Analysis of the effectiveness of measures to reduce the severity of traffic accidents in the city of Barcelona in the period 2013-2019

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Abstract

We study the severity of traffic accidents in the city of Barcelona during the period from 2010 to 2019. We intend to measure the performance of Local Road Safety Plan in Barcelona 2013-2018 actions in reducing fatal/ seriously injured victims, throughout the whole period examined. We also analyse the effect of the risk factors on accident severity to detect which are significant and therefore on which the following measures can be focused to reduce severity. We draw on data available on the Open Data Barcelona platform. Logistic regression model is applied. The results show that the 2013-2016 period presents a lower risk of fatal/serious injuries with a reduction of the severity odds ratio in 10%. This lower risk is even greater in the 2017-2019 period, with a reduction of 18%. In general terms would confirm that the measures have had an effect. Furthermore, it can be observed that there has been a reduction in severe accidents on working days, as well as on the day shift and on normal streets. On the other hand, the incidence of severe accidents has remained the same when two-wheeled or heavy vehicles are involved and when there is speeding, a run-over or a shock.

Keywords: Road traffic accidents; risk factors; road safety.

1. Introduction

The analysis of traffic accidents and the adoption of measures to reduce them is on the agenda of the European cities. The Local Road Safety Plan (LRSP) in Barcelona 2013-2018 **(Ajuntament de Barcelona, 2013)** is an initiative which in the technical field, focuses on preventive and corrective actions as well as education for safe mobility with a specific objective: reduce by 30% the number of deaths in traffic accidents and 20% of serious injuries in traffic accidents in 2018 compared to 2012 levels.

In this study we intend to measure the performance of LRSP measures in reducing fatal and seriously injured victims throughout the whole period examined. The severity of road accident casualties in urban areas and the analysis of measures taken for their reduction have been investigated in different studies (see e.g. Manner & Wünsch-Ziegler (2013); Wang *et al* (2019)). For our purposes, we use a data set with detailed information on accidents with victims that occurred in Barcelona, for the years 2010 until 2019. We evaluate the effect of the year in which the accident occurred into crash-injury severity, controlling for a number of different risk factors including type and cause of accident, number and type of vehicles involved, type of day and type of road where accident occurred. In this way, we can detect which are significant and therefore on which the following measures can be focused to reduce severity. For this purpose, we have divided the years in which accidents occurred into 3 periods: the period 2010-2012, in which the characteristics of the accident rate is taken as a reference for the design of the LRSP; the period 2013-2016, when the measures started to be implemented; and the last period 2017-2019, which coincides with the completion of the plan. To examine the contribution of the risk factors considered to the severity of the accidents, we have categorised traffic accident injury severity into fatal/serious and non-serious (minor or slight) and we have fitted a binary logistic regression model.

2. Data and methods

Traffic accident data were obtained from the database of traffic accidents managed by the local police in the city of Barcelona. The final database obtained include a total of 87,823 traffic accidents with victims during the studied period. The victims are classified into three categories: fatal, seriously injured (hospitalized for more than 24 hours) and non-seriously injured (treated at the scene of the accident, in hospital emergency services or hospitalized for less than 24 hours).

In this study, the modelling effort has been restricted to using only the predicting factors that reflect the crash/accident characteristics including accident time (*Period*, *Day* (of the week) and *Dayparts* (time of the day)); crash site (*Via* (street, avenue or fast lane)); related causes (*Pedestrian*, *Bloodalcohol*, *Speed* and *Roadcondition*); type of accident (*Runover*, *Twowheelscrash*, *Collision* and *Shock)*; the vehicle characteristics (*Vehicles* (number) and

type of vehicle involved (*Bicycle*, *Twowheels*, *Heavy* and *Light*). The study factors period, day, day parts and via were classified into several categories, the first category is the reference. In the rest of the factors, it has been necessary to convert them into dummy dichotomous variables. This potentials predicting factors have been extensively used in several studies (Vorkov-Jovic *et al.* (2006); Yau *et al*. (2006); Wang *et al*. (2019)).

To determine the associations between the probability of severity outcomes (e.g. fatal/serious injuries versus minor injuries) and all contributory factors, we fit a binary logistic regression ((Sze & Wong, 2007); Moudon *et al*. (2011)). The response variable is *Severity* with two levels (0: non-serious; 1: fatal and serious), the reference category is 'non-serious injury'. The logistic regression model, expressed in terms of the logit transformation of the ith individual's response probability, p_i (e.g. probability of fatal/serious), is a linear function of the vector of explanatory variables:

$$logit(p_i) = log\left(\frac{p_i}{1 - p_i}\right) = \beta_0 + \beta_1 x_1 + \cdots + \beta_i x_i + \cdots + \beta_n x_n \qquad (1)$$

3. Results

Table 1 shows the results of binary logistic regression model estimated:

Table 1. Results of modelling the severity of the accidents.

Variables	Logistic		
	Coef.	SE.	P-val.
Intercept	-5.059	0.134	<0.01
Period_2013-16	-0.102	0.050	0.041
Period_2017-19	0.198	0.055	<0.01
Day_Working	-0.295	0.051	<0.01
Dayparts_Afternoon	0.215	0.047	<0.01
Dayparts_Even.-Night	0.397	0.070	<0.01
Via_Avenue	0.077	0.045	0.085
Via_Fast lane	0.246	0.087	<0.01
Vehicles_1	-0.947	0.117	<0.01
Bycicle_1	0.773	0.104	<0.01
Twowheels_1	1.249	0.076	<0.01
Heavy_1	1.359	0.093	<0.01
Light_1	0.421	0.079	<0.01
Pedestrian_1	0.393	0.075	<0.01
Bloodalcohol_1	0.157	0.115	0.172
Speed_1	1.314	0.132	<0.01
Roadcondition_1	-0.904	0.342	0.013
Runover_1	1.491	0.099	<0.01
Twowheelcrash_1	0.208	0.085	0.015
Collision_1	0.706	0.108	<0.01
Shock_1	1.477	0.092	<0.01
AIC			5958.4

Source: Open Data BCN. https://opendata-ajuntament.barcelona.cat/data/es/dataset.
Own elaboration.

The reported results are the estimated coefficients for the risk factors computed and the standard error and the p-value statistic for each variable. The Akaike information criterion (AIC) is also included as an indicator of the goodness of fit of the model.

Results show that several factors are found to be associated with the injury severity. In the case of the period in which the accident occurs, assumed as an indicator of the performance of the LRSP measures, period 2013-2016 presents a lower risk of fatal/serious injuries with a reduction of the severity odds ratio in 10%. This lower risk is even greater in the period 2017-2019, with a reduction of the severity odds ratio in 18%, which in general terms would confirm that the measures have had an effect.

For the rest of risk factors, the severity odds ratio is reduced by 25% during working days and is increased in 49\% when the accident occurs in the evening-night with respect to the morning shift. Setting normal streets as the reference category there is a higher risk of a fatal/serious injury in fast lanes, with an increase of 28% in the severity odds ratio. There is a lower risk of fatal/serious injury if there is more than one vehicle involved in the accident, the odds ratio is reduced in 61% with respect to an accident with only one vehicle involved. If two-wheeled or heavy vehicles are involved there is a higher risk of fatality/serious injury than if a light vehicle is involved. For example, when a two-wheeled is involved in the accident the severity odds ratio increase 3.5 times with respect the case in which is not. Speeding increases the severity odds ratio in 3.7 times. Excess alcohol is not such a significant factor and this is probably due to collinearity with excess of speed and night. Road condition does not increase the risk of deaths/serious injuries. Finally, the results show that run over and shocks (crashes against a static element) increase more the risk of accidents with fatalities and serious injuries. In both cases, the severity odds ratio increases around 4 times. These results are consistent with those of other studies ((Valent, et al., 2002); (Barua & Tay, 2010); (Manner & Wünsch-Ziegler, 2013); (Nasri et al. (2022)).

4. Conclusions

From the evaluation of the effect of the year in which the accident occurred into crash-injury severity, the results obtained in our study show that in general terms the severity (fatal/serious injury) of road accidents has decreased in the period 2013-2019. Considering the analysed risks factors, when two-wheeled or heavy vehicles are involved continue to increase the risk of a severe accident. This is also the case when the mediate cause is speeding and when the type of accident is a run-over or a collision with a static element. This casuistry has to be evaluated in greater detail within the accident rate, in order to seek out or influence in a more efficient way measures that help to achieve the objectives set.

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