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## Comparison of severity and pattern of injuries between motorcycle riders and their pillions: A matched study

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### ARTICLE INFO

#### Article history:

Accepted 26 January 2013

#### Keywords:

Motorcycle accidents  
Matched pair study  
Comparison between motorcyclist and pillion rider  
Severity of injuries  
Distribution of injuries  
Injury Severity Score  
Injury prevention

### ABSTRACT

**Introduction:** Motorcyclists and their pillion riders are the most vulnerable group of road users in Singapore, accounting for 50% of all road traffic accident fatalities in 2011. This study aims to compare the severity and pattern of injuries between matched pairs of riders and pillions.

**Methods:** Thirty-two matched pairs who presented to the A&E of an urban hospital from 1 August 2011 to 20 March 2012 were enrolled. Data were obtained from the hospital's trauma registry records, clinical records and accident victims were interviewed individually. Analysis was done using Stata 10 and considered rider-pillion pairs.

**Results:** Thirty-one pairs agreed to participate. There was no statistically significant difference in the ISS between riders and pillions ( $p = 0.25$ ). There was no significant difference in the probability of survival, Revised Trauma Score, distribution of injuries, total duration of admission and ICU stay between riders and pillions. When one party of the matched pair sustained a head, face, thoracic, abdominal/pelvic, extremity or external injury, the likelihood that the other party had an injury in the same region was 31%, 14%, 10%, 14%, 56% and 68% respectively. Cohen's kappa values were 0.28, 0.15, 0.05, 0.17, 0.24 and  $-0.16$  for the respective regions.

**Discussion:** By comparing the severity and pattern of injuries between naturally matched pairs on the same motorcycle, one can account for potential confounding by the type and impact of collision, rider experience, amount of time to availability of medical aid, and other factors that may influence the outcome. Our study shows no statistically significant difference in the ISS and distribution of injuries between riders and pillions of matched pairs. Therefore, future health and insurance policies should provide equal coverage for both riders and pillions. Medical practitioners should approach riders and pillions similarly as there is no significant difference in their injury distribution. When one party of a matched pair presents with a head, extremity or external injury, care should be taken to look for an injury in the same region in the other party.

**Conclusion:** Our study shows that there is no statistically significant difference in the ISS of riders and pillions. The pattern of injury is also similar. This study provides us useful information in the clinical management of motorcyclists and their pillions.

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### Introduction

Singapore is a city-state with a resident population of 5.18 million and a limited land area of 684.1 km<sup>2</sup>. To prevent uncontrolled growth in the number of vehicles which will result in traffic congestion in land and road scarce Singapore, the Government encourages the use of its well-developed public transport system. Measures to manage car ownership and usage

implemented by the government make the cost of owning and driving a car in Singapore very expensive.<sup>1</sup> Motorcycles are the most affordable form of personal transport in Singapore. Therefore, they are a significant means of daily transportation in Singapore. In 2011, motorcycles formed almost one-fifth of the total number of vehicles registered in Singapore.<sup>2</sup>

All motorcycle riders and their pillions are required by law to wear a helmet while riding motorcycles. Despite this law and continued efforts by the Traffic Police in inculcating safe riding habits, motorcyclists and their pillion riders are the most vulnerable group of road users, accounting for about 50% of all road traffic accident fatalities in 2011. The Traffic Police department reported that of the 197 fatalities in 2011, there were 99

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fatalities involving motorcyclists and their pillion riders, an increase of 11.2% from the 89 fatalities recorded in 2010.<sup>3</sup> Thus, this group of road users continues to be a cause of concern for the Government as well as the medical teams involved in the management of their injuries.

Current literature on motorcycle accidents focuses mainly on comparison of injuries between unmatched motorcycle riders and pillions, where riders and pillions from different accidents were aggregated together and analysed.<sup>4–6</sup> In contrast, a matched study is one where every motorcycle rider is matched with his pillion (the passenger on the same motorcycle involved in the same accident), after which matched analysis is done on these matched pairs. The severity and distribution of injuries of matched pairs of riders and pillions has not been well studied. By estimating effects among naturally matched pairs, we can account for potential confounding by the type and impact of collision, motorcycle characteristics, rider experience, amount of time to availability of medical aid, and other factors that may influence the outcome.

Tan Tock Seng Hospital (TTSH) is strategically located in the centre of Singapore and receives the highest number of trauma patients each year. It is a 1400-bedded acute care hospital which functions as a Level 1 trauma centre for the region. In 2011, a total of 434 patients with injury severity scores (ISS) of more than 16 were admitted. This study aimed to compare the severity and pattern of injuries between matched pairs of motorcycle riders and their pillions presenting to the TTSH Emergency Department (ED).

## Methods

A prospective study was conducted from 1 August 2011 to 20 March 2012. Thirty-two matched pairs of motorcyclists and their pillions who presented to the TTSH ED after road traffic accidents (RTAs), where at least one member from each pair were admitted to hospital were enrolled in our study. Each matched pair consisted of a motorcycle rider and his pillion who were on the same motorcycle involved in a RTA. A 'rider' refers to the driver of the motorcycle and a 'pillion' refers to a passenger seated behind the rider. All pairs recruited were confirmed matched pairs.

Data were collected from the hospital's Trauma Registry records, clinical records and patient interviews. Verbal informed consent was taken and all agreeable patients were then interviewed either in person or over the telephone. Interviews were conducted by one interviewer using a standardised questionnaire to minimise interviewer bias. Data collected included demographics, riding experience, nature of accident, type and distribution of injuries, initial physiologic parameters at the ED, operative care required, intensive care unit (ICU) or high-dependency (HD) stay required, length of stay in hospital and outcome.

Scoring systems were used in the classification of the type and severity of injuries of these patients. These included the Glasgow Coma Scale (GCS), the Abbreviated Injury Scale (AIS)<sup>7</sup> and the Injury Severity Score (ISS). The most current AIS scoring system (AIS 2005 Update 2008) was used. From these, the Revised Trauma Score (RTS) and the probability of survival (Ps) were calculated. The scores between riders and pillions of the matched pairs were compared, and the ISS was used to determine outcome (whether riders or pillions were more severely injured). The ISS was computed according to the method described by Baker et al.<sup>8</sup> The distribution of injuries between riders and pillions were also compared.

Data collected were entered into Microsoft Excel. Analysis was then done with the help of a statistician using Stata (version 10.1) and considered rider–pillion pairs. The distribution of the continuous variables among pairs was compared using the Wilcoxon's Signed-rank test. Categorical variables were analysed

using the McNemar's Chi-square test. Level of significance was taken at 2-sided  $p$ -value  $< 0.05$ . In addition, the probability of the other party in a matched pair having an injury in region  $x$  when one party has an injury in the same region was calculated using those pairs with at least one party having the injury as the denominator, where  $x$  refers to either of these six respective regions: head, face, chest, abdomen/pelvis, extremity or external. The extent of the agreement that both riders and pillions have the same outcome for an injury in each region after taking the magnitude of agreement that would be expected by chance into account was also determined using Cohen's kappa analysis.

## Results

Eighty-one percent of the matched pairs consisted of a male motorcyclist and a female pillion and the remainder (19%) had both male motorcyclist and pillion. Most of the motorcyclists and their pillions were friends (48%) or husband and wife (35%). The study had 12 pairs who were both Malay. 11 pairs had a Chinese rider and 6 pairs had an Indian rider. Riders were generally older than pillions, with a mean age of 40 years as compared to 33 years. The mean number of years of riding experience was 15 years. Only 4 riders (13%) held provisional licenses (riding experience of less than one year).

The most common type of accident in our study involved collision with a car (14 pairs, 45%), self-skid accidents (29%) and collision with a bus, lorry or van (16%). Nine pairs (29%) sustained the impact of collision on either side of the motorcycle, 9 pairs (29%) self-skidded and 8 pairs (26%) were involved in head-on collisions. Only 1 pair was hit from the rear end, 1 pair collided into a sand pile and 1 pair was involved in a multiple-collision accident. The median speed (range) of the motorcycles at the time of accident was approximately 60 km/h (15–90 km/h). All the pairs sustained blunt trauma as the primary injury type and only 1 pair (both the rider and pillion) had concomitant penetrating injury. Four pairs (13%) and 2 pairs (6%) had at least one member who consumed alcohol or drugs less than 24 h before the accident respectively. Ten riders (32%) took some form of evasive action during the accident, such as trying to slow down or swerve. The median (interquartile range (IQR)) amount of time taken for transfer to hospital was 39 min (30–58 min) (Table 1).

There was no statistically significant difference in the ISS, Ps and RTS between riders and pillions of matched pairs ( $p = 0.25, 0.57, 0.32$  respectively). There were no cases of mortality in our study. The ISS of all victims of our study were low (less than 15). There was also no statistically significant difference between riders and pillions of matched pairs in these parameters compared: GCS, number of regions injured, total duration of hospital admission, duration of Intensive Care Unit (ICU) stay, number of surgeries required, duration of medical leave required and number of types of follow-up (e.g. General Surgery, Orthopaedic Surgery, etc.) required. However, pillions required a longer higher dependency stay when compared to riders ( $p = 0.04$ ) (Table 2).

There was no statistically significant difference in the distribution of injuries among riders and pillions. In matched pairs, riders and pillions do not have different proportions in sustaining injuries to the head, face, chest, abdomen/pelvis, extremities and external regions (all  $p$  values  $> 0.05$  using McNemar's test).

When one party of the matched pair sustained a head, face, thoracic, abdominal/pelvic, extremity or external injury, the probability that the other party had an injury in the same region was 31%, 14%, 10%, 14%, 56% and 68% respectively. Cohen's kappa values were 0.28, 0.15, 0.05, 0.17, 0.24 and  $-0.16$  for head, face, chest, abdominal/pelvic, extremity or external injuries respectively (Table 3).

**Table 1**  
Demographics of patients and accidents.

		No of pairs (n = 31)	%
Gender	Male rider and female pillion	25	81
	Male rider and male pillion	6	19
Relationship	Husband and wife	11	35
	Friend and friend	15	48
	Others	5	16
Riding experience	Provisional license	4	13
	Median number of years riding motorcycle (IQR)	7.5 (3–27.5)	N.A.
Type of collision	No collision	9	29
	Collided with car	14	45
	Collided with bus/lorry/van	5	16
	Collided with motorcycle	1	3
	Collided with pedestrian	0	0
	Collided with other objects	1	3
	Multiple collisions	1	3
Type of impact	Head-on	8	26
	Rear end	1	3
	Left or right side	9	29
	Skidded	9	29
	Multiple	1	3
	Unknown	3	10
Speed	Median speed (IQR) of motorcycle at time of accident (km/h)	60 (45–72.5)	N.A.
Primary injury type	Blunt	31	100
Secondary injury type	NA	30	97
	Penetrating	1	3
Time taken from accident to ED	Median amount of time taken (IQR) from accident to ED (mins)	39 (29.5–57.5)	N.A.
Mode of arrival to ED	Both by SCDF ambulance	27	87
	Both walk-in	2	6
	Rider by SCDF, Pillion walk-in	2	6

IQR, interquartile range.

**Discussion**

Mortality, morbidity, and economic costs associated with motorcycle accidents and their victims are persistent sources of concern both locally and globally. A Singapore study showed that at 1999 prices, the cost per traffic fatality was S\$1.273 million (S\$1; US \$0.56) while that of a serious injury and a slight injury was S\$163,000 and S\$12,000 respectively.<sup>9</sup> Another study done in Arizona found that the average hospital stay for patients injured in motorcycle accidents was 13 days, with a cost of US \$16,408 per patient.<sup>10</sup>

The racial distribution of patients in our study does not reflect that of Singapore's population of 74% Chinese, 13% Malays, 9% Indians and 3% other races. However, this is not surprising as it reflects the motorcycle-riding population in Singapore, of which Malays make up the largest proportion. Also, this finding is similar

to that of another Singapore study by Wong et al.,<sup>11</sup> which reported a high proportion of Malays.

Current literature on motorcycle accidents focuses mainly on comparison of outcomes between unmatched groups of riders and pillions.<sup>4–6</sup> Few matched studies have been done in this area. Unmatched studies do not account for potential confounding by various factors that may influence the outcome such as the type and impact of collision, motorcycle characteristics, rider experience, amount of time to availability of medical aid, and other factors. Our study is a matched study which addresses these factors.

In our review of the literature, the majority of unmatched pair studies have concluded that there is a difference in the injury severity between riders and pillions in motorcycle accidents.<sup>4,6</sup> In a Singapore study by Leong et al. it was reported that the mortality rate among young pillions was significantly higher than that

**Table 2**  
Comparison between rider and pillion.

	Rider	Pillion	p-Value <sup>*</sup>	Differences (rider–pillion)
Injury Severity Score (median, IQR)	3 (2–6)	5 (2–14)	0.25	–1 (–7 to 4)
Probability of Survival (median, IQR)	99.6 (97.7–99.7)	99.3 (98.0–99.6)	0.57	0 (–0.20 to 0.5)
Revised Trauma Score (median, range)	7.841 (6.9–7.8)	7.841 (6.0–7.8)	0.32	0 (–0.9 to 1.9)
Glasgow Coma Score (median, range)	15 (9–15)	15 (7–15)	0.69	0 (–6 to 7)
No. of regions injured (median, IQR)	2 (1–2)	2 (2–3)	0.34	0 (–1 to 1)
Total duration of hospital admission (median, IQR)	2 (0–5)	3 (0–6)	0.90	0 (–5 to 3)
Length of ICU stay (median, range)	0 (0–16)	0 (0–7)	0.70	0 (–7 to 16)
Length of HD stay (median, range)	0 (0–2)	0 (0–3)	0.04	0 (–3 to 2)
No. of surgeries required (median, range)	0 (0–7)	0 (0–7)	0.66	0 (–7 to 4)
Duration of medical leave required (median, IQR)	11 (4–20)	14.5 (4–27)	0.35	0 (–12.5 to 6)
No. of types of follow-up required (median, IQR)	1 (1–3)	1 (1–3)	0.82	0 (–1 to 2)

<sup>\*</sup> p-Values from Wilcoxon sign-ranked test.

**Table 3**  
Probability of the other party in a matched pair having an injury in region  $x$  when one party has an injury in region  $x$ .

Region ( $x$ )	Pairs with both parties injured (a)	Pairs with only rider injured (b)	Pairs with only pillion injured (c)	Pairs with none injured (d)	Probability = $a/(a+b+c)$	Cohen's kappa	95% confidence intervals	
							Lower bound	Upper bound
Head	4	3	6	18	$4/13=0.31$	0.28	-0.06	0.63
Face	1	2	4	24	$1/7=0.14$	0.15	-0.19	0.48
Chest	1	7	2	21	$1/10=0.10$	0.05	-0.25	0.35
Abdomen/pelvis	1	1	5	24	$1/7=0.14$	0.17	-0.12	0.46
Extremity	14	5	6	6	$14/25=0.56$	0.24	-0.11	0.59
External	21	3	7	0	$21/31=0.68$	-0.16	-0.47	0.16

among young riders. Zhao et al. found that riders sustained more severe chest and abdominal injuries than pillions, a higher incidence of fatalities involving run-over injuries for riders compared to pillions, and that the proportion of fatal injuries related to tumbling was higher for pillions than riders. However, our study shows that there is no significant difference in the severity of injuries between riders and pillions of matched pairs, which contradicts what the literature reports in unmatched pair studies.

Several studies have also suggested that there is a difference in the distribution of injuries between unmatched groups of riders and pillions. Zhao et al. noted characteristic superficial injuries on the palms, chest, abdomen and perineum in only motorcycle riders but not pillions. Fitzharris et al. found that pillions were more likely to sustain crush injuries to the lower extremity as compared to riders. However, our study shows that there is no significant difference in both the severity and distribution of injuries between riders and pillions of matched pairs, which contradicts the findings of unmatched pair studies. This finding is supported by those of two matched studies. The first is a matched study on patterns of head injury among motorcycle riders and pillions conducted by Pruthi et al. which reported that there was no significant difference between the head injuries sustained by motorcycle riders and their pillions.<sup>12</sup> Another matched study by Murphy et al. also found that overall, motorcycle riders and pillions did not differ for head injury, pulmonary injury, road rash, aortic or visceral injury.<sup>13</sup>

The initial assessment of motorcycle riders and pillions by emergency medical practitioners and trauma surgeons is extremely important. Based on our findings, we would like to propose some recommendations on the clinical management of trauma patients. When a known matched pair presents at the ED, emergency medical practitioners should be aware that the severity of the injuries of both rider and pillion are similar and manage them similarly. In the initial assessment of a known matched pair, emergency doctors should also be aware that there is no significant difference in the distribution of injuries between riders and pillions of matched pairs.

In addition, as the probability of both parties of a matched pair sustaining an injury to the head (31%), extremity (56%) and external regions (68%) are high (Table 3), care should be taken to look for these injuries when these injuries are found in either party of a matched pair. Emergency and trauma care providers should look for similar injuries between riders and pillions of matched pairs during triage. Should there be a situation where the motorcycle rider and pillion of a matched pair are managed by different teams of medical practitioners, our findings suggest that the two teams should communicate with each other regarding the injuries found in their respective patients so as to better assess the injuries present in the accident victims. However, after taking into consideration chance occurrence, the highest kappa value occurs for head injuries (0.28), followed closely by extremities (0.24). However, neither differs significantly from zero. The kappa value for external injuries (-0.16) is negative showing an agreement

worse than might be expected by chance (Table 3). Thus, after taking into account the association expected by chance using Cohen's kappa, there is a possibility that the associations suggested by the above-mentioned probability may be due to chance.

Aside from recommendations pertaining to healthcare, we have also studied some social issues and have come up with some recommendations which may be applied in the local context. In Singapore, current motorcycle insurance Schemes<sup>14,15</sup> provide coverage for the motorcyclist, motorcycle and third party costs, but not for pillions. As the results of our study show that there is no significant difference in the severity of injuries sustained by riders and pillions of matched pairs, we would like to suggest, subject to local or various country policies, that future health and motorcycle insurance policies should provide equal coverage for both motorcycle riders and pillions.

Injury prevention programmes and rider education programmes should be extended to potential pillions as well. Riders should be educated on the fact that their pillions can be similarly injured should they be involved in an accident. In Singapore, motorcyclists who pass their motorcycle driving tests are required to view an educational video at the driving test centre. We propose that the video broadcasted include a section to educate motorcycle riders on safety issues regarding carrying a pillion rider. In addition, our findings also support the proposal that both motorcycle riders and pillions should wear protective gear while riding. This is because the injuries sustained are similar between riders and pillions.

One of the limitations of this study is that it is a hospital-based study with a small sample size. Hence, it may not be an accurate reflection of the true results of an entire nation. In addition, our inclusion criteria focuses on the population of motorcyclists whose injuries resulted in hospitalisation and leaves out the group of matched pairs where both the rider and pillion perished in the accident or were both discharged from the ED. Despite these limitations, the data presented in this paper provides important and valid information on the distribution and severity of injuries in matched pairs of riders and pillions as this is a prospective matched study with strict protocols. In addition, this study is part of an ongoing study. Future studies with larger sample sizes will be useful in substantiating the findings of our study.

## Conclusion

Our matched study shows that there is no statistically significant difference in the severity of injuries between motorcycle riders and pillions of matched pairs. The pattern of injury is also similar. This study provides useful information in the clinical management of motorcyclists and their pillions and may have an impact on future local health or vehicle insurance policies. Motorcycle accidents will continue to contribute significantly to the trauma load in Singapore. Emergency medical practitioners and trauma surgeons should be prepared to meet this challenge.

Future research involving matched studies with larger sample sizes would be useful in substantiating the findings of our study and have a larger impact on trauma management involving motorcycle riders and pillion.

#### Conflict of interests statement

No conflicts of interest.

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