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PAPER

PATHOLOGY/BIOLOGY

Magdalena Lopez-Charneco,[1] *M.S.; Maria S. Conte-Miller,*[2] *M.D.; Francisco Davila-Toro,*[2] *M.D.; Enid J. García-Rivera,*[1,3] *M.P.H., M.D.; Diego E. Zavala,*[4] *Ph.D.; Yisel Torres,*[1] *M.P.H.; and Jose F. Rodriguez Orengo,*[5] *Ph.D.*

Motor Vehicle Accident Fatalities Trends, Puerto Rico 2000–2007

ABSTRACT: Motor vehicle accident fatalities (MVAF) are an important cause of death that affects millions of people worldwide. Using the Puerto Rico Institute of Forensic Science database, this study accessed the mortality trends of MVAF in Puerto Rico from 2000 to 2007. Descriptive statistics, age-adjusted mortality rates, geographical analysis, and annual percentage change were calculated. An annual mean of 559 MVAF occurred during the study period. The overall MVAF mortality rate declined from 2000 to 2007 (16.6 and 12.4 per 100,000 population, respectively)—mortality rates annually decreased 3%. Most MVAF (80.2%) occurred in men, showing a risk four times higher than women (23.6 and 5.4 deaths per 100,000 populations, respectively). Drivers aged 20–24 years and pedestrians older than 75 years had the highest risk of death. This study emphasizes the need of public health efforts to focus on the prevention of MVAF in the most affected groups.

KEYWORDS: forensic science, epidemiology, mortality trends, road traffic, fatal injury, Puerto Rico, Hispanic

Motor vehicle accident fatalities (MVAF) have been characterized worldwide as a hidden epidemic, which affects all sectors of the society (1,2). In 2000, the worldwide road traffic mortality rate was 20.8 deaths per 100,000 population (30.8 in men, 11.0 in women) (3). Over 50% of these deaths occurred among young adults in the age range of 15–44 years. In children and young people between 5 and 29 years, road traffic injuries are the second leading cause of death worldwide (4). More than 41,000 people in the U.S. die in motor vehicle crashes each year and crash injuries result in about 500,000 hospitalizations and four million emergency department visits annually (5). The economic burden of motor vehicle–related deaths and injuries is enormous, costing the U.S. more than $150 billion each year. For adults older than age 70, the motor vehicle death rate has remained stable, at about 23 per 100,000 for more than a decade (6). MVAF remain the leading cause of injury death in the U.S. (7) with a mortality rate of 14.7 per 100,000 in 2004.

In Latin America from 1997 to 2000, mortality from all land transport accidents was the 10th leading cause of death in the general population, the sixth leading cause in men, and the 16th in women (8). Studies in Mexico and Colombia indicate that pedestrians are the most vulnerable road users especially in main urban areas.

The island of Puerto Rico is a U.S. Commonwealth located in the Caribbean with an area of 3454 square miles (9104 km^2). In year 2008, the estimated population by the U.S. Census Bureau was 3,954,037 with about 1155 people per square mile, a ratio higher than most U.S. states (9). Private motor vehicles are the main source of transportation making the traffic situation in this highly populated island very complex. During the year 2007, there were 3,031,124 motor vehicles registered by the Puerto Rico Department of Transportation and Public Works, representing almost one vehicle per island resident (10). In 2007, the Puerto Rico Police Department reported 266,767 automobile "accidents," and the Puerto Rico Administration for Compensation for Automobile Accidents referred for treatment 39,888 injured persons during motor vehicle–related accidents (M. Lopez-Charneco and E.J. García-Rivera, personal communication). The congested highway system as suggested by the annual average daily traffic (rural and urban: 5022 vehicles per lane per day) makes Puerto Rico one of the 10th highest transited jurisdictions in the U.S., a fact of life for urban dwellers (11).

This article presents an analysis of mortality trends attributed to MVAF in Puerto Rico between the years 2000 and 2007. The evaluation of mortality rates by nature of injury during this period can aid in developing evidence-based prevention strategies (12).

Methods

Database Sources

We used data obtained from all motor vehicle–related deaths investigated by the Puerto Rico Institute of Forensic Sciences (PRIFS) from 2000 to 2007. The PRIFS was created in 1985 to investigate, using scientific methods, all forensic evidence to

[1]Puerto Rico Department of Health, Office of Epidemiology and Research, PO Box 70184, San Juan 00936, Puerto Rico.
[2]Puerto Rico Institute of Forensic Sciences, Calle Maga Esq. Casia Urb. Reparto Metropolitano, San Juan 00936, Puerto Rico.
[3]Department of Medicine, University of Puerto Rico School of Medicine, PO Box 365067, San Juan 00936-5067, Puerto Rico.
[4]Ponce School of Medicine, PO Box 7004, Ponce 00732-7004, Puerto Rico.
[5]Department of Biochemistry, University of Puerto Rico School of Medicine, PO Box 365067, San Juan 00936-5067, Puerto Rico.

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understand the cause, manner, and circumstances of violent deaths in Puerto Rico. This agency receives all MVAF from Puerto Rico for investigation. During the study period 19,023 deaths were investigated. Of these, 23% were caused by MVAF. In this study, we included all closed cases from January 1, 2000 to December 31, 2007. Deaths under investigation after October 21, 2008 were excluded from the analysis (represents <1% of all external cause of death).

Case Definitions and Classifications

Road traffic injury was defined as an unintentional vehicle injury occurring on a public road or highway including vehicle injuries where the place of occurrence was unspecified. MVAF were defined as an unintentional vehicle injury occurring on a public road or highway resulting in death.

We classified the victims as driver, passenger, pedestrian, motorcyclist, cyclist, and others (e.g., horseman and pilot). Gender was operationally defined as men or women. The age variable was classified in the following age groups according to the Center for Disease Control (CDC) recommendations at "The State Injury Indicators: Instructions for Preparing 2005 Data" (13): <5, 5–14, 15–19, 20–24, 25–34, 35–44, 45–54, 55–64, 55–64, 65–74, 75–84 years, and 85 or older. Month variable indicates when the incidents occurred and municipality indicates the place where the accident occurred.

Data Analysis

A descriptive analysis in time, place, and person was performed. Variables analyzed included gender and age group distribution, victim classification, year, month, and municipality of occurrence. Crude and age-adjusted mortality rates were calculated. Census populations' estimates were used as denominators in crude mortality rates calculations (Population Division, U.S. Census Bureau, 2008, http://www.census.gov/popest/municipios/PRM-EST2008-01.html). Rates were age-adjusted to the Puerto Rico standard 2000 Census population. Join point regression analysis was performed to determine the significance of trends (14). Join point regression consists of a series of permutations tests to define points in time were significant changes in trends occur. Join point presents the estimated annual percentage change (APC) for each period identified, alongside its 95% confidence intervals and is used as a way to compare the significance of changes in periods of time. The APC was calculated for overall MVAF and for the four most common victims (driver, pedestrian, passenger, and motorcyclist). The MVAF age-adjusted mortality rates by municipality were calculated and the quartiles were employed as cut-off points. Municipalities with <20 cases, during the study period, were excluded from the analysis. Epi Info 2000 (15) was used as statistical software and Epi Map was used for the geographical analysis.

Results

From January 1, 2000 to December 31, 2007, 4474 deaths attributed to MVAF were reported by the PRIFS. The annual mean of MVAF-related deaths during the study period was 559 deaths per year. Table 1 summarizes the MVAF characteristics. The overall MVAF annual mortality rate decreased from 16.6 in 2000 to 12.4 deaths per 100,000 population in 2007 (Fig. 1) with a mean annual mortality rate of 14.4 deaths per 100,000 population. Annual MVAF rates decreased by 3.1% (APC, statistically different from zero) during the study period.

TABLE 1—*Characteristics of motor vehicle accident fatalities in Puerto Rico, 2000–2007.*

	2000–2007			
Characteristics	No.*	%	Rate†	APC‡
Gender				
Male	3,589	80.2	23.6	−2.5
Female	885	19.8	5.4	−5.6§
Total	4474	100.0	14.2	−3.1§
Age				
<5	46	1.0	2.1	−13.1
5–14	108	2.3	2.2	−15.8§
15–19	431	9.0	17.9	−2.7
20–24	662	13.9	28.0	0.7
25–34	798	16.7	18.4	−0.9
35–44	612	12.8	14.6	−1.4
45–54	557	11.7	14.5	−5.2§
55–64	497	10.4	15.7	−3.7
65–74	380	8.0	18.0	−6.2§
75–84	268	5.6	22.3	−5.7
85+	91	1.9	21.0	−5.2
Unknown	24	0.5	–	–
Total	4774	100.0	14.2	−3.1§
Victim Classification				
Driver	1591	35.6	5.1	−3.9§
Pedestrian	1475	33.0	4.8	−3.6§
Passenger	768	17.2	2.5	−10.3§
Motorcyclist	528	11.8	1.7	12.3§
Cyclist	90	2.0	–	–
Other	22	0.5	–	–
Total	4474	100.0	–	–

*Cumulative cases from 2000 to 2007.
†Mean of mortality rates per 100,000 population.
‡The annual percentage change (APC) is the change in the mortality rate per year from 2000 to 2007.
§Statistically different from zero.

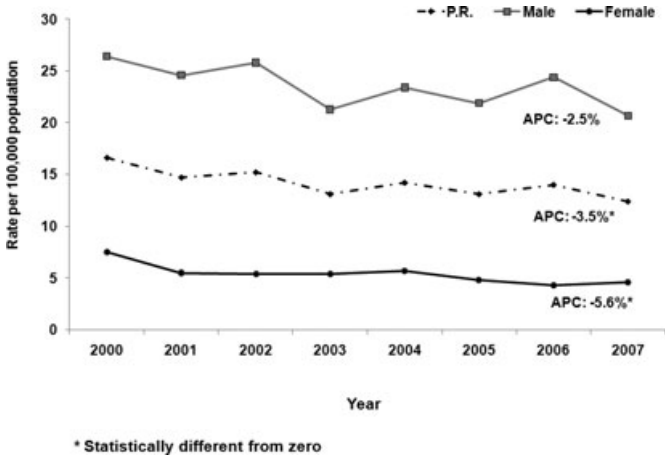

FIG. 1—*Age-adjusted mortality rate attributed to motor vehicle accident fatalities by gender, Puerto Rico, 2000–2007.*

Most MVAF occurred in men (80.2%). The rate of MVAF for men was 4.4 times the rate for women (23.6 vs. 5.4 per 100,000 population, respectively). For women, there was a significant reduction in the MVAF rates (APC: −5.6%, statistically different from zero), whereas for men, the reduction was not significant (APC: −2.5%, nondifferent from zero) (Fig. 1).

When stratified by age group, higher rates of MVAF were identified among people aged 20–24 and those older than 75 years (28.0 and 22.3 per 100,000 population, respectively) (Table 1).

There was a significant decrease in the MVAF rates for the following age groups: 5–14, 45–54, and 65–74 years (APC: −15.8, −5.2, and −6.2, respectively, and statistically different from zero). Other age groups had not significant APC in the MVAF rates.

Among women, the highest MVAF rate occurred in those between 75 and 84 years (10.7 per 100,000 population). These deaths occurred mostly among pedestrians (11.2%). On the other hand, for men, the MVAF rate was highest among men aged 20–24 years and older than 75 years (47.6 and 38.2 per 100,000 population, respectively) (Fig. 2). Deaths on younger men and adults—20 to 24 years—occurred in drivers (51.0%), motorcyclist (21.0%), and passengers (17.2%). Most fatalities (67.7%) occurring in men older than 75 years were pedestrians.

During the study period, of all MVAF victims 1591 (35.6%) were drivers; followed by pedestrians (1475, 33.0%), passengers (768, 17.2%), motorcyclists (528, 11.8%), and cyclists (90, 2.0%) (Table 1). Gender-specific analysis showed that for men, the most common MVAF occurred in drivers (38.2%) followed by pedestrian (32.8%) and motorcyclists (14.1%), while a higher percent of women died as pedestrian (38.2%) and passengers (33.7%).

In the analysis of MVAF trends by type of victim, we found that the drivers, passengers, and pedestrians mortality rates have been significantly declining over time (APC: −3.9, −3.6, and −10.3, respectively, and statistically different from zero). On the other hand, the only group showing an increasing trend was the motorcyclists (APC: 12.3, statistically different from zero) (Fig. 3). The age group distribution was different by the victim classification. The mortality rates for drivers, passengers, and motorcyclists were higher in people aged 15–34 years. Conversely, the mortality rates for pedestrians increased proportionally with age (Fig. 3).

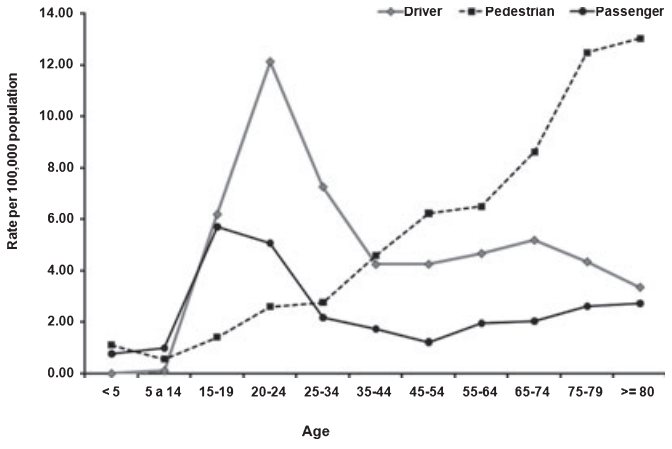

FIG. 2—*Mortality rates attributed to motor vehicle accident fatalities by age group and victim classification, Puerto Rico, 2000–2007.*

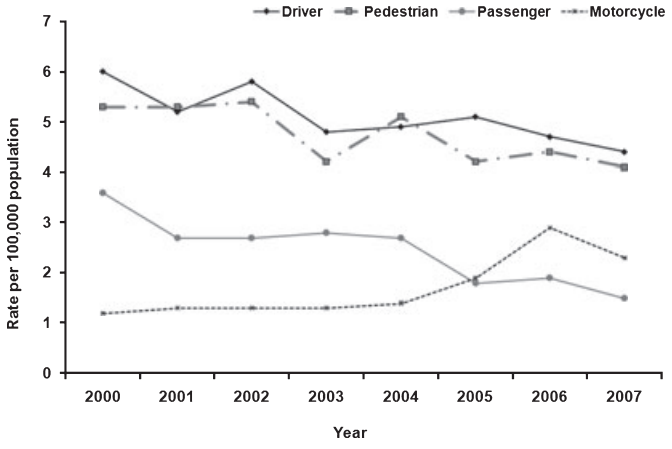

FIG. 3—*Age-adjusted mortality rate attributed to motor vehicle accident fatalities by victim classification, Puerto Rico, 2000–2007.*

There was no seasonality pattern for MVAF identified by month of occurrence, and the rates of MVAF by month show little variation throughout the years under study (range: 7.5–9.7% monthly). Figure 4 shows the geographical distribution of MVAF in Puerto Rico. The municipalities with developed road infrastructure or through which main highways have been built have the higher MVAF rates. The highest mortality rates occurred in the municipalities of San Juan, Salinas, and Manatí (23.9, 22.5, and 22.0 per 100,000, respectively).

Discussion

This study evaluates the trends in MVAF in the Puerto Rico population from 2000 to 2007. We found that, even when MVAF is still an important cause of death in Puerto Rico, the mean MVAF rate during our study period showed a significant decrease and was less than the worldwide annual estimates (20.8 per 100,000 population) for MVAF (3). Several factors might be related with this finding. Puerto Rico has established aggressive measures for the enforcement of seat belt regulations and has implemented severe alcohol restrictions for drivers. These two factors: failure to use seat belts and alcohol abuse; have been identified by experts on traffic safety as the most important risk factors for traffic injuries. The implementation of measures to enforce seat belt use in Puerto Rico have been proven to be successful. According to the National Highway Traffic Safety Administration, in 2008, seat belt use in the U.S. from a probability-based observational survey conducted by 50 states, the District of Columbia, and U.S. Territories ranged from 55.7% in American Samoa to 97.2% in Michigan. In that survey, Puerto Rico was one of the 16 jurisdictions that achieved seat belt use rates of 90% or higher (16).

Alcohol consumption is another important factor associated with MVAF. In this study, we did not evaluated the relationship between alcohol consumption and MVAF. However, according to the Fatality Analysis Reporting System, during the year 2007, 41.7% of the road fatal victims in Puerto Rico were associated with the alcohol consumption (17). However, how this behavior might be related with our findings is beyond the scope of this study. Unfortunetly, data on blood alcohol concentration was not available at the time of the analysis. Structural deficiencies in road design and traffic signals are also considered key factors (4,8).

In the Americas, Puerto Rico is categorized as a country with medium risk (mortality rate from 10 to 20 deaths per 100,000 population) for MVAF mortality (17). The mean annual mortality rate (14.2 per 100,000 population) in Puerto Rico compared with the annual age-adjusted motor vehicle–related death rates in the U.S. (range: 15.2–15.7 per 100,000 population) has remained relatively unchanged since 1999. However, among states, substantial differences are observed with average annual death rate ranging from 7.9 per 100,000 populations in Massachusetts to 31.9 per 100,000 population in Mississippi (18). In comparison with states and other U.S. jurisdictions, in 2006, Puerto Rico ranked within the 15 jurisdictions with lower mortality rates owing to MVAF (19).

Worldwide, gender-specific differences in road traffic mortality rates have been described (4). Men have higher rates than women in all regions, regardless of income level, and also across all age groups (4,8,20–23). In Puerto Rico, a similar pattern also occurs. The distribution of road traffic mortality rates in Puerto Rico was

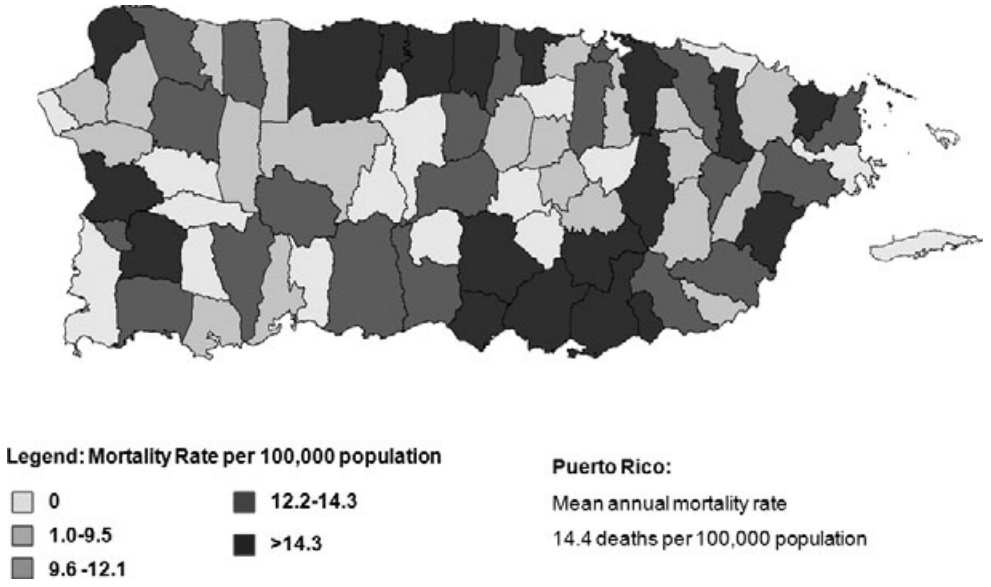

FIG. 4—*Rates attributed to motor vehicle accident fatalities by municipality of occurrence, Puerto Rico, 2000–2007.*

4.4 times higher in men than in women. However, the gender-specific rates were lower for both men (23.9 deaths per 100,000 population) and women (5.5 deaths per 100,000 population) to the rates observed in others regions of the world (30.8 in men, 11.0 in women per 100,000) (8).

Age group–specific mortality rates also showed a trend similar to what has been found in other countries, in which the productive (working) age groups (15–44 years) are most commonly affected (4,19–22,24–26). The mortality rate in both, men and women, increase for persons older than 75 years, particularly for the pedestrians. This finding emphasizes the need to develop public health interventions to reduce road traffic injury-related mortality in this vulnerable population.

We also found differences in MVAF using the victim classification. In Puerto Rico, drivers are at greater risk of death, followed by pedestrian and passengers. This is not consistent with reports from other countries that have generally found pedestrians and two-wheeler users at greater risk than vehicle occupants (4,8). This is especially true in low-income and middle-income countries, because of the greater variety and intensity of traffic mix and the lack of separation from other road users (4). Cultural behaviors, road infrastructure, and traffic regulations in Puerto Rico might be related with this difference. Motorcyclists are of special interest, because they were the only group in which MVAF showed an increasing trend. The use of motorcycles is still not common in Puerto Rico. Even when the number of registered motorcycles increased from 33,000 in 1997 to 115,000 in 2007, they still represent only 4.3% of all registered vehicles (10). Aggressive enforcement of helmet use and education of motorcyclist might be needed to reduce that increasing trend. Likewise, the use of bicycles in Puerto Rico is mostly for leisure activities, rather than as a means of transport as in many low-income countries. In addition, there is no great urban traffic mixture in Puerto Rico as that seen in the large urban developments in low-income countries where pedestrians, bicycles, and two- and four-wheeled vehicles interact greatly. Thus, the majority of MVAF in Puerto Rico occurs in occupants of motor vehicles (52.8%) and pedestrians (33.0%).

In contrast to the popular belief that most MVAF occurs during the winter, we did not find any seasonal variation in MVAF by month of occurrence. Given that the island is in the tropic, the lack of winter weather has had no effect on the MVAF. On other hand, we did find geographical differences in MVAF distribution. Urban and rural municipalities with highway infrastructure showed the highest MVAF rates. This also has important implications for MVAF prevention. In the U.S., MVAF rates were similar for the large central metro and large fringe metro counties and these rates increase as a county becomes progressively more rural (27).

While death rates are powerful indicators of the relative magnitude of the problem, they do not measure the full burden of the injuries because of road traffic injuries. Indicators of morbidity, disability, and economic cost of injuries among others are necessary to provide a full picture of the situation. MVAF are preventable and can be influenced through national policy decisions, education, and individual choices. Puerto Rico has already taken affirmative and successful actions to reduce the burden of road traffic injuries. However, there are still groups disproportionately affected by MVAF and public health interventions directed toward these groups are needed.

Conclusions

From 2000 to 2007, the overall mortality rates caused by MVAF declined. Young adults (20–24 years) had a higher risk of MVAF. The study revealed that drivers, passengers, and pedestrian mortality rates show declining trends. Public health efforts should focus on reducing MVAF in younger adult men to have an impact on MVAF mortality.

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Additional information and reprint requests:
Jose F. Rodriguez Orengo, Ph.D.
Department of Biochemistry
University of Puerto Rico School of Medicine
PO Box 365067
San Juan 00936-5067, Puerto Rico
E-mail: jose.rodriguez139@upr.edu