

Road Traffic Injuries And Deaths On Italian Motorways: are they associated with safety law violations?

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Abstract

Introduction: Road traffic injuries are an important problem in Italy. Several measures have been taken to reduce this problem, including law enforcement policies to improve safe road behaviour (e.g. wearing of seat belts and helmets). We analysed recent trends in road traffic injuries and deaths on Italian motorways and their association with safety law violations.

Methods: We used data on both road traffic injuries and safety law violations from Police registries, concerning the period 2001–2013. Using linear regression models, we evaluated two outcomes: 1) the number of fatal injuries and 2) the total number of injuries with injured people. Covariates in the analysis were the number of fines: for dangerous speed, for excess of speed, for motor cycle use without a crash helmet, for driving without safety belts, for driving under the influence of alcohol or drugs, and the season of accident occurrence. With the R² coefficient we evaluated the quality of the model.

Results: During the period considered a significant decrease of road traffic injury and fatality rates on motorways occurred. Simultaneously, fines for bad road behaviours have increased especially for dangerous driving and for not use of safety belt.

The number of fatal injuries in motorway is significantly associated with the number of fines for dangerous speed ($\beta=0.45$; $p<0.001$), for not use of safety belt ($\beta=0.69$; $p<0.001$) and for use of drugs ($\beta=-0.34$; $p=0.001$). Significant direct associations are shown for injuries with wounded people respect the fines for dangerous speed, not use of safety belt, use of the mobile phone and seasonality (all seasons registered a elevate number of injuries in comparison to the winter); while inverse association is found versus fines for speeding. In each of the two models no significant associations respect to motorway fines for not use of helmet and alcohol assumption are found.

Conclusions: More violations of the safety belt law and the dangerous speed, as indicated by the number of fines, are associated with elevate number of nonfatal and fatal injuries on Italian motorways. The low number of fines for use of drugs is associated to lower number of fatal injuries.

Keywords: Motorway; injuries; behavioural determinants; Italy.

Introduction

Traffic injuries are an important public health problem in both developed and developing countries. In Italy, 250.000 road traffic accidents and 6500 deaths occur every year. Road traffic injury trends in Italy and

other European countries have been very favourable between 1975 and 2000. Several policies influencing behaviour (safety belts, helmets, speed limits, alcohol and drug legislation) have contributed to impressive reductions in injuries and deaths during this period [1]. In Italy, several measures have been taken, including law

enforcement policies to improve safe road behaviour (e.g. wearing of seat belts and helmets). But in spite of these measures, the number of (fatal) injuries in this country is high in comparison to other industrialized countries and it is likely that many of these fatalities are preventable. In particular, the introduction of stricter laws and the increase of controls in combination with fines for incorrect conducts, could be effective in further reducing this problem.

The risk of road traffic accident involvement has been shown to be associated with the tendency to commit driving violations and fast driving. Parker et al [2] reported that a higher tendency to commit violations was associated with accidents in general, while a higher frequency of fast driving was associated with road traffic accidents.

In Italy, there is evidence that suspended driving licences belongs to the most influential factors significantly associated with road traffic injury rates. The number of suspended driving licenses is directly associated with the road traffic injury rate, probably because it is related to road behaviour and whether or not people respect the road rules (e.g. speed limit, blood alcohol level, blood drug level) [3].

In Italy about 5 million passengers passing through every day on the motorway network of 2964.7 km, and penalties on these roads are recorded promptly and exclusively from a single source, the State Police, so it is decided to conduct a study aimed at evaluating the association with the highway incidents and safety law violations. The penalties can be interpreted by some as a proxy of the habits of drivers and the other as the intensity of controls by the Police. In addition this paper describes the epidemiology of road traffic injuries occurring on motorways in Italy in the years between 2001 and 2013. The following questions are investigated:

- Have favourable trends in road traffic injuries and deaths continued in recent years on Italian motorways?
- What has been the influence of safety law violations on the observed trends in recent years?

Materials and Methods

Database and setting

The research has been performed using the Police motorway database for the period January 2001 to December 2013 [4]. This database covers the vast majority of injury occurrences on Italian motorways, involving passenger car drivers and passengers, motorcyclists and truck drivers. Sicily is the only regional area not fully covered by this registration of events (**Figure 1**).

Figure 1. Distribution of Motorways in Italy. (Source: <http://www.autostrade.it/it/la-nostra-rete>).



In our analysis, the study hypothesis was that injury occurrence would be related to safety law violations. We used the following types of fine [5] as proxies of behaviour (more fines means more violations or more controls in our analysis):

1. dangerous speed (art. 141);
2. speeding (art. 142);
3. non-use of helmet (art. 171) (Italian law went into force in March 2000);
4. non-use of safety belts (art. 172) (Italian law went into force in March 1988) [6];
5. use mobile phone without speakerphone or earphone (art.173) (data available from 1st September 2004) [7];
6. driving under the effect of alcohol (art. 186);
7. and driving under the effect of drugs (art. 187).

As far as concerns the difference between dangerous speed and speeding, one can say that while the second type of fine regards the absolute speed limit (130 Km/h is the highest speed in motorways), the first one is related to the overwhelming of velocity in different contexts (i.e., driving at a speed of 110 Km/h can be very dangerous in case of fog or rain).

Statistical analysis

In the statistical analysis, a multivariate analysis was performed using a linear regression approach.

The following data were considered as dependent variables:

- number of fatal injuries ;
- number all injuries with injured people (fatal and nonfatal combined);

We calculated correlation coefficients comparing the above dependent and independent variables. Then, two linear regression models were created in order to study the relationships between the dependent (motorway injuries and deaths) and independent variables (fines for dangerous speed, excess of speed, non-use of helmets or safety belts, talking on a cell phone while driving or driving under the effects of alcohol or drugs and season).

The multivariate approach was performed using the “backward elimination” procedure; the results are presented as beta (b) coefficients. The goodness of fit of the different linear regression models performed was evaluated using the R² statistic; the level of statistical significance was set at $p < 0.05$.

Table 1. Results of the linear regression model. Dependent variable: injuries with injured people.

Covariates	Injuries with people injured	
	β	p
N° of fines for dangerous speed	0.544	<0.001
N° of fines for speeding	-0.207	0.005
N° of fines for not use of helmet	0.024	0.816
N° of fines for not use of safety belt	0.344	0.003
N° of fines for use of mobile	0.204	0.007
N° of fines for use of alcohol	-0.031	0.772
N° of fines for use of drugs	-0.139	0.116
Season:*		
Spring (April/ June)	0.527	<0.001
Summer (July/ September)	0.603	<0.001
Autumn (October/ December)	0.432	<0.001
R ² of model	0.911	

* Winter(January/ March) as reference season.

Data processing and analysis were carried out with SPSS statistical software, release 19.0.

Results

Description of the trends, 2001-2013

During the period considered a significant decrease of road traffic injury rates on Italian motorways occurred: the linear regression analysis revealed a standardised beta coefficient of $b=-26.11$ ($p<0.001$) for all injuries (**Fig. 2**) and $b=-2.03$ ($p<0.001$) for fatal injuries (**Fig. 3**).

In relation to motorway fines, different temporal patterns could be described. An increasing trend for motorway fines for speeding (standardised beta = 0.409; $p = 0.003$) (**Fig. 4a**) use of alcohol (standardised beta = 0.715; $p < 0.0001$) was observed (**Fig. 4b**). While a decreasing trend occurred in relation to motorway fines for dangerous speeding (standardised beta = -0.755; $p < 0.001$) not using a seat belt (standardised beta = -0.745; $p < 0.0001$) and not using a helmet (standardised beta = -0.653; $p < 0.0001$), use mobile while driving (standardised beta = -0.379; $p = 0.019$) (**Fig. 4b**). Invariant trend for number of fines for using drugs was observed ($p=0.122$). In all simple linear regression models an inverse association exists between mortality injuries and the number of fines for speeding ($p = 0.027$) and use of alcohol ($p=0.001$). In all simple linear regression models an direct association exists between morbidity and mortality injuries and the number of fines for dangerous speeding ($p = 0.027$) and no use of helmet and safety belt and using mobile phone while driving ($p<0.01$).

Multivariate analysis

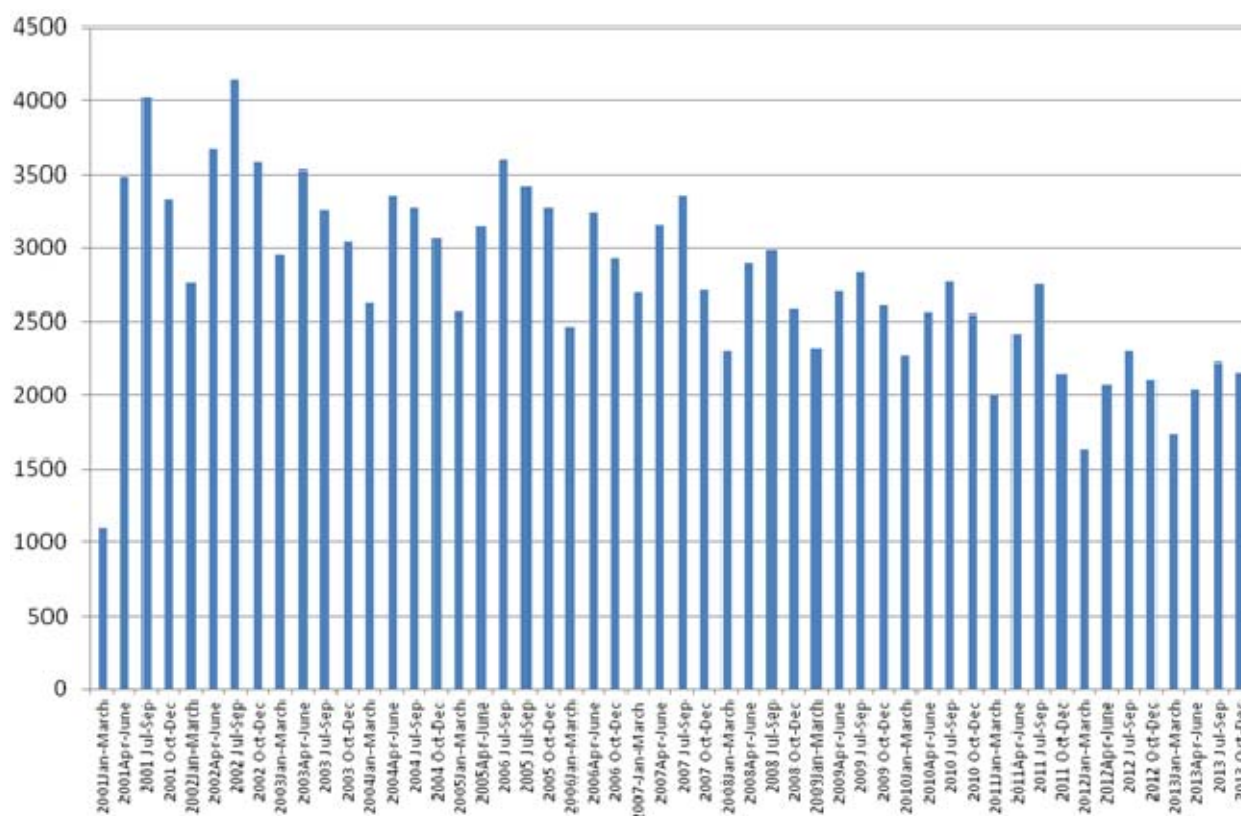
As dependent variable for the first model we used the number of “injuries with injured people” (**see Tab.1**). In this model, the significant independent variables are: number of fines for not using a safety belt ($b = 0.344$; $p = 0.003$), for the use of a cellular phone while driving ($b = 0.204$; $p = 0.007$), for dangerous speed ($b = 0.544$; $p < 0.001$), for speeding ($b = -0.207$; $p = 0.005$), and spring, summer and autumn, compared to winter ($b = 0.527$, $p < 0.001$; $b = 0.603$, $p < 0.001$; $b = 0.432$, $p < 0.001$ respectively).

The last step of the model has a R² of 91% (0.911). The second dependent variable considered was the number of fatal injuries (**see Table 2**). This model has a R² of 79% (0.787) and the covariates significantly associated in a direct way are: number of fines for dangerous speed, not using a safety belt ($\beta = 0.455$, $p < 0.001$ and $\beta = 0.698$, $p < 0.001$); while the inverse associations found are with fines for use of drugs ($\beta = -0.340$; $p < 0.001$).

Table 2. Results of the linear regression model. Dependent variable: injuries with dead people.

Covariates	Injuries with dead people	
	β	P
N° of fines for dangerous speed	0.455	<0.001
N° of fines for speeding	-0.103	0.309
N° of fines for not use of helmet	0,092	0.493
N° of fines for not use of safety belt	0.698	<0.001
N° of fines for use of mobile	0.177	0.124
N° of fines for use of alcohol	-0.003	0.985
N° of fines for use of drugs	-0.340	0.001
Season:*		
Spring (April/ June)	0.116	0.174
Summer (July/ September)	0.114	0.240
Autumn (October/ December)	0.129	0.157
R ² of model	0.817	

* Winter(January/March) as reference season.

Figure 2. Trends in all motorway injuries in Italy (2001-2013) (absolute numbers) (standardised beta coefficient = -26.11; $p < 0.001$).

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direct way are: number of fines for dangerous speed, not using a safety belt ($b = 0.455, p < 0.001$ and $b = 0.698, p < 0.001$); while the inverse associations found are with fines for use of drugs ($\beta = -0.340; p < 0.001$).

Discussion

Main findings

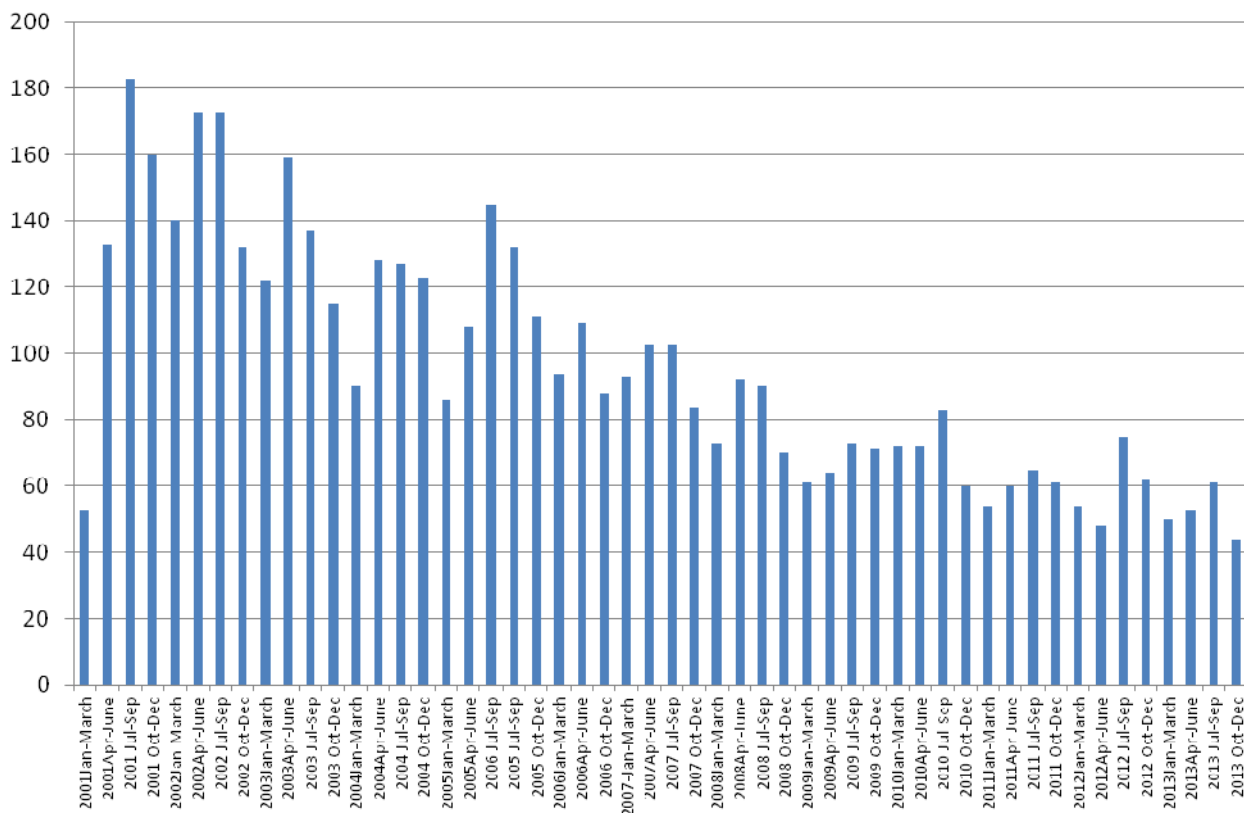
Our study shows that in the 2001-2013 study period a significant decreasing trend in all injuries and fatal injuries occurred on Italian motorways. Simultaneously, fines for bad road behaviour (speeding and use of alcohol and drugs) have increased during this period, except fines for not using seat belts or helmets, which have decreased. We found weak and non-significant associations between fines for most included road behaviours and our outcome variables. The number of fatal injuries, however, is significantly associated with the number of fines for not use of safety belt ($\beta = 0.62; p < 0.001$) and the autumn ($\beta = 0.20; p = 0.03$).

Similar associations are shown for injuries with wounded people ($\beta = 0.49; p < 0.001$ and $\beta = 0.19; p = 0.01$).

The interpretation of the aforementioned results is rather difficult, since the independent variables of our study (i.e. fines) are indicators of both population behaviour (less fines may indicate less violations) and police enforcement policies (less fines may indicate less police activities). Our interpretation of the significant effect of fines for not using a crash helmet on nonfatal and fatal motorway injuries is as follows. A recent systematic review confirmed that motorcycle helmets reduce the risk of death and head injury in motorcyclists who crashed [8]. According to this evidence, we have to consider that the use of helmets among motorcyclists in Italy is high, even before the introduction of a new law concerning the use of helmets for moped riders [9], and this is particularly true for riders in the motorway environment, where only motorcycles are admitted [10, 11].

So, driving on a motorcycle without a helmet on motorways is both rare and an extremely high risk behaviour, which will not easily escape police control. In that sense the direct relationship between fines for not using the helmet and (fatal) injuries is plausible and reflects more violations of the law without being biased by police enforcement policies.

Figure 3. – Trends in motorway fatal injuries in Italy (2001-2013) (absolute numbers) (standardised beta coefficient = - 2.031; $p < 0.0001$).



Moreover, in Italy there is evidence that road behaviour is particularly influenced by legal aspects, more than by safety education. On June 2003, the Italian government introduced a new law about driving behaviours; the so called “driver's license penalty point regulation law”. and this law seems to have had a protective effect during the early months of application [12, 13].

In addition to this, we must consider also the estimation of accident reduction due to In addition to this, we must consider also that the estimation of accident reduction could to depend to different infrastructure (ex. longitudinal barriers, pavement improvement) in the Italian motorway setting [14,15].

On the other hand, the increase of police enforcement also has a strong impact on traffic accident occurrence, especially having an effect on speed and seat belt.

Vaa [16] reported a Norwegian experience according to which an increase in police enforcement, represented mainly by stationary speed controls, in a period of six weeks, gave as a result that the average speed and the

percentage of speeding drivers were reduced for several weeks (at most 8 weeks) of the after-period.

Moreover, Johansson [17] showed that in the Swedish motorway setting the speed limit reduction has led to decrease the number of accidents that involves minor injuries and vehicle damage. In a Chinese study the impact of the use of speed detection equipment in motorway fatalities due to speeding was investigated; a decrease of 32.5% was observed in one year: “an enforcement of speeding has been successful in reducing crashes in China at the national, provincial highway and city level” [18]. Finally, there is evidence that speeding could be associated with other risk taking behavior such as drunk driving and not using seatbelts (NHTSA 2002).

Concerning the seat belt Vasudevan et al. [19] observed that the wearing rates were directly proportional to law enforcement strength, this is also confirmed by Klair & Arfan [20]. In according to the literature, the present study it's possible to observe two slumps of the fines number in 2003 and in 2007 in correspondence to the introduction in Italy of the driver's license points and a new edition of the Italian Highway Code.

Figure 4a. Temporal trends in motorway of all fines investigated in Italy (2001-2013).

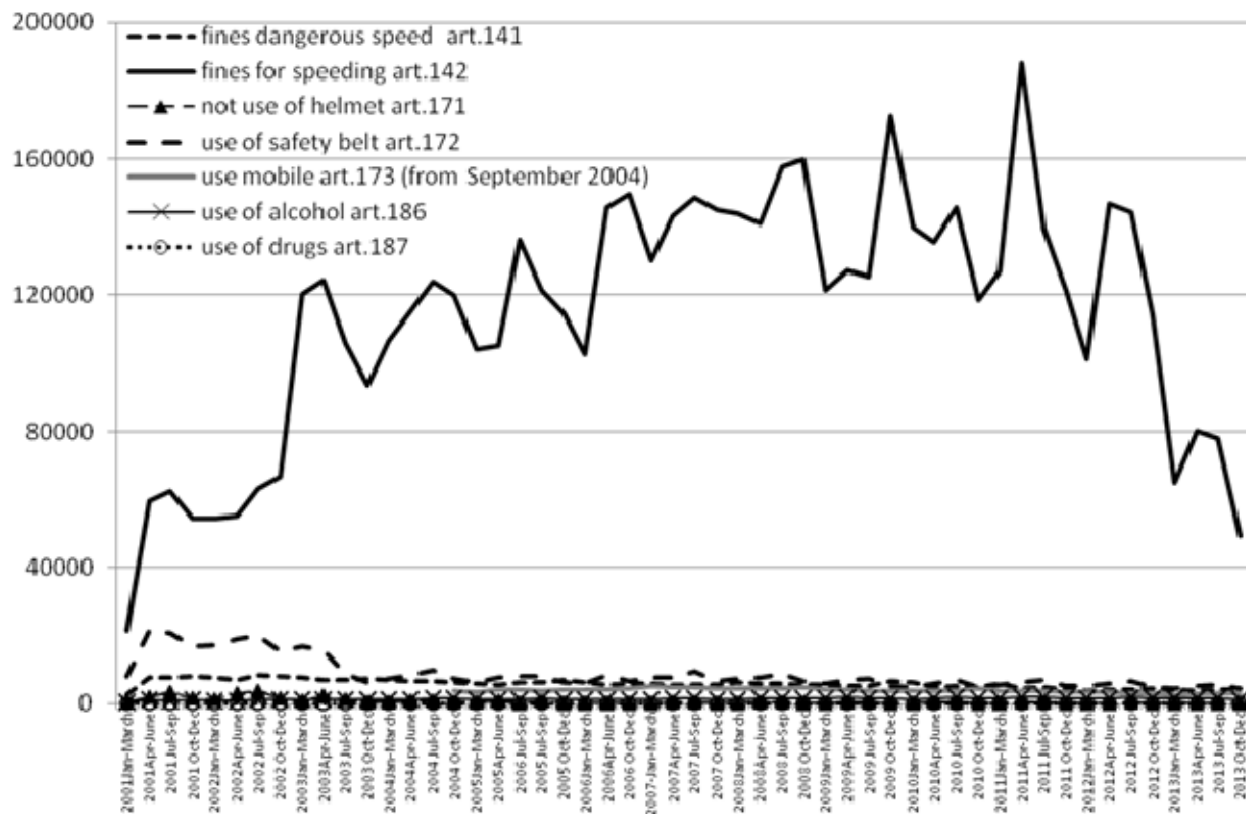
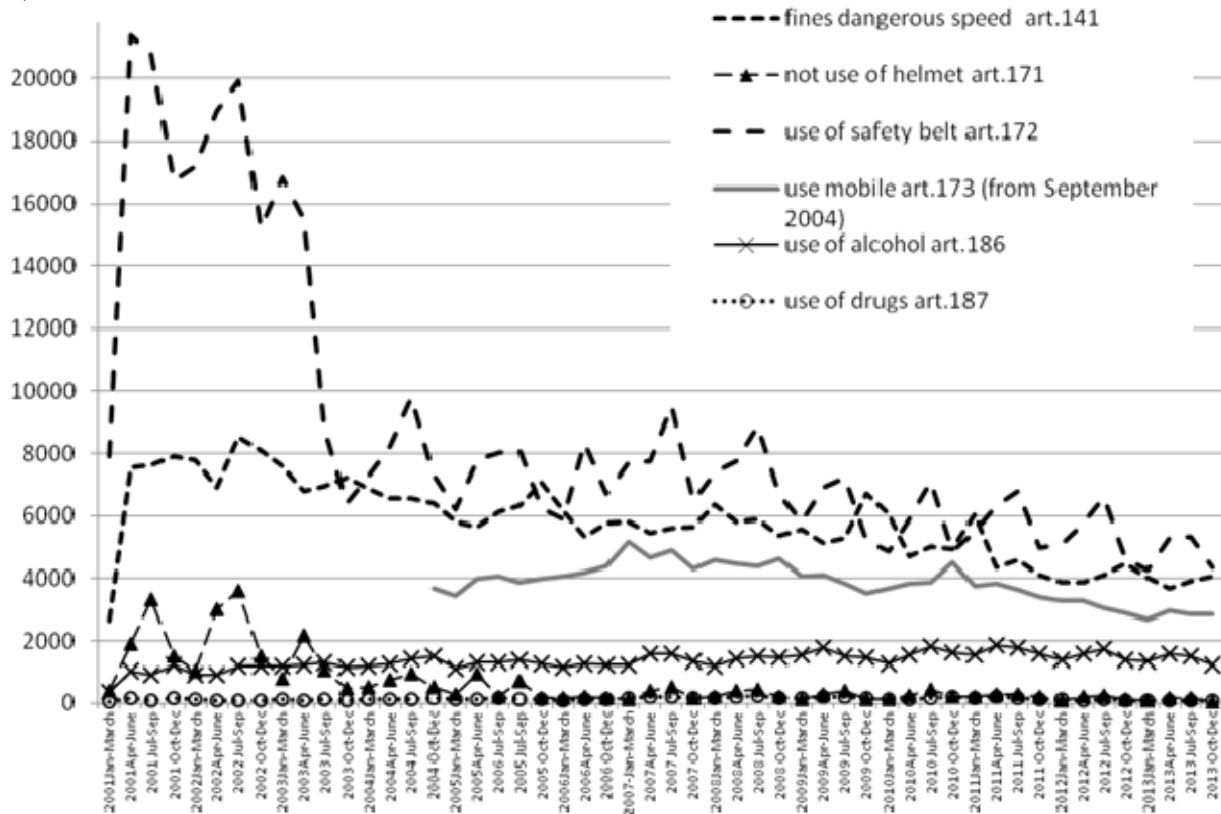


Figure 4b. Zoom of the Figure 4a on temporal trends in motorway fines (fine speeding excluded) in Italy (2001-2013).



Limitations of the study

It must be considered that the present study has some limitations. A potential limitation of this study is the accuracy of the data; even though we used data sources from established national institutes (e.g. State Policy database), one can argue that for some of them possible errors could occur. For studies on motorway injuries, however, the use of Police databases is highly reliable since traffic on motorways is fully under control of the Police and injury reporting is almost complete and is not affected by temporal influences and registration artefacts [21].

Another limitation is the impossibility to stratify the database and to conduct separate analyses by mode of transport (car, motorcycle or truck use) which would have helped interpreting the results. Finally, we used the fines as proxy indicators for drivers' behaviour (i.e. safety law violations) and this could have led to bias in the observed associations.

Finally the data of 2013 probably isn't completed and the trend interpretation isn't reliable.

Comparison with previous studies

This analysis confirms the secular decreasing trend of road injuries in the industrialised countries [22]. In addition, the multivariate approach has confirmed

previous findings that the season of the injury is always a strong predictor (in Winter there is a decline in the number of events, while during Summer there is an increased injury occurrence) [23].

There is evidence of a strong relationship between behavioural and legal factors and motorway injuries and deaths. A study conducted by Vernon et al. [24] analyzed the effects of the increased speed limit on Utah highways on total crash rates, fatal crash rates, and nonfatal crash rates, and found a significant increase in total crash rates on urban (60–65 mph) Interstate segments of highways, and in fatal crash rates on high-speed (60–65 mph) rural non-Interstate segment of highways. Moreover, Shafi and Gentilello [25] described that in 29 U.S. states with speed limits greater than 65 mph, there was a 13% increase in the risk of traffic fatalities, and they estimated that almost 3,000 lives may be saved every year with a nationwide speed limit of 65 mph or less.

The our research group has demonstrated the effect of alcohol use on regional differences in both traffic accident mortality and accident rates in Italy [26]. In this analysis we found that alcohol use is not a determinant of motorway mortality and morbidity, and this is probably due to the fact that motorway roads are much more under the Policy control and a good road behaviour

(including non-use of drugs) in this sense is more likely to occur.

Finally we have to consider that several studies found that unhelmeted riders and passengers are two-four times more likely to sustain a head trauma than helmeted users of scooters both in Italy [27, 28, 29,]; and other countries [30, 31].

How to proceed

It has been established that over the last 30 years there has been a progressive decline of road deaths in users of scooters both in Italy [27-29]; and other countries [30, 31]. most western countries. At the European level, fatal injuries declined by almost 20% between 1994 and 2003 in the 25 European Union (EU) member countries [32], and this is the result of the implementation of several road safety policies in different countries. But nowadays the mortality on world's road still remains high. WHO has estimated that between 2004 and 2030 road traffic accidents are one of the most rapidly increasing public health problems and will rise from rank 9 to rank 5 in the list of most important cause of death across the globe [33].

It has been argued that much more could, and should, be done to prevent accidents, namely with regard to control and enforcement, driving under the influence of alcohol, speed, red light cameras, road design and construction, and safe vehicle design. It has also been argued that there should be a more concerted effort to establish better emergency care, random alcohol breathalyser tests, safer cars, and rigid seat belt and helmet laws. It can be noted that several improvements have been reached over time in controlling and lowering traffic injuries, both on national roads and motorways, but the burden of accidents due to this type of injuries is still high. In the future, the effectiveness of preventive measures, especially in the motorway environment, will be assessed.. Since this represents a close environment it is conceivable that traffic control is likely to be easier than in other road environments (statal or provincial roads). Very recently Autostrade S.p.A. Company established an interesting program aiming at preventing motorway injuries due to sleepiness especially during night hours ("La vita è un soffio" [Life is a whisper], "Caffè gratis di notte" [Free coffee at night] [34], and in some motorway tracts a new speed control cameras system has been taken place. During the year 2007 these campaigns were associated with a decrease of the mortality rate of 20% [34]. This study underline that the speed control is an important risk factor in the Italian motorway; the WHO reports that the increase in average speed is directly related both to likelihood of a crash occurring and to the severity of the crash consequences [35]. So it is important to minimise the effect of this behavior with the continuous improvement of controls, that are one of the

most effective ways for reducing road traffic injuries and fatalities.

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