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Elderly Admission Trends at the Puerto Rico Trauma Hospital: A Time-Series Analysis

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ABSTRACT

Introduction: The aging process places the elderly, a worldwide increasing age group, at an increased risk for trauma. This study aims to explore changes over time in admission rates, sociodemographical, clinical, and injury-related data in elderly patients (aged ≥65 y) admitted to the Puerto Rico Trauma Hospital (PRTH) during 2000-2019.

Materials and methods: A time-series analysis was conducted. Admission rates were analyzed by fitting an exponential growth curve model. Trends were assessed using the Cochrane-Armitage and Cuzick tests for categorical and continuous data, respectively.

Results: Elderly admission rates to the PRTH have shown growth over the past 2 decades, from 6.2 cases per 100 overall admissions in 2000 to 18.2 in 2019. This trend is projected to continue with estimated 24.8 (95% CI: 21.7-27.8) cases per 100 overall admissions in 2023. Trends for mechanisms of injury such as motor vehicle accidents and pedestrians showed a significant decrease, whereas falls presented a clear positive trend, showing an increase from 25.6% in 2000-2004 to 46.2% in 2015-2019. Both Injury Severity Score ≥25 and Glasgow Coma Scale ≤8 declined significantly through time. Finally, in-hospital mortality presented a decreasing trend from 31.7% in 2000-2004 to 21.5% in 2015-2019.

Conclusions: Our analysis demonstrates an increase over time in elderly admissions, especially fall-related trauma. Also, it projects this upward trend will continue. This imposes new challenges for PRTH and other healthcare services and is a gateway for the implementation of adapted clinical management.

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Introduction

Physical trauma has not been immune to worldwide aging and demographic changes. As a leading cause of death and disability, trauma has traditionally been viewed as a disease of those aged 45 y or younger.[1,2] Nevertheless, the elderly are not immune to this disease. In the United States (US), approximately 500,000 elderly patients are admitted to trauma centers after injury on an annual basis.[3] Traumatic injury is among the leading causes of death for this population after heart disease, cancer, chronic obstructive pulmonary disease (COPD), stroke, diabetes, and pneumonia.[4] Moreover, the elderly have a higher risk of death and severe disability, along with higher hospital costs and hospital length of stay (LOS), compared to their younger counterparts when a similar trauma or injury occurs.[5]

Increased longevity and better health have come as a result of technological and medical advances.[6] As of 2017, 14.9% of the US population was comprised of people aged 65 y or older, growing by 1.6 million from 2014.[7] As per the Institute of Statistics of Puerto Rico, the population aged more than 65 y had 5% growth from 2010 to 2017. The elderly population, by 2017, increased to the extent that matched the 18 y or younger population, each comprising 20% of the total population of Puerto Rico at that time.[8] Consequently, the United States and Puerto Rico's population is shifting toward becoming an aged one, creating new challenges concerning healthcare and management.

Admission trends in the elderly population are expected to increase due to the epidemiological population changes before mentioned. For instance, the elderly population accounts for more than 25% of all trauma admissions and it is projected that by 2050 these patients will account for almost 39% of the trauma admissions in the United States.[9,10] From 2003 to 2009, based on the US National Trauma Data Bank (NTDB), the proportion of elderly patients in Level I and II trauma centers increased from 23% to 30%.[11] Even more, weighted estimates from the US NTDB from 2003 to 2012 presented an increasing trend of trauma admissions for patients aged 55 y or older, whereas admissions for those aged 44 y or younger declined.[12]

Although Puerto Rico is a US territory, the unique social, cultural, economic, and political contexts, in addition to the island's geographical situation, differ from its aging population from that of the mainland.[13] Since the elderly patient is inherently different from other trauma patients, understanding this population is essential to guide medical therapy and in-hospital care, which would ensure better outcomes and preventive measures. Therefore, this study aims to evaluate changes over time in admission rates, sociodemographical, clinical, and injury-related data in elderly patients (aged ≥65 y) admitted to the Puerto Rico Trauma Hospital (PRTH) from April 2000 through October 2019. Secondarily, the study will address the abovementioned parameters as per age groups.

Materials and Methods

Study design and population

We conducted a time-series analysis of elderly patients (defined as those aged ≥65 y, based on prior literature[6,14,15]) treated at the PRTH, a state-designed Level I trauma center, that serves as the only tertiary referral hospital for polytrauma patients in Puerto Rico and the Caribbean. The trauma registry of our center, which is a part of the US National Trauma Registry System, was queried to identify all the hospitalizations of patients aged ≥65 y from April 2000 through October 2019. We excluded patients who had no age, admission date, discharge date, or discharge status recorded. The study period was defined as per data availability; the trauma registry began to accrue data in April 2000 and, at the time of data extraction, records were completed until October 2019. This directly translates into a loss of information of 3 mo (January-March) for the initial year of study and a loss of 2 mo (November-December) for the last one.

Variables

We extracted data on sociodemographic, injury-related, and hospital course characteristics. Sociodemographic variables included gender (male and female), age (measured in a continuous scale and by categories: 65-74 y, 75-84 y, and ≥85 y; these a priori cut points are based on prior literature[6]), health insurance status (uninsured, insured), and presence of comorbid conditions (coded as "yes" or "no": any comorbidity, hypertension, diabetes mellitus, alcohol use disorder, psychiatric illness, COPD, and congestive heart failure). The specific comorbid conditions were selected based on their unconditional relative frequencies (>2%).

Injury-related factors comprised mechanism of injury (motor vehicle accident [MVA], gunshot wound [GSW], stab wound [SW], fall, pedestrian, and other), type of injury (nonpenetrating, penetrating), systolic blood pressure (<90 mmHg, ≥90 mmHg), body region injured (coded as "yes" or "no": head and neck, chest, abdomen, extremity), number of body regions involved (<three regions, ≥three regions), Injury Severity Score (ISS) (measured in a numerical scale and by categories: noncritical, <25 points; critical, ≥25 points), and Glasgow Coma Scale (GCS) (severe, ≤eight points; nonsevere, >eight points).

Hospital course data considered were admission to the trauma intensive care unit (TICU) (coded as "yes" or "no"), TICU LOS (measured in days), need for mechanical ventilation (MV) (coded as "yes" or "no"), duration of MV (measured in days), hospital LOS (measured in days), and in-hospital mortality (defined as death occurring during hospitalization and coded as "yes" or "no").

Statistical analysis

The univariate analysis is presented as mean with standard deviation (SD), median with interquartile range (IQR), or absolute (*n*) and relative (%) frequencies, as appropriate. To evaluate trends in sociodemographic, injury-related, and hospital course factors, the 20-y period covered by this study was split into four subperiods: 2000-2004, 2005-2009, 2010-2014, and 2015-2019. The Cochran-Armitage[16] and Cuzick[17] tests were employed for categorical and continuous data, respectively, when assessing trends over

time. On the other hand, comparisons among age groups were performed using the Pearson's Chi-squared test or the Kruskal–Wallis test and post hoc Dunn's test with Bonferroni adjustment for multiple comparisons, as applicable.

Furthermore, a two-parameter exponential growth curve model was fitted to present the long-term trend of elderly admission rates and to generate short-term forecasts. Elderly admission rates were calculated annually by dividing the number of patients aged ≥65 y admitted to the hospital by the total of admitted patients (i.e., all ages). The exponential model can be expressed as:

$$\widehat{Y}_t = \widehat{(\beta_1)}\,\widehat{(\beta_2)}^{t}$$

where, β_1 is the initial value of the function (or the y-intercept), β_2 is its change factor (or a constant), and the exponent t is the independent variable (year).

Our *P* value criterion for statistical significance was set at 0.05. The statistical software used to conduct the analyses was STATA, version 14 (STATA Corp, College Station, TX). This study was approved by the Institutional Review Board of the Medical Sciences Campus of the University of Puerto Rico and a waiver of consent was obtained. The authors adhered to the Strengthening the Reporting of Observational studies in epidemiology guidelines for reporting observational studies (www.strobe-statement.org).

Results

An overall of 3206 admissions were recorded from people aged 65 y or older during the study period. Elderly admission rates to the PRTH have shown an exponential growth over the past 2 decades, from 6.2 cases per 100 overall admissions in 2000 to 18.2 cases in 2019 (Fig.). This trend is projected to continue, with an estimated 21.9 (95% CI: 19.6-24.1) cases per 100 overall admissions in 2021 and 24.8 (95% CI: 21.7-27.8) cases in 2023. The parameter estimates from the exponential growth curve model are shown in Table 1.

The quinquennium-stratified analysis showed that admissions in patients aged ≥85 y (*P-trend* = 0.084) marginally increased over time, especially during the last quinquennium. Nevertheless, this age group was the least prevalent in all lustrums. When considering comorbidities, both hypertension (*P-trend* = 0.029) and alcohol use disorder (*P-trend* = 0.002) presented a significant downward trend, notably from the second subperiod (2005-2009). Of interest, however, hypertension remained the most common comorbid condition in all 5-y periods despite the registered pattern. Patients admitted with psychiatric illness (*P-trend* = 0.027), meanwhile, increased from 1.2% in 2000-2004 to 3.7% in 2015-2019 (Table 2).

Overall, the most common mechanisms of injury among our elderly were falls (42.1%), MVA (24.8%), and pedestrians (20.6%). The trend analysis showed a statistically significant

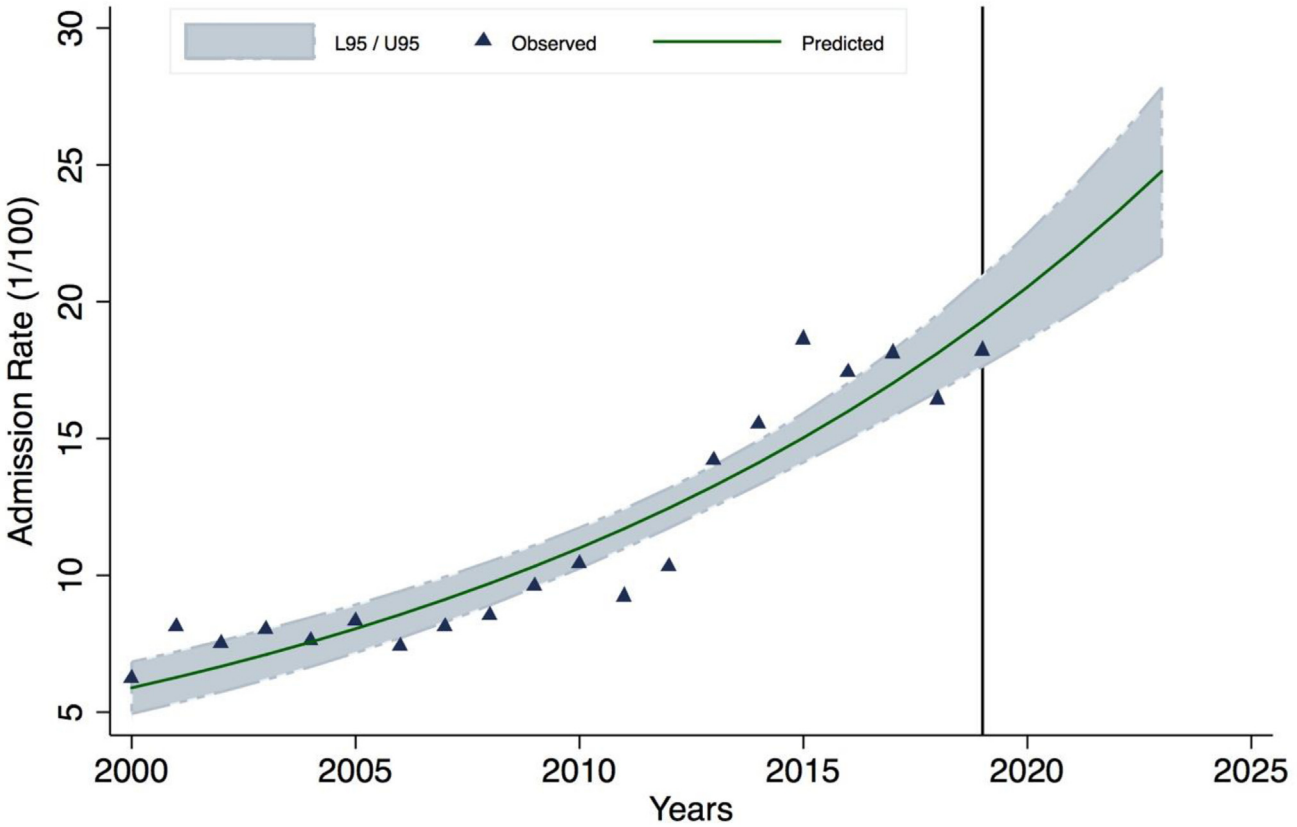

Fig. – Annual observed and predicted admission rates of elderly patients to the Puerto Rico Trauma Hospital. (The vertical line separates modeling from estimates. Elderly admission rates are presented per 100 overall admissions [i.e., all ages]. L95 = 95% lower confidence limit; U95 = 95% upper confidence limit).

Table 1 – Exponential growth curve model for annual admission rates of elderly patients to the Puerto Rico Trauma Hospital.

Parameter	Coef.	Std. Error	t-value	*P* value	R^2
β_1	5.53	0.48	11.46	<0.001	0.985
β_2	1.06	0.01	173.29	<0.001	
Estimated equation:	$\widehat{Y}_t = (\widehat{5.53})(\widehat{1.06})^t$				

Coef. = coefficient; Std. = standard.

decrease over the evaluation period for MVA (*P-trend* = 0.001) and pedestrians (*P-trend* < 0.001). On the other hand, fall-related injuries (*P-trend* < 0.001) presented a clear positive trend, showing an increase from 25.6% in the first lustrum to 46.2% in the last. Although chest injury was the most common type of body region injured, only head and neck (*P-trend* < 0.001) and extremity (*P-trend* < 0.001) categories showed a decreasing trend from 34.9% and 25.9% in 2000-2004 to 22.8% and 13.1% in 2015-2019, respectively. The severity of injuries also declined over time, as measured by the proportion of elderly patients admitted with an ISS ≥25 (*P-trend* < 0.001) or a GCS ≤8 (*P-trend* = 0.011); these percentages have reduced from 22.3% and 14.9% in the first quinquennium to 10.9% and 9.5% in the last one, respectively (Table 2).

In terms of hospital resource utilization, TICU admissions (*P-trend* < 0.001) upturned from 15.1% in the 2000-2004 lustrum to 32.3% in the 2015-2019 lustrum. The median TICU LOS (*P-trend* = 0.051) presented a marginal upward pattern as well. Furthermore, the need for MV (*P-trend* < 0.001) in the elderly nearly doubled from the first subperiod (18.5%) to the last (35.8%). The median for hospital LOS (*P-trend* = 0.005) presented a significant increasing tendency from the first quinquennium to the last. Finally, the in-hospital mortality (*P-trend* = 0.005) exhibited a strong downward trend over the evaluation period, declining from 31.7% to 21.5% (Table 2).

Elderly age subgroups analysis

Age subgroups were labeled as younger elderly (65-74), middle elderly (75-84), and older elderly (≥85). The prevalence of injured males significantly varied across groups (*P* < 0.001), with the younger elderly (76.1%) having the highest frequency of males and the older elderly (64.1%) presenting the lowest. Moreover, the younger elderly (49.2%) experienced marginally lower rates of overall comorbidities compared to the middle elderly (53.1%) and the older elderly (52.9%) (*P* = 0.090). When analyzing specific comorbidities, the proportions of both alcohol use disorder (younger elderly: 5.3%, middle elderly: 4.1%, and older elderly: 2.2%; *P* = 0.029) and psychiatric illness (younger elderly: 3.6%, middle elderly: 2.1%, and older elderly: 1.7%, *P* = 0.027) decreased with age.

The distribution of the mechanisms of injury was also statistically different among age subgroups (*P* < 0.001). MVAs were less prevalent among the older elderly (17.0%) relative to the middle elderly (27.1%) and the younger elderly (25.0%). A similar pattern was observed with pedestrians, as 17.3% of the older elderly presented with this mechanism compared to 21.8% of the middle elderly and 20.5% of the younger elderly. However, falls significantly escalated with age, from 39.2% and 41.5% in the younger elderly and the middle elderly, respectively, to 57.8% in the older elderly. As for body region injured, head and neck trauma increased as patients aged (younger elderly: 26.3%, middle elderly: 29.6%, and older elderly: 31.5%; *P* = 0.044), whereas abdominal injuries downturned (younger elderly: 8.8%, middle elderly: 7.0%, and older elderly: 3.3%; *P* = 0.001).

Likewise, the median (IQR) ISS marginally differed across the groups (*P* = 0.056), as the older elderly experienced a slightly lower score than the other two age subgroups (younger elderly: 13 [11] points, middle elderly: 13 [11] points, older elderly: 12 [8] points). Similarly, as demonstrated by the post hoc analysis, the older elderly (median [IQR]: 9 [19] d) had a shorter hospital LOS than did the middle elderly (11 [21] d; *P* = 0.027) and the younger elderly (11 [20] d; *P* = 0.021). Finally, the distribution of mortality rates confirmed that the likelihood of dying in a hospital increases with age (younger elderly: 17.8%, middle elderly: 27.1%, older elderly: 34.5%; *P* < 0.001). Table 3 compares the sociodemographic characteristics, injury profile, and hospital course among elderly age subgroups.

Discussion

The primary objective of this study was to measure the trends over time in elderly admission rates and in the injury and clinical profiles of this trauma subpopulation. Our data confirmed the increase in admission rates of elderly patients, especially those aged ≥85 y. Moreover, it highlights that admissions related to falls, which ranked as the most common mechanism of injury, increased over the past 2 decades. Finally, our data presented that in-hospital mortality among this population decreased in our institution.

The increase in elderly admissions at our hospital is consistent with results from multiple studies in various countries. Beck *et al.*, in Australia, reported that the number of elderly patients presenting major trauma more than doubled from 2007 to 2016.[6] Equally, Lowe *et al.*, in Birmingham, Alabama, documented that elderly high energy traumas almost doubled from 2005 to 2014 compared to the previous 10 y of their study period and Burstow *et al.*, in New Zealand, also found an increase in elderly admissions.[14,15] The increase of elderly admissions in the PRTH may be influenced by the upsurge of this population on the island, caused by factors such as longer life spans, healthier lifestyles, changes in birth rates and mortality, younger population migration, and medical and technological advances.[18,19] Furthermore, factors such as frailty, previous falls, living alone, walking aids, depression, cognitive deficit, and polypharmacy increase the risk of injury in the elderly, specially fall-related traumas.[20]

The results of this study are consonant with findings in preceding studies in Australia, United Kingdom, and the Netherlands, which reveal falls as the predominant mechanism of injury in the elderly.[6,21,22] This mechanism of injury is well known to be a major cause of trauma, disability, and trauma-related deaths in elders.[5,23] In a similar manner, a study from Pennsylvania supports that, as time passed, falls

Table 2 – Trends in sociodemographic characteristics, injury profile, and hospital course among patients admitted to the Puerto Rico Trauma Hospital between 2000 and 2019.

Characteristic	Overall ($n = 3206$), n (%)	2000-2004 ($n = 410$), n (%)	2005-2009 ($n = 692$), n (%)	2010-2014 ($n = 932$), n (%)	2015-2019 ($n = 1172$), n (%)	P value for trend
Sociodemographic Data						
Gender						
Male	2320 (72.4)	283 (69.0)	505 (73.0)	685 (73.6)	847 (72.3)	0.401
Age, y						
Mean (SD)	74.7 (7.3)	74.4 (7.1)	74.3 (7.3)	74.6 (7.4)	75.0 (7.4)	
Median (IQR)	73 (10)	73 (11)	73 (11)	73 (10)	74 (11)	0.079
Categories						
65-74	1760 (54.9)	225 (54.9)	387 (55.9)	512 (54.9)	636 (54.3)	0.624
75-84	1087 (33.9)	142 (34.6)	236 (34.1)	322 (34.6)	387 (33.0)	0.525
≥85	359 (11.2)	43 (10.5)	69 (10.0)	98 (10.5)	149 (12.7)	0.084
Health insurance status						
Uninsured	136 (4.3)	3 (0.8)	39 (5.8)	61 (6.6)	33 (2.8)	0.938
Comorbidities						
≥1	1632 (50.9)	138 (33.7)	434 (62.7)	544 (58.4)	516 (44.0)	0.477
Hypertension	1006 (31.4)	65 (15.9)	261 (37.7)	336 (36.1)	344 (29.4)	0.029
Diabetes mellitus	680 (21.2)	52 (12.7)	175 (25.3)	221 (23.7)	232 (19.8)	0.297
Alcohol use disorder	146 (4.6)	17 (4.2)	45 (6.5)	58 (6.2)	26 (2.2)	0.002
Psychiatric illness	92 (2.9)	5 (1.2)	21 (3.0)	23 (2.5)	43 (3.7)	0.027
COPD	86 (2.7)	10 (2.4)	11 (1.6)	47 (5.0)	18 (1.5)	0.684
Congestive heart failure	78 (2.4)	7 (1.7)	19 (2.8)	29 (3.1)	23 (2.0)	0.849
Injury-related data						
Mechanism of injury						
MVA	794 (24.8)	140 (34.1)	160 (23.3)	218 (23.4)	276 (23.6)	0.001
GSW	63 (2.0)	8 (2.0)	19 (2.8)	19 (2.0)	17 (1.4)	0.162
SW	104 (3.2)	10 (2.4)	27 (3.9)	34 (3.7)	33 (2.8)	0.763
Falls	1346 (42.1)	105 (25.6)	273 (39.8)	427 (45.9)	541 (46.2)	<0.001
Pedestrians	658 (20.6)	134 (32.7)	159 (23.2)	163 (17.5)	202 (17.2)	<0.001
Others	234 (7.3)	13 (3.2)	48 (7.0)	70 (7.5)	103 (8.8)	0.001
Type of injury						
Nonpenetrating	3000 (93.9)	391 (95.4)	634 (92.7)	868 (93.3)	1107 (94.5)	0.852
Systolic blood pressure						
<90 mmHg	187 (5.9)	44 (10.9)	38 (5.6)	50 (5.4)	55 (4.7)	<0.001
Body region injured						
Head & neck	897 (28.0)	143 (34.9)	184 (26.6)	303 (32.5)	267 (22.8)	<0.001
Chest	1505 (46.9)	215 (52.4)	290 (41.9)	428 (45.9)	572 (48.8)	0.693
Abdomen	242 (7.6)	32 (7.8)	56 (8.1)	66 (7.1)	88 (7.5)	0.684
Extremity	611 (19.1)	106 (25.9)	188 (27.2)	163 (17.5)	154 (13.1)	<0.001
No. Body regions involved						
≥3	97 (3.0)	25 (6.1)	31 (4.5)	29 (3.1)	12 (1.0)	<0.001
Injury severity score						
Median (IQR)	13 (11)	16 (13)	13 (13)	13 (11)	13 (9)	<0.001
Categories						
Critical (≥25)	539 (16.9)	91 (22.3)	145 (21.2)	176 (19.0)	127 (10.9)	<0.001

(continued)

Table 2 – (*continued*)

Characteristic	Overall ($n = 3206$), *n* (%)	2000-2004 ($n = 410$), *n* (%)	2005-2009 ($n = 692$), *n* (%)	2010-2014 ($n = 932$), *n* (%)	2015-2019 ($n = 1172$), *n* (%)	*P* value for trend
Glasgow coma scale						
Severe (≤8)	345 (10.9)	60 (14.9)	72 (10.5)	103 (11.3)	110 (9.5)	0.011
Hospital course data						
Admission to TICU						
Yes	676 (21.1)	62 (15.1)	90 (13.0)	145 (15.6)	379 (32.3)	<0.001
TICU LOS, d						
Mean (SD)	27.7 (29.3)	18.2 (13.3)	26.3 (31.8)	31.5 (32.7)	28.2 (29.0)	
Median (IQR)	19 (26)	15 (20)	17.5 (25)	21 (26)	19 (27)	0.051
MV required						
Yes	792 (24.7)	76 (18.5)	96 (13.87)	201 (21.6)	419 (35.8)	<0.001
MV, d						
Mean (SD)	23.9 (28.1)	15.3 (12.9)	25.6 (31.1)	25.3 (30.5)	24.3 (27.9)	
Median (IQR)	16 (25)	13.5 (18)	16.5 (21)	15 (26)	16 (28)	0.306
Hospital LOS, d						
Mean (SD)	21.3 (30.9)	16.5 (18.5)	22.2 (39.0)	22.8 (31.2)	21.2 (28.4)	
Median (IQR)	11 (20)	9 (16)	10 (19)	12 (22)	11 (19)	0.005
In-hospital mortality						
Dead	732 (22.8)	130 (31.7)	139 (20.1)	211 (22.6)	252 (21.5)	0.005

SD = standard deviation; IQR = interquartile range; COPD = Chronic Obstructive Pulmonary Disease; MVA = motor vehicle accident; GSW = gunshot wound; SW = stab wound; No. = number; TICU = trauma intensive care unit; LOS = length of stay; MV = mechanical ventilation.

became the leading cause of injury for all age groups (i.e., younger, middle, and older elderly).[24] Our results echo the findings of the referenced study, stating that falls becomes more predominant as age increases within the elderly population. As people get older, physiological changes that cause a decline in vision, reaction time, and cognitive function, and factors such as weakness and unsteady gait, place the elderly at a major risk for falls.[19]

The severity of injuries in our findings demonstrated a decrease over time in the elderly population. A previous study undertaken at our institution found that the pedestrian mechanism of injury is associated with higher ISSs, higher mortality rates, and worse outcomes, whereas patients admitted for falls usually presented the contrary.[25] Given the statistical relationship between mechanisms of injury and ISSs, the significant increase in fall-related admissions and the clear decline in those associated with pedestrians occurred in our hospital over time could potentially explain the observed decrease in ISSs. MV is the most common among elderly patients and patients admitted to the intensive care unit (ICU).[26] An increase in elderly ICU admissions and its relationship with the significant increase in MV use within this cohort may be associated with an increment in hospital equipment, resources, protocols, and technology during the past 2 decades. Consequently, more invasive and aggressive treatments and improved outcomes of elderly patients admitted to the ICU were observed.

The overall in-hospital mortality rate at the PRTH was higher (22.8%) compared to studies in Japan and the United States, which reported an 11.8% and 14.8% rate, respectively.[27,28] However, our study and related articles from New Zealand and Japan have highlighted a decrease in elderly trauma mortality over time.[15,29] These articles attribute the decline in elderly trauma mortality to multiple factors including public safety campaigns and trauma education, efficiency in trauma system and resuscitation protocols, intensive care treatment, and medical and technological advances.[15,29] Consistent with our results, various studies agree that with increasing age, in-hospital mortality rates also increase.[30,31] An age more than 60 y is a significant risk factor for overall death and, as people age, physiological reserve decreases, frailty and comorbidities become apparent, and response to trauma is diminished due to anatomical and physiological changes, thereby increasing the risk of trauma-related mortality as well.[3,32,33]

These patients and their unique characteristics represent significant clinical challenges; better outcomes entail intensive monitoring, aggressive management, comprehensive care, and experienced trauma teams.[34] Forthcoming, elderly admissions alongside their complexities and vulnerabilities may have a dominant role in in-hospital trauma care. The elderly account for a significant proportion of ICU admissions in the United States[35,36]; nevertheless, there is a lack of formal training in geriatric critical care management and practices.[37] The surge in expected elderly admissions will require the creation and the implementation of specialized ICUs for this cohort in Puerto Rico and the PRTH because they have been linked to improved outcomes in the places where they have been implemented.[38] Multiple hospitals in the United States have instituted specialized geriatric TICUs and many have adopted the G-60 model, which entails resources for the improvement of outcomes in elderly trauma patients and

Table 3 – Differences in sociodemographic characteristics, injury profile, and hospital course among elderly age subgroups admitted to the Puerto Rico Trauma Hospital between 2000 and 2019.

Characteristic	Younger elderly ($n = 1760$), n (%)	Middle elderly ($n = 1087$), n (%)	Older elderly ($n = 359$), n (%)	P value
Sociodemographic data				
Gender				<0.001
Male	1338 (76.1)	752 (69.2)	230 (64.1)	
Health insurance status				0.460
Uninsured	82 (4.7)	41 (3.9)	13 (3.7)	
Comorbidities				
≥1	865 (49.2)	577 (53.1)	190 (52.9)	0.090
Hypertension	537 (30.5)	354 (32.6)	115 (32.0)	0.497
Diabetes mellitus	379 (21.5)	236 (21.7)	65 (18.1)	0.310
Alcohol use disorder	93 (5.3)	45 (4.1)	8 (2.2)	0.029
Psychiatric illness	63 (3.6)	23 (2.1)	6 (1.7)	0.027
COPD	38 (2.2)	35 (3.2)	13 (3.6)	0.119
Congestive heart failure	33 (1.9)	35 (3.2)	10 (2.8)	0.070
Injury-related data				
Mechanism of injury				<0.001
MVA	439 (25.0)	294 (27.1)	61 (17.0)	
GSW	46 (2.6)	13 (1.2)	4 (1.1)	
SW	77 (4.4)	24 (2.2)	3 (0.8)	
Falls	688 (39.2)	451 (41.5)	207 (57.8)	
Pedestrians	359 (20.5)	237 (21.8)	62 (17.3)	
Others	146 (8.3)	67 (6.2)	21 (5.9)	
Type of injury				<0.001
Nonpenetrating	1618 (92.3)	1037 (95.7)	345 (96.4)	
Systolic blood pressure				0.211
<90 mmHg	100 (5.7)	72 (6.7)	15 (4.2)	
Body region injured				
Head and neck	462 (26.3)	322 (29.6)	113 (31.5)	0.044
Chest	823 (46.8)	527 (48.5)	155 (43.2)	0.212
Abdomen	154 (8.8)	76 (7.0)	12 (3.3)	0.001
Extremity	343 (19.5)	203 (18.7)	65 (18.1)	0.769
No. Body regions involved				0.582
≥3	53 (3.0)	36 (3.3)	8 (2.2)	
Injury severity score				
Median (IQR)	13 (11)	13 (11)	12 (8)	0.056
Categories				0.688
Critical (≥25)	295 (16.9)	189 (17.5)	55 (15.5)	
Glasgow coma scale				0.639
Severe (≤8)	187 (10.8)	114 (10.7)	44 (12.4)	
Hospital course data				
Admission to TICU				0.300
Yes	366 (20.8)	243 (22.4)	67 (18.7)	
TICU LOS, d				
Mean (SD)	27.0 (27.7)	29.3 (31.9)	25.8 (28.1)	
Median (IQR)	19 (25)	21 (26)	19 (31)	0.385
MV required				0.305
Yes	418 (23.8)	286 (26.3)	88 (24.5)	
MV, d				

(continued)

Table 3 – (continued)

Characteristic	Younger elderly ($n = 1760$), n (%)	Middle elderly ($n = 1087$), n (%)	Older elderly ($n = 359$), n (%)	P value
Mean (SD)	23.7 (27.1)	25.0 (29.8)	20.8 (26.7)	
Median (IQR)	16 (23)	16 (27)	9 (25.5)	0.091
Hospital LOS, d				
Mean (SD)	21.4 (32.2)	21.9 (30.6)	18.5 (24.2)	
Median (IQR)	11 (20)	11 (21)	9 (19)	0.038
In-hospital mortality				<0.001
Dead	313 (17.8)	295 (27.1)	124 (34.5)	

COPD = Chronic Obstructive Pulmonary Disease; MVA = motor vehicle accident; GSW = gunshot wound; SW = stab wound; No. = number; SD = standard deviation; IQR = interquartile range; TICU = trauma intensive care unit; LOS = length of stay; MV = mechanical ventilation.

research in the understanding of this population.[39] Also, studies have associated with the integration of geriatrician consultation with favorable outcomes in elderly trauma patients.[40] Worldwide, institutions in China have implemented the "ABCCDEFGHI bundles", treatment strategies for the elderly admitted to their geriatric ICUs, which have proven positive results in patient outcomes, and in Germany many institutions have been certified as geriatric trauma centers.[39,41]

This study, however, is subject to some limitations. Data were retrieved in a retrospective manner, and since the 20-y study period was evaluated in a time-series analysis, trends presented may not take into consideration changes over time including database patient classification and data recollection changes, population changes, hospital bed capacity, and implementation of new and advanced technology. Secondarily, the generalization of these results is limited in a view that data were only gathered from the PRTH, which is a single trauma center, albeit, the only one in Puerto Rico. Also, the data are gathered from the PRTH registry and like any other registry the accuracy of the data and the information available is dependent on appropriate medical documentation. The lack of appropriate medical documentation may compromise the completeness, quality, and validity of data available for the study.[42] Notwithstanding, our study is unprecedented in evaluating elderly trauma in Puerto Rico, which may be used to develop further research on this growing population. Also, our data are fundamental and provide starting point information for the consideration of the employment of specialized TICUs for this cohort in the PRTH. Finally, our results may be used to generate research by hospitals that receive trauma patients despite not being specialized trauma institutions.

Conclusions

Our study confirmed an upward trend in elderly patients requiring treatment for trauma-related injuries during 2000-2019, and projected that this trend will progress, placing elderly admissions as high as 24.8 cases per 100 overall admissions in 2023. Also, results revealed an overtime increase in admissions due to falls and a decrease in in-hospital mortality of elderly patients admitted to the PRTH. As the elderly are at an increased risk for injury, associated complications, and mortality, understanding the epidemiology of elderly trauma are imperative to develop injury prevention efforts and comprehensive healthcare services. Our analysis may pave the way for fall-related injury prevention programs, strategies, and further research to reduce elderly trauma and injuries. We hope our data motivate research that serves to improve the healthcare approach regarding the elderly population and emphasizes the importance of the implementation of specialized ICUs for this cohort.

Author Contributions

Adrianna Rivera was the major contributor in writing the manuscript and the study concept. Ediel Ramos contributed to the study development, design, writing, methodology, statistical analyses, and interpretation of data. Laura Ramirez, Javier Ruiz, and Pedro Ruiz contributed in writing the introduction, discussion, and manuscript review. Lourdes Guerrios and Pablo Rodríguez supervised the study and manuscript review. All authors read and approved the final manuscript.

Disclosure

Authors have no conflicts of interest or any personal or financial relationships that could bias the results or conclusions of this study.

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