Monographic

Head-on crashes on two-way interurban roads: a public health concern in road safety

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Marta Olabarria[a,b,c], Elena Santamariña-Rubio[a,b,c], Marc Marí-Dell'Olmo[a,b,c], Mercè Gotsens[a,b,c], Ana M. Novoa[b,c], Carme Borrell[a,b,c], Katherine Pérez[a,b,c,*]

[a] CIBER de Epidemiología y Salud Pública (CIBERESP), Spain
[b] Agència de Salut Pública de Barcelona, Barcelona, Spain
[c] Institute of Biomedical Research (IIB Sant Pau), Barcelona, Spain

A R T I C L E   I N F O

A B S T R A C T

Objective: To describe the magnitude and characteristics of crashes and drivers involved in head-on crashes on two-way interurban roads in Spain between 2007 and 2012, and to identify the factors associated with the likelihood of head-on crashes on these roads compared with other types of crash.
Methods: A cross-sectional study was conducted using the National Crash Register. The dependent variables were head-on crashes with injury (yes/no) and drivers involved in head-on crashes (yes/no). Factors associated with head-on crashes and with being a driver involved in a head-on crash versus other types of crash were studied using a multivariate robust Poisson regression model to estimate proportion ratios (PR) and confidence intervals (95% CI).
Results: There were 9,192 head-on crashes on two-way Spanish interurban roads. A total of 15,412 men and 3,862 women drivers were involved. Compared with other types of crash, head-on collisions were more likely on roads 7 m or more wide, on road sections with curves, narrowings or drop changes, on wet or snowy surfaces, and in twilight conditions. Transgressions committed by drivers involved in head-on crashes were driving in the opposite direction and incorrectly overtaking another vehicle. Factors associated with a lower probability of head-on crashes were the existence of medians (PR = 0.57; 95%CI: 0.48-0.68) and a paved shoulder of less than 1.5 meters (PR = 0.81; 95%CI: 0.77-0.86) or from 1.5 to 2.45 meters (PR = 0.90; 95%CI: 0.84-0.96).
Conclusions: This study allowed the characterization of crashes and drivers involved in head-on crashes on two-way interurban roads. The lower probability observed on roads with median strips point to these measures as an effective way to reduce these collisions

Colisiones frontales en vías interurbanas de doble sentido: un problema de salud pública en seguridad vial

R E S U M E N

Objetivo: Describir la magnitud y las características de las colisiones y de los conductores/as implicados/as en colisiones frontales en carretera convencional, e identificar los factores asociados a la probabilidad de colisión frontal respecto a otro tipo de colisiones, en España, en 2007-2012.
Métodos: Estudio de diseño transversal utilizando el Registro de víctimas y accidentes. Las variables dependientes fueron la colisión frontal con víctimas (sí/no) y ser un conductor implicado en colisión frontal (sí/no). Se estudiaron los factores asociados a colisión o a ser un conductor implicado en colisión frontal respecto a los otros tipos de colisión, mediante un modelo multivariado de regresión de Poisson robusta, estimando razones de proporción (RP) y sus intervalos de confianza del 95% (IC95%).
Resultados: Ocurrieron 9192 colisiones frontales en carretera convencional, con 15.412 hombres y 3862 mujeres involucrados/as. Hubo una mayor probabilidad de colisión frontal respecto a otro tipo de colisión en carreteras con 7 m o más de calzada, en curvas, estrechamiento de calzada o cambios de rasante, con superficie húmeda o nevada, y durante el crepúsculo. Conducir en dirección contraria y realizar un adelantamiento indebido se asocian a colisión frontal en conductores/as. La existencia de mediana (RP = 0,57; IC95%: 0,48-0,68) o de arcén de menos de 1,5 m (RP = 0,81; IC95%: 0,77-0,86) o de 1,5 m a 2,45 m (RP = 0,90; IC95%: 0,84-0,96) se asocian a menor probabilidad de colisión frontal.

* Corresponding author.
  E-mail address: cperez@aspb.cat (K. Pérez).

Conclusiones: Este estudio ha permitido caracterizar las colisiones y los conductores/as implicados en colisiones frontales en carretera convencional. La menor probabilidad de colisión frontal cuando existen medianas hace recomendable su implementación como medida efectiva para disminuir este tipo de colisiones.

Introduction

A two-way interurban road is that outside urban areas, which does not meet the requirements for being considered a freeway or highway, and which usually has a single carriageway in each direction.[1] These roads tend to have a worse design and are often not as well maintained as highways or trans-European road network roads.[2] Although more than half of crashes in Europe occur on two-way interurban roads, little attention has been given to this problem. In Spain, these roads account for over 90% of overall road network kilometres, they are the ones with higher crash rates, even though traffic density is lower than on motorways. According to the National Traffic Authority (DGT), mortality on interurban roads has been reduced by 70% since year 2000; however, 1,230 people were still killed in 2013 in traffic crash on these roads, representing 73.2% of overall fatalities.[3]

Head-on crash and run-off the road are dominant in this type of roads, mainly due to manoeuvres like overtaking, or to factors such as speeding, driver distraction, poor road design, restricted visibility or obstacles in the edges.[2] Some contributing factors to frequency or severity of head-on crashes reported are, maximum degree of horizontal and vertical curvature, shoulder width, side friction and increased percentage of light truck.[4–6] Gårder reported driver contributing factors for head-on collisions such driver error or misjudgment, illegal or unsafe speed and inattention/distraction, fatigue and alcohol or drug use.[7]

The Community database on Accidents on the roads for Europe (CARE database) points that these crashes represent the most prevalent fatal crashes in most European countries, mainly due to head-on crashes.[2] In Spain in 2013, according to DGT, there were 2,661 head-on injury crashes which accounted for 3.0% of all injury crashes and 222 fatalities involved in head-on crashes which represent 13.2% of all road fatalities (including urban and non-urban crashes).[3] Due to the high severity rate, head-on crashes on these types of roads are a primary focus study area and one of the priority objectives of the 2011-2020 of the Spanish Road Safety Strategy.[8] Therefore, the aims of this study are to describe the magnitude and the characteristics of crashes and drivers involved on head-on crashes occurred on two-way interurban roads in Spain between 2007 and 2012, and to identify the factors associated with a higher likelihood of head-on crashes on these roads compared to other type crash.

Methods

A cross-sectional design study was carried out using the Accidents and Victims Register of DGT. There are two study populations: *1)* crashes, in which at least one person has been injured (injury crashes), occurred on two-way interurban roads in Spain; *2)* the drivers involved in these injury crashes. The definition of interurban roads includes roads defined by the National Traffic Authority as secondary roads, secondary roads with slow lane and fast-tracks, with at least one lane in each direction and with a lane width equal to or greater than 3.25 meters.

The dependent variables were: *1)* head-on injury crash (yes; no, include the other types of crashes); *2)* drivers involved in an injury head-on crash (yes; no, include drivers involved in other types of crash), all occurred on two-way interurban roads and between 2007

and 2012. There can be more than two vehicles involved in a crash, and therefore more than two drivers.

Explanatory variables include variables related to the crash and to the driver. Crash related variables were: *1)* variables on road characteristics, such as width of the road, intersections (crossing roads), road marks, paved shoulder, median separating lanes, safety barriers and delineator posts; *2)* variables on the circumstances of the crash, such as involvement of a car, a motorcycle or moped, a bicycle, a bus and a truck or van, time and day, traffic density, illumination, atmospheric factors and surface conditions. Driver related variables used were: sex, age, vehicle type, years of experience driving (from the age of the driver's license), type of driver (professional or private), trip purpose (from the reason for travelling), number of occupants, use of safety measures (seat-belt, child restraint and helmet), driving without a license, any offence done by the driver, speed violation, alcohol or drug reporting.

Statistical analysis

First, a descriptive analysis of head-on crashes was carried out using frequency distribution of road characteristics- and crash circumstances-related variables. Second, a descriptive analysis of the drivers involved on head-on crashes was carried out of driver characteristics and driver risk behaviour-related variables. Finally, crash-related factors associated to head-on crashes and, driver-related factors associated to be involved in a head-on crash, versus other type of crashes, were studied estimating Proportion Ratios (PR) and their 95% Confidence Intervals (95%CI). The most appropriate method to estimate PR would be Log- Binomial Regression method, however this model does not converge due to the presence of discrete explanatory variables with many categories. An alternative to estimate PR would be adjusted Robust Poisson regression models using generalized linear models (GLM) with a Poisson distribution and a log link. In addition, we used a robust method for estimating the variance of the errors, to avoid overestimation of this variance and obtain better estimates of PR.[9,10] Models for men and women drivers were fitted separately.

The correlations between the explanatory variables were assessed using Spearman bivariate correlations and multicollinearity was analyzed by estimating the Variance Inflation Factor. We excluded from the final model traffic flow, post delineator and road markings because they have high multicollinearity with other variables of infrastructures such paved shoulder, medians and safety barriers. We removed also variables related to the cause of the crash, as some of them have more than 90% missing values and some of them refer to attitudes of the driver such alcohol or drug use, or inadequate speed, that were included in the models of drivers. Missing categories are included in the model in order to maintain statistical power, as some variables have a quite proportion of missing values. Only significant variables are shown in the final model.

Results

Head-on crashes on interurban roads

Between 2007 and 2012, 130,454 crashes occurred on Spanish two-way interurban roads, 7% of which were head-on crashes