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Toxicological findings in driver and motorcyclist fatalities in Scotland 2012–2015

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ABSTRACT

Fatal motor vehicle crashes (MVCs) continue to be a common occurrence worldwide. This paper presents a retrospective analysis of the toxicological investigation of drivers and motorcyclists fatally injured in MVCs in Scotland from 2012 to 2015. One hundred and eighteen cases with full toxicological analysis, *i.e.*, alcohol, drugs of abuse and prescription drugs, were examined. Of those 118 MVC cases, 74 (63%) were car drivers, 32 (27%) were motorcyclists and the remaining were drivers of other vehicles such as large goods vehicles. The majority of deceased drivers and motorcyclists were male ($N = 104$, 88%). For the toxicological findings, 51 (43%) of the cases were negative, and of the 67 (57%) positive cases, alcohol and cannabinoids were the most frequently detected substances, followed by opioids and benzodiazepines. Fifteen percent of all drivers and motorcyclists were over the prescribed blood alcohol limit at the time of analysis. In comparison to previous reports of drug use by drivers in Scotland, benzodiazepines and new psychoactive substances were less common findings in fatally injured drivers and motorcyclists than in drivers suspected of being impaired.

1. Introduction

It has long been recognized that alcohol and certain drugs may impair a person's driving ability [1]. It is also well known that drug use by drivers can increase the risk of being killed in motor vehicle collisions (MVCs) [2–4]. Both illicit psychoactive drugs such as cannabis and amphetamine, and prescription medications such as benzodiazepines can impair driving [5].

Fatal MVCs continue to be a common occurrence worldwide, with the World Health Organisation reporting that 1.25 million road traffic deaths occurred globally in 2013 [6]. Surveys of the incidence of drugs and alcohol in MVCs have been carried out in numerous countries, including Australia [7], Brazil [8], Canada [1], England & Wales [9,10], France [11], Jordan [12], New Zealand [13], Norway [14,15], Spain [16], Sweden [17] and other Northern European Countries [18], and the USA [19]. However, little is known about how frequently drugs are involved in fatal MVCs in Scotland, with the last detailed study having been published in 1999, and then only for the Strathclyde region [20]. Updated information is required in order to reflect changes in the availability of new substances, and changes in drug use trends and legislation [9].

The Toxicology Laboratory based within Forensic Medicine & Science at the University of Glasgow receives post-mortem cases from all regions of Scotland with the exception of the far northern regions. All post-mortem cases submitted to the laboratory for toxicological investigations are recorded within the in-house database, which also incorporates some demographic information [21].

The aim of this study was to examine the toxicological findings in recently fatally injured drivers and motorcyclists in Scotland, and analyse them with respect to gender, age, vehicle type and drug and alcohol findings.

2. Method

Fatal MVC cases received by the laboratory between June 2012 and September 2015 involving deceased drivers and motorcyclists were selected for this study. Deceased cyclists, pedestrians and passengers were not included in the scope. One hundred and forty-six cases were identified from the cause of death entered in the in-house database (for West of Scotland cases) or from case documentation (for other areas of Scotland).

As part of routine casework for these fatalities when they were initially submitted, whole peripheral post-mortem blood samples were collected. Preserved blood samples were analysed for

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alcohol (GC–FID) and unpreserved blood samples were analysed for drugs of abuse (ELISA), paracetamol (HPLC) and basic drugs (GC–MS) as a minimum. The basic drugs analysis targets a range of prescription medications including antidepressants, antipsychotics, antihistamines and analgesics such as methadone. The core drug groups recommended in the guidelines for this type of study were all tested [22].

Presumptive ELISA positives were confirmed by more specific and sensitive mass spectrometric techniques (GC–MS and LC–MS/MS) on unpreserved blood samples, except for cocaine analyses, which were carried out on preserved blood. Urine and vitreous humour samples were available in some cases and were analysed for alcohol and, if applicable, opiates. However, findings in urine and vitreous humour are not reported in this study. Hospital samples were analysed in nine cases ($N = 3$ whole blood samples and $N = 6$ serum samples). In cases where emergency medical treatment was indicated in the case records, findings of morphine, ketamine, midazolam or lidocaine were excluded.

3. Results & discussion

Of the 146 cases identified, only 118 had full toxicological results. In December 2014 the Scottish Government reduced the legal blood alcohol concentration (BAC) limit for drivers from 80 mg/100 mL to 50 mg/100 mL. Forty-nine of the cases examined in this study occurred after the new limit was introduced and 97 occurred before. A summary of the results of this study is shown in Table 1.

Of the 118 cases examined, 88% of the drivers and motorcyclists were male, with only 12% of deceased drivers being female. All of the females in this study were car drivers. The mean age of female drivers ($N = 14$) was 44, range = 18–71, and the mean age of male drivers and motorcyclists ($N = 104$) was 41, range = 17–86. The mean age for both genders was 41.5. The gender and age distribution for this study is shown in Fig. 1.

In this study, 24 (20% of all fatalities) drivers or motorcyclists were positive for alcohol, with or without drugs. The BACs were characterised by a mean and median of 125 mg/100 mL with a range of 10–256 mg/100 mL. Of the 24 alcohol-positive drivers and motorcyclists, all but one were male, in agreement with previous research indicating that men in Scotland are more likely to drive after drinking than women [23].

It should be noted that five of the BACs reported in this study were <50 mg/100 mL (concentrations of 10, 10, 12, 24 and 38 mg/100 mL, all post-mortem samples) and that the interpretation of BACs in post-mortem cases can be complicated by post-mortem alcohol production. Upon decomposition, alcohol can be produced by the action of microbes and the fermentation of glucose [24]. This phenomenon can lead to BACs of up to 60 mg/100 mL [25]. Consequently, the presence of alcohol in the five cases mentioned above, could have been due to post-mortem production rather than any ante-mortem consumption of alcohol by the drivers.

Fifteen percent of all fatalities in this study ($N = 18$) involved a driver or motorcyclist who was over the prescribed blood alcohol limit at the time of analysis. This is lower than all of the similar studies reported in the literature, including the 21% in Sweden (limit = 20 mg/100 mL) [17], 11% in France (limit = 50 mg/100 mL) [11], 25% in Norway (limit = 20 mg/100 mL) [14], 36% in Brazil (zero tolerance) [8], and 29% in Australia (limit = 50 mg/100 mL) [7]. Of the alcohol-positive drivers, 75% were over the prescribed limit at the time of analysis in this study, compared to 67% in a study in England & Wales (limit = 80 mg/100 mL) [9].

Table 1
Summary of the cases examined.

Case type ($N = 118$)	N	%
Negative	51	43
Alcohol-only positive (BAC ≥10 mg/100 mL)	9	8
Drug-only positive	43	36
Alcohol and drug positive	15	13
Car drivers	74	63
Motorcyclists	32	27
Other (LGV, minibus, van, tractor, scooter, quad bike)	12	10

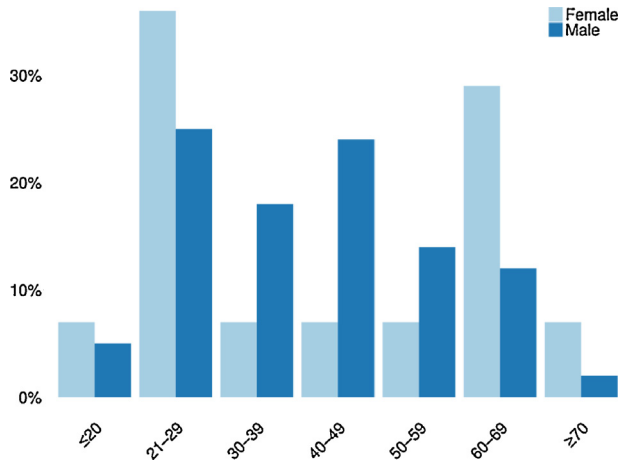

Fig. 1. Age breakdown of fatal MVCs by gender.

Across the three-year period examined, data showed the use of drugs alone increased, while the use of a combination of drugs and alcohol decreased. Only 4 cases were examined from 2012, so these cases are excluded for this comparison only to leave 114 cases with full toxicological data. The number of cases involving drug use alone in fatal driver MVCs from January to December 2013 was found to be 11 (38% of the year's cases), 10 in 2014 (25%) and 21 in 2015 (47%); it must be noted that the data for 2015 is incomplete. Alcohol and drug use were found in 14% ($N = 4$) of fatal driver MVCs in 2013, 10% in 2014 ($N = 4$) and 13.3% in 2015 ($N = 6$).

To simplify the statistical analysis, drugs were categorized into drug families [26]. *Benzodiazepines* includes diazepam and its active metabolites desmethyldiazepam, temazepam and oxazepam, and the new-generation benzodiazepine phenazepam. The *cannabinoid* group contains only the active ingredient, Δ^9-tetrahydrocannabinol (THC), and/or its carboxy metabolite (carboxy-THC); synthetic cannabinoid compounds were not included in this study. *Opioids* includes codeine, morphine, dihydrocodeine, tramadol and methadone. These opioids were part of the 'opiates' or 'basic drugs' analyses. Other opioids, such as oxycodone, require specific targeted analyses, carried out on a case-by-case basis, and were not seen in this study. The drugs included in the *other prescription medications* group were antidepressants, antihistamines and anticonvulsants. The only non-prescription medications encountered were diphenhydramine and paracetamol, and these are categorized as *over-the-counter medications.* The final drug category was *stimulants* and encompassed cocaine and/or its metabolites benzoylecgonine, ecgonine methyl ester and cocaethylene, and the amphetamine-type stimulants amphetamine, ephedrine and 3,4-methylenedioxymethamphetamine (MDMA, Ecstasy) with its main metabolite, 3,4-methylenedioxyamphetamine (MDA).

The most common drug finding in this study was cannabinoids ($N = 24$, 20% of all fatalities), with THC itself present in 8 of the 24 cases and always accompanied by carboxy-THC. Evidence of cannabis use was present in 10 cases in 2013 (34.5% of the year's cases), 7 cases in 2014 (17.5%) and 7 cases in 2015 (15.2%).