A Comparative Analysis of the Injury Patterns and In-Hospital Mortality Rates of Belted and Unbelted Motor-Vehicle Occupants - Puerto Rico, January 2000 to December 2014

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Objective: Motor vehicle collisions (MVCs) constitute a leading source of morbidity and mortality worldwide. Seatbelt use has been associated with reduced mortality in MVCs. In Puerto Rico, the impact of seatbelt use on MVC deaths has not been evaluated, although they represent a major public health threat. Therefore, this study aimed to assess the association between seatbelt use and in-hospital mortality at Puerto Rico Trauma Hospital (PRTH).

Materials and Methods: A retrospective cohort study of 2,685 MVC patients aged 1 to 96 years was conducted using the Trauma Registry at PRTH, with data collected from 2000 through 2014. The patient data included sociodemographic and clinical variables and outcomes. Logistic regression analyses were used to evaluate the mortality risk of patients of severe MVC-related trauma who had been wearing seatbelts and compare it to the risk sustained by their unbelted counterparts.

Results: Seatbelt use was more common in females than it was in males (71% vs. 62%; p<0.001) and more prevalent in older as opposed to younger patients (p<0.001). Belted severe trauma victims suffered less frequently from head injuries than did their unbelted counterparts (p<0.001). The proportions of patients with Glasgow coma scale (GCS) scores of 8 or lower (17% vs. 6%; p<0.001) and Injury Severity Scores (ISSs) of 25 or higher (24% vs. 15%; p<0.001) were greater for the unbelted group. Belted severe trauma victims had a 30% lower in-hospital mortality risk compared to their unbelted peers (OR_{unadj} = 0.70; 95% CI: 0.52–0.92). After adjusting for confounders, this difference in risk was eliminated (OR_{adj} = 1.04; 95% CI: 0.72–1.52).

Conclusion: Our findings demonstrate that seatbelt use is associated with fewer head injuries, lower ISSs, and higher GCS scores. This suggests that using seatbelts mitigates trauma severity, thereby reducing the likelihood of in-hospital mortality for those MVC victims who were wearing seatbelts at the time of their accident. [*P R Health Sci J 2018;37:213-219*]

Key words: Seatbelt use, Mortality, Motor vehicle collisions, Trauma

More than 1.25 million people worldwide die each year due to motor vehicle collisions (MVCs) (1). MVCs are a considerable burden to those involved, to their family members, and to the country in which a given MVC occurs. From 1995 to 2000 in the United States (US), those involved in MVCs lost a total of 7 million workdays per year (2). Nearly 2.7 million MVC-related injuries and 38,748 MVC-related deaths occurred in 2015 and 2016, respectively, among all age groups (3, 4). MVCs are the leading cause of death in the US among those aged 18 to 54 (5). Hence, MVCs are a problem that concerns society, and the morbidity and mortality burdens associated with these accidents need to be addressed promptly.

A seatbelt is defined as a strap in a motor vehicle that is used to keep people (passengers and drivers) secure. Seatbelts have been shown to move in coordination with a user's body and lock up during an MVC. They prevent the ejection of passengers/drivers from a crashing vehicle and the injury of those individuals by the steering wheel and/or other objects (6). A vast body of literature has demonstrated the effectiveness of seatbelts in reducing the numbers of injuries and hospital admissions resulting from MVCs (5, 7–11). Seatbelt use reduces the probability of severe

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injury and mortality for a vehicle's occupants by 40% to 60% (8). Several studies have found that seatbelt use is more likely to be reported by older persons, women, whites, individuals with high incomes, and drivers (7–9, 12–14). In addition, adults who live in non-metropolitan areas are less likely to wear seatbelts than are those who live in metropolitan areas (5).

Despite the fact that seatbelt use reduces mortality, there is a controversy related to the injury patterns of the belted vs. the unbelted vehicle occupants. There have been a number of reports that describe injuries associated with seatbelt use (7–12, 15). For instance, gastrointestinal injuries predominate in belted trauma victims compared to their unbelted counterparts (9). Additionally, belted trauma victims are more likely than unbelted ones to sustain sternal fractures, although they are less likely to suffer head injuries than unbelted trauma victims are (15).

In Puerto Rico (PR), MVCs constitute a significant public health problem. According to the Puerto Rico Annual Report, FY 2016, there were a total of 3,705 serious traffic-related injuries and 344 traffic-related fatalities on the island during 2016 (16). While this indicates that there was a slight reduction in MVC morbidity, there was an increase in mortality compared to the previous year (16). However, reports on the distribution by the age group, sex, and geography of seriously injured people are not available.

In June of 2004, vehicle and traffic law 132 of PR was enacted. The law mandates the use of a seatbelt for anyone who drives or rides as a passenger in a motor vehicle on a public road. It also states that it is the duty of the driver to ensure that all passengers have a seatbelt on and that no more passengers than the number of functional safety belts are allowed to ride in a vehicle at any given time (17). In 2003, there were 496 MVC-caused fatalities and 43,000 MVC-related injuries on the island (18). Since the time that PR law 132 was enacted, the numbers of MVC-related injuries and deaths have diminished, with seatbelt use being widely reported. However, the number of cases continues to be alarming, as the number of MVC-related fatalities has remained above 300 almost every year since the law's enactment (5, 19).

To the best of our knowledge, no studies have been published on the burden of MVC-related mortality in trauma patients in PR. This study aimed to assess the impact of seatbelt use on the mortality of subjects that experienced an MVC and received medical services at a trauma center in PR from January 2000 through December 2014. Additionally, it aimed to compare the sociodemographic and injury characteristics of severe trauma patients involved in MVCs and either wearing or not wearing seatbelts.

Materials and Methods

A retrospective cohort analysis was conducted at the Puerto Rico Trauma Hospital (PRTH) to assess the aims of this research. PRTH provides care to pediatric and adult patients with multiple physical traumas. This teaching hospital, run by residents and physicians, is the only trauma hospital in PR. During the period under evaluation, a total of 4,166 patients were admitted to the hospital due to MVCs. We classified these patients using the International Classification of Diseases, Ninth Revision (ICD 9 code: E-812). The potential participants were categorized into 2 groups based on seatbelt-use status: those who wore seatbelts (n = 1,729) and those who did not (n = 956). The other 1,481 patients were excluded from the sample because their seatbelt-use status was unknown. Information on seatbelt use is documented by paramedical personnel, and a copy of this report is attached to a given patient's medical record.

The data of these patients were retrieved from the Trauma Registry at the PRTH, which is part of the US National Trauma Registry System. Patient information is entered in the registry by trained personnel, who transcribe the data directly from medical records. This registry collects data regarding a wide range of variables, including but not limited to sociodemographic profiles, pre-hospital and in-hospital care, and clinical and prognosis parameters. It is also subject to a quarterly quality control review, which is conducted according to the standards and requirements developed by the American College of Surgeons.

The age and sex of each participant were gathered. The time, day, and season of each crash were determined. The following clinical variables were included: respiratory rate, heart rate, temperature, base status, systolic blood pressure, details of any blood transfusion, length of stay (LOS) in the hospital, trauma intensive care unit (TICU) days, mechanical ventilation (MV) days, abbreviated injury scale (AIS), Injury Severity Score (ISS), Glasgow coma scale (GCS) score, and in-hospital mortality.

The AIS is an anatomical scoring system for the accurate ranking of injury severity (20). The ISS, in turn, is a system based on the AIS that provides an overall injury severity score for patients with multiple injuries. The ISS score has a high correlation with mortality and other measures of severity (21). On the other hand, the GCS measures a patient's response to specific stimuli to assess that individual's level of consciousness (22). It is important to use the GCS since it provides the level and type of brain injury, helping determine the prognosis of the patient.

The sample was described by seatbelt-use status, using medians and interquartile ranges (or minimum and maximum values) for continuous variables and using measures of absolute and relative frequencies (n and %) for categorical ones. The bivariate analysis was carried out with Pearson's chi-squared test for categorical variables and a Mann–Whitney U Test for continuous variables. Probability values (p-values) less than 0.05 were considered statistically significant.

A logistic regression analysis was conducted to evaluate the relationship between the use of seatbelts and MVC mortality. Additionally, a Cox regression assessed the relationship between the survival probability and seatbelt-use status. All multivariate analyses were done by adjusting for those

confounders that were statistically significant in the bivariate analysis. The statistical software package used to carry out all analyses was STATA version 14.1 for Windows (23). This study received approval from the Institutional Review Board of the Medical Sciences Campus of the University of Puerto Rico (protocol number: B0030415).

Results

Of the total number of unbelted victims of severe trauma (n = 956), 70% were drivers and 30% were passengers. In the belted group (n = 1,729), 69% were drivers and 31% were passengers. Seatbelt use was more frequent in females than in males (71% vs. 62%; p<0.001). The median age for severe trauma patients who had been using a seatbelt was 32 years (min. 1, max. 96), whereas their unbelted counterparts had a median age of 27 years (min. 1, max. 85) (p<0.001). Furthermore, once age was categorized, we observed that seatbelt use was most prevalent in patients older than 40 years (p<0.001), as seen in Figure 1.

In terms of days of the week, individuals less frequently wore seatbelts on weekends than on days of the week (63% vs. 66%); this difference was marginally significant (p = 0.062). Seatbelt use also varied by time of day; the most marked difference was that seatbelt use was reported to be less frequent among individuals involved in MVCs during the 5 AM to 8 AM period (p = 0.048).

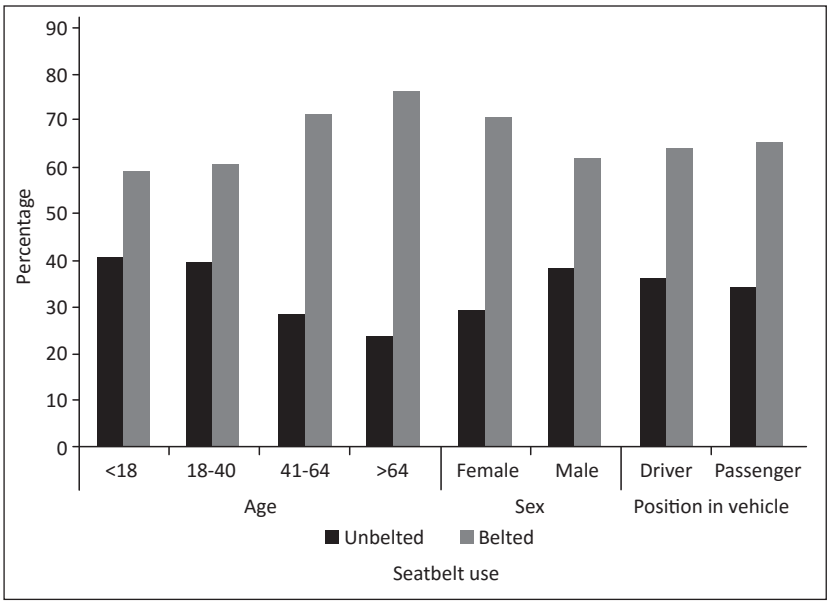

Figure 1. Sociodemographic description of the sample

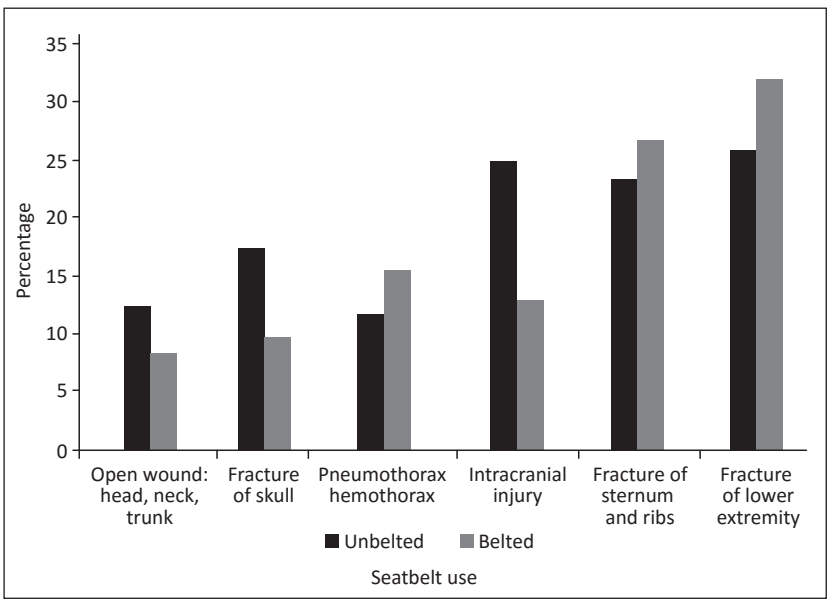

Figure 2. Prevalence of injuries, by seatbelt-use status

Unbelted severe trauma victims suffered more frequently from head injuries (i.e., fracture of skull [17.36% vs. 9.49%; p<0.001], intracranial injury [25% vs. 12.67%; p<0.001], and open wounds of the head, neck, or trunk [12.34% vs. 8.27%; p<0.001]) than did trauma patients who had been wearing seatbelts when involved in an MVC. Nevertheless, belted severe trauma victims tended to experience more fractures of the lower extremities (32.04% vs. 25.84%; p = 0.001) than their unbelted counterparts did (see Figure 2).

As can be seen in Table 1, the unbelted group had higher proportions of patients with bradycardia and tachycardia (p = 0.002), bradypnea and tachypnea (p = 0.037), and hypothermia and fever (p = 0.001) than the belted group did. Moreover, the proportion of patients with an ISS of 25 or higher (24% vs. 15%; p<0.001) and a GCS score of 8 or lower (17% vs. 6%; p<0.001) was also significantly greater in the unbelted group (see Figure 3). However, belted severe trauma victims spent more days on MV than did their unbelted counterparts (10 days vs. 7 days; p = 0.047), as shown in Table 2.

With regard to mortality, severe trauma patients who had not been wearing seatbelts during their MVCs exhibited a significantly higher proportion of in-hospital mortality than did belted victims (9% vs. 7%; p = 0.012). Belted severe trauma victims had a 33% (OR_{unadj} = 0.67; 95% CI: 0.52–0.92) reduced risk of in-hospital mortality compared to unbelted ones, before adjusting for confounders. This difference in risk was, however, eliminated after adjusting for age, hypotension, ISS, and GCS score (OR_{adj} = 1.04; 95% CI: 0.72–1.52). The hazard

Table 1. Clinical data for MVC-related severe trauma victims, by seatbelt use (N = 2,685)

Seatbelt use	Belted n (%)	Unbelted n (%)	p-value
Clinical data			
Respiratory rate			
Normal	1,111 (67.29)	609 (65.41)	0.037
Bradypnea	9 (0.55)	14 (1.50)	
Tachypnea	531 (32.16)	308 (33.08)	
Systolic blood pressure			
≥90 mmHg	1,639 (95.68)	901 (94.94)	0.383
<90 mmHg	74 (4.32)	45 (5.06)	
Temperature (ºC)			
Normal (35–38)	1,620 (96.49)	851 (93.21)	0.001
Hypothermia (<35)	41 (2.44)	44 (4.82)	
Fever (>38)	18 (1.07)	18 (1.97)	
Heart rate			
Normal	1,080 (62.79)	527 (55.71)	0.002
Bradycardia	46 (2.67)	31 (3.28)	
Tachycardia	594 (34.52)	388 (41.01)	
Base status (mEq/L)			
Normal (-199 to 1.99)	481 (27.82)	243 (25.42)	0.078
Base deficit (<-1.99)	1,117 (64.60)	656 (68.62)	
Base excess (>1.99)	131 (7.58)	57 (68.62)	
Blood transfusion			
Yes	128 (7.40)	71 (7.43)	0.982
No	1,601 (92.60)	885 (92.57)	

ratios (HRs) presented similar patterns (HR_{unadj} = 0.75; 95% CI: 0.57–0.99 and HR_{adj} = 1.02; 95% CI: 0.74–1.41) (see Table 3).

Discussion

MVCs continue to be a leading cause of death worldwide, nationwide, and in PR, especially among people aged 15 to 29 years (1). It has been documented that seatbelt use reduces mortality in MVCs (7–11). However, this phenomenon has not been studied locally (in PR). The present study assessed the impact of seatbelt use on the in-hospital mortality of severe trauma patients that experienced an MVC. We hypothesized that if patients were not wearing a seatbelt during an MVC, then their mortality rate would be higher than that of severe trauma patients who had been wearing a seatbelt, because they would have a higher prevalence of severe head injury, which is the primary cause of death in trauma. It has been stated previously in the literature that seatbelt use reduces head injuries, which, in turn, results in decreased in-hospital mortality (7, 10, 15). A possible explanation for this is that unbelted vehicle occupants could be ejected from the vehicle during a collision (7, 8, 15). Indeed, in our study severe trauma patients who had been wearing seatbelts in an MVC had a 33% reduced risk of dying compared to their unbelted counterparts. Furthermore, and consistent with prior studies, the victims of MVCs suffering from severe trauma who were most commonly found to have been wearing a seatbelt were women and were relatively older individuals (2, 7–9, 13, 15).

A limited number of studies have examined the GCS scores of MVC patients, which score is an important variable, as it provides the level and type of brain injury and the prognosis of the patient (22). In our study, a GCS score of 8 or lower was seen more often in the unbelted group of

Table 2. Severity markers in MVC-related severe trauma victims, by seatbelt use (N = 2,685)

Seatbelt use	Belted Median (IQR)	Unbelted Median (IQR)	p-value
Severity marker			
LOS	8 (10)	9 (15.5)	0.357
TICU days	11 (22)	14 (13.5)	0.212
MV days	10 (22)	7 (14)	0.047

IQR: interquartile range; LOS: length of stay; TICU: trauma intensive care unit; MV: mechanical ventilation

Table 3. Differences in mortality and survival rates between belted and unbelted severe trauma victims

Seatbelt use	OR_{unadj} (95% CI)	OR_{adj}[1] (95% CI)	HR_{unadj} (95% CI)	HR_{adj}[1] (95% CI)
Belted[2]	0.67 (0.52, 0.92)	1.04 (0.72, 1.52)	0.75 (0.57, 0.99)	1.02 (0.74, 1.41)

[1]Adjusting by age, SBP<90, ISS, and GCS score. [2]Reference category was unbelted severe trauma patients. OR: odds ratio; HR: hazard ratio; unadj: unadjusted; adj: adjusted; ISS: injury severity score; GCS: Glasgow coma scale; SBP: systolic blood pressure

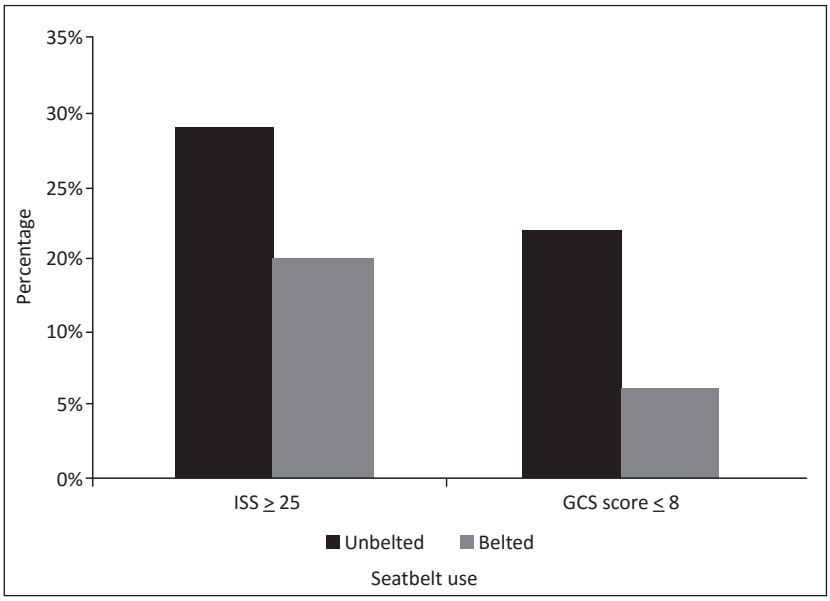

Figure 3. Differences in ISS ≥ 25 and GCS score ≤ 8 between belted and unbelted accident victims

patients than in the belted group. This is similar to what has been reported in the scientific literature and could be explained by the higher prevalence of head injuries reported in such unbelted groups (8, 9). Consistent with previous research, there was a higher proportion of severe trauma patients having suffered an MVC without wearing a seatbelt with an ISS of 25 or higher. Researchers have attributed this elevated ISS to the fact that the members of this particular group go through more violent traumatic forces than the members of the belted group do (7–9, 12).

With regard to injured body parts, besides the higher prevalence of head injuries, our severe trauma patients who had been unbelted during their accident had a higher proportion of open wounds to the neck, which is consistent with Rutledge et al. (1991) (9). However, other authors, such as Coley et al. (2002), have found that this type of injury is more prevalent in belted victims suffering from severe trauma (10).

Our study also found a higher prevalence of pneumothorax and hemothorax injuries among the members of the belted group, while other investigators found a greater proportion in the members of the unbelted group (8, 11). In addition, injuries to the ribs occurred more frequently in belted accident victims than unbelted ones in our study, which may be the result of strangulation by the belt. Weaver et al. (2015), however, found the opposite result, in that, according to their study, unbelted severe trauma victims more commonly suffered injuries to the ribs than did belted victims (11). Sternum fractures were also more common in severe trauma patients who had been wearing seatbelts during an MVC, which is similar to what has been found in other studies (11, 15). A possible explanation for this is that these types of injuries might be caused by seatbelt pressure.

Even though the findings of our study show that seatbelt use is associated with lower ISSs, higher GCS scores, and lower in-hospital mortality, belted severe trauma victims sustained lower extremity injuries more often than their counterparts did. In the literature, there are some inconsistencies regarding this issue. Several researchers have found that unbelted severe trauma victims suffer more frequently from lower extremity injuries than they do from injuries to any other part of the body (7, 8, 11). Porter et al. (1998), meanwhile, reported results consistent with those observed in our analysis (15).

In this research, the LOSs were similar between the groups, in contrast with other studies that found that unbelted severe trauma victims had higher LOSs, which represents an increase in the cost of treating these patients (8–10). Notwithstanding, our severe trauma patients who had been wearing seatbelts during their accidents spent more days on MV than their unbelted counterparts did. Although this variable has not been widely studied, Rutledge et al. (1991) reported results opposite to those of our analysis (9).

Differences in mortality and survival rates between belted and unbelted severe trauma victims were studied in detail in this analysis. Patients who wore their seatbelts during their MVCs had a lower risk of in-hospital mortality than did those who did not wear their seatbelts. After adjusting for age, hypotension, ISS, and GCS score, the difference in risk between belted and unbelted trauma victims was eliminated; the implication of the previous is that wearing a seatbelt (during an MVC) mitigates trauma severity, particularly with regard to the sustaining of head injuries.

Evaluating the impact of seatbelt use on the morbidity and mortality of severe trauma patients is, ultimately, an assessment of the effectiveness of public policy. This study focused on a valuable population for the evaluation of PR law 132. The government has statistics on MVCs and MVC deaths on public roads. However, the severity and injury characteristics, as well as in-hospital mortality, of MVC trauma patients has not been evaluated yet. This analysis provides evidence of the benefits of seatbelt use, as we found a lower proportion of severe trauma patients with ISSs greater than or equal to 25 and GCS scores less than or equal to 8, and with fewer head injuries in the members of the group who wore seatbelts than in those who did not wear them; and all of these factors influence in-hospital mortality. These findings demonstrate that the enforcement of the seatbelt-use policy is necessary. Nearly 1,000 of the patients in our study were not wearing their seatbelts when they were involved in their MVCs. Given that, together with the results of our study, it is clear that new and better strategies and measures must be implemented to convince unbelted motor vehicle occupants of the need to wear seatbelts.

This study had several limitations. Given the retrospective nature of the research, not all data were available for all participants, meaning that there may have been an information or a selection bias (or both) – most especially among the 1,000+ patients whose seatbelt use was unknown and who were excluded from the study. It is important to note, however, that we performed statistical analyses to explore whether patients whose seatbelt status was unknown shared characteristics with patients known to have been either unbelted or belted when involved in an MVC. We found that patients whose seatbelt status was unknown were similar to unbelted patients in terms of sex, age, head injury, ISS, GCS score, and in-hospital mortality. Therefore, our results may be biased towards the null hypothesis, and, thus, the effect of seatbelt use may be underestimated.

Furthermore, this analysis excluded individuals that died on the scene, those whose injuries were not so severe as to require hospital care, and those who went to other public or private health care centers. The study sample included only those patients admitted to the PRTH, who typically are the most severely injured. Additionally, information regarding MVC circumstances and motor-vehicle characteristics and features that could affect the impact of seatbelt use on the severity of injuries and mortality were not considered. Another drawback of the study was that we were unable to determine when seatbelts were and were not being used appropriately.

On the other hand, the key strength of this analysis is the fact that it evaluated the impact of seatbelt use in severe trauma patients, a population that has not been deeply studied in

previous research. Furthermore, the retrospective nature of the study allowed for an evaluation that covered an extended period of time (15 years) with a large sample size (2,685 patients), adding significant reliability to our findings.

Even though over 90% of adults in PR report using seatbelts, 36% of all MVC patients treated at PRTH (with a known seatbelt status) were not wearing a seatbelt at the time the MVC happened (19). Therefore, although PR law 132 (2004) was enacted, we must continue working on this public health threat until all motor-vehicle occupants wear their seatbelts (24). It is important to note that a large body of scientific literature has shown that seatbelts reduce the numbers of serious crash-related injuries and deaths (7, 8, 10, 12).

Our findings demonstrate that using a seatbelt is associated with fewer head injuries, lower ISSs, and higher GCS scores, all of which are strong predictors of reduced trauma mortality. This suggests that using seatbelts mitigates trauma severity and, thus, it could reduce the likelihood of in-hospital mortality for those victims who were wearing seatbelts at the time of their MVCs. This evidence, supported by the scientific literature, should be used by policymakers and stakeholders to develop seatbelt-usage awareness campaigns and related strategies. These measures should be aimed primarily at vehicle occupants who are 40 years of age or younger, as they have the lowest seatbelt-wearing rates. Additionally, further research is needed to evaluate the use of seatbelts in PR and to evaluate, as well, the barriers to their use.

Resumen

Objetivo: Los accidentes de tránsito (en inglés, *motor vehicle collisions* [MVCs]) constituyen una fuente importante de morbilidad y mortalidad. El cinturón de seguridad reduce la tasa de mortalidad por MVCs. En Puerto Rico, el impacto del cinturón en las muertes por MVCs no ha sido evaluado. Este estudio evaluó la asociación entre el uso del cinturón y la mortalidad en el Hospital de Trauma de Puerto Rico. Métodos: Se realizó un estudio retrospectivo con 2,685 pacientes que tuvieron MVCs entre el 2000 y el 2014. Se recopilaron variables sociodemográficas, clínicas y de prognosis. Se utilizó una regresión logística para evaluar el riesgo de mortalidad de pacientes que habían usado cinturón al momento del MVC en comparación con pacientes que no lo usaron. Resultados: El uso del cinturón fue más frecuente en mujeres que en hombres (71% vs. 62%; p<0.001), y más prevalente en personas mayores (p<0.001). Los pacientes que habían usado cinturón durante el MVC tuvieron menos lesiones de cabeza que los pacientes que no lo usaron (p<0.001). Las proporciones de pacientes con puntuaciones de *Glasgow coma scales* (GCSs) ≤8 (17% vs. 6%; p<0.001) y *Injury Severity Scores* (ISSs) ≥25 (24% vs. 15%; p<0.001) fueron mayores en el grupo que no usó cinturón. Los pacientes que habían usado cinturón tuvieron 30% menos riesgo de mortalidad que sus contrapartes sin cinturón (OR_{unadj}=0.70; IC 95%: 0.52-0.92). Luego de ajustar, esta protección se perdió (OR_{adj}=1.04; IC95 %: 0.72-1.52). Conclusión: Los hallazgos demuestran que el uso del cinturón está asociado con menos lesiones de cabeza y menores ISSs y mayos puntuaciones de GCSs. Esto sugiere que el uso de cinturones mitiga la gravedad del trauma, reduciendo así la probabilidad de mortalidad intrahospitalaria para los pacientes que usaron cinturón al momento del MVC.

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Publishable Disclosure Statement. Oral presentations of this project were made: 1) at the Raffucci Surgical Research Forum, American College of Surgeons, Puerto Rico Chapter, February 2016; 2) at the 36th annual Research and Education Forum, Medical Sciences Campus, University of Puerto Rico, May 2016.

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