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Injury patterns in elderly cyclists and motorcyclists presenting to a tertiary trauma centre in Singapore

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ABSTRACT

Introduction: In our ageing population, there are increasing numbers of elderly cyclists and motorcyclists. Compared to younger riders, this cohort sustains more injuries and has poorer outcomes. The aim of this study was to describe and compare patient demographics, injury patterns and outcomes among elderly cyclists and motorcyclists presenting to a Level 1 trauma centre.

Methods: Data of all cyclists, motorcyclists and pillion riders aged 65 years and above, who presented to the emergency department after accidents from 1 January 2013 to 31 December 2017 were extracted from the hospital's trauma registry and reviewed.

Results: Cyclists and motorcyclists formed 42.0% and 58.0%, respectively, of 157 recruited patients. At the time of incident, 40.8% of patients were employed. Mean age of patients was 71.6 ± 5.8 years. Extremities and pelvic girdle injuries (61.1%) were the most frequent, followed by chest injuries (48.4%), and head and neck injuries (40.1%). For severe injuries (defined as Abbreviated Injury Scale score ≥ 3), chest injuries (39.5%) were the most common, followed by head and neck injuries (36.3%). Overall mortality rate was 9.6%, with cyclists at nearly three times the risk of motorcyclists. More cyclists than motorcyclists (18.2% vs. 11.0%) required intensive care. There were no significant differences in length of hospital stay.

Conclusion: Elderly riders have unique injury patterns and consume significant healthcare resources. Trauma systems need to acknowledge this changing injury epidemiology and equip trauma centres with necessary resources targeted at elderly patients. Future work should focus on strategies to minimise extremity and chest injuries.

Keywords: geriatric trauma, injury patterns, motorcycle accidents

INTRODUCTION

Singapore is a city-state with a high population density of 7,804 persons/km^2 and an ageing population with nearly 13% of the population aged above 65 years.[1] During 2013–2017, national statistics showed a total of 21,415 motorcycle fatalities.[2] Of these, 12% were associated with motorcyclists aged above 60 years.[2] Motorcycles and bicycles are important and affordable modes of transport. Their increasing popularity also has to do with the advent of bicycle-sharing systems and a demand for food-delivery services. Motorcyclists and cyclists are among the most vulnerable road users. This was supported by data from the Singapore Police Force and other local studies.[3-5] Regionally, motorcyclists and cyclists (together with pedestrians) make up half of all road traffic deaths in Southeast Asia.[6] Studies have shown that compared to younger riders, elderly motorcyclists sustain more injuries,[7-9] more severe injuries[9-14] and show different injury patterns.[9,14] The increasing age of motorcyclists correlated with prolonged hospital stay,[9,10,14,15] increased complications,[9,10,15] increased mortality[10,14,15] and higher care demands after discharge.[9] Similarly, for cyclists, older age was associated with increased injury severity, mortality and length of intensive care unit stay.[16-19]

Current literature comparing cyclists and motorcyclists has revealed differences in injury patterns and outcomes.[20-22] However, to our knowledge, no study has been done to evaluate the injury patterns and outcomes specifically in elderly cyclists and motorcyclists. This study aimed to describe and compare the patterns of injuries in elderly cyclists and motorcyclists presenting to the emergency department (ED) at Tan Tock Seng Hospital (TTSH), Singapore.

METHODS

This was a retrospective review of all electronic medical records of cyclists, motorcyclists and pillion riders aged 65 years and above, who presented to the ED at TTSH from 1 January 2013 to 31 December 2017 following accidents. TTSH is a 1,600-bed Level 1 trauma centre situated in a region of high population density and older housing estates. It has the busiest ED in Singapore, with over 170,000 attendances annually.

Data was obtained from the hospital's trauma registry. Data collected included patient demographics, mode of conveyance to the ED, triage Patient Acuity Category (PAC) scores, injury characteristics and patient outcomes. Injury characteristics included the epidemiology and severity of injuries according to Abbreviated Injury Scale (AIS) scores, Injury Severity Score (ISS), Revised Trauma Score (RTS) and Probability of Survival (Ps) scores. The National Healthcare Group domain specific review board approved the study.

Analysis was done using IBM SPSS Statistics version 25 (IBM Corp, Armonk, NY, USA). Means and standard deviations, and medians and interquartile ranges were calculated for normal and non-normal variables, respectively. Frequencies were tabulated for categorical variables. Accordingly, Student's *t*-test and chi-square test were used for analysis. A p-value < 0.05 was considered to be statistically significant.

RESULTS

A total of 157 elderly cyclists and motorcyclists presented to our centre from 1 January 2013 to 31 December 2017. Of these, 42.0% (n = 66) of patients were cyclists. Mean age of patients was 71.6 ± 5.8 years. Most riders (94.3%) were men. At the time of accident, 40.8% of patients were employed. A majority (81.5%) of patients arrived at the ED via emergency ambulance services and was assigned triage PAC 2 (64.3%). One-third (34.4%) of patients was assigned triage PAC 1 and managed in the resuscitation area. Characteristics of cyclists and

motorcyclists were similar, except for a higher proportion of elderly cyclists who were retired/unemployed (66.7%) when compared to motorcyclists (46.2%). Table I shows the demographics of the study population.

Table I. Demographics of elderly cyclists and motorcyclists.

Variable	**No. (%)**		
	All (n = 157)	**Cyclists (n = 66)**	**Motorcyclists (n = 91)**
Age (yr)*	71.6 ± 5.8	73.0 ± 6.0	70.5 ± 5.4
Male gender	148 (94.3)	61 (92.4)	87 (95.6)
Mode of arrival at ED			
Emergency ambulance service	128 (81.5)	52 (78.8)	76 (83.5)
Private ambulance	10 (6.4)	4 (6.1)	6 (6.6)
Own transport	19 (12.1)	10 (15.2)	9 (9.9)
Employment status			
Employed	64 (40.8)	19 (28.8)	45 (49.5)
Retired/unemployed	86 (54.8)	44 (66.7)	42 (46.2)
Unknown	7 (4.5)	3 (4.5)	4 (4.4)
Triage PAC score			
PAC 1	54 (34.4)	20 (30.3)	34 (37.4)
PAC 2	101 (64.3)	45 (68.2)	56 (61.5)
PAC 3	2 (1.3)	1 (1.5)	1 (1.1)

**Data presented as mean ± standard deviation. ED: emergency department; PAC: Patient Acuity Category*

Table II shows the injury patterns categorised according to AIS regions. Excluding AIS region 6 (external system), injuries involving extremities and pelvic girdle (61.1%) were the most frequent, followed by chest injuries (48.4%), and head and neck injuries (40.1%). For severe injuries (defined as AIS score ≥ 3), chest injuries were the most common (39.5%), followed by head and neck injuries (36.3%), and extremities and pelvic girdle injuries (34.4%). The occurrence of severe chest injuries ($p = 0.045$), and extremities and pelvic girdle injuries ($p = 0.035$) among motorcyclists were significantly higher than among cyclists. Among extremity injuries, femoral fractures (24.2%) were the most common. A significantly higher proportion of motorcyclists sustained upper extremity injury when compared to cyclists ($p = 0.003$). Cyclists sustained significantly more femoral fractures than motorcyclists ($p = 0.023$).

The reverse was observed for tibia/fibular fractures (p = 0.012). There were no significant differences in the mean ISS, RTS and Ps scores between cyclists and motorcyclists, and proportion of patients with major trauma (defined as ISS ≥ 16).

Table II. Injury patterns of elderly cyclists and motorcyclists according to AIS regions.

Variable	**No. (%)**			**p-value**
	All (n = 157)	**Cyclists (n = 66)**	**Motorcyclists (n = 91)**	
Region of injury				
Head and neck	63 (40.1)	30 (45.5)	33 (36.3)	0.246
Face	25 (15.9)	10 (15.2)	15 (16.5)	0.822
Chest	76 (48.4)	26 (39.4)	50 (54.9)	0.054
Abdominal and pelvic contents	15 (9.6)	6 (9.1)	9 (9.9)	0.866
External	113 (72.0)	46 (69.7)	67 (73.6)	0.588
Extremities and pelvic girdle	96 (61.1)	34 (51.5)	62 (68.1)	0.035
Upper extremity	43 (27.4)	10 (15.2)	33 (36.3)	0.003
Lower extremity	62 (39.5)	27 (40.9)	35 (38.5)	0.757
Fracture site				
Scapula	11 (7.0)	2 (3.0)	9 (9.9)	NS
Clavicle	16 (10.2)	4 (6.1)	12 (13.2)	NS
Humerus	7 (4.5)	2 (3.0)	5 (5.5)	NS
Forearm	6 (3.8)	1 (1.5)	5 (5.5)	NS
Hand	7 (4.5)	1 (1.5)	6 (6.6)	NS
Pelvic ring	6 (3.8)	3 (4.5)	3 (3.3)	NS
Acetabulum	6 (3.8)	2 (3.0)	4 (4.4)	NS
Femur	38 (24.2)	22 (33.3)	16 (17.6)	0.023
Patella	3 (1.9)	1 (1.5)	2 (2.2)	NS
Tibia/fibula	16 (10.2)	2 (3.0)	14 (15.4)	0.012
Foot	3 (1.9)	0 (0)	3 (3.3)	NS
Injury severity score*				
ISS*	16.1 ± 10.3	16.6 ± 10.6	15.7 ± 10.0	0.587
RTS	7.5 ± 1.0	7.4 ± 0.9	7.6 ± 1.1	0.505
Ps	87.7 ± 20.2	85.2 ± 21.7	89.5 ± 18.9	0.185
ISS ≥ 16	51 (32.5)	23 (34.8)	28 (30.8)	0.590

**Data presented as mean ± standard deviation. AIS: Abbreviated Injury Scale; ISS: Injury Severity Score; NS: not significant; Ps: Probability of survival; RTS: Revised Trauma Score*

Table III shows the outcomes of our patients. One patient succumbed to injuries within the ED. All other patients required hospital admission, with a median length of stay of 6 (range 2.0–10.5) days. Overall mortality rate was 9.6%, with cyclists at nearly three times the risk of

motorcyclists. Among 15 patients who died, all were men and had an average age of 74 years. A third of patients were motorcyclists. The average length of stay before death was 3.6 days, with 11 patients dying within the first day of admission, three patients dying within the first week and one patient dying after a prolonged stay of one month. Head injuries (n = 9) were the overwhelming cause of death, with other reasons being head and chest injuries (n = 2), multiple injuries (n = 2) and blunt abdominopelvic injuries (n = 1). The patient who died at the one-month mark succumbed to pneumonia and renal failure subsequent to head injury. Among the survivors, one-third of both cyclists and motorcyclists required admission to the intensive care unit or high dependency unit; most others were admitted to the general ward. More cyclists than motorcyclists (18.2% vs. 11.0%) required intensive care. There were no significant differences in the length of hospital stay and disposition status among these patients. A majority (55.4%) of patients were discharged home and 28.0% of patients were discharged to a rehabilitation facility.

Table III. Outcomes of elderly cyclists and motorcyclists.

Patient outcome	**No. (%)**		
	All (n = 157)	**Cyclists (n = 66)**	**Motorcyclists (n = 91)**
Disposition from ED			
Intensive care unit	22 (14.0)	12 (18.2)	10 (11.0)
High dependence unit	32 (20.4)	12 (18.2)	20 (22.0)
Surgical acute care unit	1 (0.6)	0 (0)	1 (1.1)
General ward	101 (64.3)	42 (63.6)	59 (64.8)
Death within ED	1 (0.6)	0 (0)	1 (1.1)
Length of hospital stay (day)*	6 (2.0–10.8)	6.5 (2.0–10.3)	5 (2.0–11.0)
Length of intensive care unit stay (day)*	2 (1.0–4.0)	1 (1.0–3.0)	2 (1.0–7.0)
Discharge location			
Home	87 (55.4)	27 (40.9)	60 (65.9)
Rehabilitation facility	44 (28.0)	23 (34.8)	21 (23.1)
Nursing home	6 (3.8)	3 (4.5)	3 (3.3)
Discharged against medical advice	5 (3.2)	3 (4.5)	2 (2.2)
In-hospital mortality	15 (9.6)	10 (15.2)	5 (5.5)

**Data presented as median (interquartile range). ED: emergency department*

DISCUSSION

To our knowledge, this is the first study to compare injury patterns among elderly cyclists and motorcyclists internationally. According to local statistics, elderly motorcyclists made up approximately 12% of all traffic casualties during the period of study.[2] Our results showed that 40.8% of patients were employed at the time of accident. This suggests that despite the prevailing retirement age of 62 years, a large proportion of elderly remains actively employed and contributes to the economy. Accidents in this cohort thus represent potential societal economic losses.

Care for this group consumes more healthcare resources than for younger patients, as evidenced by one-third of our patients requiring management in the resuscitation area, with subsequent admission to the intensive care unit and high dependency unit. More than a quarter of our patients were discharged to a rehabilitation facility. Unfortunately, longitudinal data on functional outcomes was incomplete and the impact on long-term outcomes among our patients could not be determined. Nevertheless, our findings emphasise the impact older riders have on healthcare resource utilisation and were similar to findings of other studies.[9,18]

Results revealed that among elderly cyclists and motorcyclists, the extremities and pelvic girdle region were the most vulnerable to injury. This was consistent with previous studies involving cyclists[18,19,23-27] and motorcyclists.[11,27,28] However, the patterns of extremity injuries differed between cyclists and motorcyclists in our study. Motorcyclists sustained significantly higher rates of upper extremity injuries and tibia/fibular fractures, while cyclists sustained significantly more femoral fractures. Apart from Liu et al,[20] who found that cyclists had a higher odds ratio for femoral fractures when compared to motorcyclists, few studies have been done to investigate these differences. Further studies focusing on injury mechanisms are needed. Unlike head injuries, which may be reduced by helmet use, less is known about prevention of extremity injuries. Studies have shown that extremity injuries have

high healthcare and productivity costs,[29,30] and are negatively associated with quality of well-being outcome.[31,32] Resources should be allocated to investigate ways to minimise extremity injuries in order to reduce associated morbidity and economic costs.

The occurrence of severe chest injuries was significantly higher in elderly motorcyclists than cyclists. Thoracic injuries are clinically significant because these are more likely to be associated with fatal outcomes[7,33] and this risk increases with age.[12] Since the area of thoracic exposure is comparable, a possible explanation could be that motorcyclists sustain greater impact during accidents due to higher speeds. This has significant bearing on injury prevention for elderly motorcyclists. Possible strategies to explore include stricter laws regarding speed limits and protective gear.

It is well established that helmets reduce the frequency and severity of head injuries in riders. Current traffic laws do not mandate the use of helmets for cyclists. Interestingly, our study did not show any significant differences in head injuries between cyclists and motorcyclists. However, as this was not an *a priori* analysis, further studies specifically designed to evaluate the utility of helmets for head injury prevention in our population are necessary.

There were some limitations to this study. This was a retrospective, single-centre study, with a small sample size. It omitted data from riders who did not present to the ED or died at the scene of accident. Though it can be assumed that persons who did not present to the ED probably had more minor injuries, injury patterns among the most severely injured patients in our study were not captured. Longitudinal data regarding functional capacity after discharge was also unavailable for comparison due to these patients being lost to follow-up.

In conclusion, elderly motorcyclists and cyclists have unique injury patterns and consume significant healthcare resources. As our population ages and two-wheeled vehicles continue to be an indispensable mode of transport, this burden of injury will only increase.

Trauma systems need to acknowledge this changing injury epidemiology and equip trauma centres with the necessary resources targeted at elderly riders. Future work should focus on strategies to minimise extremity and chest injuries. A prospective multicentre study using the nation's trauma database would be useful to assess the national burden of geriatric trauma among cyclists and motorcyclists. In addition, such study should address possible differences in epidemiology and outcomes among younger riders when compared to older ones.

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