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Risk factors of road crash: An empirical analysis among an Italian drivers sample

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ABSTRACT: With the aim of increasing information about risk factors for crashes in the area of Parma, North Italy, a total of 1489 road accidents occurred in the year 2008 was analyzed. Logistic regression was used to evaluate the association between drivers, accidents characteristics and accident outcomes (killed, severely, and mildly injured). Age classes much involved in road crash were 26-25 and 36-35 years. Men were much frequently responsible for accident than women. The hourly distribution of crash for working days, Saturday and Sunday showed that the prevalence was higher during the late night hours (0-3 on Sunday and 20-23 on Saturday, respectively). The youngest age class was involved in a greater number of accidents especially on 0-3 time of day class. About half of road crashes was directly attributed to violations. High-speed, alcohol and drug abuse affected only a small portion of cases. The highest combined risk of dying or being severely injured was found in males, driving a motorcycle. These results will influence transport and local safeties measures and policies, which will change inappropriate behaviors of drivers and protect the least experienced road users.

KEYWORDS: vehicle accidents, risk variables, driver behavior, accident outcomes.

1 BACKGROUND

Road accidents are complex events resulting primary from human, technical, and environmental contributing factors. The notion of factor can be used to pinpoint possible actions on the condition of transportation system components [1], [2], [3] [4], [5], [6] [7], [8], [9]. For example, a level of blood alcohol greater than the legal norm gives rise to actions in the fields of information, control and enforcement [10], [11], [12], [13]. Investigations carried out on accident phenomena have shown the complexity, dynamic character and the significance of many dimensions in accident production.

The present study is focused on the causal factors that have determined road accidents basing on the task-capability interface (TCI) model [14]. In this model, task difficulty arises out of the dynamic interface between the demands of the driving task and the capability of the driver. Where the capability exceeds demand, the task is easy; where capability equals demand the driver is operating at the limits of his/her capability and the task is very difficult. Where demand exceeds capability, then the task is by definition just too difficult and the driver fails at the task, loss of control occurs, and this perhaps leads to a collision. Thus, in essence, task difficulty is inversely proportional to the difference between task demand and driver capability. With a static level of capability, any event that pushes up task demand will therefore reduce this critical difference, increase task difficulty and potentially challenge safety. For instance, the use of a mobile phone can be an

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additional task, which pushes demand beyond driver capability. Driver capability is initially constrained by biological characteristics of the driver, such as information processing capacity and speed, reaction time, physical reach, motor coordination. Built on top of these characteristics are knowledge and skills arising out training and experience. Such knowledge includes formal elements such as rules of the road, procedural knowledge defining what to do under what circumstances and a representation of the dynamic of road and traffic scenario which enables prediction of how this scenario will develop. Skills include control capabilities associated with basic vehicle control as well as handling skills in challenging conditions. Together, these biological characteristics and acquired characteristics through training and experience determine the upper limit of competence of the driver. However, this competence is not necessarily what is delivered at any moment of time because capability is vulnerable to a host of human factor variables including attitude, motivation, fatigue, drowsiness, time-of-day-drugs, distraction, emotion and stress [15]. Any of these can detract from driver competence to yield a somewhat lower level of capability [14], [16].

Added to environmental factors, such as visibility, road alignment, road marking, road signs and signals or other road users who can occupy critical areas in the projected path of the driver, are elements of task demand over which the driver has immediate and direct control, such as speed selection [17], [8], [18] [9], [19], [20]. Task demand and capability are not independent elements. Capability is determined by many variables and one of these is the driver's level of arousal or activation, partly caused by endogenous factors such as the circadian rhythms but under the influence of external stimulation. Also, driver behavior is determined by task difficult perception; in other words, a driver will determine a range of task difficulty that she/he is prepared to accept, a kind of target margin or envelope of task difficulty. What determines the preferred level will be motivation for speed, perceived capability and effort motivation [21]. Drivers' ability to recognize the relationship between the demands of the driving task and their own capability was defined "calibration" and the importance in driver training of putting less emphasis on specific skills training but more on developing a reliable evaluation of the relationship between task demand and capability or feelings of risk should be stressed [1], [22], [9]. The TCI model and the associated hypothesis of task difficulty homeostasis are both descriptive of the interaction of key factors, which influence driver behavior and provide a dynamic control-motivational framework for understanding driver action, very useful in order to design safety network improvements or local safety policies.

Analyzing the underlying psychological mechanisms leading to the errors, it was estimated that approximately 40% of the accidents were due to attentional problems (e.g. lack of care, distraction, failed to look, and lack of attention), approximately 25% were due to perceptual problems (e.g. looked but failed to see, misjudgment of speed and distance) and approximately 15% were due to judgment problems (e.g. lack of judgment and wrong decision). It was also concluded that in 28% of the accidents, road and environmental factors were identified as contributory factors; in 8.5% of the accidents, vehicles features were identified as contributory factors and in 65% of the accidents, the road user was identified as the sole contributor. Despite this, compared to other domains in which human error was considered as a major trouble (e.g. air transport), there has been only limited investigation focusing on causal factors that contribute to accidents [9]. A number of factors consistently emerge in the international literature as contributors to driver crashes. Driver characteristics include age, gender, license status [23], [12], [24], [25], driving experience, consumption of alcohol or drugs [10], [11], [13], [8], fatigue [26], [3], [18], [19], inattention or not wearing seat belts [20].

The main purpose of the present study was to identify the most probable factors for crashes in the area of Parma, North of Italy, and to suggest possible preventive measures. In addition to cars and motorcycles, in this area also bicycles and mopeds are very common means of transportation; they are frequently used by the elderly and by the youth (mopeds can be ridden by anyone aged $\geq$ 14 years without license). Within the European Commission strategy, reducing serious injuries and deaths from alcohol related road accidents is a main priority. Target of European Union is 50% reduction of road death and 40% of serious injures by 2020. Thus, our primary purpose was to determine which factors or combinations of factors play a role in influencing crash occurrence and suggesting possible safety campaigns [27].

2 MATERIAL AND METHOD

2.1 DATA SAMPLING

In Italy, the ISTAT (Istituto Nazionale di Statistica) collects data on all accidents occurred on roads open to public traffic, in which at least one person was killed or injured and in which at least one moving vehicle was involved. The Police officers (Traffic Policemen, Carabineers or Municipal Policemen) who arrive at the site of the accident are responsible for filling the appropriate structured form (Rapporto Statistico di Incidente Stradale or ISTAT/CTT/INC) and for sending it to ISTAT. Information reported includes time and place of the accident, characteristics of the involved vehicles, gender and age of drivers, injured passengers and pedestrians. The ISTAT definition of 'trucks' includes vehicles used for carrying objects only,

trailer trucks with tow, articulated vehicles, semitrailers, vehicles equipped with special instruments, tractors and vehicles used for towing only. On the contrary, vans and pickups are considered as cars. Information about seat belt and helmet use at the time of accident is collected but neither on airbags nor on uses of child restraint systems. Complete information is acquired for up to three drivers. If more than three vehicles are involved in the same incident, the exceeding drivers can only contribute to the total number of injured persons, with no distinction from other vehicles occupants. Consequences of accidents are defined as non-fatal injury (regardless of its severity) or fatal injury (if death occurs within 7 days from the date of the accident). Police reports grossly underestimate the current prevalence of driving under the influence of alcohol (DUI) and a few individuals are tested for levels of blood alcohol concentration (BAC) since such an exam was not performed by forensic pathologists on the accident victims.

Demographic, accident and injury characteristics on all road crash occurred in the province of Parma during the year 2008 were obtained from police records. Since the goal of our analysis was to identify factors influencing road accidents, we chose to use the driver, rather than any subject involved in the accident, as the unit of analysis. In fact, the driver, but generally not the passenger, may hold some responsibility of the accident and should be the main target of prevention. Initially we considered the following characteristics: a) gender, b) age, c) nationality, d) type of vehicles, e) road surface, f) road type, g) road lighting, h) day time, i) day of the week, l) road characteristics, m) weather condition, n) accident causes, o) traffic density, p) injury, q) death. The severity of injuries was graded according to the "*New Injury Severity Score*" (NISS) [28]. We asked to four master degree students to independently classify each crash. These students had previously had road safety training, including practical work on analyzing accident cases. They had also trained on a different sampling of accidents and coding systems until the total agreement on occurrence or non-occurrence of specific variables in police reports was gained. JIAS hopes that Researchers, Graduate students, Developers, Professionals and others would make use of this journal publication for the development of the scientific research. Accepted papers are available freely with online full-text content upon receiving the final versions, and will be indexed at major academic databases. There is no submission or publication fee [5], [6], [7].

2.2 STATISTICAL ANALYSIS

For all accidents combined, we estimated the likelihood of being involved in a severe versus non-severe or fatal crash. For car, motorcycles and truck drivers, we estimated both the likelihood of being severely injured versus not severely injured. The odds ratio (OR) was used to estimated the likelihood of the more severe outcome as compared with the lesser serious, under the condition that a road crash with at least one lesion had occurred. Therefore, the ORs we report are estimates of the relative risk of people being injured given that they have been involved in an accident. Multivariate logistic models included terms for gender and age of involved persons, vehicle type, road type, time of day and weekday. Two tailed 95% CI were also computed. The models were tested against the global null hypothesis using the log likelihood ratio test. Their goodness of fit was tested using the Hosmer and Lemeshow test [29]. According to traffic police reports, a series of personal characteristics and road variables were investigated. As certain circumstances were rare, the factor levels for the analysis of variance were grouped as in previous investigation [3]:

- Gender (*male, female*);
- Seven age classes (*< 18, 18-25, 26-35, 36-45, 46-55, 56-65, over 65 years*);
- Nationality (*Italian, non-Italian*);
- Three classes of type of motor vehicles: *motorcycle, car and truck* (that includes: *ambulance, bus, and lorry with trailer*) while *agricultural machine* and *velocipede* were eliminated;
- Two classes for road surface (*dry* and *wet*, that includes: *wet, damp and frozen*);
- Road type (*urban, extra-urban, tangential, highway*);
- Two classes of road lighting: *good, insufficient* (that includes *insufficient* and *poor*);
- Six time intervals within a day (*0-3, 4-7, 8-11, 12-15, 16-19, 20-23*);
- Three classes for the day of the week (*working day, Saturday* and *Sunday*);
- The variable "road characteristics" was eliminated;
- Weather condition (*rain, fog, snow*);
- Accident causes (*violations, speed*, *alcohol or drug, loss of control, dangerous driving, block on roadway, lack of attention, stroke, doze off, failure, not reported*);
- Traffic density (*normal, poor* and *intense*);
- Injured prevalence (*slight* and *severe injured*);
- Death prevalence.

Possible differences in proportions of categorical variables were subjected to a chi-square (χ^2) test. To calculate the association between crashes and any probable risk factor, adjusted odds ratios (OR) with 95% confidence interval (95% CI) were obtained through a multivariate unconditional logistic regression [29]. All potential confounding factors were entered into the logistic model. In this model the odds ratio can be considered as a relative risk. Unadjusted ORs are not calculated since the interest of the present study was not aimed to establish a causal relationship for each single factor. Data were subjected to the statistical analyses by means of SPSS 14.0 software.

Table 1. Characteristics of crash cases and distributions of demographic variables, vehicle, road and factors derived from police records

***Gender of driver* n (%)**	
Female	357 (24.0%)
Masculine	1132 (76.0%)
Age of driver classes	
< 18	14 (0.9%)
18-25	248 (16.7%)
26-35	384 (25.8%)
36-45	346 (23.2%)
46-55	226 (15.2%)
56-65	128 (8.6%)
>65	141 (9.5%)
Unknown	2 (0.1%)
Nationality	
Italian	1102 (74.0%)
Non Italian	244 (16.4%)
Unknown	143 (9.6%)
Type of Vehicle	
Motorcycle	94 (6.3%)
Car	1199 (80.5%)
Truck	150 (10.1%)
Unknown	46 (3.1%)
Road surface	1173 (78.8%)
Asphalted	21 (1.4%)
Slipping	295 (19.8%)
Unknown	
Road condition	986 (66.2%)
Dry	201 (13.5%)
Wet	302 (20.3%)
Unknown	
Traffic	655 (44.0%)
Normal	340 (22.8%)
Poor	188 (12.6%)
Intense	306 (20.6%)
Unknown	
Day of the week	1074 (72.1%)
Working days	216 (14.5%)
Saturday	199 (13.4%)
Sunday	
Road Type	848 (57%)
Urban	499 (33.5%)
Extra-urban	100 (2.6%)
Tangential	100 (6.7%)
Highway	3 (0.2%)
Unknown	

2. RESULTS

3.1. FREQUENCIES DISTRIBUTION OF ROAD CRASHES

In Table 1. are reported the characteristics of cases, the distributions of demographic variables, accidents, the vehicle, the road and the other factors obtained from police records. Drivers mean age was 40.86 years (SD=15.819). As far as the gender is concerned, 1132 (76%) drivers were males, 357 (24%) were females (see Table 1). Accidents appeared not to be severe at first sight and those involving a single vehicle were more likely. A significant difference was shown for incident occurrence in the different age classes (χ^2=472.31, p< .01): The most frequency was found both in 26-35 years (25.8%) and 36-45 years (23.2%). Figure 1. shows the frequencies distribution of road crashes in relation to gender and age. Male drivers were more frequently involved in accident than female drivers but statistical analysis did not reveal any age difference between genders: the majority of road crashes occurred in the same age classes (26-35 and 36-45). As far as the variable "*Nationality*", the great majority of accident (74%) occurred to Italian drivers contrasting with the 16.4 percent occurred to non-Italian drivers Concerning the "*Vehicle type*" we found the maximum number of accident for "*Car"* (80.5%), followed by "*Truck"* drivers (10.1%). The general conditions and driving situations more frequently represented included: "*Asphalted*" (78.8%) and "*Dry*" (66.2%) road, in *"Normal*" (44.0%) traffic condition, and in "*Urban*" road (57%). Concerning the variable "*Lighting*", the great majority occurred in "*Good*" lighting conditions (68.2%).

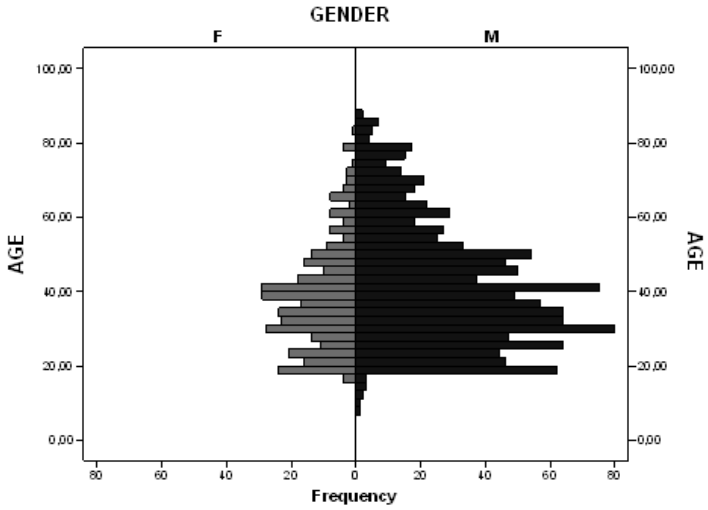

Fig. 1. Distribution of road crashes for gender and age

3.2. DISTRIBUTION OF ACCIDENT FOR DAYS AND TIME RANGES

Relative to the day of the week, the maximum number of accidents occurred on working days (n=1074), while 216 and 199 accidents occurred during Saturday and Sunday, respectively. The day of the week was marked as slightly significant in the statistical analysis but interacted significantly with other factors, producing different time and age patterns. A significant difference shows that crash occurrence is different along the different time of the days of the week (χ^2=58.99, p<.001). The hourly distributions of accidents are compared in Table 2 where standardized cell residuals scores are reported. During working days, 0-3 hour range leads to the fewest road accidents. On the contrary, on Saturday between 20-23 hour range and particularly between 0-3 on Sunday, the impact of road crashes was significantly higher.

Table 2. Distribution of accident for days and time ranges

	Accidents: timetable					
	0-3	**4-7**	**8-11**	**12-15**	**16-19**	**20-23**
Working days	**5.7** ***-2.3***	11.3 *.0*	21.1 *1,2*	23.3 *.6*	28.9 *.6*	9.7 *-1.5*
Saturday	**11.2** *1.8*	12.6 *.6*	15.8 *-1.2*	18.6 *-1.2*	25.1 *-.8*	**16.7** ***2.4***
Sunday	**14.6** ***3.5***	9.6 *-.7*	14.6 *-1.5*	21.7 *-.2*	25.8 *-.6*	13.6 *1.0*

In other words, the highest risk was found from Saturday night to the first hours of Sunday. The counts of accidents occurred on Saturday and Sunday nights exceeded the values of Friday and working days. A significant association is also showed in the accidents occurrence between time and gender (χ^2=19.708, p<.001) where a different distribution is shown in the 20-23 class with the most accidents frequency for male drivers (84.1%). A remarkable association was found among the age distribution and the time of day (χ^2=81.672, p<.001): while all age classes show accidents majority in 8-11, 12-15 and 16-19 day span, the youngest drivers were involved in a greater number of accident which greatly increased on 0-3 time of day class (standardized cell residuals: 3.6). As far as the causes of road crashes, 739 (49%) were attributed to violations. High-speed was the second more frequent road crashes cause (12.8%) surpassing alcohol and drug abuse (11.6%), and loss of vehicle control (9.7%).

3.3. ACCIDENT OUTCOMES AND RISK FACTORS

Concerning accident outcome, four consequences have been considered (dead, severe injuries, mild injures, and no injuries). A significant association between type of vehicle and risk involvement in injures outcome was found. If vehicle was a motorcycle, the risk involvement in severe injuries is very high (OR=2.85; 95% IC:1.72-4.76), and the probability to not report any injury notably low (OR=.432; 95% IC:.155-1.205). About twenty five percent of all motorcycle drivers resulted severely injured in comparison with truck (13.5%) and car drivers (10.9%). The majority (69.1%) of the people who drove a motorcycle reported also mild injuries. Truck drivers had a greater chance to not report any injury (OR=2.12; 95% IC:1.10-4.0). Driving a car showed a high risk for dying (even if this finding did not reach statistic significance). Moreover, women are more likely not seriously injured and less likely seriously injured, in other words they are less at risk of severe injury (OR= .465, 95%IC: .288-.752) and death (OR= .753; 95%IC: .415-.837). No significant relationship was found between drug abuse and accident outcomes.

3. DISCUSSION

The present study had both an applied and a theoretical focus, investigating the role of different factors within the context of road accident. Road crash reports can be a very useful and efficient means for studying driving behavior and incident factors and causes. But at their best Police reports can't provide reliable in-depth information about behaviors, as well as about the motives leading to risky driving and errors. The statistical analysis of our data revealed that predictors of road accident were violations, gender, age, two-wheeled vehicles, days and time of the days. Violations and fast driving were reported in many studies more frequently by males than by females. Women were involved in fewer accidents than men. In addition, female drivers were less likely to die or be severely injured. The most likely explanation is the difference in risk-taking behavior between males and females [30]. The age ranges comprised between 26-35 years (25.8%) and 36-45 years (23.2%) resulted more involved in accidents, particularly when men riding motorcycles than when driving cars or trucks.

Our study showed that Saturdays and Sundays are particularly dangerous for drivers, particularly during late night hours; the consumption of alcohol, that is a well-known risk factor for severe motor vehicles crashes, may be particularly high during night hours. Moreover, alcohol intake may be increased by the cold because of its warming effects on drinkers. Alcohol dependence may lead to higher risk of injury and accidents, but acute effects among inexperienced drinkers, such as adolescents, may put the person at a greater, short term, risk. As to the influence of time of the day, our data put into evidence clear circadian and semi-circadian effects with evidence of high incidence of sleep-related accident around 0 and 3 a.m. and in the early afternoon. Such a pattern is highly correlated with the well-known circadian and semi-circadian rhythm of alertness-sleepiness, reported by several laboratories [3]. Sleepiness is a typical manifestation of the biological need of sleep and increased sleepiness is associated with a decrement in reaction time, psychomotor coordination, information processing and decision making which influence the probability of having accidents. Although the lack of appropriate norms

for road use, day of the week and time of day do not allow discriminating between the exposure and the risk of sleep related-accidents at the level of detail used in this study, our data account for a specific risk for younger drivers. We can infer that old drivers are less exposed to risk of accidents during the night hours and are more likely to drive during the afternoon, so that the high incidence of accidents for younger adults during the night could be interpreted as a mixture of higher risk and higher exposure. This view is corroborated by data on the difference between working days and weekends: the occurrence of late night socializing and poor sleep habits on Saturdays and Sundays are likely to prevent younger drivers from getting sufficient sleep thus increasing their risk and their exposure at the same time. These data could be the expression of a strong rise in accidents due to the increased number of young people adopting a lifestyle that involves behaviors which put them at risk, i.e., late night socializing, early morning driving after sleep deprivation, fatigue due to dancing and noisy environment and possible interference due to alcohol and psychotropic substances.

4. CONCLUSION

The findings of this study may be used as starting point for speculations about possible attitude- and behavior-change strategies. In terms of interventions designed to reduce aggressive behavior on the road, the finding suggests that interventions helping drivers to increase self-awareness about human factors variables, managing stress and relaxing while driving may help to reduce these behaviors, particularly with reference to younger, male, and high-mileage drivers. Some methodological limitations of the present investigation that may limit the generalizability of our findings should be acknowledged. Although we are unable to address personal risk factors for fatal accidents such as risk-taking behavior or DUI because of lack of information, we identified groups of subjects and conditions that were associated with higher road crash risk. In conclusion, our data presents important implications, both for road-safety researchers and for social psychologists. Because the contributory role of many risk factors on Italian roads is still underestimated, a more detailed assessment of road incident and related factors is necessary. Our findings promote the inclusion of crash circumstances, individuals and environmental data. By achieving a greater understanding of the specific types of aberrant behavior on the roads and by investigating the groups that perform these various behaviors to a greater or lesser extent, safety campaigns can be designated to target particular individuals in relations to specific target groups together with their beliefs, norms, and attitudes.

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