Traffic Injury Risk Based on Mobility Patterns by Gender, Age, Mode of Transport and Type of Road

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Abstract: The role of gender and age in the risk of Road Traffic Injury (RTI) has not been fully explored and there are still significant gaps with regard to how environmental factors, such as road type, affect this relationship, including mobility as a measure of exposure. The aim of this research is to investigate the influence of the environmental factor road type taking into account different mobility patterns. For this purpose, a cross-sectional study was carried out combining two large databases on mobility and traffic accidents in Andalusia (Spain). The risk of RTI and their severity were estimated by gender and age, transport mode and road type, including travel time as a measure of exposure. Significant differences were found according to road type. The analysis of the rate ratio (Rate\textsubscript{men}/Rate\textsubscript{women}), regardless of age, shows that men always have a higher risk of serious and fatal injuries in all modes of transport and road types. Analysis of victim rates by gender and age groups allows us to identify the most vulnerable groups. The results highlight the need to include not only gender and age but also road type as a significant environmental factor in RTI risk analysis for the development of effective mobility and road safety strategies.

Keywords: road traffic injury; exposure measure; mobility patterns; sex; gender; road type

1. Introduction

Road traffic accidents are one of the world’s major public health problems, causing more than one million deaths annually [1]. The magnitude of this problem reveals the need to strengthen research in the field of road traffic injuries. A Road Traffic Injury (RTI) is defined as a fatal or non-fatal injury incurred as a result of a collision on a public road involving at least one moving vehicle [1].

RTI risk estimation uses rates that relate the number of accidents or casualties to the amount of exposure of a given population over a period of time. Exposure measures can be expressed in different units (vehicle fleet, number of drivers, number of trips, distances travelled, travel times, etc.). To obtain more accurate results, it is essential to use exposure measures that quantify the mobility of people [2–4], such as number of trips, distances travelled or travel times. The concept of mobility refers to the movements made by people between two points in order to carry out the activities of daily life. Each profile or social group has different mobility needs and this will undoubtedly influence their road accident risk. In particular, the influence of gender on RTI is not fully known. To better understand this relationship, it is necessary to take into account the role of gender in the intensity of exposure to this risk and in the accident participation rate at equal exposure [5,6].

Many authors have been concerned with analysing RTI risk by considering the mobility of men and women. However, fundamental environmental factors such as road type have been surprisingly overlooked in such research, and there is evidence that mobility patterns in urban and rural settings vary by gender. In general, women travel shorter...
distances than men [7,8], which leads into more urban trips and their different modal split compared to men [9]. There are studies that associate gender with the severity of RTIs specifying the type of road, among drivers [10–12], motorbike riders [13] or pedestrians [14], although they do not include mobility data as a measure of exposure. Other studies that considered measures of mobility exposure such as distances travelled [15] or number of road users [16] were only focused on fatal driver injuries.

As shown, there are important gaps in knowledge, such as how gender affects the severity of the injury according to age, mode of transport and/or the type of road, and which are the most vulnerable groups according to these variables. This research attempts to answer these questions by analysing data from a region belonging to the European Mediterranean Basin. Specifically, it is focused on Andalusia.

The aim of this research is to investigate the influence of the environmental factor of road type on the risk of RTI, taking into account different mobility patterns. The risk of RTI and their severity were estimated by gender and age, transport mode and road type, including travel time as a measure of exposure.

2. Background

2.1. Influence of Mobility Patterns to the Exposure of Risk of RTI

In order to estimate the risk of RTI more accurately, it is essential to use appropriate exposure measures that refer to the mobility of people [3], such as number of trips, distances travelled or travel times. This risk is estimated as the rate of the number of accidents or victims divided by the amount of exposure of a population over a period of time.

Exposure to the risk of RTI is influenced by demographic factors, socio-economic characteristics, mode of transport, road environment, etc. In terms of gender, the mobility patterns of men and women are key in determining their RTI risk. Gender and mobility are inseparable and their relationship is complex. It is known that there are significant differences in the mobility habits of men and women [7,8,17,18]. In general, women’s daily mobility in terms of distance is lower than men’s [7,8], which is related to the fact that women make more trips on urban roads and men on rural roads. For women, mobility is concentrated around the home, as opposed to the more expanded mobility of men. This fact influences their modal choice. Women use more sustainable modes of transport such as public transport and walking, while men make greater use of private vehicles [7,9,18,19].

In addition, gender differences in modal split vary across different life stages. For example, middle-aged women (30–45 years) are characterised by a higher car dependency, thus approaching the male mobility pattern, due to the accumulation of work and personal life obligations (including raising children) at this age [17].

This highlights the need for mobility data disaggregated by different variables (gender, age, mode of transport, type of road, etc.).

2.2. Risk Factors in Road Accidents

Road accidents are considered multi-causal events involving human, vehicle and environmental risk factors [18,19]. Among these three groups of factors, it is widely recognised that the human factor has the highest causal attribution [20], as it is the decision maker when using the vehicle and the road. Researchers have noted for decades that there are significant differences in driving behaviour and attitudes between men and women, and between young and adult drivers, which in turn lead to differences in risk of RTI. Globally, men are more likely than women to be involved in road traffic crashes. Nearly three-quarters of road traffic fatalities involve men under the age of 25, and they are three times more likely to die compared to young women [1]. These statistics show that gender and age are human risk factors to be taken into account in road safety. Inequalities in the risk of RTI by mode of transport have also been found [21,22], a vehicle-related risk factor. As for environmental factors, referring to the road and the surround, some authors included the time of day [23], and others detected the importance of including the type of road in future research [22,24–26].
The risk of RTI also depends on where people live, as this influences all of the above factors. Low- and middle-income countries report more than 93% of road traffic fatalities, even though these countries have approximately 60% of the world’s registered vehicles [1]. In addition to the vehicle fleet, other factors such as availability of public transport, vehicle miles travelled, safety measures such as speed limit, etc., should be considered.

From a gender perspective, the geographical, social and cultural context causes differences in the mobility patterns of men and women [8]. Gender differences in modal split increase in urban areas, where the greater availability of public transport leads women to further reduce their use of private vehicles [9]. In relation to social and cultural aspects, there are countries where women’s mobility is traditionally restricted and men acquire more car ownership.

Findings and gaps from studies relevant to the research question of this work can be mentioned below. Looking at motor vehicle drivers, a study located in the USA, using distance travelled as a measure of exposure, found that the risk of fatal crashes was higher for younger men (on all type of roads), while for older people, it was higher for men on urban roads and for women on rural ones. It is notable that older drivers (over 85 years old) had a higher risk of fatal crashes despite lower exposure (in terms of kilometres driven) [15]. In Spain, higher fatality rates have been found in older age groups on both urban and non-urban roads, especially in women [16]. Both studies focused only on drivers and fatal injuries. Other studies that did not include mobility data as a measure of exposure found that car drivers with higher risk to be seriously injured or killed were women and older people on rural roads [10–12] and male drivers at excessive speeds, on urban links and with bad visibility in Croatia [27]. In the case of motorcyclists, a study of at-fault crashes in Alabama (USA) found that men were less likely to be seriously or fatally injured, and on urban roads, there is a higher risk of minor injuries for young men and serious and fatal injuries for older women [13]. Among pedestrians, females are more likely to be seriously injured in urban areas in a study of pedestrian at-fault crashes in Alabama (USA) [14]. These studies are limited as many of them either do not include mobility-related exposure measures and focus only on fatal injuries or analyse one mode of transport (Table A1).

More road accident research is needed that analyses gender along with other variables of interest such as age, mode of transport and type of road in an integrated way, alluding to the multi-causality of road accidents and also including more precise exposure measures that quantify people’s mobility.

3. Materials and Methods

3.1. Study Area

The geographical context of the study was Andalusia (Spain) (Figure 1), located in the Mediterranean Basin of Southern Europe. It is the most populated region in Spain, with 8.4 million inhabitants [28], and the second most extensive, even more than some European countries, spread over an area of 87,599 km² [29] and an average population density of 96 inhabitants/km².

The regions of the European Mediterranean Basin have a number of common features that differentiate them from other geographical locations on the globe and are related to the use of certain modes of transport. In relation to urban morphology, they are characterised by mainly compact and dense municipalities with a mix of land uses [30]. However, there is also evidence of a certain tendency towards urban sprawl, mainly around large cities [30]. Andalusia reflects both of these urban patterns: compact cities and sprawl cities. However, the current trend is to redirect the urban configuration towards the typical compact and sustainable Mediterranean city model [31].

In terms of mobility, the physical proximity of spaces promotes social cohesion and shortens distances for the development of citizens’ daily activities, facilitating the use of more sustainable modes of transport such as public transport, cycling and walking. The use of non-motorised modes is further encouraged by the area’s warm and sunny climate. In contrast, the dispersed urban pattern results in increased reliance on the private motorised
vehicle [32]. The interest of the urban characterisation of the study area is supported by the existence of links between urban development, mobility patterns and road safety [33].

Figure 1. Map of study area.

According to statistics from the National Traffic Authority, Andalusia has the highest number of drivers in Spain and the largest vehicle fleet. The figures amount to 4,848,250 drivers (59% men and 41% women) and 5,731,487 vehicles in 2018 [34,35]. Regarding the number of motor vehicles per household, 34.2% have one vehicle, 36.3% have two and 15.5% have three or more, while 14.0% have no vehicle [36]. The average number of journeys made by the population on a working day (pre COVID-19) was 2.3 trips, falling to 2 on a weekend day [37].

Regarding gender differences in mobility patterns in Andalusia, previous studies indicate that women predominantly travel on foot, by car as a passenger and by public transport, while men mainly use the car as a driver [7]. These patterns can be related to the results of a study in Andalusia on work-related mobility, which found that men make more inter-municipal trips than women [38], revealing a higher male use of rural roads.

Focusing on official road accident statistics, in general terms, Andalusia has been experiencing a downward trend in the number of road accident victims in recent decades. This decrease is in line with that experienced in Spain, due to measures adopted from different areas such as the introduction of the points-based driving licence, the improvement of the road network, vehicle technology and the improvement of road safety education, among others. However, in 2019, 17,964 road accidents were recorded with 304 fatalities and 1348 hospitalised injuries [39]. These figures place Andalusia among the regions in Spain with the highest number of road accidents and show that the measures adopted for the prevention of traffic injuries are still insufficient, far from achieving the objectives set out in the various road safety policies in force, which highlights the interest of the study in this geographical location.
3.2. Study Design

A cross-sectional study was conducted in which the study population included all the residents of Andalusia aged 16 and over, during the period from January 2008 to December 2013.

3.3. Data Sources and Selection of Variables

This study used two data sources. The first one was the “Mobility survey in Andalusia” [40], which was carried out by the region’s Institute of Statistics and Cartography. This is the most recent survey of these characteristics carried out in Andalusia. This survey was taken by 5767 people between 13 September and 25 November 2011. The confidence level was set at 95.5% with a relative error of 1.5%. From this database, travel times disaggregated by gender, age, mode of transport and type of road were extracted. Exposure times were obtained by multiplying the times people spend on their weekday journeys by 249 (number of working days in 2011).

The use of travel time as a measure of exposure allows more accurate and consistent estimates of RTI risk; it is more adaptable to all types of situations and more flexible in relation to different environmental and personal risk circumstances (different drivers and vehicles, different roads, traffic conditions, etc.) [3,4].

The second data source was the “Register of Accidents and Victims of the National Traffic Authority” [41]. This database included all road traffic accidents with victims registered in Spain. Accident data collection suffers from incomplete information worldwide. In particular, in Spain, the percentage of incomplete accident records consulted due to missing sex and age data is 8%. Data were extracted for victims aged 16 years and over of traffic accidents occurring in Andalusia on working days (Monday to Friday) for the period 2008–2013, disaggregated by gender, age, mode of transport, type of road and degree of severity of injury (referring to the first 24 h after the accident). Records of victims with unknown values for the variables considered were eliminated, resulting in 93% of useful records. After this filtering process, data were obtained for 70,652 victims (over 16 years of age in pedestrian, car, motorcycle, bicycle and public transport).

Finally, a database was constructed by combining the two previous filtered databases. This provides the victims and travel times disaggregated by the following variables:

- Gender: Men, women.
- Age group: 16–29 years old, 30–39 years old, 40–49 years old, 50–64 years old, over 64 years old.
- Mode of transport: Pedestrian, car (drivers and passengers of cars with or without trailers and disabled cars), motorcycle (drivers and passengers on motorcycle/moped), bicycle, public transport (passengers of public service vehicle up to 9 seats, regular bus, school bus and other bus).
- Type of road: Urban road, interurban rural road (hereafter rural road).
- Injury severity: Minor (victims hospitalised less than 24 h or not hospitalised), serious (victims hospitalised more than 24 h), fatal (death occurring within 24 h after the accident).

The study focused on weekdays (Monday to Friday) because they concentrate the highest number of trips and have a more homogeneous travel pattern than weekends, which may provide more consistent results.

As for the modes of transport, only pedestrians, cars and motorcycles could be included in the study because the data available for the bicycle and public transport modes were insufficient to draw conclusions.

Finally, in relation to injury severity, due to the high level of disaggregation of data (by gender, age group, mode of transport and type of road), the frequency of cases of serious and fatalities separately was very low, which prevented us from obtaining consistent results. It was, therefore, necessary to consider fatal and serious injuries together.
3.4. Statistical Analysis

To assess the risk of suffering an RTI taking into account mobility patterns as a measure of exposure, specific rates of road traffic accident victims were calculated, using the following expression:

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\frac{\text{(Road traffic accident victims aged 16 and over on working days 2008-2013)}}{\text{(No. person-hours travelled on a working day in 2011 × 249 working days/year) × 6 years)}} \times 10,000,000
\]

This rate was expressed as victims per 10 million person-hours travelled and provided an estimation of the risk of RTI. Rates were calculated by gender and age group, for each mode of transport (pedestrian, car, motorcycle), type of road (urban, rural) and injury severity (minor, serious, fatal).

In addition, 95% confidence intervals were calculated for the rates using the Poisson distribution [42]. The Poisson distribution is best suited to the study of RTI, where the probability of occurrence at a given point in time or space under observation is very small.

Finally, to assess gender differences in RTI risk, Rate Ratios (RR) were calculated. The rate ratio was defined as Rate_{men}/Rate_{women}. We have considered statistically significantly those rate ratios in which 95% confidence intervals excluded 1.

4. Results

During the study period, 68,265 road traffic accident victims (over 16 years of age in pedestrian, car and motorcycle modes of transport) were recorded. Of these, 41,683 were male (61.06%) and 26,582 were female (38.94%).

In terms of mobility patterns, on urban roads, women spent more time on pedestrian and car journeys, and men on motorcycles. On rural roads, men always spend more time on all modes of transport analysed.

In terms of road traffic victim rates, for minor injuries on urban roads (Figure 2, Table 1), female pedestrians in the age group 64 and over are more at risk. In cars, men are 5% more at risk than women (RR = 1.05). In particular, the highest risk in cars is found in the youngest age category. In the case of motorcycles, women are 30% more at risk than men (RR = 0.70), with younger women being the most at risk.

For minor injuries on rural roads (Figure 2, Table 2), in the pedestrian mode, men have twice the risk than women (RR = 2.14), with the difference being much greater in the 40–49 age group. In the car, the risk is 29% higher for women (RR = 0.71). The most pronounced gender differences are found in the 50–64 age group. For motorcycles, the risk is higher for women by 23% (RR = 0.77), with the risk for both genders being higher among young people.

In terms of serious and fatal injuries on urban roads (Figure 2, Table 3), for pedestrians, the highest victim rates are in the older age category, especially for women (RR = 0.64). In cars, the risk is highest for males (RR = 1.82), with the highest risk and the largest difference in the youngest age group. On motorcycles, the risk is generally higher for men (RR = 1.26), with the risk for women aged 16–29 and men aged 30–39 being notable.

For serious and fatal injuries on rural roads (Figure 2, Table 4), for pedestrians, as with minor injuries, men are almost four times more at risk than women (RR = 3.85). In cars, men are more at risk than women (RR = 1.27); however, women over 64 years of age are the group most at risk. On motorcycles, the risk is higher for men (RR = 1.37), especially for younger men.
Figure 2. Traffic accident victim rates (2008–2013) per 10 million hours of travel-people on working days by gender, age group, injury severity, mode of transport and type of road. Bars represent 95% confidence interval (Poisson).

Table 1. Number of hours of travel-people (2011), number and rates of minor victims in traffic accidents (2008–2013) on working days by gender, age group and mode of transport on urban roads.

| Urban Roads | Minor Victims in Traffic Accidents (2008–2013) |
|-------------|---------------------------------------------|
| Men         | Women                                      |
| Age (Years Old) | Hours Travel-People 2011 (Mill) | Victims | Rate ¹ (95% CI) ² | Hours Travel-People 2011 (Mill) | Victims | Rate ¹ (95% CI) ² | Rate Ratio Men/Women (95% CI) |
| 16–29       | 30.41                                      | 366     | 20.06 (18.01–22.12) | 36.14 (15.95–17.58) | 424    | 19.55 (17.69–21.41) | 1.03 (0.89–1.18) |
| 30–39       | 18.74                                      | 238     | 21.17 (18.48–23.86) | 36.55 (12.54–15.68) | 253    | 11.54 (10.12–12.96) | 1.84 (1.54–2.19) |
| 40–49       | 20.43                                      | 237     | 19.33 (16.87–21.79) | 36.50 (12.05–14.52) | 309    | 14.11 (12.54–15.68) | 1.02 (1.16–1.62) |
| 50–64       | 41.53                                      | 338     | 13.57 (12.12–15.01) | 55.96 (12.05–14.52) | 446    | 13.28 (12.05–14.52) | 1.02 (0.89–1.18) |
| >64         | 51.43                                      | 456     | 14.78 (13.42–16.14) | 38.95 (20.18–23.99) | 516    | 22.08 (20.18–23.99) | 0.67 (0.59–0.76) |
| Total       | 162.52                                    | 1635    | 16.77 (15.95–17.58) | 204.09 (15.20–16.61) | 1948   | 15.91 (15.20–16.61) | 1.05 (0.99–1.13) |
### Table 1. Cont.

#### Urban Roads

**Minor Victims in Traffic Accidents (2008–2013)**

| Age (Years Old) | Hours Travel-People 2011 (Mill) | Victims | Rate \(^1\) (95% CI) \(^2\) | Hours Travel-People 2011 (Mill) | Victims | Rate \(^1\) (95% CI) \(^2\) | Rate Ratio Men/Women (95% CI) |
|-----------------|--------------------------------|---------|--------------------------|--------------------------------|---------|--------------------------|-----------------------------|
| **Car**         |                                |         |                          |                                |         |                          |                             |
| 16–29           | 30.95                          | 3102    | 167.03 (161.16–172.91)   | 37.97                          | 2740    | 120.26 (115.76–124.76)  | 1.39 (1.32–1.46)            |
| 30–39           | 38.55                          | 2068    | 89.41 (85.56–93.26)      | 43.55                          | 1879    | 71.91 (68.66–75.16)     | 1.24 (1.17–1.32)            |
| 40–49           | 41.18                          | 1282    | 51.89 (49.05–54.73)      | 42.54                          | 1267    | 49.64 (46.91–52.37)     | 1.05 (0.97–1.13)            |
| 50–64           | 40.64                          | 983     | 40.32 (37.80–42.84)      | 21.25                          | 980     | 76.88 (72.06–81.69)     | 0.52 (0.48–0.57)            |
| >64             | 9.43                           | 401     | 70.87 (63.94–77.81)      | 8.62                           | 289     | 55.85 (49.41–62.29)     | 1.27 (1.09–1.48)            |
| **Total**       | 160.74                         | 7836    | 81.25 (79.45–83.05)      | 153.94                         | 7155    | 77.47 (75.67–79.26)     | 1.05 (1.02–1.08)            |

**Motorcycle**

| Age (Years Old) | Hours Travel-People 2011 (Mill) | Victims | Rate \(^1\) (95% CI) \(^2\) | Hours Travel-People 2011 (Mill) | Victims | Rate \(^1\) (95% CI) \(^2\) | Rate Ratio Men/Women (95% CI) |
|-----------------|--------------------------------|---------|--------------------------|--------------------------------|---------|--------------------------|-----------------------------|
| 16–29           | 6.70                           | 4418    | 1099.16 (1066.75–1131.57)| 2.14                           | 1946    | 2857.46 (2730.50–2984.42)| 1.38 (0.36–0.41)            |
| 30–39           | 3.60                           | 2367    | 1097.16 (1052.96–1141.36)| 2.32                           | 830     | 595.58 (555.06–636.10)  | 1.84 (1.70–1.99)            |
| 40–49           | 10.99                          | 1904    | 288.63 (275.67–301.60)   | 1.89                           | 545     | 481.44 (441.02–521.86)  | 0.60 (0.55–0.66)            |
| 50–64           | 4.23                           | 1221    | 480.89 (453.91–507.86)   | 1.25                           | 233     | 310.40 (270.54–350.26)  | 1.55 (1.35–1.78)            |
| >64             | 1.40                           | 275     | 327.75 (289.01–366.48)   | 0.00                           | 19      | -                        | -                           |
| **Total**       | 26.92                          | 10,185  | 630.59 (618.34–642.83)   | 6.60                           | 3573    | 902.89 (873.29–932.50)  | 0.70 (0.67–0.73)            |

\(^1\) Rate: Victims per 10 million hours of travel-people.
\(^2\) CI: Confidence interval (Poisson). Statistically significant results are shown in bold (\(p < 0.05\)).

### Table 2. Number of hours of travel-people (2011), number and rates of minor victims in traffic accidents (2008–2013) on working days by gender, age group and mode of transport on rural roads.

#### Rural Roads

**Minor Victims in Traffic Accidents (2008–2013)**

| Age (Years Old) | Hours Travel-People 2011 (Mill) | Victims | Rate \(^1\) (95% CI) \(^2\) | Hours Travel-People 2011 (Mill) | Victims | Rate \(^1\) (95% CI) \(^2\) | Rate Ratio Men/Women (95% CI) |
|-----------------|--------------------------------|---------|--------------------------|--------------------------------|---------|--------------------------|-----------------------------|
| **Pedestrian**  |                                |         |                          |                                |         |                          |                             |
| 16–29           | 0.64                           | 39      | 101.56 (69.69–133.44)    | 0.48                           | 23      | 80.23 (47.44–113.02)    | 1.27 (0.76–2.12)            |
| 30–39           | 0.00                           | 30      | -                        | 0.71                           | 20      | 47.03 (26.42–67.65)     | -                           |
| 40–49           | 0.23                           | 39      | 282.61 (193.91–371.31)   | 0.90                           | 16      | 29.49 (15.04–43.94)     | 9.58 (5.36–17.15)          |
| Age (Years Old) | Hours Travel-People 2011 (Mill) | Pedestrian | Car | Motorcycle |
|-----------------|--------------------------------|------------|-----|------------|
|                  | Victims | Rate $^1$ (95% CI) $^2$ | Victims | Rate $^1$ (95% CI) $^2$ | Rate Ratio Men/Women (95% CI) |
| 50–64           | 2.08    | 35 | 28.04 (18.75–37.34) | 0.29 | 20 | 114.39 (64.25–164.52) | 0.25 (0.14–0.42) |
| >64            | 0.57    | 34 | 99.42 (66.00–132.83) | 1.78 | 19 | 17.79 (9.79–25.80) | 5.59 (3.19–9.79) |
| Total          | 3.52    | 177 | 83.81 (71.46–96.15) | 4.16 | 98 | 39.25 (31.48–47.02) | 2.14 (1.67–2.73) |

1 Rate: Victims per 10 million hours of travel-people. 2 CI: Confidence interval (Poisson). Statistically significant results are shown in bold ($p < 0.05$).
Table 3. Number of hours of travel-people (2011), number and rates of serious or fatal victims in traffic accidents (2008–2013) on working days by gender, age group and mode of transport on urban roads.

| Urban Roads | Serious or Fatal Victims In Traffic Accidents (2008–2013) |
|-------------|----------------------------------------------------------|
|             | Men | Women | Rate 1 (95% CI) 2 | Hours Travel-People 2011 (Mill) | Victims | Rate 1 (95% CI) 2 | Hours Travel-People 2011 (Mill) | Victims | Rate Ratio Men/Women (95% CI) |
| Age (Years old) |     |       |                  |                            |         |                  |                            |         |                        |
| Pedestrian   |      |       |                  |                            |         |                  |                            |         |                        |
| 16–29        | 30.41| 37    | 2.03 (1.37–2.68) | 36.14                       | 55      | 2.54 (1.87–3.21) | 31.86                       | 49      | 0.80 (0.53–1.21)        |
| 30–39        | 18.74| 33    | 2.94 (1.93–3.94) | 36.55                       | 31      | 1.41 (0.92–1.91) | 31.86                       | 49      | 2.08 (1.27–3.39)        |
| 40–49        | 20.43| 47    | 3.83 (2.74–4.93) | 36.50                       | 39      | 1.78 (1.22–2.34) | 31.86                       | 49      | 2.15 (1.41–3.29)        |
| 50–64        | 41.53| 62    | 2.49 (1.87–3.11) | 55.96                       | 76      | 2.26 (1.75–2.77) | 31.86                       | 49      | 1.10 (0.79–1.54)        |
| >64          | 51.43| 159   | 5.15 (4.35–5.95) | 38.95                       | 189     | 8.09 (6.93–9.24) | 31.86                       | 49      | 0.64 (0.52–0.79)        |
| Total        | 162.52| 338 | 3.47 (3.10–3.84) | 204.09                      | 390     | 3.18 (2.87–3.50) | 31.86                       | 49      | 1.09 (0.94–1.26)        |
| Car          |      |       |                  |                            |         |                  |                            |         |                        |
| 16–29        | 30.95| 79    | 4.25 (3.32–5.19) | 37.97                       | 39      | 1.71 (1.17–2.25) | 31.86                       | 49      | 2.49 (1.69–3.65)        |
| 30–39        | 38.55| 35    | 1.51 (1.01–2.01) | 43.55                       | 25      | 0.96 (0.58–1.33) | 31.86                       | 49      | 1.58 (0.95–2.64)        |
| 40–49        | 41.18| 29    | 1.17 (0.75–1.60) | 42.54                       | 19      | 0.74 (0.41–1.08) | 31.86                       | 49      | 1.58 (0.88–2.81)        |
| 50–64        | 40.64| 39    | 1.60 (1.10–2.10) | 21.25                       | 14      | 1.10 (0.52–1.67) | 31.86                       | 49      | 1.46 (0.79–2.68)        |
| >64          | 9.43 | 21    | 3.71 (2.12–5.30) | 8.62                        | 10      | 1.93 (0.73–3.13) | 31.86                       | 49      | 1.92 (0.90–4.08)        |
| Total        | 160.74|203  | 2.10 (1.82–2.39) | 153.94                      | 107     | 1.16 (0.94–1.38) | 31.86                       | 49      | 1.82 (1.44–2.30)        |
| Motorcycle   |      |       |                  |                            |         |                  |                            |         |                        |
| 16–29        | 6.70 | 478   | 118.92 (108.26–129.58) | 1.14 | 119 | 174.74 (143.34–206.13) | 0.68 (0.56–0.83) |
| 30–39        | 3.60 | 310   | 143.69 (127.70–159.69) | 2.32 | 46 | 33.01 (23.47–42.55) | 4.35 (3.19–5.93) |
| 40–49        | 10.99| 266   | 40.32 (35.48–45.17) | 1.89 | 52 | 45.94 (33.45–58.42) | 0.88 (0.65–1.18) |
| 50–64        | 4.23 | 211   | 83.10 (71.89–94.31) | 1.25 | 38 | 50.62 (34.33–66.72) | 1.64 (1.16–2.32) |
| >64          | 1.40 | 62    | 73.89 (55.50–92.29) | 0.00 | 3 | - | - |
| Total        | 26.92|1327  | 82.16 (77.74–86.58) | 6.60 | 258 | 65.20 (57.24–73.15) | 1.26 (1.10–1.44) |

1 Rate: Victims per 10 million hours of travel-people. 2 CI: Confidence interval (Poisson). Statistically significant results are shown in bold (p < 0.05).
Table 4. Number of hours of travel-people (2011), number and rates of serious or fatal victims in traffic accidents (2008–2013) on working days by gender, age group and mode of transport on rural roads.

| Age (Years Old) | Hours Travel-People 2011 (Mill) | Serious or Fatal Victims in Traffic Accidents (2008–2013) |
|-----------------|-------------------------------|------------------------------------------|
|                 | Men                           | Women                                    |
|                 | Rate 1 (95% CI) 2             | Rate 1 (95% CI) 2                       |
|                 | Victims                       | Victims                                  |
|                 | (Per 10 million hours)        | (Per 10 million hours)                   |
|                 | (95% CI)                      | (95% CI)                                 |
| Pedestrian      |                               |                                          |
| 16–29           | 0.64                          | 39                                       |
|                 | 101.56 (69.69–133.44)         | 0.48                                     |
|                 | 12                            | 41.86 (18.18–65.54)                     |
|                 | 2.43 (1.27–4.63)              |                                          |
| 30–39           | 0.00                          | 47                                       |
|                 | -                             | 0.71                                     |
|                 | 7                             | 16.46 (4.27–28.66)                      |
| 40–49           | 0.23                          | 40                                       |
|                 | 289.86 (200.03–379.68)        | 0.90                                     |
|                 | 13                            | 23.96 (10.94–36.99)                     |
|                 | 12.10 (6.47–22.62)            |                                          |
| 50–64           | 2.08                          | 45                                       |
|                 | 36.06 (25.52–46.59)           | 0.29                                     |
|                 | 25                            | 142.98 (86.93–199.03)                   |
|                 | 12.10 (6.47–22.62)            |                                          |
| >64             | 0.57                          | 67                                       |
|                 | 195.91 (149.00–242.82)        | 1.78                                     |
|                 | 16                            | 14.98 (7.64–22.33)                      |
|                 | 13.07 (7.58–22.56)            |                                          |
| Total           | 3.52                          | 238                                      |
|                 | 112.69 (98.37–127.01)         | 4.16                                     |
|                 | 73                            | 29.23 (22.53–35.94)                     |
| Car             |                               |                                          |
| 16–29           | 35.38                         | 768                                      |
|                 | 36.18 (33.62–38.74)           | 27.45                                    |
|                 | 323                           | 19.61 (17.47–21.75)                     |
|                 | 1.84 (1.62–2.10)              |                                          |
| 30–39           | 61.83                         | 593                                      |
|                 | 15.99 (14.70–17.27)           | 39.10                                    |
|                 | 221                           | 9.42 (8.18–10.66)                       |
|                 | 1.70 (1.45–1.98)              |                                          |
| 40–49           | 59.44                         | 374                                      |
|                 | 10.49 (9.42–11.55)            | 35.82                                    |
|                 | 202                           | 9.40 (8.10–10.69)                       |
|                 | 1.12 (0.94–1.32)              |                                          |
| 50–64           | 48.23                         | 364                                      |
|                 | 12.58 (11.29–13.87)           | 21.80                                    |
|                 | 198                           | 15.14 (13.03–17.25)                     |
|                 | 0.83 (0.70–0.99)              |                                          |
| >64             | 12.08                         | 232                                      |
|                 | 32.02 (27.90–36.14)           | 5.69                                     |
|                 | 158                           | 4.63 (3.90–5.32)                        |
|                 | 0.69 (0.56–0.85)              |                                          |
| Total           | 216.95                        | 2331                                     |
|                 | 129.85 (117.18–148.63)        | 1102                                     |
|                 | 1.27 (1.18–1.36)              |                                          |
| Motorcycle      |                               |                                          |
| 16–29           | 1.16                          | 395                                      |
|                 | 566.07 (510.24–621.89)        | 0.37                                     |
|                 | 74                            | 329.13 (254.14–404.12)                  |
|                 | 1.72 (1.34–2.20)              |                                          |
| 30–39           | 3.87                          | 397                                      |
|                 | 170.97 (154.15–187.79)        | 0.45                                     |
|                 | 34                            | 126.99 (84.31–169.68)                   |
|                 | 1.35 (0.95–1.91)              |                                          |
| 40–49           | 2.35                          | 328                                      |
|                 | 232.67 (207.49–257.84)        | 0.19                                     |
|                 | 30                            | 257.86 (165.59–350.14)                  |
|                 | 0.90 (0.62–1.31)              |                                          |
| 50–64           | 0.86                          | 232                                      |
|                 | 450.17 (392.24–508.09)        | 0.22                                     |
|                 | 17                            | 127.52 (66.90–188.13)                   |
|                 | 3.33 (2.16–5.78)              |                                          |
| >64             | 0.00                          | 87                                       |
|                 | -                             | 0.00                                     |
|                 | 3                             | -                                        |
|                 | -                             | -                                        |
| Total           | 8.24                          | 1439                                     |
|                 | 291.00 (275.97–306.04)        | 1.24                                     |
|                 | 158                           | 212.87 (179.68–246.07)                  |
|                 | 1.37 (1.16–1.61)              |                                          |

1 Rate: Victims per 10 million hours of travel-people. 2 CI: Confidence interval (Poisson). Statistically significant results are shown in bold (p < 0.05).

5. Discussion

This study has analysed, from a gender and age perspective, the risk of traffic injuries and their severity by mode of transport and type of road in a region of the Mediterranean Basin (Andalusia), including travel time as a measure of exposure of mobility.

Sorting by mode of transport, for pedestrians, the higher risk of RTIs presented by women aged 64 years and over on urban roads for both minor and serious or fatal injuries, despite the fact that they walk less than men of that age, which is at variance with a study highlighting the higher risk for women (26–64 years) for serious injuries [14]. This finding could be explained by the fact that, according to a study in England, as age increases, women make more unsafe crossing decisions and are less accurate in estimating their walking speed [43]. However, for pedestrians on rural roads, men aged 40–49 years are the most at risk in all degrees of severity, although women in this age range are almost
4 times more exposed. This is partly consistent with a study of pedestrian fatal injuries in Spain, which found that men had higher rates, especially in the 24–54 age group, and that exposure (time and distances travelled) was higher in women, although not differentiated by road type [44]. According to a study in France, the higher risk in male pedestrians is due to their greater tendency to violate traffic rules [45].

In cars, on urban roads, young men have the highest risk of RTI for both minor and serious or fatal injuries, even though women at these ages use cars slightly more. This finding is partially consistent with those of a US study of fatal driver injuries that used distance travelled as a measure of exposure, since, in addition to finding the highest risk in young men on urban roads, older men were also found to be at higher risk [15]. Studies in the literature help to explain the high risk found in young men, who are more likely to engage in risky or aggressive driving behaviour [46–48]. This is in addition to driving inexperience at this age [49,50]. Young men have also been found to be more prevalent than women in driving under the influence of alcohol [51] or drugs [52]. On urban roads, seat belt use decreases among young people and men [53]. These trends in young men’s driving behaviour have also been detected in Spain [24].

In contrast, in cars on interurban roads, the risk of RTI is higher for women. Some authors indicate that women are more easily distracted and have more perception failures than men when driving [54]. In particular, the present study reveals that young women are more at risk of minor car injuries, which may be explained by fearfulness or lack of experience, as the average distance travelled during the first months of licensing is lower in women than in men [55]. This is consistent with our results indicating that in the 16–29 age group, women spend less time in the car on interurban roads than men. However, when it comes to serious or fatal injuries, those with the highest RTI risk are women older than 64 years, in agreement with other authors [10,11,16]. This is also in line with the results of Zwerling et al. 2005, who included kilometres travelled as exposure measure, although they added young men as higher risk groups of fatal injuries [15]. The excess risk found in women could be due to comparatively inexperienced or less skilled driving, with shorter recorded car travel time on rural roads for women compared to men. The higher risk of RTI in older drivers may be explained by their longer reaction times and their lower ability to maintain a constant distance to the vehicle in front [56]. In addition to the above assumptions, the deterioration of people’s physical condition at older ages makes them more fragile and vulnerable to road crashes [57], especially in the case of women, which is related to their higher incidence of osteoporosis [58]. Furthermore, both younger and older women tend to drive city and utility cars [59], which are less safe in the event of a traffic accident. Women tend to drive smaller vehicles and the best, most powerful or newer vehicle in the household is usually driven by men [60,61].

As for the motorcycle, as expected, it is the most dangerous mode for both genders, especially for young people. On urban roads, young women are the highest risk group in all degrees of RTI. This finding could be explained by women’s lower riding experience, which increases their crash risk [62]. Other authors also found more female risk, although among older women [13]. On rural roads, the trend is reversed, with young men being at higher risk. This differs from other authors who found that older motorcyclists were more likely to be seriously injured in crashes in rural areas, although they focused only on at-fault motorcyclist crashes and did not include mobility data as a measure of exposure [13].

It is worth mentioning that some discrepancies between the results obtained and those of other studies could also be due to social, cultural and territorial differences.

The results of this research lead us to suggest the priority groups to establish preventive measures. In particular, special attention should be paid to users of rural roads—in particular, young male motorcyclists, adult male pedestrians and older women in cars.
6. Conclusions

The results illustrate the existence of important differences in the risk of Road Traffic Injury (RTI) and their degree of severity according to the type of road, taking into account travel time as a measure of mobility exposure.

The rate ratio analysis provides the following conclusions:

- For pedestrian mode and on rural roads, males are more likely to suffer injuries of any degree of severity.
- For motorcycles and regardless of road type, males have a higher risk of serious or fatal injuries, and females have a higher risk of minor injuries.
- In cars, males have a higher risk of serious or fatal injuries regardless of road type, while the risk of minor injuries is higher for females on rural roads.

As can be seen, men always have a higher risk of serious or fatal injuries in all modes of transport and regardless of the type of road.

Analysis of victim rates by gender and age groups shows that on urban roads, the highest risks of both minor, serious and fatal injuries are observed for older women as pedestrians, young women as motorcyclists and young men in cars. In contrast, on rural roads, the highest risks are for middle-aged men as pedestrians, young men on motorcycles and young women (minor) and older women (serious and fatal) in cars.

The joint analysis of all variables has allowed us to identify the most vulnerable groups.

The findings reveal the need to mainstream gender in mobility and road safety policies, and also highlight the importance of including road type as a key environmental factor in the development of effective road accident prevention strategies.

The research carried out allows us to advance in the knowledge of the role that people’s mobility patterns play in the risk of RTIs, providing empirical support to achieve an equitable, sustainable and safe mobility model.

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Appendix A

Table A1. Studies on traffic accidents on urban and rural roads.

| Author and Location | Methodology | Mobility Exposure Measure | Mode of Transport | Details |
|---------------------|-------------|---------------------------|-------------------|---------|
| [10] Chen et al., 2016 New Mexico (USA) | Hierarchical ordered logit model | No | Drivers | To examine significant factors in predicting driver injury severities in rural non-interstate crashes |
| | | | | Road type: Rural non-interstate crash dataset extracted from traffic crash records in New Mexico 2010-2011 |
| | | | | Injury Severity: No injury, complaint of injury/possible injury, visible injury, incapacitating injury and death |
| | | | | Results: Road segments far from intersection, wet road surface condition, collision with animals, heavy vehicle drivers, male drivers and driver seatbelt used tend to induce less severe driver injury outcomes than the factors such as multiple-vehicle crashes, severe vehicle damage in a crash, motorcyclists, females, senior drivers, drivers with alcohol or drug impairment and other major collision types. |
### Table A1. Cont.

| Author and Location | Methodology | Mobility Exposure Measure | Mode of Transport | Details |
|---------------------|-------------|----------------------------|-------------------|---------|
| [11] Chen et al., 2016 New Mexico (USA) | Hierarchical Bayesian logistic model | No | Drivers | Objective: To examine the significant factors at crash and vehicle/driver levels and their heterogeneous impacts on driver injury severity in rural interstate highway crashes. Accident Data: Rural interstate crash data extracted from two-year New Mexico crash records from 2010 to 2015. Injury Severity: Low injury severity level (including no injury and complaint of injury) and high injury severity level (including visible injury, incapacitating injury and fatality). Results: Road curve, functional and disabled vehicle damage in crash, single-vehicle crashes, female drivers, senior drivers, motorcycles and driver alcohol or drug involvement tend to increase the odds of drivers being incapacably injured or killed in rural interstate crashes, while wet road surface, male drivers and driver seatbelt use are more likely to decrease the probability of severe driver injuries. |
| [12] Wu et al., 2016 New Mexico (USA) | Nested logit models and mixed logit models | No | Drivers | Objective: To analyse driver injury severities for single-vehicle crashes occurring in rural and urban areas. Accident Data: Data on Single-vehicle Crashes Rural and Urban Areas 2010-2011. Injury Severity: No injury, Possible injury, Visible injury, Incapacitating injury and fatality. Results: Significant differences exist between factors contributing to driver injury severity in single-vehicle crashes in rural and urban areas. However, what is common in both rural and urban areas is that the drivers, who are female, senior, alcohol impaired or involved in overturn or fixed-object crashes are more likely to be injured severely. |
| [13] Islam et al., 2017 Alabama (USA) | Random parameter logit models of injury severity | No | Motorcycle | Objective: To explore the factors contributing to the injury severity resulting from the motorcycle at-fault accidents in rural and urban areas. Accident Data: Data on motorcycle at-fault crashes Rural and urban areas in Alabama 2010-2014. Injury Severity: Fatal, major, minor and possible or no injury. Results: Clear weather, young motorcyclists and roadways without light were found significant only in the rural model. On the other hand, older female motorcyclists, horizontal curves and at intersections were found significant only in the urban model. Some variables (such as, motorcyclists under influence of alcohol, non-usage of helmet, high speed roadways, etc.) were found significant in both models. Men were less likely to be seriously or fatally injured on urban and rural roads. Specifically, on urban roads, young men were more likely to suffer minor injuries and older women serious and fatal injuries. |
| [14] Islam et al., 2014 Alabama (USA) | Random parameter logit models of injury severity | No | Pedestrians | Objective: To explore the factors contributing to the injury severity resulting from pedestrian at-fault crashes in rural and urban locations in Alabama. Accident Data: Pedestrian at-fault crash data Rural and urban locations 2006 to 2010. Injury Severity: Major injury (included fatal and incapacitating injuries), minor injury (non-incapacitating injuries) and possible/no injury (included no visible injuries, no injuries and property damage only crashes). Results: There are differences between the influences of a variety of variables on the injury severities resulting from urban versus rural pedestrian at-fault accidents. Females and the 24-64 age group are more likely to be seriously injured in urban areas. |
Table A1. Cont.

| Author and Location | Methodology | Mobility Exposure Measure | Mode of Transport | Details |
|---------------------|-------------|---------------------------|-------------------|---------|
| [15] Zwerling et al., 2005 USA | Decomposition method | Yes (vehicle miles travelled) | Drivers | To explore the factors associated with increased fatal crash involvement rates in rural compared with urban communities |
| [16] Pulido et al., 2016 Spain | Crude (CDRR) and adjusted (ADRR) death rate ratios | Yes (quasi-induced exposure) | Drivers | To compare the age and gender differences in death rates with and without adjustment by exposure |
| [30] Vorko et al., 2006 Zagreb (Croatia) | Simple and bivariate analysis using χ², odds ratio, and confidence interval of 95% | No | Not specified | To analyse the risks of urban traffic accidents |

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