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# The risk of road traffic crashes for occupational drivers: A responsibility study with comparison to the general population

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## Abstract.

**BACKGROUND:** Road accidents are the leading type of work-related fatalities, but the impact of work-related travel on overall traffic safety has been scarcely studied.

**OBJECTIVE:** The main objective of the present study was to assess drivers' relative road accident risk between work-related and personal journeys.

**METHODS:** A responsible/non-responsible case-control study was performed on a sample of 7,051 road accidents in France from the VOIESUR project. Logistic regression determined odds-ratios according to work-related versus personal travel, and identified risk factors for responsibility, specific to each of the two sub-groups.

**RESULTS:** Drivers traveling on duty or commuting home were significantly less often responsible for accidents than drivers on personal journeys: OR = 0.75 [0.63; 0.89] and 0.65 [0.53; 0.80] respectively. Responsibility was significantly more frequent in commuting to versus from work: OR = 1.38 [1.06; 1.78]. Among on-duty drivers, professional passenger-transport drivers had the lowest risk of responsibility (OR = 0.25 [0.11; 0.58]), while those on temporary or work/study contracts and professional light goods vehicle drivers had the highest risk (OR = 11.64 [2.15; 62.94] and OR = 29.83 [5.19; 171.38] respectively). When driving under the influence of alcohol, risk of responsibility was higher in commuting home than in personal journeys.

**CONCLUSION:** On-duty drivers showed lower risk of responsibility for an accident than other drivers. However, on-duty drivers on temporary or work/study contracts, who are usually not subject to specific regulations, showed higher risk, and should be the subject of particular attention regarding occupational risk prevention.

Keywords: Occupational accidents, traffic accidents, on duty accident, commuting, responsibility, risk factors

## 1. Introduction

Road accidents leave some 1.35 million deaths worldwide each year. With an average rate of 27.5

deaths per 100,000, mortality is about three times higher in low-income countries as in high-income countries where the rate is 8.3 deaths per 100,000 inhabitants [1]. In France in 2019, road risk as estimated by the police was responsible for 56,016 injuries and 3,244 deaths at 30 days [2].

Road accidents are the main form of fatal work accident [3, 4]. In France, in 2019, road risk was

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responsible for 12% of fatal work accidents and 28% of occupational deaths if commuting journeys are included [5]: i.e., 1.48 deaths per 100,000 workers covered by the national health insurance system.

The impact of work-related travel on road safety as a whole has been little studied. According to the 2019 review by the French National Interministerial Road Safety Observatory (ONISR), 12% of road accident fatalities involved a heavy goods vehicle, and 38% of injuries involved at least one road user traveling for work [2]. These figures raise the question of the relative responsibility of on-duty drivers, and the advisability of targeting preventive measures on this category of road users.

Drivers traveling for work show specific features, some of which constitute known accident risk factors: longer time on the road [6–8], fatigue or lack of rest breaks [9], time pressure [4], demands from the hierarchy or from clients [6], distraction [10]. On the other hand, professional drivers have greater driving experience and training, with specific driving licenses for certain types of vehicle.

The main aim of the present study was to compare the relative risk of being responsible for a road accident in drivers driving to work, home from work or on duty versus drivers on personal journeys. The secondary objective was to identify responsibility risk factors specific to work-related contexts.

## 2. Materials and methods

### 2.1. Study data

The study data were taken from the VOIESUR (Vehicle-Occupant-Infrastructure Road-User Safety Studies project ANR11-VPTT-0007), which set up an information system based on analysis and meticulous coding of police reports, computerized and centralized by the TransPV agency, which provides insurance companies with police road accident reports [11–13]. When necessary, the data collection services provided important missing elements such as accident diagrams, vehicle photographs or injury assessments. This collection of information was based on injury or fatal accidents collected by the police for the year 2011 in metropolitan France (excluding overseas territories). The database included all fatal accidents recorded in France (accidents with at least one person killed on the spot or within 30 days), all non-fatal injury accidents recorded in the Rhone department (administrative

area of 1.6 million inhabitants), and 1/20 (drawn at random) of the non-fatal injury accidents recorded in France (excluding the Rhone department). Consequently, the sampling weights applied were: 1 for all fatal accidents, 1 for non-fatal injury accidents in the Rhone department, 20 for non-fatal injury accidents outside the Rhone department. The database thus comprised 8,541 accidents, described in terms of more than 300 variables.

### 2.2. Survey plan

A retrospective responsible/ non-responsible retrospective case-control study included all drivers involved in an injury or fatal accident, aged 18–65. Responsible drivers were considered cases, and non-responsible drivers were considered controls. To select a population representative of the working population, drivers who were retired or unemployed, or driving a vehicle on a trial basis or participating in a competition, going to or returning from a party, dance, concert, festival, or discotheque, were excluded.

### 2.3. Study groups and risk factors

Four populations were distinguished:

1. *drivers on personal journeys* (going on or coming back from vacation, shopping, personal matters, leisure, touring, visits to family, friends or personal acquaintances, and journeys to or from school or university);
2. *drivers on duty*;
3. *drivers commuting from home to work*;
4. *and drivers commuting home from work*.

Study risk factors comprised:

- driver's age, in 7 categories: 18–20, 21–25, 26–30, 31–40, 41–50, 51–60 and 61–65 years;
- driver's gender;
- driver's socio-occupational category: French national statistics institute (INSEE) level 1, or level-2 artisans, shopkeepers and business owners, or level-3 professional drivers;
- blood alcohol level at time of accident: positive if  $\geq 0.5$  g/l;
- frequency of driving at the accident site;
- vehicle owner or not;
- type of vehicle.

Vehicles were classified in 10 categories:

- cycles: bicycles, electric bicycles, any other pedal vehicle;
- limited-speed motorcycles: <math>50\text{cm}^3</math> 2-wheelers, non-pedal cycles requiring helmet;
- scooters: rear-engine 2-wheelers without tank between the knees (motorized tricycles were counted as scooters);
- motorcycles:  $\geq 50\text{cm}^3$  front-engine 2-wheelers with tank between the knees;
- automobiles: registered as “private” or “company” cars under the French vehicle registration system;
- heavy utility vehicles: registered as utility vehicles <math>< 3.5</math> metric tonnes, panel or window van with cab or double-cab chassis;
- light utility vehicles: registered as utility vehicles <math>< 3.5</math> metric tonnes, with panel or window van chassis or pick-up;
- heavy goods vehicles: registered as lorry/truck  $\geq 3.5$  metric tonnes;
- special/agricultural vehicles: registered as “special” or “agricultural”;
- buses and coaches: registered as “bus”, able to transport standing or seated passengers.

#### 2.4. Determination of responsibility and constitution of case and control groups

The underlying principle of responsibility studies as used here is to compare a group of drivers considered to have been responsible for an accident [14], due to directly causal action or inaction, versus a group of drivers involved in an accident for which they did not bear responsibility. The hypothesis is that the latter show characteristics similar to those of drivers not involved in any accident [12]. Road-user responsibility is not being used here in a legal sense. A person causing or contributing to an accident is deemed responsible due to an inappropriate maneuver, such as driving against the traffic, failure to respect a red light, obvious loss of control, etc.) or failure to act (braking too late, etc.). It is essential that responsibility be defined in terms of these actual behaviors, and not of their causes (e.g., fatigue, consumption of drugs or alcohol, etc.), otherwise the impact of such risk factors would be widely overestimated. Responsibility was determined by an expert panel based on all available evidence, including accident diagrams and comments by those involved and by the police. This provided a responsibility criterion

that was both reliable (in the sense of “contributive”) and as objective as possible (i.e., based on facts).

The two comparison groups were based on 5 categories: 1- completely responsible; 2 – largely responsible; 3- partially responsible; 4- largely non-responsible; and 5- not at all responsible. The “Responsible” group comprised categories 1, 2 and 3. “Largely” and “partially” responsible drivers were included here because accidents frequently occur due to a combination of factors, the absence of any one of which would often have avoided the accident; in other words, the accident would not have happened if the driver had not done something that led the expert to hold them completely or partially responsible. The Responsible group thus comprised drivers who made a mistake considered necessary (even if not sufficient) for the accident to have occurred. On this approach, several drivers may all be deemed responsible in a single accident. The “Non-responsible” group comprised categories 4 and 5: drivers considered to be involved by bad luck, being in the wrong place at the wrong time. Based on this concept of “responsibility”, the study can be seen epidemiologically as a case-control study. The source population comprised all drivers using public roads or private roads open to the public, and both groups came from this source population, as they were involved in accidents meeting this inclusion criterion.

#### 2.5. Data imputation

Simple imputation of missing data was applied, using the MICE (Multivariate Imputations by Chained Equations) method [15]. This was mainly used to impute the type of journey, when unknown, using all relevant variables. Thus, variables imputed and used in the imputation model comprised: type of journey, driver’s occupational status, gender and socio-occupational category, being the owner of the vehicle or not, vehicle category, day of the week and time of accident, intended travel distance, distance actually traveled, frequency of driving at the accident site, accident occurring in an administrative area (*Département*) other than the driver’s home area, and vehicle categorized as “Special” (taxi, ambulance, fire-engine, police car, school bus, or dangerous goods transport vehicle).

#### 2.6. Statistical analysis

Statistical analyses used R software, version 3.2.4.

227 Sampling weighting was applied to each driver for  
 228 all analyses: 1 for drivers involved in a fatal accident,  
 229 and 20 for those involved in an injury accident.

230 We used the `svyglm` function of the R survey  
 231 library to take into account the weighting of the data  
 232 (1 for fatal accidents, 1 for non-fatal injury accidents  
 233 in the Rhone department, 20 for non-fatal injury acci-  
 234 dents outside the Rhone département) and thus obtain  
 235 valid variances. The goodness of fit was tested using  
 236 Cox & Snell's pseudo-R squared (`psrsq` function).

237 Statistical tests were 2-tailed, with the significance  
 238 threshold set at  $p < 0.05$  and 95% confidence inter-  
 239 vals were established. Logistic regression modeled  
 240 responsibility according to type of journey; because  
 241 our goal was to see whether certain risk factors for  
 242 being responsible for an injury accident were sta-  
 243 tistically different by type of journey, we tested the  
 244 (first-order) interactions between these factors and  
 245 type of journey. The significance of each factor or  
 246 interaction was tested by comparing the likelihoods  
 247 of the nested models (with and without each factor or  
 248 interaction).

### 249 3. Results

#### 250 3.1. Type of journey

251 After application of exclusion criteria detailed in  
 252 the survey plan paragraph, a total of 7,051 police  
 253 reports were analyzed. After weighting, 69,352  
 254 drivers were involved in a fatal or injury accident  
 255 in France in 2011. 1,631 (2.4%) had died within 30  
 256 days, 33,782 (49.2%) were injured, 33,211 (48.4%)  
 257 were uninjured, and data were missing in 0.6% of  
 258 cases.

259 Type of journey was known in 75.2% of cases,  
 260 and imputed in the other 24.8%. After imputation, a  
 261 majority of drivers (50.2%) were on personal jour-  
 262 neys, 15.3% and 13.3% commuting to or from work  
 263 respectively, and 21.1% traveling on duty.

#### 264 3.2. Road accident victims (Table 1)

265 Drivers involved in an accident while traveling  
 266 home from work, to work from home or for per-  
 267 sonal purposes were relatively similar in terms of  
 268 age, gender and socio-occupational category. Notable  
 269 differences concerned a lower rate of artisans, shop-  
 270 keepers and business owners commuting to work and  
 271 of 18-20 year-old injured drivers traveling home from  
 272 work, and a slightly higher rate of males on personal  
 273 journeys.

274 Drivers on duty differed in some respects from  
 275 drivers on other types of journey, with higher rates  
 276 of professional drivers and of males ( $p < 0.001$ ) (Fig-  
 277 ure 1), and a lower rate of 18-25 year-olds than for  
 278 drivers on personal journeys ( $p < 0.05$ ).

279 The vehicle involved in the accident was most  
 280 often a private or company car, whatever the type of  
 281 journey. Logically, on the other hand, occupational  
 282 vehicles (utility, heavy goods, special or agricultural  
 283 vehicles, buses/coaches and tramcars) figured more  
 284 frequently in on-duty accidents than in other types of  
 285 journey (Figure 2).

286 Drivers on duty were those least often testing pos-  
 287 itive for alcohol, followed by those commuting to or  
 288 from work. Drivers on personal journeys were more  
 289 than 7 times more likely to test positive for alcohol  
 290 (at  $\geq 0.5$  g/l) than on-duty drivers ( $p < 0.001$ ). On the  
 291 other hand, blood alcohol level in alcohol-positive  
 292 injured drivers did not significantly differ according  
 293 to type of journey.

#### 294 3.3. Risk factors for being responsible for an 295 injury or fatal accident

296 Responsibility was attributed in 97.3% of police  
 297 reports, and about 80% of drivers were considered  
 298 completely responsible (42.3%) or completely non-  
 299 responsible (37.5%) by the experts. Responsibility  
 300 was considered partial in only 5.8% of drivers.

301 Analysis of road accident responsibility risk  
 302 according to type of journey revealed lower risk in  
 303 on-duty drivers and drivers commuting home than in  
 304 drivers on personal journeys ( $p < 0.001$ ), the lowest  
 305 risk being for journeys home from work (Table 2).  
 306 After adjustment for gender and age, the difference  
 307 remained significant (models 1 and 2). After adjust-  
 308 ment for blood alcohol level, on the other hand,  
 309 the protective effect of commuting home was lower  
 310 and that of being on duty disappeared (model 3).  
 311 After further adjustment on the frequency of driv-  
 312 ing at the accident site, the odds ratio between  
 313 commuting home and personal journeys no longer  
 314 differed significantly from 1 (model 4). However,  
 315 there remained extra risk for commuting to ver-  
 316 sus from work (OR = 1.38 [1.06; 1.78],  $p = 0.015$ ).  
 317 Adjustment on the time of the accident was also  
 318 tested; multivariate analysis including all the vari-  
 319 ables in model 3 plus time of accident did not  
 320 significantly affect the results for commuting to or  
 321 from work for on-duty driving: changes in OR for  
 322 significant variables were less than 10%.

Table 1  
 Characteristics of drivers involved in an accident according to type of journey (weighted population)

	Commuting to work (N = 10,640)	On-duty (N = 14,628)	Commuting home (N = 9,244)	Personal (N = 34,840)
<b>Age (years)</b>				
18-20	662 (6.2%)	411 (2.8%)	396 (4.3%)	2701 (7.8%)
21-25	1,738 (16.3%)	2,008 (13.7%)	1,614 (17.5%)	5,988 (17.2%)
26-30	1,483 (13.9%)	1,827 (12.5%)	1,276 (13.8%)	4,932 (14.2%)
31-40	2,565 (24.1%)	4,196 (28.7%)	2,294 (24.8%)	8,620 (24.7%)
41-50	2,571 (24.2%)	3,277 (22.4%)	1,960 (21.2%)	7,405 (21.3%)
51-60	1,435 (13.5%)	2,447 (16.7%)	1,496 (16.2%)	4,401 (12.6%)
60-65	186 (1.7%)	462 (3.2%)	208 (2.3%)	793 (2.3%)
<b>Gender</b>				
Female	3,402 (32.0%)	1,569 (10.7%)	2,859 (30.9%)	9,246 (26.5%)
Male	7,238 (68.0%)	13,059 (89.3%)	6,385 (69.1%)	25,594 (73.5%)
<b>Socio-occupational category</b>				
Artisans	85 (0.8%)	420 (2.9%)	270 (2.9%)	974 (2.8%)
Shopkeepers	116 (1.1%)	432 (3.0%)	286 (3.1%)	784 (2.3%)
Business owners	28 (0.3%)	232 (1.6%)	151 (1.6%)	583 (1.7%)
Executive or higher intellectual professions	1,779 (16.7%)	1,255 (8.6%)	1,407 (15.2%)	5,044 (14.5%)
Middle-level professions	2,544 (23.9%)	1,658 (11.3%)	1,820 (19.7%)	7,250 (20.8%)
Office-workers	2,347 (22.1%)	1,986 (13.6%)	2,320 (25.1%)	8,223 (23.6%)
Manual workers	2,226 (20.9%)	1,403 (9.6%)	2,056 (22.2%)	6,853 (19.7%)
Professional drivers	693 (6.5%)	6,843 (46.8%)	542 (5.9%)	1,505 (4.3%)
Bus/coach	0 (0.0%)	817 (5.6%)	22 (0.2%)	0 (0.0%)
Special or agricultural vehicle	0 (0.0%)	61 (0.4%)	1 (0.0%)	0 (0.0%)
2-wheelers	223 (2.1%)	701 (4.8%)	83 (0.9%)	470 (1.3%)
Light utility	1 (0.0%)	104 (0.7%)	1 (0.0%)	42 (0.1%)
Heavy goods	28 (0.3%)	2,946 (20.1%)	51 (0.6%)	27 (0.1%)
Trains or Tramcars	0 (0.0%)	146 (1.0%)	1 (0.0%)	0 (0.0%)
Others	441 (4.1%)	2,068 (14.1%)	383 (4.1%)	966 (2.8%)
Farmers	85 (0.8%)	243 (1.7%)	94 (1.0%)	466 (1.3%)
Temporary or study/work contract	624 (5.9%)	51 (0.4%)	291 (3.2%)	2,628 (7.5%)
Others	113 (1.1%)	105 (0.7%)	7 (0.1%)	530 (1.5%)
<b>Type of vehicle</b>				
Bicycle	504 (4.7%)	182 (1.2%)	548 (5.9%)	1,073 (3.1%)
Scooter	183 (1.7%)	40 (0.3%)	61 (0.7%)	478 (1.4%)
Scooter ≤ 125cm <sup>3</sup>	1,139 (10.7%)	1,207 (8.3%)	1,120 (12.1%)	2,924 (8.4%)
Scooter > 125cm <sup>3</sup>	182 (1.7%)	180 (1.2%)	245 (2.7%)	457 (1.3%)
Motorcycle	1,728 (16.2%)	808 (5.5%)	1,464 (15.8%)	4,596 (13.2%)
Private/company car	6,352 (59.7%)	4,565 (31.2%)	5,224 (56.5%)	23,962 (68.8%)
Utility vehicle	499 (4.7%)	3,038 (20.8%)	457 (4.9%)	1,251 (3.6%)
Heavy utility	117 (1.1%)	935 (6.4%)	127 (1.4%)	414 (1.2%)
Light utility	195 (1.8%)	538 (3.7%)	93 (1.0%)	243 (0.7%)
Not specified	187 (1.8%)	1,525 (10.4%)	235 (2.5%)	568 (1.6%)
Heavy goods	49 (0.5%)	3,110 (21.3%)	77 (0.8%)	49 (0.1%)
Special/agricultural	4 (0.0%)	446 (3.1%)	25 (0.3%)	27 (0.1%)
Bus/coach	0 (0.0%)	840 (5.7%)	22 (0.2%)	0 (0.0%)
Train/tramcar	0 (0.0%)	151 (1.0%)	1 (0.0%)	1 (0.0%)
Other	0 (0.0%)	61 (0.5%)	0 (0.0%)	22 (0.1%)
<b>Frequency of driving at accident site</b>				
Daily	9,711 (91.3%)	2,794 (19.1%)	8,083 (87.4%)	4,457 (12.8%)
Several time weekly	456 (4.3%)	7,798 (53.3%)	667 (7.2%)	16,612 (47.7%)
Several time monthly	282 (2.7%)	3,060 (20.9%)	166 (1.8%)	7,658 (22.0%)
Less than once a month	65 (0.6%)	495 (3.4%)	183 (2.0%)	1,747 (5.0%)
Very rarely or first time	126 (1.2%)	481 (3.3%)	145 (1.6%)	4,366 (12.5%)
<b>Vehicle owner</b>				
Driver or spouse	9,046 (85.0%)	3,729 (25.5%)	7,795 (84.3%)	28,768 (82.6%)
Not driver or spouse	1,594 (15.0%)	10,899 (74.5%)	1,449 (15.7%)	6,072 (17.4%)
<b>Blood alcohol test</b>				
Negative	10,240 (96.2%)	14,351 (98.1%)	8,915 (96.4%)	30,506 (87.6%)
Positive (>0.5 g/l)	400 (3.8%)	277 (1.9%)	329 (3.6%)	4,334 (12.4%)

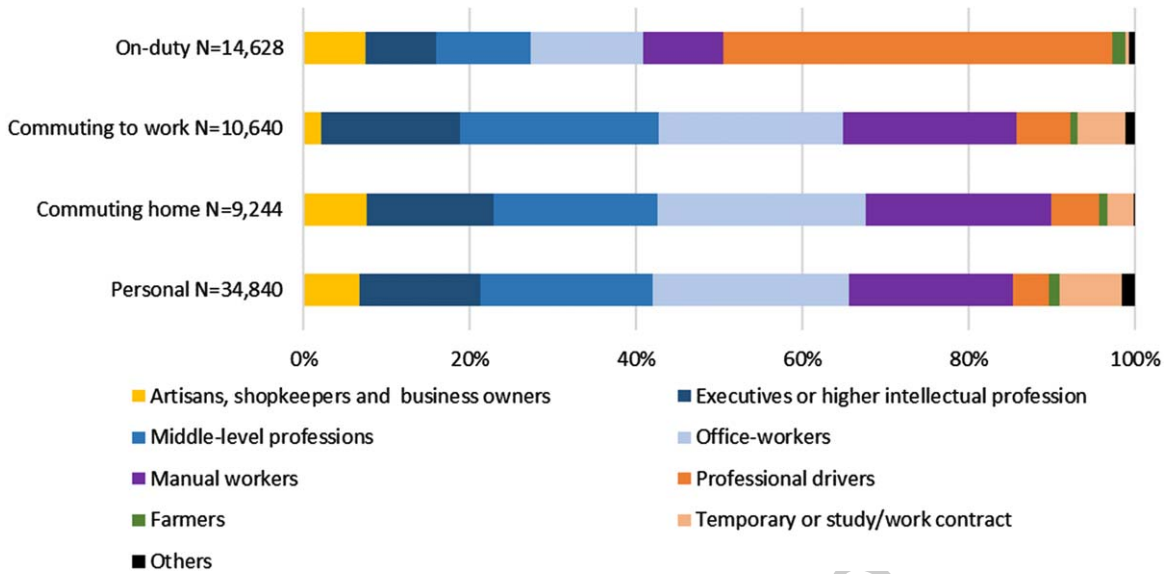


Fig. 1. Occupational categories according to the type of journey, drivers involved in a fatal or injury accident in France in 2011.

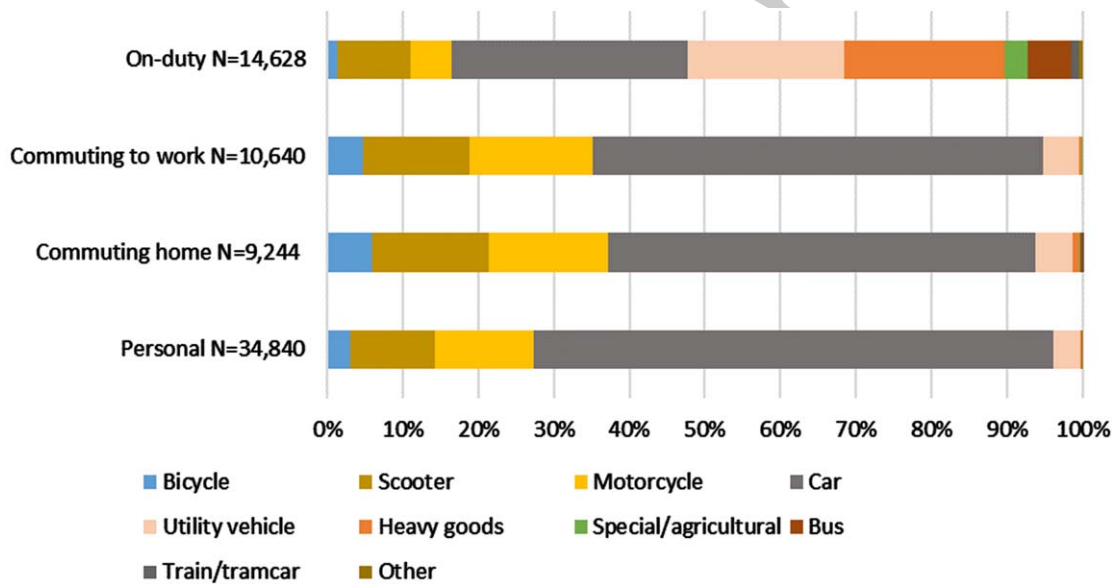


Fig. 2. Vehicle driven according to the type of journey, drivers involved in a fatal or injury accident in France in 2011.

323 Model 4 tested each interaction between each risk  
 324 factor and the type of journey. There was no signif-  
 325 icant interaction in the case of age, suggesting that  
 326 age-linked risk is independent of type of journey. The  
 327 impact of alcohol, on the other hand, differed accord-  
 328 ing to type of journey, being significantly greater in  
 329 commuting to work (“alcohol x commuting to work”  
 330 interaction: OR = 6.77;  $p = 0.02$ ) and in commuting  
 331 home (“alcohol x commuting home” interaction:  
 332 OR = 5.74;  $p = 0.02$ ) than in personal journeys. Also,

although the interaction between driving on duty and  
 gender was not significant, being on duty neverthe-  
 less reduced the extra risk of male gender seen in  
 other types of journey (“male x on-duty journey”  
 interaction: OR = 0.61;  $p = 0.06$ ). Finally, the impact  
 of frequency of driving at the accident site differed  
 according to type of journey. In the case of sites driven  
 through less than once monthly, risk was greater when  
 commuting to work than when on a personal journey  
 (“site driven through less than once monthly x com-

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343 muting to work” interaction: OR = 13.51 ( $p < 0.01$ );  
344 “site driven through very rarely or for the first time x  
345 commuting to work” interaction: OR > 50 ( $p < 0.01$ )).

346 Analysis by type of journey (Table 3) for on-duty  
347 drivers showed lower risk for bus and coach drivers  
348 (OR = 0.29 [0.14; 0.59]) and higher risk for light util-  
349 ity vehicle drivers (OR = 3.97 [1.42; 11.05]) than for  
350 private and company car drivers. Light utility vehi-  
351 cle drivers’ risk was especially high for professional  
352 drivers (OR = 29.83 [5.19; 171.38]). Risk was sig-  
353 nificantly higher for on-duty drivers on temporary  
354 or work/study contracts than for manual workers  
355 (OR = 11.64 [2.15; 62.94]). Multivariate analysis  
356 including all the variables in Table 3, plus age, did  
357 not significantly change results for commuting to or  
358 from work or on-duty driving; changes in OR for  
359 significant variables were less than 10%.

360 Finally, on-duty driver risk did not significantly  
361 differ between taxi, ambulance, fire engine, police  
362 vehicle, school transport and dangerous goods vehi-  
363 cle drivers versus drivers of other vehicles, with or  
364 without adjustment on age and gender.

#### 365 4. Discussion

366 Accident risk analysis according to reasons for  
367 travel showed that drivers on personal journeys or  
368 commuting to work were more often responsible for  
369 the accident than those driving on duty or commuting  
370 home. The lowest risk for on-duty drivers concerned  
371 passenger transport (buses, coaches, trains and tram-  
372 cars), and the highest concerned drivers on temporary  
373 or study/work contracts.

374 This lower risk in on-duty drivers seemed to  
375 involve several factors. Firstly, driving under the  
376 influence of alcohol was less prevalent, and alcohol  
377 is a major contributor to poor driving behavior and  
378 hence to responsibility for accidents [16]. Alcohol  
379 is known to be the substance that increases accident  
380 risk the most [7]; the present results confirm this, with  
381 an almost 30-fold greater risk in case of blood alco-  
382 hol level exceeding 0.5 g/l. Secondly, experience may  
383 play a major role: an impact of experience on accident  
384 risk is reported elsewhere [6, 8]. Hours et al. found  
385 that risk per 100,000 km was inversely proportional  
386 to the number of kilometers driven in the year in ques-  
387 tion [8]. Within the present population, however, the  
388 protective effect of on-duty driving disappeared on  
389 simple adjustment for alcohol consumption, indicat-  
390 ing that the lower risk in on-duty drivers was mainly  
391 due to the lower prevalence of driving under the influ-

392 ence of alcohol and to a moderate professional driving  
393 effect. Thirdly, the proportion of 18–25 year-olds was  
394 lower in on-duty than in personal driving, and this  
395 age group is associated with maximal risk; this may  
396 thus be a factor in the difference between on-duty  
397 drivers and others. Moreover, age is not merely cor-  
398 related with driving experience, but seems to exert  
399 an effect in itself: young drivers tend to overestimate  
400 their skill, and show poorer perception of risk [18].  
401 Older drivers are less often responsible for accidents  
402 [19]. The present results, however, suggest that the  
403 age effect is not enough to account for the lower  
404 risk observed in on-duty driving, which did not sig-  
405 nificantly change after adjustment on age. Fourthly,  
406 there was a greater proportion of males among on-  
407 duty drivers, and males show greater accident risk  
408 than females. The interaction between on-duty driv-  
409 ing and gender, however, indicated that the gender  
410 effect on responsibility risk was lower in case of on-  
411 duty driving; moreover, the impact of on-duty driving  
412 did not significantly change after adjustment on gen-  
413 der. This was probably due to the extra risk associated  
414 with male gender being very likely related to higher  
415 alcohol consumption, which, however, was lower  
416 when driving on duty. Lastly, risk of responsibility  
417 for an accident while driving on duty varied accord-  
418 ing to type of vehicle. Passenger transport drivers  
419 (buses, coaches, trains and tramcars) showed lower  
420 risk, while drivers of special or agricultural vehicles,  
421 and especially light utility vehicle drivers, showed  
422 higher risk. This extra risk applied to persons who  
423 drove for a living, but without any specific driver’s  
424 license regulations: an ordinary license (“type B in  
425 the French driving license regulations”) is enough to  
426 drive a light utility vehicle, and agricultural workers  
427 require no driving license at all to drive a tractor.

428 There was thus considerable extra risk associated  
429 with temporary or study/work contracts, unchanged  
430 by adjustment on multiple factors and thus apparently  
431 free of confounding effects of age, gender, frequency  
432 of driving through the accident site, alcohol consump-  
433 tion or type of vehicle. Moreover, no such extra risk  
434 was seen in driving for non-duty purposes, which  
435 would seem to rule out any specific associated person-  
436 ality effect bearing on these drivers’ attitude – unless,  
437 that is, the specific personality manifestations vary  
438 with reasons for travel. This then raises issues of expe-  
439 rience, working conditions and stress at work, which  
440 may be worsened with these less secure contracts  
441 [20].

442 The reasons for the lower risk associated with com-  
443 muting home probably concern other factors than



Table 2

Accident responsibility risk according to type of journey. Without adjustment; adjusted on age (model 1); adjusted on age and gender (model 2); adjusted on age, gender and alcohol test (model 3); and adjusted on age, gender, alcohol test and frequency of driving at accident site (model 4) (weighted population)

	OR Univariate		OR Multivariate model 1		OR Multivariate model 2		OR Multivariate model 3		OR Multivariate model 4	
<i>Type of journey</i>										
Personal (=ref)	1		1		1		1		1	
Commuting to work	0.86	[0.71;1.05]	0.88	[0.72; 1.07]	0.89	[0.73; 1.08]	1.00	[0.82; 1.23]	1.20	[0.93; 1.55]
On-duty	<b>0.75</b>	<b>[0.63;0.89]</b>	<b>0.79</b>	<b>[0.66; 0.94]</b>	<b>0.75</b>	<b>[0.63; 0.90]</b>	0.90	[0.75; 1.08]	0.95	[0.70; 1.14]
Commuting home	<b>0.65</b>	<b>[0.53;0.80]</b>	<b>0.66</b>	<b>[0.53; 0.81]</b>	<b>0.66</b>	<b>[0.54; 0.82]</b>	<b>0.73</b>	<b>[0.59; 0.90]</b>	0.87	[0.67; 1.13]
<i>Age (years)</i>										
18-20	<b>2.34</b>	<b>[1.70; 3.23]</b>	<b>2.25</b>	<b>[1.63; 3.10]</b>	<b>2.17</b>	<b>[1.57; 3.00]</b>	<b>2.29</b>	<b>[1.64; 3.20]</b>	<b>2.28</b>	<b>[1.63; 3.19]</b>
21-25	<b>1.71</b>	<b>[1.38; 2.12]</b>	<b>1.70</b>	<b>[1.38; 2.11]</b>	<b>1.70</b>	<b>[1.37; 2.10]</b>	<b>1.76</b>	<b>[1.41; 2.19]</b>	<b>1.77</b>	<b>[1.42; 2.21]</b>
26-30	<b>1.28</b>	<b>[1.03; 1.60]</b>	<b>1.27</b>	<b>[1.02; 1.59]</b>	<b>1.27</b>	<b>[1.02; 1.59]</b>	<b>1.27</b>	<b>[1.01; 1.60]</b>	1.24	[0.99; 1.57]
31-40 (=ref)	1		1		1		1		1	
41-50	1.16	[0.96; 1.40]	1.15	[0.95; 1.40]	1.16	[0.95; 1.41]	1.18	[0.97; 1.44]	1.18	[0.96; 1.44]
51-60	1.15	[0.92; 1.43]	1.16	[0.93; 1.45]	1.17	[0.94; 1.46]	1.23	[0.98; 1.54]	1.22	[0.97; 1.53]
60-65	1.46	[0.92; 2.31]	1.47	[0.92; 2.34]	1.47	[0.92; 2.35]	1.51	[0.94; 2.42]	1.46	[0.91; 2.35]
<i>Gender</i>										
Female (=ref)					1		1		1	
Male	<b>1.30</b>	<b>[1.12; 1.52]</b>			<b>1.20</b>	<b>[1.11; 1.52]</b>	1.18	[1.00; 1.38]	1.16	[0.99; 1.37]
<i>Alcohol &gt; 0.5 g/l</i>										
Negative (=ref)	1						1			
Positive	<b>30.08</b>	<b>[14.85; 60.91]</b>					<b>28.78</b>	<b>[14.11; 58.70]</b>	<b>29.66</b>	<b>[14.54; 60.52]</b>
<i>Frequency of driving at accident site</i>										
Daily	1								1	
Several time weekly	<b>1.23</b>	<b>[1.05; 1.44]</b>							1.20	[0.96; 1.48]
Several time monthly	1.21	[1.00; 1.48]							1.17	[0.91; 1.50]
Less than once a month	0.91	[0.63; 1.31]							0.87	[0.58; 1.30]
Very rarely or first time	<b>2.03</b>	<b>[1.53; 2.69]</b>							<b>2.05</b>	<b>[1.48; 2.83]</b>

Table 3

Accident responsibility risk according to type of vehicle, socio-occupational category, gender, alcohol test, frequency of driving at accident site, and vehicle ownership, for each type of journey, Univariate analysis (weighted population).

	Commuting to work (responsible = 5,568 not responsible = 4,625) <b>OR [95% CI]</b>	On-duty (responsible = 7,250 not responsible = 6,917) <b>OR [95% CI]</b>	Commuting home (responsible = 4,201 not responsible = 4655) <b>OR [95% CI]</b>	Personal (responsible = 19,481 not responsible = 13,988) <b>OR [95% CI]</b>
<b>Type of vehicle</b>				
Bicycle	1.58 [0.68; 3.67]	1.04 [0.28; 3.90]	0.53 [0.23; 1.21]	<b>0.45 [0.26; 0.79]</b>
Scooter	0.73 [0.20; 2.70]	0.85 [0.05; 13.81]	<b>0.02 [0.00; 0.17]</b>	1.07 [0.47; 2.44]
Scooter ≤ 125cm <sup>3</sup>	1.29 [0.73; 2.31]	0.95 [0.53; 1.68]	0.82 [0.46; 1.49]	1.18 [0.82; 1.68]
Scooter > 125cm <sup>3</sup>	1.52 [0.36; 6.43]	0.28 [0.06; 1.44]	0.42 [0.12; 1.52]	1.09 [0.46; 2.57]
Motorcycle	1.04 [0.64; 1.68]	0.90 [0.45; 1.80]	1.17 [0.69; 1.98]	<b>0.68 [0.51; 0.90]</b>
Private/company car (= ref)	1	1	1	1
Utility vehicle				
Heavy	2.72 [0.52; 14.15]	1.04 [0.28; 3.90]	2.88 [0.66; 12.50]	1.15 [0.48; 2.71]
Light	1.71 [0.47; 6.18]	<b>3.97 [1.42; 11.05]</b>	<b>11.18 [3.43; 36.43]</b>	1.14 [0.40; 3.85]
Not specified	1.52 [0.38; 6.14]	0.92 [0.54; 1.56]	0.58 [0.17; 1.89]	1.00 [0.46; 2.15]
Heavy goods	<b>0.06 [0.01; 0.31]</b>	0.94 [0.63; 1.38]	1.17 [0.29; 4.73]	0.68 [0.07; 6.94]
Special/agricultural	1.79 [0.16; 20.02]	0.52 [0.22; 1.25]	7.72 [0.92; 65.01]	2.85 [0.36; 22.54]
Bus/coach	–	<b>0.29 [0.14; 0.59]</b>	–	–
Train/tramcar	–	<b>0.13 [0.02; 1.07]</b>	–	–
Other	–	0.56 [0.09; 3.37]	–	14.24 [0.95; 214.43]
<b>Socio-occupational category</b>				
Artisans	0.79 [0.12; 5.24]	0.41 [0.15; 1.13]	1.41 [0.45; 4.38]	0.78 [0.42; 1.43]
Shopkeepers	2.04 [0.41; 10.09]	1.18 [0.44; 3.12]	0.56 [0.19; 1.68]	0.81 [0.42; 1.57]
Business owners	0.21 [0.03; 1.55]	1.05 [0.29; 3.74]	1.27 [0.29; 5.56]	0.70 [0.33; 1.52]
Executive or higher intellectual profession	1.35 [0.76; 2.40]	0.95 [0.48; 1.90]	0.89 [0.48; 1.64]	<b>0.51 [0.37; 0.71]</b>
Middle-level professions	0.95 [0.57; 1.58]	0.60 [0.32; 1.13]	0.64 [0.36; 1.12]	<b>0.57 [0.42; 0.77]</b>
Office-workers	0.81 [0.48; 1.36]	0.82 [0.44; 1.50]	0.74 [0.43; 1.25]	<b>0.65 [0.48; 0.87]</b>
Manual workers	1	1	1	1
Professional drivers				
Bus/coach	–	<b>0.25 [0.11; 0.58]</b>	<b>0.00 [0.00; 0.00]</b>	–
Special or agricultural vehicle	–	<b>43.65 [4.32; 440.75]</b>	–	–
2-wheeler	0.95 [0.28; 3.27]	0.65 [0.29; 1.47]	2.86 [0.30; 27.79]	0.78 [0.34; 1.80]
Light utility	–	<b>29.83 [5.19; 171.38]</b>	–	0.49 [0.03; 6.91]
Heavy goods	<b>0.09 [0.01; 0.67]</b>	0.81 [0.47; 1.41]	<b>0.32 [0.13; 0.77]</b>	<b>0.04 [0.01; 0.35]</b>
Train or Tramcar	–	0.12 [0.01; 1.00]	–	–
Other	0.57 [0.22; 1.45]	0.95 [0.52; 1.74]	0.92 [0.34; 2.48]	<b>0.46 [0.26; 0.82]</b>
Farmers	0.78 [0.12; 5.22]	0.71 [0.21; 2.37]	0.80 [0.14; 4.51]	0.69 [0.30; 1.58]
Temporary or study/work contract	0.67 [0.30; 1.48]	<b>11.64 [2.15; 62.94]</b>	0.89 [0.31; 2.54]	0.86 [0.57; 1.32]
Other	0.62 [0.12; 3.04]	0.47 [0.08; 2.77]	0.68 [0.15; 3.20]	0.73 [0.33; 1.62]
<b>Gender</b>				
Female (= ref)	1	1	1	1
Male	1.05 [0.73; 1.52]	0.86 [0.54; 1.36]	1.30 [0.88; 1.93]	<b>1.59 [1.28; 1.97]</b>
<b>Alcohol &gt; 0.5 g/l</b>				
Negative (= ref)	1	1	1	1
Positive	<b>149.06 [34.19; 649.85]</b>	<b>159.37 [19.90; 1276.40]</b>	<b>126.84 [36.76; 437.62]</b>	<b>23.47 [11.14; 49.43]</b>
<b>Frequency of driving at accident site</b>				
Daily	1	1	1	1
Several time weekly	<b>2.42 [1.01; 5.79]</b>	1.21 [0.82; 1.77]	1.00 [0.51; 1.96]	1.13 [0.84; 1.51]
Several time monthly	0.59 [0.21; 1.67]	1.38 [0.88; 2.17]	1.36 [0.40; 4.62]	1.06 [0.76; 1.47]
Less than once a month	<b>12.25 [2.13; 70.61]</b>	1.27 [0.56; 2.87]	1.11 [0.29; 4.38]	0.69 [0.42; 1.12]
Very rarely or first time	>50***	<b>3.72 [1.53; 9.04]</b>	1.17 [0.25; 5.55]	<b>1.58 [1.08; 2.32]</b>
<b>Vehicle owner</b>				
Driver or spouse	1	1	1	1
Not driver or spouse	0.70 [0.43; 1.12]	0.93 [0.66; 1.30]	1.62 [0.97; 2.71]	<b>1.48 [1.14; 1.92]</b>

Note: Multivariate analysis including all the variables from table 3, plus age, did not significantly change results for commuting to or from work or on-duty driving; changes in OR for significant variables were less than 10%

are distinguished: human, environmental and vehicle-related. In commuting home, the vehicle used and the environment can be presumed to be comparable to those when commuting to work, suggesting that it is human factors that are relevant. The differences to be expected are thus to be sought in terms of attention (distraction), vigilance or attitude. The most likely hypotheses regarding commuting to work concern either suboptimal vigilance due to driving too soon after waking up, increased stress and aggressiveness due to pressure to get to work on time, or greater use of distractors (cellphone personal organizer or e-mail functions, hair adjustment or make-up, etc.).

Finally, drivers commuting to or from work showed a greater impact of alcohol consumption on risk of responsibility for an accident. This is hard to explain, but may be due to workplace drinking by persons unused to alcohol and more susceptible to its effects.

To our knowledge, no previous studies focused on risk of responsibility for an accident according to type of journey. The strong point of the study lay in its being founded on a database representative of all road accidents in France over a full year. The VOIESUR database moreover includes expert assessment of the responsibility of each driver involved in the accident.

However, the study also had several limitations. For some items, there were up to 25% missing data. However, analyses were made taking account of this, and results suggest no significant biases or, especially, differentials. Moreover, missing data were imputed, so that all drivers involved in the accidents and meeting the inclusion criteria could be taken into account in the analyses.

Another limitation concerned expert attribution of responsibility, for which no standard written protocol exists. There may thus be some question as to the impact of certain factors, such as blood alcohol concentration, on attribution of responsibility. Here again, analyses were performed to screen for bias. In particular, a responsibility prediction model was constructed using an alcohol-negative population; applying this to the alcohol-positive population showed good prediction of the experts' attributions, suggesting independence between factors such as alcohol level and expert attribution of responsibility. Moreover, the fact that about 80% of drivers were considered by the experts to be completely responsible or non-responsible suggests that the experts had a fairly clear idea of the concept of responsibility.

Finally, this kind of study raises two methodological questions. The first concerns the data available and

their collection, which is not exhaustive, and possibly biased. Amoros et al. proposed improving data quality by means of correction coefficients [21, 22]; the method is robust as far as prevalences are concerned, but was not applied here due to possible uncertainties in more complex analyses. The second issue relates to risk analysis in terms of responsibility. The method assumes that drivers not responsible for the accident in which they were involved represent a random sample of the general driving population [14, 23, 24], which is strictly speaking impossible to confirm, as it would require data for drivers not involved in an accident at all but having the same exposure characteristics as those involved in an accident. In the absence of any such group, the control group used here comprised drivers involved in an accident for which they did not bear responsibility; the advantage of this was to have the same quality of information for both cases and controls.

Nevertheless, this study provides interesting knowledge regarding the prevention of road safety in the workplace. Indeed, as 38% of injuries involve drivers travelling for work, it is reasonable to question the responsibility of these drivers for the occurrence of accidents in order to better prevent them focusing on the user at higher risk. In this sense, the findings of this study suggest that prevention should target drivers of commercial vehicles and employees on temporary contracts for on duty journeys. Finally, the issue of commuting to and from work, which is considered an occupational risk in some countries, deserves to be better investigated in order to be the target of specific prevention measures."

## 5. Conclusion

The present study sheds new light on road risk associated with work-related journeys, with suggestions for preventive measures. Firstly, risk is greater commuting to than from work; further studies would be useful to assess the respective roles of distraction, time pressure and vigilance in these accidents.

When on duty, light utility drivers showed significant increased risk. Heavy goods vehicle drivers, on the other hand, who undergo extra training and aptitude testing, showed below-average risk. Temporary workers showed increased risk. These findings raise the question of the effect of occupational experience and training on work-related driving situations.

It would be of interest to study the temporal evolution of these results with the upcoming VOIESUR

549 project that is expected to be implemented in the next  
550 few years.

## 551 Ethical approval

552 The study was approved by the Voiesur Project  
553 Authorization CNIL (No 1571622).

## 554 Informed consent

555 Not applicable. Data came from the coding of  
556 a police data collection. They are anonymous, but  
557 include many details about crash circumstances,  
558 responsibility of drivers involved, traffic violations  
559 and injury pattern.

## 560 Conflict of interest

561 The authors declare that they have no conflict of  
562 interest.

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