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Powered two-wheelers riders’ crash injury risk on urban arterial streets  

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ABSTRACT

Context: In recent years, the use of powered two-wheelers has experienced extraordinary growth in Europe, notably in densely population areas (CARE, 2012). Nevertheless, the powered two-wheelers' crash risk is still very poorly documented. It is mainly due to a lack of available accurate exposure data about this road user category and its subcategories. Thus, powered two-wheelers' accident risk is generally overall and roughly studied.

Method: Based on data held by the Police, a case-control study was conducted. The cases comprised 110 powered two-wheelers riders and 157 motorists involved in injury crashes occurred on nine arterial streets in the Marseille metropolitan area (France) from 1st January 2011 to 31st December 2011. The controls were powered two-wheelers riders and motorists who passed the crash sites at the same time of day and same day of week as when the crashes occurred. These controls were collected during periodic roadside surveys.

Results: Per kilometer travelled, powered two-wheelers have significantly greater chance of being involved in a crash than motorists (odds ratio 3.81, 95% confidence interval 2.97 to 4.89). Concerning the risk of being injured, powered two-wheelers riders are 22.3 times (95% confidence interval 13.7 to 36.3) more likely to be injured compared to motorists. Significant differences are found in these risks between mopeds, light motorcycles and heavy motorcycles riders.

Conclusion: This study quantifies both the crash risk and risk of injury for different categories of powered two-wheelers (mopeds, light motorcycles and heavy motorcycles) and confirms that the over-representation of powered two-wheelers in accidents statistics in large metropolitan areas seems more due to their extreme vulnerability rather than their over-implication in collisions.

Keywords: crash risk, powered two-wheeler, moped, motorcycle, case-control study

INTRODUCTION

In France, powered two-wheelers contribute disproportionately to the burden of road traffic casualties. In 2011, it was estimated that powered two-wheelers accounted for about 2% of kilometers driven on public roads (CGDD, 2012), but during this year, they accounted for 25% of road traffic deaths and 32% of injured road users reported (ONISR, 2012). Thus, per kilometer traveled, motorcyclists and moped users have respectively a 15 and 13 times higher risk of death in a crash than car occupants. The risk of being injured is greater by a factor of 18 and 37 respectively for motorcycle and moped users compared to car occupants. Concerning the risk of being involved in a crash\(^1\), it is respectively 10 and 19 times higher for motorcyclists and moped users than for car occupants (same reference). However, the main limitation of these indicators is that they use as the denominator the total number of powered two-wheelers registered in the whole country multiplied by the average annual distance traveled estimated by national postal or telephone survey. Thus, they assume a constant level of risk of being killed or injured per kilometer over the entire distance of travel (Lin and Kraus, 2008). Nevertheless, the crash risk for a given kilometer for light motorcycles users who accumulate their mileage on congested city streets for commuting purpose is for example probably different compared with riders of heavy motorcycle who accumulate their mileage on rural roads for leisure purpose.

\(^1\) In this paper, the term « crash » refers to injury accident, that is to say resulting in at least one injured or killed person.

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The second limitation of these indicators is that they are based on old exposure data. Indeed, the last French extensive survey on powered two-wheelers ownership and their utilization dates back to 2001. However, in recent years, in France like in the rest of Europe, the use of powered two-wheelers has experienced important growth and changing patterns, notably in densely populated areas (CARE, 2012). For example, in Paris, the use of this means of transport, as examined on some boulevards, has risen by 64% between 1997 and 2009 (Maestracci et al., 2012). In, Marseille, which - with more 1.5 million inhabitants - is the second French urban zone (INSEE, 2011), the number of journeys using motorcycle has risen from around 80% between 1997 and 2009 (Marseille’s Urbanism Agency, 2011). These increase and recent changing in the use of powered two-wheelers probably have had an impact on casualty crash risk of this road user category.

The aims of this study were to determine the risk per kilometer travelled of being involved in a crash and the risk of being injured for riders of different categories of powered two-wheelers (moped, light motorcycle and heavy motorcycle) relying on recent exposure data collected on arterial streets of a French large metropolitan and to compare these risks with those of motorists.

**METHOD**

A case-control study was conducted on nine arterial streets (see figure 1) of the Marseille metropolitan area. Marseille is located on the Mediterranean coast in a warm climate region where mopeds and motorcycles are a relatively common means of transportation. The study population was drawn from all motorists and powered two-wheelers riders travelling on nine urban arterial streets located in the Marseille downtown over a one year period from the 1st January 2011 to the 31st December 2011, Sundays and legal holidays excluded, between 6h00 and 22h00. Powered two-wheelers riders and motorists travelling Sundays, legal holidays and between 22h00 and 6h00, were excluded because of low traffic volumes in these situations.

The cases were, with the exclusions described above, all powered two-wheelers riders and all motorists injured and/or involved in an injury accidents occurred in 2011 on the nine arterial streets studied. The identification of cases was based on the exploitation of national data from the French police for the year 2011; i.e. Bulletins d’Analyse des Accidents Corporels de la Circulation (BAAC). The BAACs are the computerized version of the police reports which the police have the obligation to draw up for all injury accidents occurring on public roads. Each BAAC provides information on time, location of the accident and some characteristics on vehicles and on the users involved.

Controls were all non-accident-involved powered two-wheelers riders and motorists traveling in 2011 (with the exclusions described above) on the nine sites studied. Concerning the exposure of motorists, was made use of hourly traffic volume collected by magnetic loop detectors. Concerning the exposure of powered two-wheelers riders, we conducted periodic roadside surveys to obtain the mean proportion of powered two-wheelers (and the proportion of each category of powered two-wheelers) in traffic. 52 hours of observations were conducted on the nine arterial streets studied. For these surveys, the day, the hour, the site and the side of the street were randomly allocated. Once the total number of vehicles traveling in 2011 on the sites studied

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2 Let’s note that all of nine streets studied contain bus lanes.

3 In France, three main official powered two-wheelers categories are distinguished: the mopeds, which with an engine displacement less than 50 cm3, can be driven after a short formation by any person over 14 years old; light motorcycles which with an engine displacement between 50 cm3 and 125 cm3, can be driven with a car license under certain conditions; heavy motorcycles, which with engine size over 125 cm3, need a motorcycle license.

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and the proportion of powered two-wheelers among these vehicles were known and once the number of injury accidents and casualties for each road user category were known, odds ratios (ORs) with 95% confidence intervals, were calculated for each site. Injury accident being rare event, we use a Poisson distribution. Then, was calculated a synthetic odds ratio using meta-analysis techniques. Meta-analysis is a statistical technique used to systematically summarize the results of a group of individual studies. The method has been largely used to summarize the effects of various road safety interventions (Elvik and Vaa, 2004).

Figure 1. Location of streets on which the study was conducted

Let’s note that the automated vehicles detection systems used in Marseille count powered two-wheelers but don’t distinguish them from others vehicles (Clabaux, Michel and Fournier, 2012).

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RESULTS

7032 powered two-wheelers were recorded on the nine sites studied during the 52 hours of observations conducted. These powered two-wheelers represent 16.3% of traffic. This proportion is close to the one recorded by Kopp (2011) on some boulevards of Paris. Among these 7032 powered two-wheelers, light motorcycles which are dedicated to be used in urban areas, are the most numerous: they represent 48% of the powered two-wheelers recorded. Most of them are scooters. Then, heavy motorcycles represent 32% of powered two-wheelers observed. Concerning mopeds, they represent about 20% of powered two-wheelers in traffic.

110 powered two-wheelers’ riders (31 mopeds’ riders, 33 light motorcycles’ riders and 46 motorcyclists) and 157 motorists were involved during 2011 in an injury accident on the nine streets studied. 89 powered two-wheelers’ riders (22 mopeds’ riders, 29 light motorcycles’ riders and 38 motocyclists) and 19 motorists were injured.

Concerning the risk per kilometer traveled of being involved in a crash for powered two-wheelers, Table 1 gives the numbers of powered two-wheelers’ riders and motorists exposed and involved in a crash, the odds ratios and their 95% confidence intervals, for each street and for the year 2011.

Table 1. Numbers of powered two-wheelers’ riders and motorists exposed and involved in an injury accident in 2011 for each street, relative risk and 95% confidence interval

<table>
<thead>
<tr>
<th>Streets</th>
<th>Riders exposed*</th>
<th>Motorists exposed*</th>
<th>Riders involved in an injury accident</th>
<th>Motorists involved in an injury accident</th>
<th>Relative risk</th>
<th>CI 95 %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Blvd. Baille</td>
<td>1524144</td>
<td>7728124</td>
<td>15</td>
<td>20</td>
<td>3.80</td>
<td>1.95 - 7.43</td>
</tr>
<tr>
<td>Blvd. Corderie</td>
<td>397401</td>
<td>2014303</td>
<td>2</td>
<td>2</td>
<td>5.07</td>
<td>0.71 - 35.98</td>
</tr>
<tr>
<td>Blvd. F. Duparc</td>
<td>1892313</td>
<td>9638034</td>
<td>19</td>
<td>30</td>
<td>3.23</td>
<td>1.82 - 5.73</td>
</tr>
<tr>
<td>Av. Mazargues</td>
<td>579354</td>
<td>2933875</td>
<td>3</td>
<td>4</td>
<td>3.80</td>
<td>0.85 - 16.97</td>
</tr>
<tr>
<td>Blvd. Michelet</td>
<td>3534359</td>
<td>17837188</td>
<td>8</td>
<td>12</td>
<td>3.36</td>
<td>1.37 - 8.23</td>
</tr>
<tr>
<td>Av. Prado 1</td>
<td>1950733</td>
<td>9877126</td>
<td>27</td>
<td>32</td>
<td>4.27</td>
<td>2.56 - 7.13</td>
</tr>
<tr>
<td>Av. Prado 2</td>
<td>1516459</td>
<td>7679217</td>
<td>9</td>
<td>16</td>
<td>2.85</td>
<td>1.26 - 6.45</td>
</tr>
<tr>
<td>Rome street</td>
<td>473035</td>
<td>2400185</td>
<td>23</td>
<td>21</td>
<td>5.56</td>
<td>3.08 - 10.04</td>
</tr>
<tr>
<td>Blvd. Schloesing</td>
<td>2084719</td>
<td>10568511</td>
<td>4</td>
<td>10</td>
<td>2.03</td>
<td>0.64 - 6.47</td>
</tr>
</tbody>
</table>

*Expressed in driver-kilometers traveled

The results obtained show a risk of being involved in a crash for powered two-wheelers’ riders, in comparison with motorists, comprised between 2.03 and 5.56. This difference is statistically significant for six of the nine streets studied. The results of each individual study listed in Table 1 are then combined by means of meta-analysis method. The meta-analysis of the nine individual estimates of relative risk gave a mean relative risk of being involved in crash for powered two-wheelers riders of 3.81, with 95% confidence that the relative risk is between 2.97 and 4.89.

Statistical tests indicated the absence of heterogeneity in the data set ($Q = 3.86$; $p-value = 0.87$).

Same analysis were performed for each category of powered two-wheelers. The results indicate a relative risk of 5.84 (confidence interval: [3.96; 8.59]) for mopeds’ riders, 2.58 (confidence interval: [1.76; 3.77]) for light motorcycles’ users and 5.45 (confidence interval: [3.90; 7.60]) for motorcyclists. For each category of powered two-wheelers, statistical tests showed the absence of heterogeneity in the data sets.

Concerning the risk per kilometer traveled of being injured for powered two-wheelers riders, Table 2 gives the numbers of riders and motorists exposed and injured, the odds ratios and their 95% confidence interval for the nine streets and for the year 2011.

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The results obtained show a risk of being injured for powered two-wheelers’ riders, in case of a crash in comparison with motorists, comprise between 16 and 45. The result is statistically significant on all the streets studied. The meta-analysis of the nine individual estimates of relative risk gave a mean relative risk of being injured for powered two-wheelers riders of 22.3 with 95% confidence that the relative risk is between 13.7 and 36.3. Statistical tests indicated the absence of heterogeneity in the data set ($Q = 1.05 ; p-value = 0.99$). Same analysis were performed for each category of powered two-wheelers. The results indicate a relative risk of 28.6 (confidence interval: [15.4 ; 53.2]) for mopeds’ riders, 15.9 (confidence interval: [8.9 ; 28.5]) for light motorcycles’ users and 31.8 (confidence interval: [18.4 ; 55.0]) for motorcyclists. For each category of powered two-wheeler, statistical tests showed the absence of heterogeneity in the data sets.

**DISCUSSION AND CONCLUSIONS**

This work gives an estimation of the crash risk and risk of injury for different categories of powered two-wheelers (mopeds, light motorcycles and heavy motorcycles) in comparison with motorists who used the same roads at the same time. For this work, were collected relatively robust exposure data. In that respect, this work brings an original contribution because of the current lack of exposure data concerning the use of powered two-wheelers and their subcategories (mopeds, light motorcycles, heavy motorcycles), notably in urban areas (Lin and Kraus, 2008; Vlahogianni, Yannis and Golias, 2012). On another hand, this research work shows that in large metropolitan areas, despite the important growth of the use of powered two-wheelers in recent years, the risk of being injured for powered two-wheelers riders is still considerably higher than the risk for motorists (about 22 times higher risk of being injured in a crash than motorists). This excess risk has to be considered as a minimum because of the police under-reporting of non-fatal road accident casualties, which is often more important for powered two-wheelers than for motorists (Amoros, Martin and Laumon, 2006; Elvik and Vaa, 2004). Furthermore, results show that, in urban areas, the risk of being involved in a crash and the risk of injured are similar for mopeds riders and heavy motorcycles riders (respectively about 5 times for accident involvement and 30 times for risk of injury greater than for motorists) whereas these risks are about two times lower for light motorcycle users (relative risks respectively about 2.5 times for accident involvement and 16 times for risk of injury greater than motorists). These differences probably reflect differences in usage patterns and rider-dependent factors among the different categories of powered two-wheelers.

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<table>
<thead>
<tr>
<th>Streets</th>
<th>Riders exposed*</th>
<th>Motorists exposed*</th>
<th>Riders injured</th>
<th>Motorists injured</th>
<th>Relative risk</th>
<th>CI 95 %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Blvd. Baille</td>
<td>1524144</td>
<td>7728124</td>
<td>13</td>
<td>3</td>
<td>21.98</td>
<td>6.26 ; 77.11</td>
</tr>
<tr>
<td>Blvd. Corderie</td>
<td>397401</td>
<td>2014303</td>
<td>2</td>
<td>0</td>
<td>25.34</td>
<td>1.22 ; 527.92</td>
</tr>
<tr>
<td>Blvd. F. Duparc</td>
<td>1892313</td>
<td>9638034</td>
<td>16</td>
<td>5</td>
<td>16.30</td>
<td>5.97 ; 44.49</td>
</tr>
<tr>
<td>Av. Mazargues</td>
<td>579354</td>
<td>2933875</td>
<td>3</td>
<td>0</td>
<td>35.45</td>
<td>1.83 ; 686.30</td>
</tr>
<tr>
<td>Blvd. Michelet</td>
<td>3534359</td>
<td>17837188</td>
<td>8</td>
<td>2</td>
<td>20.19</td>
<td>4.29 ; 95.06</td>
</tr>
<tr>
<td>Av. Prado 1</td>
<td>1950733</td>
<td>9877126</td>
<td>18</td>
<td>4</td>
<td>22.78</td>
<td>7.71 ; 67.32</td>
</tr>
<tr>
<td>Av. Prado 2</td>
<td>1516459</td>
<td>7679217</td>
<td>9</td>
<td>1</td>
<td>45.58</td>
<td>5.77 ; 359.74</td>
</tr>
<tr>
<td>Rome street</td>
<td>473035</td>
<td>2400185</td>
<td>16</td>
<td>3</td>
<td>27.06</td>
<td>7.88 ; 92.87</td>
</tr>
<tr>
<td>Blvd. Schloesing</td>
<td>2084719</td>
<td>10568511</td>
<td>4</td>
<td>1</td>
<td>20.28</td>
<td>2.27 ; 181.43</td>
</tr>
</tbody>
</table>

*Expressed in driver-kilometers traveled
Despite the limits of this investigation due in particular to the small number of sites studied, the results presented suggest that transport policy in large metropolitan areas should more consider their implications on the use of powered two-wheelers due to the very high casualty rate of this means of transport. Any transport policy which would lead to an increase in the use of powered two-wheelers probably would have a harmful effect on the safety of the transport system. Furthermore, this work suggests that the over-representation of powered two-wheelers in accidents statistics in large metropolitan areas\(^5\), seems more due to their extreme vulnerability rather than their over-implication in collisions (Elvik, 2009).

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**REFERENCES**


\(^5\) For example, in 2009, within Paris, powered two-wheelers’ riders were involved in 62.7 % of injury accidents and represent 43 % of fatalities (Maestracci et al., 2012). In Barcelona, according to Albalate and Fernández-Villadangos (2010), they represent 42 % of fatalities.