Do young insured drivers slow down after suffering an accident?

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Abstract

Being involved in an accident may modify the behavior of an insured at the wheel due to their having an aggravated perception of risk. Here, we analyze how the behavior of young drivers is modified after an accident by comparing percentage distances driven above posted speed limits before and after the event. The possibilities afforded by telematics, in terms of gathering information about such variables as speeding, undoubtedly constitute an important step forward in quantifying effects that hitherto have gone unanalyzed in the field of road safety and car insurance. Our results show a greater reduction in the speeding of young drivers that suffer severe bodily injuries, especially in the case of men and, particularly, among those that committed more frequent speed violations prior to the accident.

Keywords: telematics, speed limit violations, pay-as-you-drive insurance, bodily injuries, property damage, gender.

1. Introduction

We seek to examine how the personal experience of being involved in an accident affects the subsequent, short-term speed choices made by young drivers. To do so, we analyze the driving patterns of young drivers with a pay-as-you-drive (PAYD) insurance policy that have suffered an accident. Our research is based on real driving data recorded by GPS. We analyze speed patterns both before and after the accident and determine whether there have been any changes in speed limit violations following the event.

Speeding is one of the most frequent driving behaviors to negatively affect road safety. Indeed, it has been clearly demonstrated that speed is a key factor in determining the severity of an accident (Dissanayake & Lu, 2002; Elvik, Christensen, & Amundsen, 2004; Jun, Ogle, & Guensler, 2007; Jun, Guensler, & Ogle, 2011). For example, Ayuso, Guillen, & Alcañiz (2010) predicted the severity of accidents with victims by using traffic violations as explanatory variables in a multinomial logistic regression. The authors found that traffic violations related to excess speed significantly increase the odds of serious or fatal accidents versus those of slight accidents. This result was further corroborated by Abegaz, Berhane, Worku, Assrat, & Assefa (2014) who used a generalized ordered logit model to examine factors that might influence the severity of crash injury and found that speeding presented varying coefficients for different levels of injury, its greatest effects being on severe and fatal crashes. More recently, Imprialou, Quddus, Pitfield, & Lord (2016) revisited the crash-speed

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relationship by creating a new crash data aggregation approach that enables improved representation of the road conditions just before crash occurrences and found that higher speed is related to more serious crashes. Additionally, Yu & Abdel-Aty (2014) concluded that large variations in speed prior to a crash increase the likelihood of a severe accident.

Speed behavior and attitudes towards speeding have also been analyzed in the literature. Broughton, Fuller, Stradling, Gormley, Kinnear, O'Dolan, & Hannigan (2009) investigated the reasons why drivers and powered two-wheeled riders break the speed limit, and found that most do so when overtaking (67% vs. 84% for drivers and riders, respectively), and keeping up with traffic (49% vs. 52%, respectively). In the case of riders, good conditions for breaking the speed limit were an empty, daytime road (61% for riders vs. 39% for drivers). Mannering (2009) analyzed how much above the speed limit drivers felt they could drive before their safety was threatened and found that a critical determinant was the speed at which they considered themselves likely to receive a ticket. Other variables found to be significant determinants of the speed above the limit at which safety is threatened include age, gender and having been stopped previously for speeding. For young drivers, gender, car ownership, reward sensitivity, depression, and personal attitudes have been identified as being significant predictors (Scott-Parker, Hyde, Watson, & King, 2013). In an extensive literature review undertaken by Leal, Watson, & Armstrong (2010), the authors examine the increased risk young drivers are at of being involved in a crash and they report the specific risk-taking behavior displayed by this group of drivers (namely, driving for recreational purposes and illegal street racing).

More recently, Stephens, Nieuwesteeg, Page-Smith, & Fitzharris (2017) analyzed a sample of 5,179 drivers in Australia and found that almost half (47%) reported driving above the speed limit in 100 km/h zones. Compared to their compliant peers, non-compliant drivers perceived less risk of a serious crash and/or of being detected. Again, age and sex were related to speed non-compliance, with males being more excessive speeders. The association between gender and risky driving was also stressed by Ayuso, Guillen, & Pérez-Marín (2014, 2016a, 2016b) and Fergusson, Swain-Campbell, & Horwood (2003).

In general, adolescence is characterized by rapid physical, psychological, cognitive and social development, individual processes that interact with a wealth of negative, neutral and positive moods and emotions (see Scott-Parker, 2017, for an exhaustive literature review of studies examining the emotions and behavior of young drivers). Yet, while we would expect a driver, especially a young driver, to be emotionally affected by an accident, previous research alerts us to the difficulty of associating changes in a driver's speed behavior based solely on their having been involved in such an event (af Wåhlberg, 2012). Elliott and Thomson (2010), working within the framework of the theory of planned behavior, indicate that the offending driver's speeding behavior is explained not only by past events but also by such factors as attitude (instrumental/cognitive and affective/emotional), perceived social pressure (social norms), and perceived behavioral control (self-efficacy or control over internal factors, that is, the ability or otherwise to keep the vehicle speed within the legal limit, and the perceived controllability, or control over external factors, that is, other traffic driving in excess of the speed limit). Behavior can also be influenced by the riskiness of the drivers involved and their propensity to commit traffic infringements such as speeding (Leal, Watson, & Armstrong 2010). Moreover, in line with the tenets of the health belief model, when a driver perceives that their behavior may cause severe damage to the health of others (perceived severity and perceived benefits), they can be motivated to change their behavior (Tavafian, Aghamolaei, Gregory, & Madani, 2011).

As mentioned above, it would be only natural for a driver to experience a certain amount of distress following an accident, even more so in the case of a young driver involved in their first accident. However, we have no information about the homogeneity of this impact: for instance, we do not know whether the reaction of men and women is similar, nor do we know how this reaction might vary depending on the degree of damage caused. To gain greater insights into these two questions, there are two driver indicators that we might usefully examine: First, the average number of kilometers driven per day; and, second, the occurrence of speed limit violations. It might be the case that some young drivers react to an accident by refusing to drive, which would reduce the average distance driven per day. Here, af Wåhlberg (2012) stresses the relevance of including risk exposure when analyzing the effects of driving behavior, as this factor can offer a better explanation than that provided by the actual reaction to the accident. Yet, more relevantly, it may well be the case that the percentage of kilometers driven above the speed limit would be reduced after an accident, as drivers involved in an accident would be more cautious than those that have not suffered such an occurrence.

In addition to these factors, it is our contention that specific driving experiences, above all accidents and near misses, have an impact on driving patterns, especially in the period immediately following such incidents, on the understanding that they increase levels of driver caution and awareness of risk. In the long term, we would expect this effect to fade. Jun, Guensler, & Ogle (2011) investigated whether the driving speed patterns in everyday conditions of 'crash-involved' drivers differed from those of 'crash-not-involved' drivers. They found that in most instances (spatially and temporally), drivers with experiences of being involved in a crash tended to drive at higher speeds than 'crash-not-involved' drivers, except on freeways during morning peak hour traffic. 'Crash-involved' drivers also showed a greater tendency towards a non-compliance with the posted speed limit, as reported previously by Evans & Wasielewski (1982), who observed that 'accident-involved' drivers and drivers cited for violations exhibit higher levels of risk in everyday driving than 'accident-free' and 'citation-free' drivers. The factors that could help explain this contradiction are widely analyzed in Elliott & Thomson (2010) and Leal, Watson, & Armstrong (2010).

Recently, in this line of the literature examining the effect of accident experiences, Sanders (2015), in a study focused on cyclists, investigated potential pathways between collisions and near miss experiences, perceived traffic risk, and cycling frequency. He found that direct experiences—and the absence thereof—are significantly related to perceptions of traffic risk and cycling frequency. Therefore, accidents and near misses heighten awareness of risk and have some impact on taking to the road. Lheureux & Auzoult (2016) analyzed the effects of non-accident experience with regard to the violation of traffic safety regulations. A non-accident-experience refers to the fact of not having been involved in an accident following the adoption of a behavior socially recognized as promoting its occurrence. Their results support the hypothesis that experiences of this type have a strong impact on attitudes and habits with regard to traffic offences, such as speeding and drink-driving. Their results are based on a sample of French drivers who participated in a voluntary, online, questionnaire-based study. The questionnaire measured habits, attitudes, personal and vicarious experiences of accidents and non-accidents, and other personal information. The authors also found that the variables associated with accident experiences were only very loosely linked to attitudinal dimensions and habits related to speeding and drink-driving; however, the study was only based on a small sample, 543 drivers, of whom only 229 had experienced an accident at some point in the past.

Here, we undertake an empirical analysis of differences in speed limit violations recorded by young drivers before and after their involvement (a maximum period of six months) in a traffic accident, distinguishing between victims suffering bodily injuries and those physically unharmed as well as by gender. The study does not specifically consider whether the accident was attributable to speeding or another cause (e.g. texting, fatigue, sleepiness, etc.), but a reduction in speed violations is considered more likely if the accident was due to speeding or at least perceived as being due to speeding. Classifying the drivers into low and high-speed groups before the accident helps us prevent this factor from influencing our results. In the following section, we present the data used in this study together with our descriptive statistics and outline the classical method used to estimate the influence of involvement in an accident on the driver's subsequent speed behavior. In the third section, we present the results and provide a discussion of the empirical evaluation. Finally, we highlight the main conclusions and limitations that can be drawn from our study.

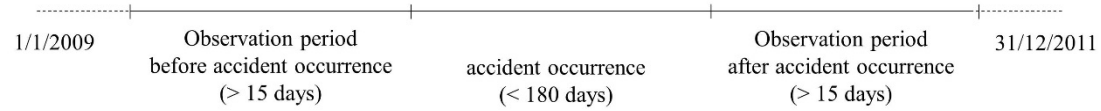
2. Materials and methods

2.1 Database and descriptive statistics

Our sample is made up of 1,071 insured drivers with a PAYD policy signed between 2009 and 2011 with a leading Spanish insurance company and who at some point were involved in an accident (in which they may or may not have been at fault). The observation period ends on 12/31/2011 or sooner if the drivers withdrew from the policy at an earlier date. The information was collected using a GPS device installed in the car. This emits a signal that is collected by an external telematics provider, who has access to information associated with a particular PIN, that is, an identification code that does not contain any personal information about the driver. The provider then sends the telematics information to the insurance company via an automated process, but without revealing the exact location of the vehicle (this is only revealed to the insurer in case of impact – and if the company is unable to contact the insured driver – or in case of theft – if a claim has previously been filed). The information provided by the insurance company for carrying out this study describes driving patterns during successive periods of time but these are not always of the same duration. In all cases, data are collected recording excess speed (i.e. percentage of km circulated above the posted limits) in three observation periods: the period prior to that in which the accident occurred, the period in which the accident occurred and the period following the accident.

For all drivers, the periods before and after the accident for which a claim was made were longer than 15 days, while the duration of the period in which the accident occurred was less than 180 days. Figure 1 illustrates the observation periods employed. We first fix an interval of less than 180 days around the occurrence of the accident. This is done to avoid the interference of any circumstances that occurred around the time of the accident (essentially, vehicle repair) and the consequent lack of data on driving during that period. We then examine speed violations recorded both before and after the interval in which the claim is made. The observational period is at least 15 days long, but for most drivers in our sample it has a duration of 180 days. Our objective is to analyze policyholders with minimum experience as regards driving habits, that is, in terms of excess speed, both before and after the accident. Our variable of interest is the percentage of kilometers traveled by the driver at a speed in excess of the legally established limits.

Figure 1. Observation periods



The mean age of all drivers in the sample is 24.44 years (standard deviation 3.03), while the mean driving experience (time elapsed since obtaining a driving license) is 3.80 years (standard deviation 2.82). Note that in the participating insurance company, PAYD policies are only offered to young drivers (the maximum age in the sample being 31).

We focus specifically on two variables for which the existing literature identifies a clear association with speed: the driver's gender and the type of damage suffered in the accident. In the case of this second variable, we distinguish between 'property damage' – that is, only the vehicle suffered damage, and 'bodily injuries' – that is, those involved in the accident suffered injuries or there were casualties. Our sample comprised 54.06% of male drivers and 45.94% female. Of the accidents recorded, 77.5% involved property damage, 5.2% involved bodily injuries, and 17.3% involved both. Our dependent variable is the percentage of kilometers traveled at a speed in excess of the posted limit by the insured driver after the accident, taking into account as a regressor their behavior in terms of speed violations before the claim. In Table 1 we present the average values observed in the sample for the percentage of kilometers traveled above the posted limits in the periods before and after the accident, differentiating by gender and the type of damage suffered.

Table 1. Mean and standard deviation (in parentheses) of the percentage of kilometers traveled above the mandatory speed limits
- by gender and type of damage suffered

		Gender		Damage		
		Female n=579	Male n=492	Property damage n= 830	Bodily injury n=56	Property damage and bodily injury n=185
Percentage of kilometers above posted speed limits	Before the accident	7.24 (7.42)	9.52 (8.53)	8.59 (8.28)	7.60 (7.93)	8.22 (7.43)
	After the accident	5.72 (5.85)	7.44 (7.54)	6.74 (6.96)	5.03 (3.87)	6.74 (7.10)

The results presented in Table 1 were analyzed using the corresponding contrasts of means. By gender, the differences observed between men and women with respect to the average percentage of kilometers traveled at excess speed before the accident (9.52 vs 7.24%, respectively) are statistically significant, indicating that men commit this type of offense more frequently than women. Both percentage figures fall significantly after the accident (7.44 vs 5.72%, respectively), though they remain higher for men and the differences between the genders remain statistically significant. In all cases, a Kruskal-Wallis test was carried out, obtaining a p-value <0.0001 (previously the Kolmogorov-Smirnov test of normality rejected this hypothesis).

Focusing separately on each gender, we test whether the difference between the percentages of kilometers traveled at excess speed before and after the accident are statistically significant. In the case of women, we conclude that they are (Wilcoxon rank test for dependent samples with p-value <0.0001, since once again we reject the hypothesis of normality with a Kolmogorov-Smirnov test). An analogous result is obtained when the contrast is made only for men before and after the accident. Being involved in an accident, therefore, significantly reduces speed violations, and this regardless of gender.

The same contrasts are made for the type of damage suffered (property and/or bodily injury) with analogous results in terms of statistical significance. In all cases, the differences between the percentage of kilometers traveled at excess speed before and after the accident are statistically significant (again, Wilcoxon rank test for dependent samples with p-value <0.0001; again, we reject the normality hypothesis with a Kolmogorov-Smirnov test). Thus, a reduction in the percentage of kilometers traveled above the posted speed limits is observed regardless of the type of damage, though it is greater in instances when only bodily injuries are recorded (almost 2.6 percentage points lower).

Moreover, in the case of accidents involving bodily injuries, the driver's behavior seems to differ depending on the severity of the injuries suffered by those involved. Clearly, if one of the victims dies, the impact on a driver's behavior is substantially different to that if only minor injuries are suffered. Note, here, we have information about the compensation paid out by the insurance company and these amounts are directly related to the severity of injuries.

2.2 Statistical methods

Our objective is to model the influence of involvement in an accident on a driver's propensity to speed, measured as the percentage of kilometers traveled at a speed in excess of the posted limit after the accident over the total number of kilometers driven. To do so, we specify a classical linear regression model with the dependent variable Y_i, defined as the percentage of kilometers circulated above the speed limit in the period after making the insurance claim. We include gender, type of damage, percentage of kilometers traveled at excess speed before the accident as regressors, as well as each driver's risk exposure based on the number of daily kilometers traveled. Variable definitions and their main descriptive statistics are provided in Table 2.

The objective is to minimize the sum of the squared errors (difference between the observed value and the predicted value of the dependent variable for each individual observation), that is:

$$Mín \sum_{i=1}^{n} (y_i - \hat{y}_i)^2$$

where $\hat{y}_i = x_{ik}^{'} \hat{\beta}_k$, being x_{ik} the vector of *K* explanatory variables for each individual *i* (n is the sample size) and β_k the corresponding parameter. The OLS estimation was carried out with software SAS 9.4 version. A complete analysis of the linear regression model can be found in Greene (2018). The analysis of the global and individual significances of the parameters is especially relevant. Each parameter indicates the elasticity of each of the variables, i.e. how the percentage of kilometers traveled at excess speeds marginally increases when we observe an unitary increment for each regressor. Negative signs of the parameters indicate marginal reductions in the percentage of kilometers driven at excess speed before unitary increments of the variables.

3. Results and discussion

Our estimation results are presented in Table 3 together with some interactions between the variables. The model is globally significant at the 1% level (F = 128.92, p-value <0.0001) and the statistical significance is shown for six of the eight parameters included in the model specification. The eight parameter estimates of the linear regression model are also reported in Table 3.

Table 2. Model variables and descriptive statistics

	Description	Mean	Std. Dev.	Minimum	Lower Quartile	Median	Upper Quartile	Maximum
Dependent variable								
Speed_after acc.	Percentage of kilometers after the accident above speed limits (%)	6.65	6.86	0.00	2.17	4.35	8.76	56.26
Independent variables								
Speed_before acc.	Percentage of kilometers before the accident above speed limits (%)	8.47	8.12	0.00	2.84	5.80	11.71	58.51
Male	Sex of insured driver (1 if male, 0 female)	54.06	-	-	-	-	-	-
Property damage	Cost of damage to property (in euros)	774.23	828.24	0	370.62	717.09	882.00	8,796.75
Bodily injury	Cost of bodily injury (in euros)	715.64	2,957.17	0	0	0	0	42,645.94
Daily kilometers_before acc.	Kilometers per day travelled by the insured driver before the accident	38.31	23.84	0.13	21.22	34.52	50.50	217.30

Table 3. Linear regression for the percent of km circulated above the speed limit. (standard deviation in parentheses)

Variable	$\hat{\beta}_k$	P-*value*
Intercept	1.99 (0.40)	<0.0001
Speed_before acc.	0.46 (0.03)	<0.0001
Male	-1.05 (0.45)	0.0193
Speed_before acc. & Male	0.18 (0.04)	<0.0001
Property damage	2.09×10^{-4} (1.90×10^{-4})	0.2724
Bodily injury	2.54×10^{-4} (8.23×10^{-5})	0.0020
Speed_before acc. & Bodily injuries	-3.12×10^{-5} (8.27×10^{-6})	0.0002
Daily kilometers_before acc.	5.83×10^{-3} (6.77×10^{-3})	0.3898

R^2= 0.46.

The expected percentage of kilometers driven at a speed in excess of the posted limits after the accident is still statistically significant, as shown by the p-value obtained for the model constant. Intuitively, if the rest of the regressors are equal to zero, there would still be excess speed after the accident, equivalent to approximately 2% of the kilometers traveled ($\hat{\beta}_0 = 1.99$).

The effect of the percentage of kilometers traveled at excess speed before the accident on the percentage of kilometers traveled at excess speed after it is also statistically significant at the 1% significance level. The positive sign for the parameter that multiplies the variable *Speed_before acc*. indicates that the higher the percentage of kilometers traveled at excess speed before the crash, the higher the percentage that exceeds the speed limits after the crash, but with a marginal increment lower than 1. This result confirms a higher perception of risk after the accident in drivers who commit speed violations, although it does not seem to be a sufficient enough reason to stop drivers committing them entirely.

The percentage of kilometers driven at excess speed after the accident decreases more sharply for male drivers than it does for female drivers (coefficient with a statistically significant negative sign at 5%); although, as we saw in Table 1, the percentage of kilometers driven at speeds in excess of the posted limits is clearly higher in the case of men. However, if the driver is a man this decrease in speeding after the accident is less pronounced the higher the percentage of speeding before the accident (positive coefficient and statistically significant for the interaction between the variables *speed_before acc* and *male*). In any case, this result seems to confirm a change in attitude towards this traffic violation, because although the coefficient is positive, it is clearly lower than 1.

No significant effects are observed in the case of the variable indicating that the driver's vehicle suffered damage, while the coefficient is positive and statistically significant at 1% in the case of bodily injuries (cost of such accidents other than zero). According to this result, as the cost of bodily injuries increases (which could be an indicator of a greater degree of severity), there exists less risk aversion after the accident, with an increase in the percentage of kilometers traveled at excess speed. This result, which we could consider *a priori* as being

unexpected, is better understood when we interact the kilometers traveled at excess speed before the accident and the cost of bodily injuries (*Speed_before acc.* & *Bodily injuries*). In this case, the parameter that is significant (at the 1% level) shows a negative sign, implying a reduction in the percentage of kilometers traveled at excess speed after the accident. As the percentage of kilometers driven at excess speed before the accident increases and the cost of bodily injuries also increases, the percentage of kilometers traveled at excess speed following the accident decreases. It would appear, therefore, that the speed reduction depends on the association made by the driver between the severity of the injuries incurred and the speed above the limit at which he or she was driving before the accident; that is, whether or not the driver associates the accident with excess speed.

In order to analyze this result in greater depth, we divided the sample of drivers who presented percentages of kilometers traveled at excess speed before the accident between those recording values above ('high') and below ('low') 5% (approximately the median value of this variable) and categorized the variable measuring the cost of bodily injuries by intervals (as shown in Table 4). We present the results by gender and total, taking into account whether the percentage of kilometers traveled at excess speed decreased-remained constant or increased with respect to the percentage before the accident.

Among those reported as driving a 'high' percentage of kilometers at excess speed, the vast majority (76.02%) reduced or maintained their speed of driving after the accident (75.35% in the case of men, 77.06% in the case of women). But, among those who drove a 'low' percentage of kilometers at excess speed, their behavior was found to vary. Almost half increased their speed after the accident, while the other half reduced or maintained it (the results being similar for both sexes), a result that contrasts with that observed when the frequency of excess speed was 'high'. In fact, the presence of bodily injuries resulting from the accident did not affect the behavior of this former group, with approximately 45.87% of drivers reducing their speed (45.10% in the case of men, 46.55% in the case of women) in contrast with the same percentages in the case of drivers circulating more frequently ('high') at excess speed before the accident (76.52%; 81.71% in the case of men, 68.00% in the case of women). When only damage to the vehicle was reported, 75.88% of this later group ('high') of drivers (73.45% for males; 79.56% for females) reduced their velocity once the claim had been made; only 51.07% (49.12% for males; 52.71% for females) did so when the excess speed was lower. In all situations, it would seem that when drivers do not associate the accident with speeding (because their frequency of driving at excess speed is low), they do not change their behavior after the accident. However, they do make a change when the association between the accident and speeding is more evident.

To illustrate this behavior, Figures 2 and 3 show the percentage of kilometers driven at excess speed as predicted by the estimated regression model after an individual has suffered an accident (axis y), bearing in mind that the driver has suffered bodily injuries (z-axis), and depending on the percentage of kilometers that the individual traveled at excess speed before the accident occurred (x axis). In Figure 2 we present the result for men, and in 3 for women, considering the value of property damaged and the daily kilometers travelled before the accident to be equal to the average sample means for men and women, respectively. The surfaces of the graphs show a reduction in the percentage of kilometers traveled at excess speed as the amount paid for bodily injuries increases, when the drivers (both men and women) drove at excess speed before the accident. When the excess velocity before the accident is low, however, this same behavior is not observed.

Table 4. Relationship between the percentage of kilometers travelled at excess speed and the cost of bodily injuries caused by the accident (overall values and separate by gender).

	Speed_before acc.<=5% ('low')						Speed_before acc.>5% ('high')					
	All		Male		Female		All		Male		Female	
	Speed after accident equal or lower	Speed after accident higher	Speed after accident equal or lower	Speed after accident higher	Speed after accident equal or lower	Speed after accident higher	Speed after accident equal or lower	Speed after accident higher	Speed after accident equal or lower	Speed after accident higher	Speed after accident equal or lower	Speed after accident higher
Only property damage	191	183	84	87	107	96	346	110	202	73	144	37
	51.07%	48.93%	49.12%	50.88%	52.71%	47.29%	75.88%	24.12%	73.45%	26.55%	79.56%	20.44%
	79.25%	75.62%	78.50%	75.65%	79.85%	75.59%	77.40%	78.01%	75.09%	82.95%	80.90%	69.81%
With bodily injuries (cost in euros)												
(0-2,500]	31	38	16	19	15	19	68	18	46	10	22	8
	44.93%	55.07%	45.71%	54.29%	44.12%	55.88%	79.07%	20.93%	82.14%	17.86%	73.33%	26.67%
	62.00%	64.41%	69.57%	67.86%	55.56%	61.29%	67.33%	58.06%	68.66%	66.67%	64.71%	15.09%
(2,500-5,000]	14	14	5	7	9	7	13	9	8	3	5	6
	50.00%	50.00%	41.67%	58.33%	56.25%	43.75%	59.09%	40.91%	72.73%	27.27%	45.45%	54.55%
	28.00%	23.73%	21.74%	25.00%	33.33%	22.58%	12.87%	29.03%	11.94%	20.00%	14.71%	11.32%
(5,000-10,000]	3	1	1	0	2	1	13	2	9	0	4	2
	75.00%	25.00%	100.00%	-	66.67%	33.33%	86.67%	13.33%	100.00%	-	66.67%	33.33%
	6.00%	1.69%	4.35%	-	7.41%	3.23%	12.87%	6.45%	13.43%	-	11.76%	3.77%
(10,000-20,000]	1	3	0	0	1	3	5	1	2	1	3	0
	25.00%	75.00%	-		25.00%	75.00%	83.33%	16.67%	66.67%	33.33%	100.00%	-
	2.00%	5.08%	-		3.70%	9.68%	4.95%	3.23%	2.99%	6.67%	8.82%	-
+20,000	1	3	1	2	0	1	2	1	2	1	0	0
	25.00%	75.00%	33.33%	66.67%	-	100.00%	66.67%	33.33%	66.67%	33.33%	-	-
	2.00%	5.08%	4.35%	7.14%	-	3.23%	1.98%	3.23%	2.99%	6.67%	-	-
Total with bodily injuries	50	59	23	28	27	31	101	31	67	15	34	16
	45.87%	54.13%	45.10%	54.90%	46.55%	53.45%	76.52%	23.48%	81.71%	18.29%	68.00%	32.00%
	20.75%	24.38%	21.50%	24.35%	20.15%	24.41%	22.60%	21.99%	24.91%	17.05%	19.10%	30.19%
Total	241	242	107	115	134	127	447	141	269	88	178	53
	49.90%	50.10%	48.20%	51.80%	51.34%	48.66%	76.02%	23.98%	75.35%	24.65%	77.06%	22.94%
N	483		222		261		588		357		231	

1st row: Absolute number of claims in each category; 2nd row: percentage with respect to the total for each interval of costs (all, males, females); 3rd row: percentage with respect to the total for each category of excess speed after the accident (speed after accident equal or lower, speed after accident higher). Note that for claims with bodily injuries (numerical intervals) percentages in the 3rd row are calculated according to the total number of claims with bodily injuries.

Figure 2. 3-D graph of the percentage of kilometers driven at excess speed after an accident, as predicted by the model for men, according to bodily injuries incurred

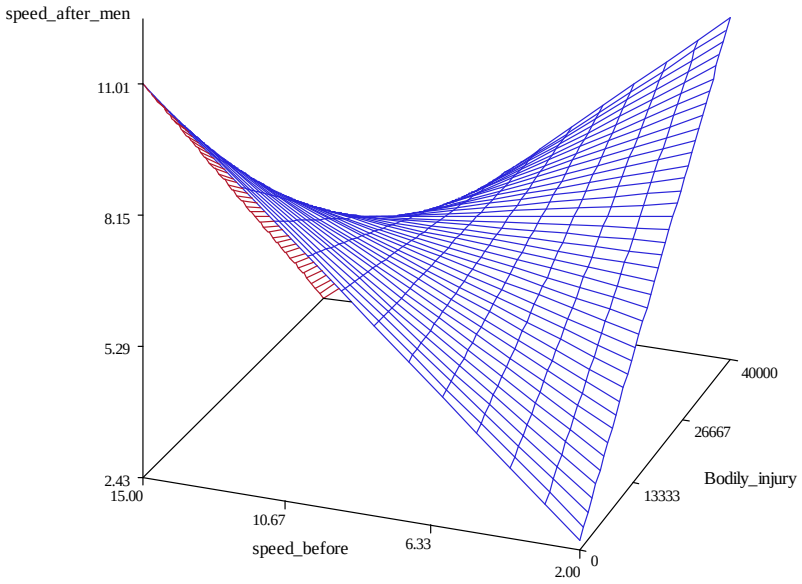


Figure 3. 3-D graph of the percentage of kilometers driven at excess speed after an accident, as predicted by the model for women, according to bodily injuries incurred

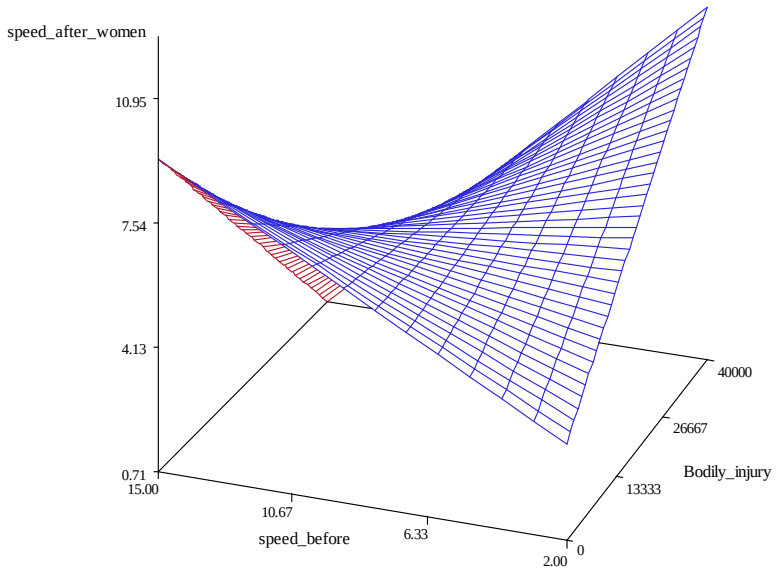
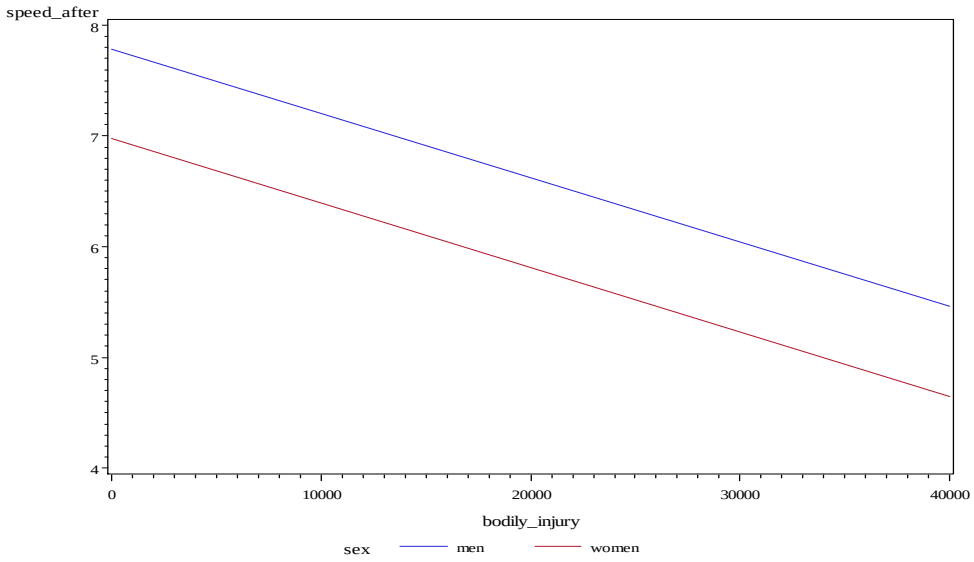


Figure 4 presents an example of how the estimated percentage of kilometers driven at excess speed after an accident decreases depending on the cost of bodily injuries, both for male and female drivers. We suppose that before the accident the percentage of kilometers driven at excess speed was very high (10%). For this particular case, the figure shows a clear association between the cost of bodily injuries and the reduction in excess speed. Moreover, male drivers present higher percentages of excess speed after the accident than women. At bodily injury costs of 10,000 euros, the amount of excess speed falls from 10 to 7.2% in the case of men, and to 6.4% in the case of women. In the case of bodily injury costs of 40,000 euros, the estimated percentage of excess falls from 10 to 5.5% in the case of men, and to 4.6% in the case of women.

Figure 4. Estimated percentage of kilometers traveled at excess speed after an accident for a driver traveling at an excess speed for 10% of the distance covered before the accident
By amount of bodily injuries and gender



Finally, we found no statistical significance between the parameter indicating whether the total number of kilometers traveled each day by the driver before the accident influences the percentage of kilometers traveled at excess speed after it. Therefore, we can draw no conclusions about the influence that risk exposure has on individual behavior in relation to speeding based on the analysis carried out herein.

4. Conclusions

We find evidence of a substantial change in the behavior of young drivers that have been involved in an accident. Here, the severity of that accident plays a crucial role in the subsequent change of behavior, to the extent that we observe greater changes in driving habits when the consequences of an accident are severe compared to less severe accidents. Considered within the framework of the health belief model, this could be a relevant finding indicating that a subjective assessment of the severity of a health problem caused by an

accident could influence driver behavior. However, one limitation of our analysis is that it does not consider how the change in speeding behavior is brought about. Yet, we believe that novice drivers – a group that is highly represented in our sample – are likely to experience feelings of insecurity after being involved in an accident.

Earlier studies have examined whether such variables as the fear of receiving a fine or the degree of social acceptance of behavior of this kind affect the probability of young drivers exceeding the posted speed limit (Mannering, 2009; Watson, Watson, Siskind, Fleiter, & Soole, 2015; Elliot & Thomson, 2010). Here, in contrast, our objective was to determine the extent to which being involved in an accident might affect a drivers' propensity to reduce their speeding. However, as mentioned, our study does not inform us as to what exactly causes the change in behavior: Is it the injury or the fine the driver has to pay or both? Here, information about the fines drivers might have paid following an accident is not available and, therefore, this factor could not be analyzed. Moreover, this analysis differs from those carried out in a number of previous studies (Ayuso, Guillen, & Alcañiz, 2010; Abegaz, Berhane, Worku, Assrat, & Assefa, 2014; Imprialou, Quddus, Pitfield, & Lord, 2016; among others) that seek to demonstrate an association between speeding and the degree of severity of the injuries suffered by the victims. The results obtained here allow us to identify changes in the percentage of kilometers driven at excess speed after a young driver is involved in a crash, and the relationship of this change in behavior with the severity of the injuries suffered. Although the information available to us here is not especially accurate regarding whether an accident might be attributed directly to speeding (and not to driver fatigue or another cause), the differences recorded in the changes in the drivers' speed behavior depending on whether the driver had previously been assigned to the high or low speeding group before the accident help us validate this effect. Thus, in line with previous research, our study concludes that speed violating drivers involved in accidents have a higher probability of violating the posted speed limit again but with a marginal increment that is lower than one.

Being involved in an accident significantly reduces a driver's propensity to speed, regardless of gender, although recent studies (see Stephens, Nieuwesteeg, Page-Smith, & Fitzharris, 2017; Ayuso, Guillen, & Pérez-Marín, 2014, 2016a, 2016b, and others) have shown that gender is associated with speed violations, with men driving faster. Here, we analyze drivers' speeding behavior not only before the accident, but also after it. We conclude that the percentage of kilometers traveled above the posted speed limit is significantly lower after an accident, both for male and female drivers. However, the greater excesses in speed observed for male vs female drivers before an accident are still observed after it and while men reduce their speeding behavior after the accident they continue to drive faster than women.

The analysis carried out allows us to identify a change in driving habits in terms of compliance with the posted speed limits, probably reflecting a greater perception of risk. However, this change in behavior is not complete, so that drivers continue to commit speed violations, albeit to a lesser degree. This outcome is even more accentuated among male drivers that commit speeding offences. This result is in line with Watson, Watson, Siskind, Fleiter, & Soole (2015) who found that younger males were significantly more likely to be repeat high-range offenders.

Changes in driving behavior (i.e. moderating speed violations) after a driver has suffered bodily injuries are noted only when the percentage of kilometers driven above the allowed speed limits before the accident was high. When this percentage was not high, the driver appears not to associate the accident with speeding and so tends to maintain the same driving

habits, even increasing the percentage of kilometers driven at excess speed. Stephens, Nieuwesteeg, Page-Smith, & Fitzharris (2017) show that younger drivers perceive less risk of a serious crash, and report themselves more likely to exceed the speed limit when they believe they will not be detected as well as reporting a higher level of social acceptability of speeding.

It would be interesting to determine whether an individual that drives many kilometers per day changes this behavior after being involved in an accident, that is, if suffering an accident causes them to modify their perception of risk by reducing their average daily driving distance (using, for example, more public transportation) or using other routes. It is a limitation of our study that we hope to analyze in future research.

The results obtained here allow us to further the study of the effects an accident can have on drivers' habits and attitudes and their commission of traffic infractions, in line with earlier studies, most notably Lheureux & Auzoult (2016), Jun, Guensler, & Ogle (2011), and Jun, Ogle, & Guensler (2007). In our case, we find a reduction in speeding violations and an association between accidents and a subsequent reduction of excess speed. However, our analysis is focused solely on those involved in an accident.

The study conducted here has been carried out specifically within the framework of PAYD insurance policies, which provide rich data about a driver's habits thanks to telemetry. Under such policies, car insurance premiums are determined by taking into account not only the traditional risk factors (driver's age, number of years with a license and the vehicle age, among other factors) but also new indicators such as the number of kilometers driven in a given period of time, the percentage of kilometers driven at night, the percentage of kilometers driven in an urban area, and the percentage of kilometers driven at excess speed (Ayuso, Guillen, & Nielsen, 2018; Guillen, Nielsen, Ayuso, & Pérez-Marín, 2018). The results obtained here should be of interest to insurers when they define risk groups and, particularly, when analyzing how the insured drivers can move from one risk group to another, taking into account not only the fact of their having suffered an accident, but also the expected changes in their driving habits as a result of it. Maintaining long data series over time would also allow insurers to analyze the duration of these behavior changes, that is, whether reductions in excess speed are maintained over time or not.

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