**Road crashes among underage motorcyclists’ compared with young motorcyclists of legal driving age: A Cross-Sectional Study from an Urban Setting in Low-Middle Income Country, Karachi, Pakistan**

**Abstract**

**Introduction**

The burden from deaths and injuries in motorcyclists is high in low- and middle income countries. Many injured motorcyclists are underage in these settings. The aim of this study is to assess the association between age and severe injury in young motorcyclists.

**Methods**

We analyzed road traffic injury surveillance data from emergency rooms of five hospitals in Karachi between January 2007 and June 2014. We used logistic regression to assess the association of the age of motorcyclists, categorized as underage riders 13-17 years, early licensure age 18-19 years and late licensure age 20-24 years with severe injury.

**Results**

The study sample included 38,910 motorcycle riders. There were 8806 (22.6%) motorcyclists of age 13-17 years, 8502 (21.9%) of age 18-19 years and 21,602 (55.5%) of age 20-24 years. Almost all were males (99%). Being in the age group 18-19 years was associated with higher odds of severe injury (aOR 1.439; 95% CI 1.11, 1.74) while the odds of severe injuries were lower for age group 13-17 years (aOR 0.97; 95% CI 0.75, 1.25), as compared to the age group 20-24 years, in adjusted analysis.

**Conclusion**

Motorcyclists in the age group 18-19 has significantly higher odds of severe injuries, as compared with the age group 20-24 years.

**Background**

About 200,112 young people aged 10-24 years died from road traffic injuries in 2019, the most common cause of death in this age group.[1] Out of the total number of road traffic deaths among those aged 10-24 years, 51,353 (26%) deaths were in motorcyclists.[1] An overwhelming 94% of deaths of motorcyclists occur in low and middle income countries and 84% of those involved are males.[1]

In the US, underage adolescents’ drivers are involved in fatal crashes three times more often compared with adults.[2] The number of road traffic crashes per one million miles driven is six times higher in adolescents compared with adults.[3] Adolescents are vulnerable to road traffic crashes due to limited experience and more risk taking behaviors.[4, 5]

In most countries the minimum driving age is 18 years but many adolescents start to drive earlier than the legal age if they have access to vehicles in the household.[6, 7] Underage driving is linked to adolescents’ aspiration of becoming independent and experience adventure, augmented with peer pressure.[8]

Demographic and socioeconomic factors, behaviors and consequences related to road crashes by adolescent car drivers have been studied in high- income countries (HICs).[9, 10] The common crash risks in HICs among adolescent drivers are speeding, violation of safety rules, drink driving and use of cell phones.[11, 12] Graduate driving license program in some high income countries aims to restrict the road traffic exposure of adolescent drivers; and have been shown to successful in reducing fatal crashes in young drivers.[13]

It is unclear how underage drivers are contributing to the crash burden in low and middle income settings. Studies from many Asian countries show that underage motorcycle riding exists and boys as young as eight years have been reported to ride motorcycles.[14-18] Underage riders rarely use helmets and are often involved in crashes.[16] Understanding underage motorcycle driving can be critical in suggesting preventive measures in low-income settings, as these countries account for about 90% of road deaths in adolescents globally.[19]

Unlike high-income countries, many low-income settings lack stringent rules for obtaining driving license. Previous studies report high crash rates in the early licensure period regardless of age of licensure compared to adults.[4, 20-25] The risk of crashes is particularly high in the first 12 to 18 months of independent driving after obtaining license.[26]

The aim of this study is to assess the association between age and severe injury in young motorcyclists.

**Methods**

**Design**

We conducted a cross-sectional study using data collected between 2007 and 2015.

**Setting**

The study setting is Karachi, a large urban area of Pakistan with an estimated population of 18 million and a total length of the road network of over 8,000 kilometers.[27]

Injury data were extracted from a road traffic injury surveillance project in emergency departments (ED) of all of the three government trauma centers in the city, and the two private tertiary care hospitals. The detailed methods have been described previously.[28] These hospitals receive nearly all major trauma cases from the city. Almost 98% of study patients were enrolled from the three public hospitals.

The research assistants of the surveillance project gathered demographic information on the injured patients and details of the crash by asking victims, their relatives, ambulance drivers or any eyewitnesses. The system was piloted in late 2006 and formally launched in 2007.

**Participants**

Road traffic crash victims of age 13-24 years who were riders of motorcycles and reported to emergency departments of participating hospitals with injuries.

**Outcomes**

The outcome was severe injury, defined as an injury severity score (ISS) ≥ 16 .[29, 30]

**Exposure**

Age, categorized as 13-17 years (underage riders), 18-19 years (early licensure age) and 20-24 years (late licensure age).

**Co-variates**

Gender, night time or daylight during crash, weekday versus weekend, summer versus winters months, crash in intersection versus mid-blocks, crash location within city versus outside city, helmet use, transporting vehicle, hospital, Glasgow Coma scale (GCS) and injured body regions.

**Ethics approval**

Study was approved by the Institutional Review Board of the Jinnah Post Graduate Medical Center, which is the coordinating site of this road surveillance project.

**Data analysis**

We performed the analysis using R.[31] All variables were categorical and are described using frequencies and percentages. We used logistic regression to assess the unadjusted and adjusted associations of age group (13-17 years and 18-19 years compared with 20-24 years) and severe injury (ISS ≥ 16). We conducted a complete case analysis, estimated 95% confidence intervals, and interpreted differences with confidence intervals that excluded no difference as statistically significant.

**Results**

The original dataset included 56,592 riders of motorcycles aged 13-24 years. After removing patients with missing values, the final study sample included 38,910 patients. The details of missing data is given in Table 1. Some of the variables, such as vehicles involved in crash and type of collision (head-on, rear-end etc), were not included in the analysis due to 50% percent missing data.

**Table 1: Missing data in variables of interest**  n =56,592

|  |  |
| --- | --- |
| Variables | n (%) |
| Glasgow coma scale | 8507 (15 |
| Helmet use | 2720 (5) |
| Place of crash | 2363 (4) |
| Midblock versus intersection crashes | 2344(4) |
| Profession | 2318 (4) |
| Injury severity score | 1811 (3) |
| Daylight versus night time | 1351 (2) |
| Weekday versus weekend | 1479(2.61) |
| Transporting vehicle | 1041(1.84) |
| Gender | 15 (0.03) |
| Season | 0 |
| Hospital | 0 |

Table 2 shows descriptive characteristics of the young motorcyclists in the three age groups. There were 8806 (22.6%) motorcyclists aged 13-17 years, 8502 (21.9%) aged 18-19 years and 21,602 (55.5%) aged 20-24 years. Almost all were males (99%). Majority (77%) of motorcyclists were students in the age group 13-17 years, more than half (55%) were students in age group18-19 years while majority (72%) were professionals in age group 20-24 years. Helmet use was very low in all age groups 1.5 %, 2% and 4% respectively in age 13-17 years, 18-19 years and 20-24 years. Midblock was the location in more than 70% of crashes among the three age groups. More than 60% motorcyclists had external injuries, more than 50% had extremity injuries, and more than 30% had head and face injuries in all three age groups. Around 2% had severe injuries and 1% died.

**Table 2: Characteristics of underage motorcyclists versus young motorcyclists of legal driving age (n=38,910)**

|  |  |  |  |
| --- | --- | --- | --- |
| **Variables** | **13-17 years**  **n=8806 (%)** | **18-19 years**  **n=8502 (%)** | **20-24 years n=21602 (%)** |
| Gender  Male  Female | 8754 (99.4)  52 (0.6) | 8447 (99.4)  55 (0.6) | 21438 (99.2)  164 (0.8) |
| Profession  Student  Professional | 6774 (76.9)  2032 (23.1) | 4637 (54.5)  3865 (45.5) | 5959 (27.6)  15643 (72.4) |
| Time of the day  Daylight  Night time | 5305 (60.2)  3501 (39.8) | 4536 (53.4) 3966 (46.6) | 12422 (57.5)  9180 (42.5) |
| Days of the week  Weekday  Weekend | 5791 (65.8)  3015 (34.2) | 5574 (65.6)  2928 (34.4) | 14626 (67.7) 6976 (32.3) |
| Season  Winter  Summer | 2666 (30.3)  6140 (69.7) | 2661 (31.3)  5841 (68.7) | 6591 (30.5)  15011 (69.5) |
| Road Structure  Intersection  Midblock | 2112 (24.0) 6694 (76.0) | 2183 (25.7)  6319 (74.3) | 5914 (27.4)  15688 (72.6) |
| Crash location  Inside city  Out of city | 8595 (97.6)  211 (2.4) | 8252 (97.1)  250 (2.9) | 20966 (97.1)  636 (2.9) |
| Helmet use  Yes  No | 128 (1.5)  8678 (98.5) | 189 (2.2)  8313 (97.8) | 931 (4.3)  20671 (95.7) |
| Patient transfer vehicle  Ambulance  Police  Private  Public  Others | 2056 (23.3)  12 (0.1)  6638 (75.4)  93 (1.1)  7 (0.1) | 2059 (24.2)  19 (0.2)  6309 (74.2)  101 (1.2)  14 (0.2) | 5937 (27.5)  31 (0.1)  15321 (70.9)  284 (1.3)  29 (0.1) |
| Hospital  1  2  3  4  5 | 3045 (34.6)  222 (2.5)  7 (0.1)  3360 (38.2)  2172 (24.7) | 3130 (36.8)  167 (2.0)  7 (0.1)  2723 (32.0)  2475 (29.1) | 7998 (37.0)  443 (2.1)  18 (0.1)  7106 (32.9)  6037 (27.9) |
| GCS Score  13 to 15  9 to 12  6 to 8  4 to 5  3 | 8339 (94.7)  318 (3.6)  50 (0.6)  11 (0.1)  88 (1.0) | 8012 (94.2)  344 (4.0)  43 (0.5)  13 (0.2)  90 (1.1) | 20321 (94.1)  869 (4.0)  134 (0.6)  37 (0.2)  241 (1.1) |
| Body region injured (multi responses)  Head Injury  Face Injury  Extremity Injury  Abdominal Injury  Chest Injury  Spine Injury  External Injury | 2924 (33.2)  2763 (31.4)  5055 (57.4)  143 (1.6)  128 (1.5)  24 (0.3)  5473 (62.2) | 3106 (36.5)  2859 (33.6)  4898 (57.6)  135 (1.6)  96 (1.1)  15 (0.2)  5477 (64.4) | 7747 (35.9)  6919 (32.0)  12486 (57.8)  322 (1.5)  254 (1.2)  56 (0.3)  13740 (63.6) |
| Injury Severity score  Less than 16  More than or equal to 16 | 8604 (97.7)  202 (2.3) | 8264 (97.2)  238 (2.8) | 21064 (97.5)  538 (2.5) |
| Outcome in Emergency Department  Survived  Death | 8707 (98.9)  99 (1.1) | 8398 (98.8)  104 (1.2) | 21335 (98.8)  267 (1.2) |

Table 3 shows unadjusted and adjusted associations of age group with severe injury (ISS => 16). The odds of severe injury were lower in the age group 13-17 years (OR 0.97; 95% CIs 0.75, 1.25 and aOR 0.97 95% CIs 0.75, 1.25) while the odds of severe injury were significantly higher in the age group 18-19 years (unadjusted OR 1.39; 95% CIs 1.11, 1.74, and aOR 1.39; 95% CIs 1.11, 1.74), as compared to the age group 20-24 years.

Association of night time versus daylight, weekend versus weekday, summers versus winters and crash location with severe injuries were not statistically significant in adjusted analysis. The odds of severe injury were significantly higher for midblock crash in unadjusted as well as adjusted analysis (OR 2.02; 95% CIs 1.7, 2.42 and aOR 1.60; 95% CIs 1.27, 2.03).

In the unadjusted analysis, the odds of severe injury were significantly lower in motorcyclists without helmet as compared to those with helmet (OR 0.57; 95% CIs 0.43, 0.76). In the adjusted analysis, the direction of this association was reversed and the odds were significantly higher in those without helmet (aOR 1.94; 95% CIs 1.30, 2.92). Transferring vehicle and hospital were significantly associated with severe injuries in both unadjusted and adjusted analysis. GCS were also significantly associated with severe injuries in both analysis.

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| --- | --- | --- | --- | --- |
| **Table 3: Unadjusted and adjusted associations of age and severe injury in young motorcyclists (n=38,910)** | | | | |
| **Variables** | **Severe injury (ISS<16)**  n = 37932 | **Severe injury (ISS>=16)**  n = 978 | **Unadjusted ORs**  **(95% CIs)** | **Adjusted ORs**  **(95% CIs)** |
| Age groups  20-24 years  18-19 years  13-17 years | 21064 (55.5)  8264 (21.8)  8604 (22.7) | 538 (55.0)  238 (24.3)  202 (20.7) | 1  1.13 (0.96, 1.31)  0.92 (0.78, 1.08) | 1  1.39 (1.11, 1.74)  0.97 (0.75, 1.25) |
| Gender  Male  Female | 37668 (99.3)  264 (0.7) | 971 (99.3)  7 (0.7) | 1  1.03 (0.44, 2.02) | 1  2.04 (0.73, 4.74) |
| Profession  Student  Professional | 16952 (44.7)  20980 (55.3) | 418 (42.7)  560 (57.3) | 1  1.08 (0.95, 1.23) | 1  1.04 (0.85, 1.28) |
| Time of the day  Daylight  Night time | 21674 (57.1)  16258 (42.9) | 589 (60.2)  389 (39.8) | 1  0.88 (0.77, 1) | 1  1.08 (0.90,1.29) |
| Days of the week  Weekday  Weekend | 25325 (66.8)  12607 (33.2) | 666 (68.1)  312 (31.9) | 1  0,94 (0.82, 1.08) | 1  0.93 (0.77, 1.12) |
| Season  Winter months  Summer months | 11610 (30.6)  26322 (69.4) | 308 (31.5)  670 (68.5) | 1  0.96 (0.84, 1) | 1  1.13 (0.94, 1.37) |
| Road Structure  Intersection  Midblock | 10061 (26.5)  27871 (73.5) | 148 (15.1)  830 (84.9) | 1  2.02 (1.7, 2.42) | 1  1.60 (1.27, 2.03) |
| Crash location  Inside city  Out of city | 36950 (97.4)  982 (2.6) | 863 (88.2)  115 (11.8) | 1  0.2 (0.16, 0.25) | 1  0.73 (0.53, 1.01) |
| Helmet use  Yes  No | 1195 (3.2)  36737 (96.8) | 53 (5.4)  925 (94.6) | 1  0.57 (0.43, 0.76) | 1  1.94 (1.30, 2.92) |
| Patient transfer vehicle  Ambulance  Police  Private  Public  Others | 9265 (24.4)  55 (0.1)  28112 (74.1)  451 (1.2)  49 (0.1) | 787 (80.5)  7 (0.7)  156 (16.0)  27 (2.8)  1 (0.1) | 1  1.5 (0.62, 3.08)  0.07 (0.05, 0.08)  0.7 (0.46, 1.03)  0.24 (0.01, 1.1) | 1  2.28 (0.67, 6.33)  0.27 (0.22, 0.34)  1.17 (0.68, 1.93)  0.42 (0.01, 3.76) |
| Hospital  1  2  3  4  5 | 13766 (36.3)  563 (1.5)  21 (0.1)  13056 (34.4)  10526 (27.7) | 407 (41.6)  269 (27.5)  11 (1.1)  133 (13.6)  158 (16.2) | 1  16.16(13.55, 19.26 )  17.72 (8.19, 36.28)  0.34 (0.28, 0.42)  0.51 (0.42, 0.61) | 1  13.09 (9.95, 17.23)  9.75 (2.60, 32.66)  0.47 (0.36, 0.61)  0.79 (0.61, 1.02) |
| GCS Score (%)  13 to 15  9 to 12  6 to 8  4 to 5  3 | 36435 (96.1)  1271 (3.4)  100 (0.3)  29 (0.1)  97 (0.3) | 237 (24.2)  260 (26.6)  127 (13.0)  32 (3.3)  322 (32.9) | 1  22.76 (18.81, 27.52)  109.23 (82.19, 145.04)  147 (90.17, 240.47)  351.01 (276.48, 448.33) | 1  10.12 (8.13,12.60)  85.26 (60.67,119.88)  97.27 (54.53, 172.93)  356.94 (270.18, 475.28) |

**Discussion**

Our study shows that the age group 18-19 years had significantly higher odds of severe injuries, while the underage motorcyclists in the age group 13-17 years did not have significantly higher odds of severe injuries, compared to those of late licensure age in the age group 20-24 years.

The higher odds of severe injuries in the age group 18-19 years might be due to inexperience of the riders who might have just learnt and started independent riding.[3] Additionally, they may have a sense of achievement by obtaining a license that may have increased their confidence. This confidence might lead to aggressive driving resulting in severe injuries. In contrast, many of the riders of this age may have not obtained a license thus they may be unaware of many traffic rules and regulations, subsequently involving in road crashes. Irrespective of status of licensing, the quality of driving skills and road safety knowledge of rider are questionable due to poor license obtaining system. The professional training of driving is mostly limited to learning driving without much understanding of rules and regulations.[32, 33]

Compared to 18-19 years riders, 20-24 years old may have more experience of driving leading to improvement in their judgement for risks in the road. While underage riders 13-17 years may need to be extra careful in riding as they are fearful of any face off with police. A study from New Zealand showed consistent result that motorcyclists aged 15-19 years were at higher odds of injury compared with older riders more than 25 years of age.[34] Furthermore, research also showed that younger drivers were more involved in crashes than older drivers, when adjusted for duration of license.[35]

Underage driving in Pakistan may be due to various socioeconomic reasons. Motorcycle is an accessible and cheap transport for the lower middle class in Pakistan. Alternate and convenient transportation options are very limited in Karachi city.[27] The legal age to obtain a license in Pakistan is 18 years but there are many underage motorcyclists.Lack of safe built environment does not encourage walking and leads to short quick market trips on motorcycles usually by underage boys. Leisure trips for thrill seeking by underage motorcyclists are also reported due to almost non-existent recreational activities in Pakistan.

Many underage boys ride motorcycles to support commute of women because motorcycle driving is not considered safe and modest for women and therefore they use it as passengers.[36]

The age limit for obtaining driving license can be reconsidered due to contextual needs in Pakistan. Else, underage riders of motorcycles in Pakistan keeps on driving as the enforcement of road safety laws is weak in Pakistan.[15, 37] There is a need to understand perceptions of underage motorcyclists about their early driving. Modification in laws such as early licensing and mandatory helmet should be put into effect to promote safety.

**Limitations**

Missing data was a challenge as we missed 17,682 data points however the presented analysis is the best possible effort for the study question. Age was used in our study as proxy for experience in driving. We did not know the actual period of driving experience nor the status of driving license. For example, the motorcyclists of 18 years of age may just have started riding or had experience of a few years of underage driving. It would have given more depth to understanding of our findings if we knew status of experience and license. We recommend to fill this gap in future studies.

**Conclusion**

Compared to motorcyclists in the age group 20-24 years, motorcyclists in the age group 18-19 years had significantly higher odds of severe injury, while those in the age group 13-17 years did not have significantly higher odds. The young motorcyclists are vulnerable to injuries and it is important to understand circumstances and their needs to avoid lifelong impact on them and families.

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