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Pedestrian- and driver-related factors associated with the risk of causing collisions involving pedestrians in Spain

Eladio Jiménez-Mejías[a,b,*], Virginia Martínez-Ruiz[a], Carmen Amezcua-Prieto[a,b], Rocío Olmedo-Requena[a], Juan de Dios Luna-del-Castillo[b,c], Pablo Lardelli-Claret[a,b]

[a] Department of Preventive Medicine and Public Health, School of Medicine, University of Granada, Spain
[b] Centros de Investigación Biomédica en Red de Epidemiología y Salud Pública (CIBERESP), Spain
[c] Department of Biostatistics, School of Medicine, University of Granada, Spain

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ABSTRACT

This study aimed to quantify the association between pedestrian- and driver-related factors and the risk of causing road crashes involving pedestrians in urban areas in Spain between 1993 and 2011. From the nationwide police-based registry of road crashes with victims in Spain, we analyzed all 63,205 pairs of pedestrians and drivers involved in crashes in urban areas in which only the pedestrian or only the driver was at fault. Logistic regression models were used to obtain adjusted odds ratios to assess the strength of association between each individual-related variable and the pedestrian's odds of being at fault for the crash (and conversely, the driver's odds of not being at fault).

The subgroups of road users at high risk of causing a road crash with a pedestrian in urban areas were young and male pedestrians, pedestrians with psychophysical conditions or health problems, the youngest and the oldest drivers, and drivers with markers of high-risk behaviors (alcohol use, nonuse of safety devices, and driving without a valid license). These subgroups should be targeted by preventive strategies intended to decrease the rate of urban road crashes involving pedestrians in Spain.

1. Introduction

Road crashes are among the leading causes of deaths in all countries, especially among young people. Pedestrians, as victims of this health problem, should be considered a highly vulnerable group of road users, not only in less developed countries (World Health Organization, 2013a) but also in developed countries, where pedestrian-related mortality contributes a non negligible proportion of all crash-related deaths. In Spain, for example, pedestrian deaths accounted for 20% of all traffic crash-related deaths in 2012 (Dirección General de Tráfico, 2013). The magnitude of this health problem is expected to increase in the future due to population aging (because the risk of injury and death in older pedestrians is very high) (Rolison et al., 2012), and because of foreseeable (and desirable) changes in mobility patterns in urban areas. In these settings, walking, cycling and the use of public transport are expected to increase whereas the use of private motorized transport is expected to decrease (Shinar, 2012).

Against this background, analyses of risk factors for road crashes involving pedestrians in urban areas seem well justified in order to prioritize strategies aimed at minimizing this health problem. Previous studies have focused mainly on the role of factors related with the severity of crashes involving pedestrians (Abay 2013; Aziz et al., 2013; Hanson et al., 2013; Tefft, 2013), but few studies have been designed to analyze factors related to the risk of being involved in a crash, mainly because of the difficulty in estimating pedestrians' exposure (i.e., the amount of time during which a pedestrian is at risk of being struck by a vehicle) (Keall, 1995; Lam et al., 2014; Lassarre et al., 2007).

Here we propose an indirect approach to identify and compare individual factors related to the risk of causing collisions involving pedestrians in urban areas. Our approach is based in the selection and analysis of a subgroup of crashes involving pedestrians in which either the pedestrian or the vehicle driver was identifiable as the person at fault for the collision. We used this subsample of all road crashes to quantify the association of both pedestrian- and driver-related factors with the risk of causing a crash involving pedestrians in urban areas in Spain between 1993 and 2011.

* Corresponding author at: Departamento de Medicina Preventiva y Salud Pública, Facultad de Medicina Universidad de Granada. Avda. de la Ilustración 11, Edificio A, 8ª Planta, Granada, Spain.
E-mail address: eladiojimenez@ugr.es (E. Jiménez-Mejías).

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2. Methods

Our source population was all 197,944 traffic accidents in Spain from 1993 to 2011 that occurred in urban areas and in which pedestrians were involved, as recorded in the road crash register held by the Spanish General Traffic Directorate. This police-based register contains information on all road crashes with victims recorded by the police in Spain. It includes information about the crash (time, place, concurring circumstances, etc.), the vehicles, and all persons involved. From this database we selected a subsample of 63,204 pedestrians involved in road crashes in urban areas which met the following inclusion criteria (the procedure we used to derive this subsample is shown in Fig. 1):

- Crashes involving only one pedestrian and one motorized vehicle.
- The police officer who investigated the crash at the scene completed a closed questionnaire in which he or she indicated the commission of any of the infractions listed in Appendix A. Separate lists were used for drivers and pedestrians. Infractions may be committed by both the driver and the pedestrian (the two people actively involved in the collision), either of them, or neither of them. We selected records with complete information regarding infractions committed by both the pedestrian and the driver of the vehicle.
- Collisions in which only one of the two actively involved persons (i.e., the pedestrian or the driver of the vehicle) committed an infraction. We therefore excluded crashes in which either neither or both persons committed an infraction. With this procedure, we assumed that the person at fault (the driver or the pedestrian who committed the infraction) was likely to have caused the collision. The study design is thus grounded on a comparison of the characteristics of at-fault and non-at-fault pedestrians (and conversely, of non-at-fault and at-fault drivers).
- No missing data for pedestrian's age (between 5 and 94 years) and sex.

From the database we recorded information for the following variables:

i) Pedestrian-related variables: age (grouped in 5-year strata from 5–9 to 85–94 years old), sex, severity of injuries (death, severe injury requiring hospitalization, injury not requiring hospitalization, no injury), prior physical conditions (none, visual, hearing, upper limb, lower limb, other limitation), prior psychophysical circumstances (none, under the influence of alcohol without a breath test, under the influence of alcohol with a positive breath test, under the influence of other drugs, sudden illness, drowsiness, tired, worried, other).
ii) Driver-related variables: age (<18, 18–24, 25–34, 35–44, 45–54, 55–64, 65–74, >74 years), sex, prior physical conditions (none, vision, other), prior psychophysical circumstances (none, under the influence of alcohol, other), use of safety devices (none, helmet or seat belt), previous administrative infractions (none, driving without a valid driving license, other), type of driver (nonprofessional, professional).
iii) Vehicle-related variables: type (passenger car, two-wheeled motorized vehicle, truck weighing <3500 kg, van, truck weighing >3500 kg, bus, heavy machinery), number of passengers in addition to of the driver (none, one, two, or more).
iv) Environment-related variables: year, hour of the day, type of day (work day, holiday, day before a holiday, day after a holiday), light conditions (daylight, dawn, night with good light, night with poor light, night without light), place of crash (straight road, smooth curve, sharp curve, T/Y intersection, X/+ intersection, intersection with exit or entrance ramp, traffic circle, other), road surface (normal, altered), priority regulation (none, police officer, traffic light, stop sign, yield sign, other traffic signs, pedestrian crossing, other), road width (less than 6 m, 6–6.99 m, more than 7 m), sidewalks (yes, no), visibility conditions (good, restricted), traffic flow (light, heavy, stopped [traffic jam]).

2.1. Analysis

Multivariate logistic regression was used to obtain adjusted odds ratios (aOR) to quantify the strength of association between each individual-related variable and the odds that the pedestrian was responsible (at fault) for the crash (and conversely, the odds that the driver was not at fault). The dependent variable was assigned a value of 1 if the pedestrian committed an infraction (and conversely, the driver did not), and a value of 0 if the pedestrian did not commit any infraction (and conversely, the driver did). The model included, as independent terms, all pedestrian-, vehicle- and driver-related characteristics plus all environmental variables. Regarding reference categories for age, we selected 50–54 years old for pedestrians and 35–44 for drivers, in order to obtain OR estimates higher than 1 (easier to interpret) for most of the remaining age categories. The likelihood ratio test detected a significant interaction ($p < 0.001$) between pedestrian's age and sex. We therefore calculated the aOR for age separately in each sex, and the aOR for male sex separately in each age stratum. Because values were missing for many independent variables, the adjusted model considered only the 18,623 records without any missing values for all the independent variables. Table 1 compares the distribution of pedestrian-related variables in this last subgroup of pedestrians with the distribution of the same variables in both the original source population of pedestrians involved in crashes in urban areas ($n = 197{,}944$), and in the population of pedestrians who met the selection criteria described above ($n = 63{,}204$). The distributions were very similar across these three populations.

To determine the association between driver- and vehicle-related characteristics with the odds of the driver being at fault, we calculated the inverse value of the original aOR estimates obtained with the model (1/aOR) because the original aOR estimated the association with the odds that the driver was not at fault. All analyses were done with version 13.0 of the Stata statistical package (Stata Corporation 2013).

3. Results

Table 2 shows the absolute numbers of at-fault and non-at-fault pedestrians for each age and sex category, as well as the aOR for the association between pedestrian's age and sex and being at fault. Compared to the reference age category (50–54 years old), the odds of being at fault were highest for pedestrians younger than 15 years old, followed by those aged 15–19 years old. These increases were higher for males than females. In females, the odds of being at fault were fairly constant and close to the null in the remaining age groups, with no age-related trend. In males, the aOR values were much more variable depending on the age group. Compared to the reference category, significant aOR estimates higher than 1 were found in all age groups from 25 to 59 years old, in the 65–69 year old group, and in the oldest pedestrians (>79 years old). Regarding sex differences, the aORs for the association between male sex and the pedestrian being at fault in each age category are also shown in Table 2. All values were higher than 1 (except in the 70–74 age group, in which a significant inverse association was found), and significant differences were observed for pedestrians younger than 30 years old, and in the 40–49, 65–69, 75–79 and 85–94 year old age groups. The magnitude of the aOR seemed to be higher in the