Diseases, consumption of medicines and responsibility for a road crash: A case–control study

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ABSTRACT

The role of medical conditions in crashes is a topic of public debate. Some studies suggest that there has been a reduction in road traffic crashes subsequent to the medical restrictions introduced on drivers with medical deficiencies. As in today’s society the car is an important factor for independence and socialization, it seems important to consider whether diseases or consumption of drugs increase the risk of causing a road crash in comparison to well-known major crash risk factors. A case–control study was conducted (733 injured drivers). The cases were subjects who were partly or totally responsible for their crash. The 304 controls were the non-responsive drivers. Diseases and medicine consumption were analyzed using logistic regression models. Cases were characterized by a higher percentage of young men. They were more frequently affected by fatigue, as were subjects who had consumed alcohol. A higher risk in subjects suffering from hypertension is observed (adjusted odds ratio [adjOR] = 3.82; 95%CI = [1.42–10.24]). An association between antidepressant consumption and responsibility appeared (adjOR = 3.61; 95%CI = [1.30–10.03]).

Conclusion: Medical factors associated with responsibility were arterial hypertension and antidepressant consumption. Other medical conditions do not seem to play a preponderant role comparing to individual behaviours.

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1. Introduction

In many countries, the role of diseases or drugs in road traffic crashes is a topic of public debate which is renewed each time an elderly person or a professional driver affected by an illness is designated as having been responsible for a crash. The diseases that are most frequently mentioned in this connection are cardiovascular diseases (McGwin et al., 2000; Norton et al., 1997; Sagberg, 2006), diabetes (Lagarde et al., 2005; Norton et al., 1997) and anxiety or depression (Norton et al., 1997). The consumption of medicines is also considered to be linked to responsibility for a road crash (Lagarde et al., 2005), particularly in the case of benzodiazepines (McGwin et al., 2000; Movig et al., 2004), or, for diabetics, being treated by insulin rather than an oral antidiabetic (Hemmelgarn et al., 2006). Furthermore, the risk of being responsible for a crash is increased by the use of alcohol and psychoactive substances (Movig et al., 2004), in particular in the case of simultaneous consumption of alcohol and drugs (Laumon et al., 2005).

Regulations with regard to obtaining a driving licence have become stricter in many countries. It is not unusual for political leaders to mention the possibility of reinforcing the law in the case of the above diseases. Two North American studies (Marshall et al., 2002; Vernon et al., 2001) suggest that there has been a reduction in road traffic crashes subsequent to the medical restrictions introduced on drivers with certain medical deficiencies. In France, a decree of 2005 (Ministère des transports, 2005) lists the medical conditions which are incompatible with obtaining or retaining a driving licence, or for which a medical examination is necessary. The list covers the whole field of medicine.

As in today’s society the car is an important factor for independence and socialization, it seems important to consider whether
2. Materials and methods

This is a case–control study in which the variable of interest is responsibility (Robertson and Drummer, 1994; Williams and Shabanova, 2003) for a road traffic crash, that has been conducted using the ESPARR cohort.

2.1. The ESPARR project

The “ESPARR” project aims to monitor a population of road crash casualties in order to study the short and medium term consequences of the crash. The inclusion period is from 1 October 2004 to 31 December 2005. All casualties who sought medical care after a crash in health facilities of the Rhône administrative area (from public and private hospitals) were eligible to be included. The inclusion criteria are as follows:

- having had a road traffic crash involving at least one mechanical transport mode;
- living and having had the crash in the Rhône administrative area (1.6 M inhabitants);
- having survived the crash, and
- having been a patient in one of the area’s hospital.

Because of the large disproportion between casualties with minor injuries (90% of casualties) and those with severe injuries, inclusion has been stratified on the basis of the maximum injury severity using the abbreviated injury scale (AAAM, 1990). This classification is used to standardize the data on the injuries sustained by the subjects. The MAIS is the highest AIS sustained by a casualty. The objective was to recruit all crash-involved individuals with a serious to critical injury (MAIS ≥ 3), with one casualty in two having a moderate injury (MAIS 2) and one casualty in six having a minor injury (MAIS 1). The presence of the interviewers in the emergency units was planned with this aim. In all, 1373 subjects (all ages included) agreed to participate in the project, forming the ESPARR cohort. Among them, 733 were drivers of motorized vehicles; others were passengers, pedestrians, cyclists, etc.

At the time they were receiving hospital care, subjects were asked to participate in a study on the consequences of road crashes, which was the main objective of the cohort; a team of investigators interviewed them, as soon as possible in the emergency department or later in the surgical wards, in order to collect information on the circumstances of the crash, their state of health, their social and family life, their normal behaviour on the road, and their consumption habits. The aim of this first interview was to collect data on the situation of the subjects before the accident in order to compare their state of health 6 months, 1 year and 3 years after the accident with their situation before the accident. The secondary objectives (case–control analysis on diseases/drugs related to the responsibility) were not presented at the moment of the interview.

2.2. The cases and the controls

Of the 939 injured subjects, who were all over 15 years of age and drivers of motorized vehicles and contacted a view to joining the ESPARR study, 733 agreed to participate: the refusal rate was 17.7%; 40 subjects (4.2%) did not participate for other reasons (essentially language problems, or discharge from the hospital before being contacted by the researcher, 3 subjects were not included due to psychiatric problems, two due to police intervention, one was too deeply upset to be interviewed (death of his spouse during the accident). There was no difference in the gender or age distribution of the crash-involved individuals who agreed to take part in the study and those who refused.

The crash responsibility was determined on the basis of self-reporting. The subjects were asked to answer the question “do you consider that you were responsible for the crash?”. Four levels of responsibility were used: “yes, completely responsible”, “yes, partly responsible”, “not responsible” and “doesn’t know”.

The cases were drivers who were involved in a car-to-car crash (collision) for which they stated they were completely or partially responsible (132 subjects) and drivers who were involved alone in a single vehicle crash (248 subjects). The 304 controls were drivers who were involved in a collision for which they stated they were not responsible. The basic idea for this choice is that these controls are considered as fairly representative of all the drivers on the road (Laumon et al., 2005; Lenguerrand et al., 2006). The 36 people who stated that they did not know whether they were responsible and the thirteen people who eluded this question were excluded from the analysis (i.e. 6.7% of the subjects).

2.3. The studied diseases

During the initial interview, information on the diseases and medicines were collected through several open questions and finally by a closed series of questions listing health problems. Questions about neurological/psychiatric drugs (name of the drugs) absorbed during the week preceding the accident and during the 3 h before the accident were asked. Consumption of alcohol, tobacco and other substances were similarly asked. The diseases which were reported by the subjects were grouped together on the basis of the six categories of diseases listed in the 2005 decree: (1) cardiovascular diseases, (2) visual impairment, (3) lung or otorhinolaryngological diseases, (4) neurological or psychiatric diseases and addictive practices, (5) locomotor disorders and (6) metabolic diseases and transplants. For each of these categories, the diseases reported by the patients were coded according to the following criteria: no disease in this category of the decree, disease probably in this category, disease certainly in this category. Because of the small number of subjects we then performed regrouping and presence/absence dichotomous coding.

The following diseases were then dealt with individually: diabetes, migraine, epilepsy, heart rhythm disorders, hypertension, asthma, osteoarticular disorders, hearing problems, sleep disorders, glaucoma, astigmatism and myopia.

We only obtained the name of drugs for the psychiatric/neurological drugs; for the others we only have the notion of consumption of drugs for specific diseases such as: asthma treatment, antihypertensive drugs, etc. From the name of each neurological drug, we grouped the medicines together following their pharmacological family, and then following their sedating type.

The researcher who coded diseases and drugs for the totality of the cohort was not aware of the status of the subjects (road user type, responsibility, etc.).

2.4. Statistical analysis

A road trauma registry has been in operation in the Rhône administrative area since 1995. The registry covers all casualties
**Table 1**

Description of the study population

<table>
<thead>
<tr>
<th>Variables</th>
<th>Cases (N=380)</th>
<th>Controls (N=304)</th>
<th>Crude OR</th>
<th>95%CI</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Sociodemographic characteristics</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gender: male</td>
<td>277 72.9</td>
<td>188 61.8</td>
<td>1.75</td>
<td>1.27–2.44</td>
</tr>
<tr>
<td>Age at the time of the crash</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>[16; 19]</td>
<td>68 17.9</td>
<td>25 8.2</td>
<td>3.47</td>
<td>1.92–6.29</td>
</tr>
<tr>
<td>[20; 29]</td>
<td>143 37.6</td>
<td>104 34.2</td>
<td>1.61</td>
<td>1.06–2.44</td>
</tr>
<tr>
<td>[30; 39]</td>
<td>84 22.1</td>
<td>84 27.6</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>[40; 49]</td>
<td>41 10.8</td>
<td>59 19.4</td>
<td>0.70</td>
<td>0.41–1.21</td>
</tr>
<tr>
<td>≥50 years</td>
<td>44 11.6</td>
<td>32 10.5</td>
<td>1.37</td>
<td>0.77–2.44</td>
</tr>
<tr>
<td><strong>Family situation</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Living as part of a couple</td>
<td>147 38.7</td>
<td>147 48.4</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Single</td>
<td>200 52.6</td>
<td>118 38.8</td>
<td>1.89</td>
<td>1.34–2.65</td>
</tr>
<tr>
<td>Separated, divorced, widowed</td>
<td>33 8.7</td>
<td>39 12.8</td>
<td>0.66</td>
<td>0.37–1.17</td>
</tr>
<tr>
<td><strong>Socio-occupational group</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Farmers, tradesmen</td>
<td>25 6.6</td>
<td>22 7.3</td>
<td>1.28</td>
<td>0.65–2.52</td>
</tr>
<tr>
<td>Senior managerial staff and higher intellectual professions</td>
<td>32 8.4</td>
<td>38 12.5</td>
<td>0.68</td>
<td>0.39–1.17</td>
</tr>
<tr>
<td>Middle level professions</td>
<td>27 7.1</td>
<td>21 6.9</td>
<td>0.97</td>
<td>0.49–1.87</td>
</tr>
<tr>
<td>Clerical and service staff</td>
<td>164 43.3</td>
<td>141 46.5</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Manual workers</td>
<td>58 15.3</td>
<td>45 14.9</td>
<td>1.11</td>
<td>0.68–1.82</td>
</tr>
<tr>
<td>Non-working</td>
<td>73 19.3</td>
<td>36 11.9</td>
<td>1.88</td>
<td>1.16–3.03</td>
</tr>
<tr>
<td><strong>Information concerning the crash</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Type of journey</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Home-to-work</td>
<td>98 25.9</td>
<td>124 40.8</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Private</td>
<td>257 67.8</td>
<td>160 52.6</td>
<td>2.10</td>
<td>1.48–2.97</td>
</tr>
<tr>
<td>Business</td>
<td>24 6.3</td>
<td>20 6.6</td>
<td>1.86</td>
<td>0.94–3.67</td>
</tr>
<tr>
<td>Type of vehicle</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Four-wheeled vehicle</td>
<td>187 49.2</td>
<td>194 63.8</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Motorized two-wheeled vehicle</td>
<td>193 50.8</td>
<td>110 36.2</td>
<td>2.82</td>
<td>2.02–3.95</td>
</tr>
<tr>
<td>Time of accident</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Time night [22H; 7H]</td>
<td>57 15.0</td>
<td>28 9.2</td>
<td>1.72</td>
<td>0.98–3.01</td>
</tr>
<tr>
<td>Weekend</td>
<td>113 29.7</td>
<td>61 20.1</td>
<td>1.75</td>
<td>1.18–2.58</td>
</tr>
<tr>
<td>Consumption of alcohol 3 h before the crash</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>65 17.6</td>
<td>11 3.6</td>
<td>5.12</td>
<td>2.40–10.94</td>
</tr>
<tr>
<td>Don’t know</td>
<td>83 21.8</td>
<td>22 7.2</td>
<td>3.32</td>
<td>1.99–5.54</td>
</tr>
<tr>
<td><strong>Fatigue at time of crash</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>14 3.7</td>
<td>5 1.6</td>
<td>2.99</td>
<td>0.94–9.50</td>
</tr>
</tbody>
</table>

*a* Missing information for one case and one control. 
*b* Missing information for one case.

from road crashes reported by all health care facilities in the area. As a first step, we controlled the representativeness of our subjects, by comparing: (1) respondents and non-respondents; (2) respondents and all the victims of road crashes in the road trauma registry, for the same period; (3) respondents for the question on responsibility and non-respondents to this question. \( \chi^2 \)-tests and comparison of means (continuous variables) were carried out.

A univariate analysis was then performed to identify the risk factors associated with responsibility. These consisted on the one hand of non-medical risk factors: gender, age, type of journey, type of driver, day of the week (weekend or other), tiredness at the time of the crash, alcohol consumption during the 3 h prior to the crash and annual mileage driven, and on the other hand of medical conditions starting with the six categories defined in the 2005 decree then the diseases described individually above and, lastly, the consumption of antidepressants, anxiolitics, hypnotics drugs, antihypertensive drugs, antidiabetics, etc. during the last week before the crash.

Three multivariate modelling processes were conducted for each of the three above approaches. Fitting was first of all performed for the variables selected from among the general factors that were globally significant at the 20% level in the univariate analysis. The multivariate analysis strategy then attempted to select those which were significantly associated with responsibility using a top-down procedure. Last, only the adjustment variables which modified the odds ratios of the diseases/drugs by more than 10% were retained in the final model (Greenland, 1989).

The statistical analysis referred to the sampling plan. A logistic regression model that took account of the sampling weight on the basis of the severity level (3 M.AIS levels) was used to determine the risk factors for causing a road traffic crash. The survey logistic procedure in the SAS® software, Version 9.1 was used (SAS Institute Inc., Cary, NC, USA).

### 3. Results

#### 3.1. Non-medical factors

The subjects who were responsible for their crash were characterized by a higher percentage of young men (Table 1); these individuals were more frequently students, single, two-wheeled vehicle users and involved in a crash that occurred more frequently during the weekend or at night in the course of a private journey. They were more frequently affected by fatigue, as were subjects who had consumed alcohol in the 3 h leading up to the crash.
Table 2
Adjusted odds ratios for the 6 categories defined in the 2005 decree (weighted logistical regression; adjusted for age, alcohol consumption within the 3 h preceding the crash and fatigue at the time of the crash)

<table>
<thead>
<tr>
<th>Category of the 2005 decree</th>
<th>Cases</th>
<th>Controls</th>
<th>Odds ratio</th>
<th>95%CI</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>n</td>
<td>%</td>
<td>n</td>
<td>%</td>
</tr>
<tr>
<td>Cardiovascular diseases</td>
<td>17</td>
<td>4.6</td>
<td>24</td>
<td>7.9</td>
</tr>
<tr>
<td>Visual impairment</td>
<td>100</td>
<td>27</td>
<td>92</td>
<td>30.3</td>
</tr>
<tr>
<td>Otorhinolaryngological and lung diseases</td>
<td>44</td>
<td>11.9</td>
<td>30</td>
<td>9.9</td>
</tr>
<tr>
<td>Addictive practices—neurological and psychiatric disorders</td>
<td>53</td>
<td>14.3</td>
<td>30</td>
<td>9.9</td>
</tr>
<tr>
<td>Locomotor disfunctions</td>
<td>4</td>
<td>1.1</td>
<td>5</td>
<td>1.6</td>
</tr>
<tr>
<td>Metabolic diseases and transplants</td>
<td>6</td>
<td>1.6</td>
<td>4</td>
<td>1.3</td>
</tr>
</tbody>
</table>

* Reference group are cases and controls who do not suffer from a pathology of the category.

3.2. Diseases or drugs associated with responsibility

3.2.1. Diseases grouped together in classes as in the 2005 decree

After adjustment, no risk of responsibility (Table 2) is associated with having cardiovascular diseases or visual impairment, neither with the otorhinolaryngological or lung diseases nor with nervous and psychiatric diseases and addictive practices. The number of subjects affected by class 5 diseases (locomotor disfunctions) and class 6 diseases (metabolic diseases and transplants) is low, which makes it impossible to interpret the odds ratios.

3.2.2. Specific diseases

An excess risk of responsibility in subjects suffering from hypertension is observed (Table 3). Persons suffering from heart rhythm disorders had no risk of responsibility. More cases declared suffering of asthma but the difference was not significant. Hearing problems and migraine were not associated with higher risk. Neither astigmatism nor myopia was associated with responsibility.

Five cases and two controls suffered from glaucoma. Only 10 drivers (6 responsible and 4 non-responsible) suffered from diabetes; and the same number of individuals had a history of epilepsy. Only 5 cases and 4 controls suffered from sleep apnoea, i.e. 1.3% of the drivers. Due to this small numbers it was not possible to evaluate the risk of causing a crash associated with these diseases.

No excess risk was observed in the case of sleep disorders in general (crude odds ratios [OR] = 1.23; 95% CI = 0.83–1.83). More detailed analysis of the types of sleep disorder showed a higher odds ratio in the case of individuals reporting early waking which could be a symptom of the depression.

Table 3
Adjusted odds ratios for specific diseases (weighted logistical regression; adjusted for age, alcohol consumption within the 3 h preceding the crash and fatigue at the time of the crash)

<table>
<thead>
<tr>
<th>Pathology</th>
<th>Cases</th>
<th>Controls</th>
<th>Odds ratio</th>
<th>95%CI</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>n</td>
<td>%</td>
<td>n</td>
<td>%</td>
</tr>
<tr>
<td>Heart rhythm disorders</td>
<td>8</td>
<td>2.2</td>
<td>14</td>
<td>4.7</td>
</tr>
<tr>
<td>Arterial hypertension</td>
<td>21</td>
<td>5.8</td>
<td>10</td>
<td>3.3</td>
</tr>
<tr>
<td>Migraine</td>
<td>39</td>
<td>10.8</td>
<td>39</td>
<td>13.0</td>
</tr>
<tr>
<td>Asthma</td>
<td>30</td>
<td>8.3</td>
<td>16</td>
<td>5.3</td>
</tr>
<tr>
<td>Osteoarticular disorders</td>
<td>57</td>
<td>15.8</td>
<td>52</td>
<td>17.3</td>
</tr>
<tr>
<td>Hearing problem</td>
<td>19</td>
<td>5.3</td>
<td>18</td>
<td>6.0</td>
</tr>
<tr>
<td>Early waking</td>
<td>42</td>
<td>11.7</td>
<td>20</td>
<td>6.7</td>
</tr>
<tr>
<td>Astigmatism</td>
<td>47</td>
<td>13.1</td>
<td>33</td>
<td>11.0</td>
</tr>
<tr>
<td>Myopia</td>
<td>63</td>
<td>17.5</td>
<td>67</td>
<td>22.3</td>
</tr>
</tbody>
</table>

* Reference group are cases and controls who do not suffer from the specific pathology.

3.2.3. Consumption of medicines

An association between antidepressant consumption during the week preceding the crash and responsibility appeared (Table 4). The consumption of anxiolytics did not lead to a significant increase in the risk of causing a crash. We did not find a trend with the sedating effect of psychiatric/neurological drugs (Class 2: OR = 1.63; 0.87–3.04; class 3: OR = 1.10; 0.46–2.68 but the analysis was made on small numbers).

Table 4
Adjusted odds ratios for the consumption of medicines during the week preceding the crash (weighted logistical regression; adjusted for age, type of journey, alcohol consumption within the 3 h preceding the crash and fatigue at the time of the crash)

<table>
<thead>
<tr>
<th>Consumption of medicines in the week preceding the crash</th>
<th>Cases</th>
<th>Controls</th>
<th>Odds ratio</th>
<th>95%CI</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>n</td>
<td>%</td>
<td>n</td>
<td>%</td>
</tr>
<tr>
<td>Anxiolytics</td>
<td>15</td>
<td>4.1</td>
<td>7</td>
<td>2.3</td>
</tr>
<tr>
<td>Antidepressants</td>
<td>17</td>
<td>4.6</td>
<td>7</td>
<td>2.3</td>
</tr>
<tr>
<td>Hypnotics</td>
<td>10</td>
<td>2.7</td>
<td>6</td>
<td>2.0</td>
</tr>
<tr>
<td>Antihypertensive medicines</td>
<td>10</td>
<td>2.7</td>
<td>4</td>
<td>1.3</td>
</tr>
<tr>
<td>Other cardiovascular medicines</td>
<td>7</td>
<td>1.9</td>
<td>3</td>
<td>1.0</td>
</tr>
<tr>
<td>Anti-inflammatory</td>
<td>8</td>
<td>2.2</td>
<td>4</td>
<td>1.3</td>
</tr>
<tr>
<td>Antiepileptic</td>
<td>2</td>
<td>0.5</td>
<td>3</td>
<td>1.0</td>
</tr>
<tr>
<td>Opiate analgesics</td>
<td>1</td>
<td>0.3</td>
<td>3</td>
<td>1.0</td>
</tr>
<tr>
<td>Thyroxin and other thyroid medicines</td>
<td>0</td>
<td>0</td>
<td>4</td>
<td>1.3</td>
</tr>
</tbody>
</table>

* Reference group are subjects who do not take the corresponding medicines.
The percentage of individuals who had taken medicines, during the last week before the crash, to control hypertension (2.7% of the cases versus 1.3% of the controls), hypnotics (2.7% versus 2.0%) or anti-inflammatory drugs (2.2% versus 1.3%) was higher among the cases than among the controls, but these differences were not significant.

In general, the consumption of any type of medicine during the 3 h before a crash was associated with responsibility for it (adjusted OR = 2.99, 95% CI = 1.14–7.87).

4. Discussion

We set up a case–control study within a cohort of road traffic crash casualties. The recruitment protocol for this cohort ensured that the recruited subjects were representative of road crashes victims in the Rhône area. The major factors associated with responsibility were those which are usually recognized as potential crash-involvement or crash mortality risk factors: age, driving a two-wheeler, alcohol consumption, night or weekend driving (Laumon et al., 2005; Rice et al., 2003; Vorko-Jovic et al., 2006). Medical conditions, which have been a topic of much controversy for several years, seem to play a less predominant role compared to individual behaviours. These results are consistent with other findings (Guibert et al., 1998; Parmentier et al., 2005). In our study, the only disease or medicine associated with responsibility was arterial hypertension and antidepressant medicine.

4.1. Comparison with other studies

The risk crash responsibility is lower for individuals who belong to category 1 in the 2005 decree (cardiovascular diseases). However, in our study, arterial hypertension is clearly associated with the risk of being responsible for the crash. A Canadian study (Laberge-Nadeau et al., 1996) has shown that bus drivers with hypertension were more frequently involved in severe crashes than those without the problem. Several studies have shown the existence of an association between arterial hypertension and accidental death (Lardelli-Claret et al., 2003); in particular, a significant excess risk appears as soon as systolic pressure exceeds 150 mm Hg or diastolic pressure exceeds 105 mm Hg (Lam and Lam, 2005; Terry et al., 2007; Variainen et al., 1994). Sagberg (2006) has shown that, in Norway, there is an excess incidence of crash responsibility among drivers with a history of myocardial infarction or cerebral ischemia. Lam (Lam and Lam, 2005) has demonstrated a higher incidence of sudden illness amongst people involved in a severe crash. The question is how hypertension could increase the risk. Several subjects said that they had a sudden sensation of malaise just before the accident. Hypertension is causative of malaise, vertigo, etc. just as antihypertensive medicines have been described as responsible for orthostatic low blood pressure; both could explain this relation. In our study, the odds ratio for hypertension is significantly increased, which is not the case for hypertensive drugs in spite of a high odds ratio. However, it is difficult to separate the part of the disease and that of antihypertensive drugs.

We have not found any link between responsibility and migraine, despite the fact that in Norton’s study (1997), individuals treated for migraine were found to have had twice as many injury crashes as individuals who do not suffer from migraine.

Diabetes and epilepsy are the two diseases that are the most frequently reported as being associated with higher road traffic crash risk (Lagarde et al., 2005; Norton et al., 1997). On the contrary, Kennedy (Kennedy et al., 2002) found that diabetes was not responsible for an increase in road traffic crashes. We were not able to investigate the association between diabetes or epilepsy and responsibility because of the small number of cases; in any case, taking into account the low prevalence of these diseases amongst the injured drivers (1.4% of the drivers in our study), they are not a priority in terms of public health, although the issue of excess risk is an important one for subjects who suffer from these diseases.

We have observed excess risk associated with the consumption of antidepressants, but not in the case of anxiolytics. All the antidepressants correspond to medicines whose harmful pharmacodynamic impacts on driving dominate over individual susceptibility. The antidepressants may adversely affect driving (sleepiness, visual disorders and behavioural disorders). Their consumption was associated with crash responsibility in Norway (Sagberg, 2006). The taking of antidepressants doubles the risk of road traffic crash involvement in the case of elderly people (Hu et al., 1998).

In an Australian study (Lam et al., 2005), drivers with suicidal thoughts who do not take antidepressants have a higher crash risk (OR = 4.2) than drivers who do not have suicidal thoughts and who do not take antidepressants. We have not revealed an increase in the risk of responsibility among individuals who belong to class 4 of the decree that relates to neurological or psychiatric diseases. These negative results can no doubt be blamed on a lack of specificity in the classes defined by the decree.

Fatigue plays an important role: another study on all traffic crashes with at least one severe injury or fatality (Philip et al., 2001) has shown that fatigue (OR = 1.5; 95% CI = 1.4–1.6) and more specifically fatigue associated with alcohol intake was a major risk factor for traffic crashes.

4.2. Sampling and consistency consideration

The participation rate of the injured drivers contacted and meeting the criteria of the study was 78%. The group of non-participants did not differ from that of participating subjects, whether on the basis of distribution by gender, age or injury severity. Compared to the Rhône Area road traffic crash register which systematically and exhaustively records the crash-involved individuals in the same recruitment zone, there was no significant difference among subjects with an M-AIS equal to or less than 2. Among subjects with more severe injuries, there was no difference in average age, but the oldest drivers were slightly less numerous, and men participated less than women too: 61.2% in our study, versus 67.7% in the register.

The majority of studies are based on severely injured populations or on populations that are surveyed as a result of intervention by law enforcement agencies: the level of under-recording of injury crashes by police forces is higher in the case of minor injuries than severe crashes (Amoros et al., 2006). Our study is based on drivers who were injured in a crash who received care in a health care facility, whatever the degree of injury. The study dealt with responsibility for a road traffic crash in the case of all drivers of motorized vehicles who were injured in a road traffic crash, irrespective of the severity of the crash. Lastly, statistical analysis was based on the sampling plan used, which took account of injury severity.

Moreover, our results are very consistent with the risk factors that are already recognized: thus, alcohol consumption is an important factor for both crashes and responsibility. Our results are comparable with several studies of responsibility within different populations (Desapriya et al., 2006; Laumon et al., 2005). The same applies to the factors that reveal risk-taking (Lagarde et al., 2004).

In order to study the concept of responsibility, the “not-responsible” crash-involved driver must be independent from the “responsible” crash-involved driver. As only 9 cases and 9 controls were involved in the same collision (i.e. 3% of
crash-involved drivers), it is not necessary to take account of dependencies between subjects and generalized linear models for non-hierarchical data to remain valid (Lenguerrand et al., 2006).

4.3. The concept of responsibility

We have validated the subject’s declaration of responsibility on a subsample of our population, involved in a two-car crash, by comparing the subject’s statement with the responsibility assigned by the Robertson and Drummer algorithm (Robertson and Drummer, 1994) on the basis of information about the circumstances of the crash provided by police data. This method has been used and validated by Laumon et al. (2005) in a study on the role of drugs in fatal crash causation. Among the 194 crash-involved subjects, for whom adequate data was available in both databases (ESPARR and police), 91.1% stated that they were responsible (51 out of 56) and this was confirmed by the Robertson and Drummer method. Conversely, 43 out of 138 who stated they were not responsible, were assigned some responsibility by the algorithm: we found that they were not different to the subjects without any responsibility when comparing different variables (age, sex, M-AIS, state of health, normal behaviour on the road, and consumption habits).

Some authors used other ways to attribute the responsibility in car crashes. The attribution of the responsibility by modellisation is understandable when authors worked on national or regional databases, where the circumstances of the crash are not easy to use (Wasielewski and Evans, 1985). Lafont (Lafont et al., 2008) attributed the responsibility in equal part to each driver involved in one accident with the aim of counteracting a selection bias related to the fact that older drivers are more likely to be involved in fatal or severe crashes (the inclusion in the study was dependant of the studied criteria). In our study we looked for risk factors related to the responsibility for a subject of being injured in a road accident, while we obtained the description of the crash and his/her own opinion about his/her responsibility from the injured driver, which is very different from the two other approaches.

Using the responsibility declared by the subjects to classify the cases and the controls might underestimate the odds ratios, but there is no reason for a greater underestimation for diseases or drugs than for alcohol or fatigue: the odds ratios for alcohol are very close to previous publications as seen below in Section 4.4.

4.4. The representativeness of the controls

The representativeness of non-responsible subjects in relation to the population of drivers has been much discussed in papers dealing with quasi-induced exposure and, to a lesser extent, in responsibility analyses, where it is almost as debatable (Lardelli-dealing with quasi-induced exposure and, to a lesser extent, in responsibility analyses, where it is almost as debatable (Lardelli-dealing with quasi-induced exposure and, to a lesser extent, in responsibility analyses, where it is almost as debatable (Lardelli-dealing with quasi-induced exposure and, to a lesser extent, in responsibility analyses, where it is almost as debatable (Lardelli-dealing with quasi-induced exposure and, to a lesser extent, in responsibility analyses, where it is almost as debatable (Lardelli-

4.5. Selection bias

Our study may therefore suffer from a selection bias and underestimate some factors associated with responsibility. We have no information on uninjured drivers who were involved in an injury crash. Moreover, the drivers who were killed in a crash do not satisfy the criteria for the study. Over 60 years of age, more than 70% of drivers who were responsible for a fatal crash were among those killed (Williams and Shabanova, 2003; Lafont et al., 2008). Nevertheless, according to Valant (Valent et al., 2002) the crash risk factors are similar, whether drivers are injured or killed in the course of a crash.

Some individuals may have had a medical deficiency at the time of the crash, and refused to take part in the study for fear of having their driving licence suspended. However, the design of the initial study had another objective, that of studying the consequences of the crash. The risk of underreporting with regard to the current objective, which was unknown to subjects at the time of inclusion and the low percentage of refusals (17.6%) led us to conclude that underestimation of this type is on a minor scale.

Some eligible subjects who may have been responsible could not be included in the study (because of psychological disorders or prosecution by the police for an offence). Only 6 subjects fell into this category (i.e. 2.9% of the subjects who were not included), so this factor is only marginal.

The fact that we did not separate the drivers of two-wheeled vehicles from the drivers of four-wheeled vehicles could also affect the evaluation of risk levels. The drivers of two-wheeled vehicles are often younger and more frequently involved in single-vehicle crashes, for which they are automatically considered responsible. This choice was guided by the fact that they are involved in crashes which are frequently severe, which occur in large numbers and which therefore represent an increasingly crucial public health issue. We therefore considered that it was important to investigate possible diseases/drug consumption for this group of drivers too.

4.6. Information bias with regard to the diseases

Information bias must be considered in studies that deal with private life, in particular diseases and the consumption of medicines. The reason for this is that subjects who know they are ill and fear their driving licence will be suspended can deliberately hide their health problems. Some diseases may therefore have been inaccurately assessed (for example, heart rhythm disorders), even though they belong to major categories which are well known to the
public. They may have affected the power of the study but they were not responsible for bias. The reason for this is that all the subjects were asked the questions in an identical manner. The interviewer did not know that such a study would be done.

The users of drugs known to affect consumers’ concentration could have declared more systematically their responsibility in the crash: we controlled the data set common to the two databases (ESPARR and BAAC): people who did not say they were responsible, when the algorithm said they were partly responsible, have the same habits than people really non-responsible: in particular, we find a similar percentage of use of several drugs. Therefore, we think that this information bias, if any, does not affect the calculation of the odds ratios.

Also, we grouped the diseases together ourselves with reference to the 2005 decree on the basis of the subjects’ responses to a variety of questions (open and closed), about their diseases, medicine consumption and hospitalization. This phase of the study was conducted blind with respect to the phase in which responsibility was established.

The information on diseases did not refer to the precise time of the accident, but rather referred to the “chronic” diseases reported by the subject, to medicines usually consumed during the week before the accident and to medicines which were consumed in the preceding 3 h.

Last, as mentioned above, the prevalence rates of some conditions in the control group are consistent with those observed in the general adult population in France, which validates the collected information.

For these reasons, we do not think that a bias due to the knowledge of his/her medical conditions by the patients could explain our results.

To conclude, by comparing drivers in our study who were injured in a crash for which they were responsible to injured drivers who were not responsible for the crash, the major risk factors which have emerged as those identified in previous studies, and with similar levels. Diseases, with the exception of arterial hypertension and the consumption of antidepressants, do not seem to play a preponderant role in road traffic crash responsibility compared to the well-known behavioural factors.

5. Competing interest

None.

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