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Contribution of exposure, risk of crash and fatality to explain age- and sex-related differences in traffic-related cyclist mortality rates

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ABSTRACT

This study was designed to quantify the percent contribution of exposure, risk of collision and fatality rate to the association of age and sex with the mortality rates among cyclists in Spain, and to track the changes in these contributions with time. Data were analyzed for 50,042 cyclists involved in road crashes in Spain from 1993 to 2011, and also for a subset of 13,119 non-infractor cyclists involved in collisions with a vehicle whose driver committed an infraction (used as a proxy sample of all cyclists on the road). We used decomposition and quasi-induced exposure methods to obtain the percent contributions of these three components to the mortality rate ratios for each age and sex group compared to males aged 25–34 years. Death rates increased with age, and the main component of this increase was fatality (around 70%). Among younger cyclists, however, the main component of increased death rates was risk of a collision. Males had higher death rates than females in every age group: this rate increased from 6.4 in the 5–14 year old group to 18.8 in the 65–79 year old group. Exposure, the main component of this increase, ranged between 70% and 90% in all age categories, although the fatality component also contributed to this increase. The contributions of exposure, risk of crash and fatality to cyclist death rates were strongly associated with age and sex. Young male cyclists were a high-risk group because all three components tended to increase their mortality rate.

1. Introduction

Traffic injuries in cyclists are a health problem of growing interest in developed countries, mainly as a result of increased bicycle use (European Road Safety Observatory, 2012; World Health Organization, 2013). In Europe, bicycle fatalities accounted for 7% of the total number of road accident fatalities in 2010 (European Road Safety Observatory, 2012). Although in Spain this figure is lower (4% in 2013) (Dirección General de Tráfico, 2014) because of the still comparatively low use of bicycles as a mode of transport (Dirección General de Tráfico, 2011), the expected increase in bicycle use will probably lead to a worldwide increase in cyclist crash mortality rate (CCMR = number of deaths among cyclists involved in a crash × 100,000 population). This increase can be expected particularly in countries such as Spain, which still lack suitable infrastructures or specific traffic laws for cycling (Anaya et al., 2012; Observatorio Nacional de Seguridad Vial, 2011).

As in other groups of road users, the death of a cyclist may be viewed as the final outcome of a causal chain composed of three links acting as necessary causes: exposure (use of a bicycle), involvement in a crash, and severe injury leading to death. This simple model is useful to understand some well-known characteristics of crash-related mortality in cyclists. For example, most of the excess CCMR among younger Spanish people is clearly related with the much greater use of bicycles by young people compared to older people (Dirección General de Tráfico, 2011). Several previous individual-level studies have analyzed the contribution of factors such as age or sex on the risk of crash, severe injury or death among cyclists (Boufous et al., 2012; Persaud et al., 2012; Roberts et al., 2012). However, to our knowledge no previous studies at an individual level have attempted to investigate a complementary issue: the relative contributions of some key factors to the overall

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risk of death defined according to characteristics such as age and sex. Among these factors are (i) the amount of exposure (measured as distance traveled, time spent cycling or number of trips) (Mindell et al., 2012), (ii) the exposure-adjusted risk of involvement in a crash, and (iii) the risk of death after a crash. This gap in our knowledge most likely reflects difficulties with identifying a large cohort of cyclists and following them during many years in order to obtain enough cases of crash-related deaths for analysis. However, the methodological challenge may be partly overcome with an ecological approach, e.g., by applying decomposition methods. These methods make it possible to estimate the relative contribution (e.g., as percentage values) of each of the three links noted above in the causal chain at a group level (e.g., the exposure rate of cycling in the entire population chosen for study, the crash rate among cyclists, and the fatality rate among cyclists involved in a crash). As a result, decomposition methods provide a way to explain the differences in CCMR between age and sex subgroups in the target population. Although such methods have been widely used in analyses of other road users (Dellinger et al., 2002; Goldstein et al., 2011; Hermans et al., 2006; Zhu et al., 2013), we found only one study (Li and Baker, 1996) that applied this method to identify the determinants of differences in CCMR between males and females in the USA in 1990.

To design and implement specific measures aimed at reducing the risk of cycling-related deaths, it is essential to know the relative contributions of each of these three possible determinants of risk in age and sex subgroups within a given population. This fact contrasts sharply, however, with the scarcity of epidemiologic research on this topic in Spain. Accordingly, we designed the present study to use a decomposition procedure in order (i) to determine the specific contributions of exposure, risk of crash and fatality to age- and sex-related differences in CCMR in Spain during the period from 1993 to 2011, and (ii) to determine how these contributions changed during the study period.

2. Methods

The main source of information for this ecological study was the Spanish Register of Road Crashes with Victims held by the Spanish General Traffic Directorate. The characteristics of this police-based register, designed to include all road crashes with victims in Spain, have been described previously (Martínez-Ruiz et al., 2013). From this database we collected information for all 50,042 cyclists involved in road crashes in Spain from 1993 to 2011 for whom information was recorded about their age (5–79 years) and sex. One of the variables in the database was whether the cyclist had committed an infraction or whether the driver or drivers of other vehicles involved in the collision had committed a driving infraction. From this information we selected a subset of 13,119 cyclists involved in so-called clean collisions, i.e., collisions involving a non-infractor cyclist and another vehicle whose driver committed a driving infraction. Fig. 1 shows the procedure used to select this subsample of cyclists. We assumed that the likelihood that these cyclists were responsible for the collision was low. Therefore, we considered them as a representative sample of cyclists on the road who were passively involved in a collision with another vehicle. In accordance with the quasi-induced exposure method (Stamatiadis and Deacon, 1997), their age and sex distribution can be assumed to reflect that of the whole population of cyclists exposed to the risk of being struck by another vehicle. For all cyclists involved in a crash we collected information about their age (5–14, 15–24, 25–34, 35–44, 45–54, 55–64, 65–79 years), sex and outcome with the first 24 h after the crash (death, severe injury, minor injury, no injury).

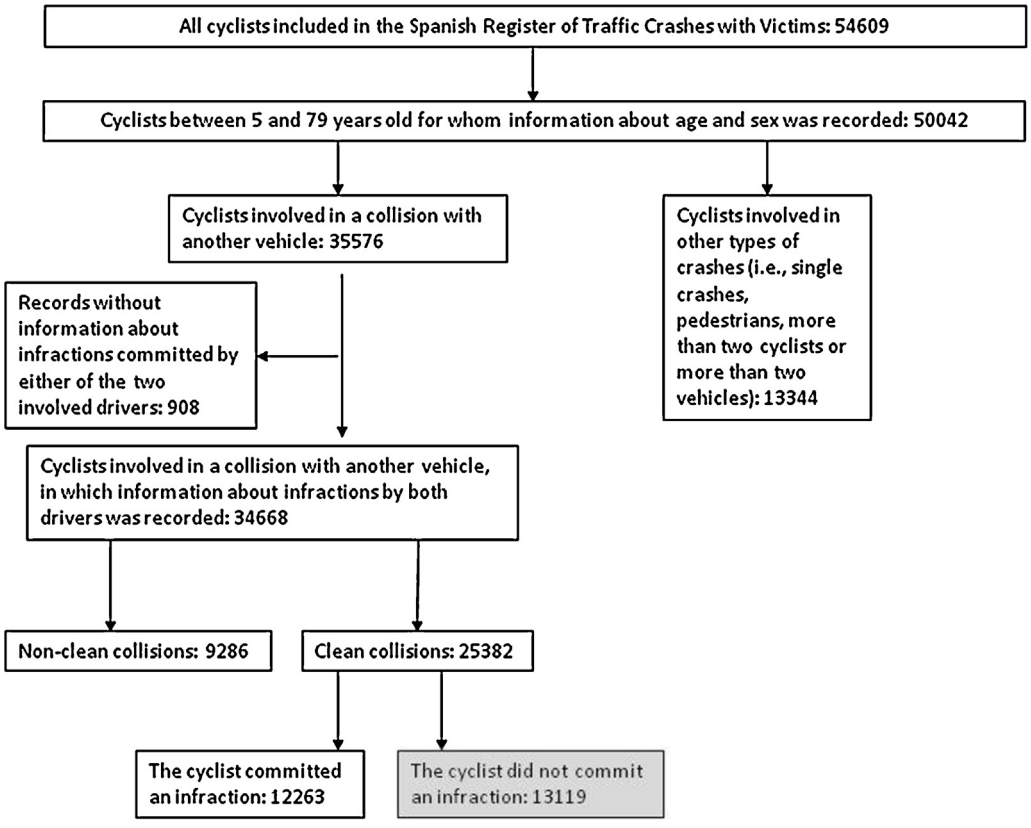

Fig. 1. Flow chart illustrating the selection of the subpopulations of cyclists used in the study.