≥9 (1=Yes; 0=No)                   | 45 (10.3%)  |               |         |         |
| *BAC ≥22 µg/100 ml (1=Yes; 0=No)        | 13 (3.0%)   |               |         |         |
| *Driver's gender (1=Male; 0=Female)     | 399 (90.9%) |               |         |         |
| *Day of week (1=Weekday; 0=Weekend)     | 292 (66.5%) |               |         |         |

\*Categorical variables

DOP=driving-offence points

As shown in Table 2, alcohol impairment in drivers led to a noticeably higher injury risk in external casualties, with an odds ratio of 4.2 ( $p=0.02$ ) (95%CI =1.21, 14.36). In addition, crashes on weekdays seemingly would lead to a lower injury outcome (odds ratio=0.57,  $p=0.08$ ), although not at a statistically significant level. The proposed model approximated injury outcome ( $G=15.1$ ) well at the 1% significance level.

## Discussion

We first attempt to determine the injury outcome of casualties other than the subject drivers that could be attributed to alcohol impairment, driver demographics, and driving attitude. This approach is rare in the field. The External Casualty Model was specifically designed to reveal the injury risk of this specific group of traffic casualties.

We report that alcohol impairment on driver significantly increases the risk of severe injury to other road users by four times. Recently, there is a public outcry in Hong Kong for more vigilant action against drink-driving, including a lower legal alcohol limit and a heavier subsequent penalty.<sup>9</sup> Our result suggests that safety education campaign should stress on the adverse

impact of drink driving, including the mortality and severe injury that may incur to innocent people other than the drivers themselves.

This study also shows that crashes on weekends seemingly lead to a higher injury risk, which could be related to a higher vehicular speed and lower traffic volume on weekends. It could also be attributed to a difference in traffic pattern between weekdays and weekends; or to the influence of the inexperienced driving behaviour of "holiday drivers" who may have limited driving skills and perceptions of road safety.

This study fails to demonstrate an association between driver's DOP and higher injury risk to other road users. Probably, DOP only reflects the driver's reckless driving behaviour like speeding or ignoring road sign but not specifically or precisely the act of drink-driving. In future studies, we should consider incorporating the attribute of prior driving under influence (DUI) offence into the analysis. If we can demonstrate that prior DUI offence is predictive of higher injury risk, we shall have strong evidence to support the compulsory use of alcohol interlock device for all adjudicated first time offenders.

The effects of alcohol intoxication on traffic injuries are very complicated. Judgments of speed and distance,

**Table 2.** Results of logistic regression analysis

|  | Coefficient        | Standard error | Odds ratio (95%CI)  |
|--|--------------------|----------------|---------------------|
| Constant   | -0.60              | 0.76           | 0.55 (0.12, 2.44)   |
| BAC $\geq 22$ $\mu\text{g}/100$ ml (1=Yes; 0=No) | 1.43               | 0.63           | 4.16 (1.21, 14.36)* |
| Driver's gender (1=Male; 0=Female)               | -0.45              | 0.49           | 0.63(0.24, 1.66)    |
| Driver's age                                     | -0.02              | 0.01           | 0.98 (0.95, 1.01)   |
| Average annual DOPs in past two years            | -0.12              | 0.10           | 0.89 (0.74, 1.07)   |
| Day of week (1=Weekday; 0=Weekend)               | -0.57              | 0.33           | 0.57 (0.30, 1.07)   |
| Number of observations                           | 439                |                |                     |
| Restricted log likelihood function               | -145.11            |                |                     |
| Unrestricted log likelihood function             | -137.58            |                |                     |
| Likelihood ratio test                            | 15.06 <sup>†</sup> |                |                     |

\*Statistically significant at the 5% level.

<sup>†</sup>Statistically significant at the 1% level.

DOP=driving-offence points

attentiveness, reaction time, and perceptions of safety could be impaired under the influence of alcohol. Intoxicated drivers have been reported to drive at higher speeds or with risky behaviours.<sup>10,11</sup> Higher collision speeds could represent higher kinetic energy transfer and therefore could incur more severe injury to other road users. In addition to vehicle speed, other factors also determine the kinetic energy transfer, including the mass of the vehicle, the collision type, the point of contact, shape mismatch, the capacity for vehicle deformation and performance.<sup>12</sup> Also, the impact of kinetic force on other road users could be noticeably differentiated by the casualties who are within or outside the vehicle cabinet. Even within the cabinet, the location of the passenger and the use of protective measures also affect the injury outcome. In this study, we could not examine these factors precisely because the above-mentioned attributes were not collected by the RoCIS. The four times higher injury risk to external casualties reported in this study could be interpreted as a collective outcome of several attributes directly or indirectly relating to the alcohol effect on the drivers only.

In the proposed model, alcohol intoxication was taken as a binary variable, with a BAC level of 22 µg/100 ml as the stratification point. This classification could be too simplified and introduce a possible misclassification error. However, even if the variable was taken as a continuous variable, one still could not eliminate the effects of the high inter-individual variability of alcohol threshold levels and exposure-response patterns.<sup>13</sup>

Besides, the current study was limited to a sample size of one year of data only. Attention has to be paid to the fact that there were a small number of drivers with BAC level above the legal limit as well as a higher proportion of inadequate BAC information for the more severely injured drivers, which may have introduced a possible bias in the association measures. In future studies, a longer observation period could produce a more elaborate dataset to overcome this limitation. Furthermore, the present ECM has intrinsic weaknesses like not accounting for the effect of multiple casualties and other concurrent DUI,

particularly that of illicit drug. Some interesting attributes like prior DUI offence and spatial characteristics<sup>14,15</sup> should also be included as attributes to improve the model.

## Conclusions

Combining casualty information from hospital database and crash information from the Police crash database, the RoCIS was established to obtain a more comprehensive analysis of the associations among traffic flow, road environment, driver attributes, and injury outcome. Specifically, the crash consequences for road users other than the impaired driver are revealed by the External Casualty Model. This study demonstrates that alcohol impairment on driver significantly increases the risk of severe injury to other road users by four times. The safety education campaign should stress on this adverse impact of drink driving on innocent people. Also, crashes on weekends are more likely to result in severe injury.

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