**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 deaths due to motorcyclists in developing countries has high burden. The aim of this study is to see association of underage driving compared to legal age by motorcyclists with road traffic deaths and injury severity. Methods: We analysed data from road traffic injury surveillance at five hospitals of Karachi from January 2007 to June 2014. Research assistants collected data of road traffic injured patients in these hospitals. . We used logistic regression to assess the association of the age of motorcyclists, categorized as underage drivers 13-17 years, drivers of license obtaining age 18-19 years and post license obtaining age with some driving experience 20-24 years, and severe injury and in hospital death. Results: The final dataset included 31,221 patients. There were 17,688 (56.5%) drivers of motorcycles of age 20-24 years, 6757 (21.6%) of 18-19 years and 6776 (21.7%) of age 13-17 years. Almost all were males (99.8%) . The adjusted odds ratios were higher for deaths in both the age groups 18-19 years and 13-17 years compared to 20-24 years in the adjusted analysis but the confidence intervals were not statistically significant (OR1.16; 95% CI 0.72, 1.85 and OR 1.62; 95% CI 0.96, 2.69). The age group 18-19 years was associated with higher odds of severe injury (OR 1.23; 95% CI 0.95, 1.60) while the odds of severe injuries were lower for age group 13-17 years (OR 0.84; 95% CI 0.63, 1.13) in adjusted analysis. The other exposure variables such as transporting vehicle and hospital were associated with severity of injuries and deaths. In addition, helmet use, midblock road structure and district of city were associated with severity of injuries. Conclusion: Underage (13-17 years) motorcycle driving is not associated with severity of road traffic injuries and in-hospital deaths compared to initial age of driving (18-19 years and 20-24 years). However, the burden of underage drivers is comparable to young age drivers of legal driving age (18-24).

**Background**

About 200,112 young people 10-24 years of age died from road 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, 51353 (26%) deaths were due to motorcycles.(1) An overwhelming 94% of deaths due to motorcycles occur in low and middle income countries and 84% of those involved are males.(1)

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 driving exist and boys as young as eight years have been reported to drive motorcycles.(14-17) (18) Underage drivers 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.(5, 20-25) The risk of crashes is particularly high in the first 12 to 18 months of independent driving after obtaining license.(26)

Our aim is to determine association of age of young motorcyclists with injury severity and in-hospital death due to road crash in Karachi, Pakistan.

**Methods**

**Design**

We conducted a cross-sectional study with data collected during the period 2007-2014.

**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.

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.(27)

These hospitals receive nearly all major trauma cases from the city. The data collectors 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 drivers of motorcycles or any other vehicle and reported to emergency departments of participating hospitals with injuries.

**Outcomes**

Injury severity score (ISS) >= 16 6 and in hospital death due to road traffic crash. Most previous literature agreed to take ISS of 16 and greater as severe injuries.(28) (29)

**Exposure**

Age, categorized as 13-17 years (underage), 18-19 years (early licensure age) and 20-24 years (post licensure age with some driving experience).

**Study variables**

Gender, darkness or daylight during crash, weekday versus weekend, summer months versus winters months, crash in intersection (two or more intersecting road polylines(30)) versus mid-blocks road polyline center points(30)), crash district, helmet use, transporting vehicle, hospital, Glasgow Coma scale (GCS) and injured body regions.

**Ethics approval**

Ethics of study methods were approved from the Institutional Review Board of the Jinnah Post Graduate Medical Center, which is coordinating site of this road surveillance project.

**Data analysis**

We performed the analysis using R.(31) The categorical variables are described using frequencies and percentages . We used logistic regression to assess the association of age group (13-17 years and 18-19 years compared with 20-24 years) and the outcomes severe injury (ISS ≥ 16) and in hospital death. 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 total dataset included 46.115 drivers of motorcycles aged 13-24 years. After removing patients withmissing values, the final dataset included 31,221 patients. The details of missing data is given in Table 1. Few of the variables such as vehicles involved in crash and type of collision (head-on, rear-end etc) were not included in analysis due to 50% percent missing data.

**Table 1: Missing data in variables of interest**

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| --- | --- |
| **Missing Data n=46,155** | **n (%)** |
| Gender | 15 (0.03) |
| Profession | 2160 (4.68) |
| Daylight versus darkness | 1178 (2.55) |
| Weekday versus weekend | 1(0.002) |
| Season | 0 |
| Midblock versus intersection crashes | 1798 (3.90) |
| District of crash | 1540 (3.34) |
| Helmet use | 2194 (4.75) |
| Transporting vehicle | 941(2.04) |
| Hospital | 0 |
| GCS | 8452 (18.31) |
| ISS | 1617 (3.50) |

Table 2 shows descriptive characteristics of the young motorcyclists in the three age groups 13-17 years (underage driving age), 18-19 years (early licensure age) and age 20-24 years (post two years of licensure age). There were 17,688 (56.5%) drivers of motorcycles of age 20-24 years, 6757 (21.6%) of 18-19 years and 6776 (21.7%) of age 13-17 years. Almost all were males (99.8%). More than three-fourths were students in the age group 13-17 years while a little less three-fourth were professionals in age 20-14 years. Almost 55% were students in 18-19 years. Helmet use was very low in all age groups but higher in the age group 20-24 (5%) compared with the age group 18-19 years of age (2%) and the age group 13-17 (2%). The distributions of other variables of interest were similar across age groups. Midblock was the location in almost 70% of crashes among the three age groups. Overall, more than half of motorcyclists had external injuries, about 60% had extremity injuries, and 30% had head injuries. More than 2% had severe injuries and 1% died.

**Table 2: Characteristics of underage motorcyclists versus young motorcyclists of**

**legal driving age (n=31,221)**

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| **Variables** | 20-24 years n=17688 | 18-19 years  n=6757 | 13-17 years  n=6776 |
| Gender  Male  Female | 17649 (99.8)  39 (0.2) | 6743 (99.8)  14 (0.2) | 6761 (99.8)  15 (0.2) |
| Profession  Student  Professional | 4810 (27.2)  12878 (72.8) | 3696 (54.7)  3061 (45.3) | 5196 (76.7) 1580 (23.3) |
| Time of the day  Daylight  Darkness (after sunset) | 9671 (54.7)  8017 (45.3) | 3361 (49.7) 3396 (50.3) | 3892 (57.4)  2884 (42.6) |
| Days of the week  Weekday  Weekend | 11843 (67.0) 5845 (33.0) | 4353 (64.4)  2404 (35.6) | 4368 (64.5) 2408 (35.5) |
| Season  Winter  Summer | 5289 (29.9)  12399 (70.1) | 2073 (30.7) 4684 (69.3) | 2037 (30.1) 4739 (69.9) |
| Road Structure  Intersection  Midblock | 5058 (28.6)  12630 (71.4) | 1847 (27.3)  4910 (72.7) | 1735 (25.6) 5041 (74.4) |
| District  Central  East  Kemari  Korangi  Malir  South  West  Out of city | 4193 (23.7)  2961 (16.7)  905 (5.1)  1719 (9.7)  950 (5.4)  5354 (30.3)  1062 (6.0)  544 (3.1) | 1551 (23.0)  1001 (14.8)  334 (4.9)  755 (11.2)  398 (5.9)  2128 (31.5)  398 (5.9)  192 (2.8) | 1990 (29.4)  961 (14.2)  264 (3.9)  795 (11.7)  389 (5.7)  1854 (27.4)  349 (5.2)  174 (2.6) |
| Helmet use  Yes  No | 848 (4.8)  16840 (95.2) | 160 (2.4)  6597 (97.6) | 118 (1.7)  6658 (98.3) |
| Patient transfer vehicle  Ambulance  Police  Private  Public  Others | 4637 (26.2)  28 (0.2)  12738 (72.0)  256 (1.4)  29 (0.2) | 1549 (22.9)  19 (0.3)  5089 (75.3)  86 (1.3)  14 (0.2) | 1535 (22.7)  11 (0.2)  5149 (76.0)  74 (1.1)  7 (0.1) |
| Hospital  1  2  3  4  5 | 6687 (37.8)  4894 (27.7)  427 (2.4)  15 (0.1)  5665 (32.0) | 2585 (38.3)  1946 (28.8)  155 (2.3)  6 (0.1)  2065 (30.6) | 2405 (35.5)  1692 (25.0)  204 (3.0)  6 (0.1)  2469 (36.4) |
| GCS Score (%)  13 to 15  9 to 12  6 to 8  4 to 5  3 | 16616 (93.9)  731 (4.1)  115 (0.7)  30 (0.2)  196 (1.1) | 6365 (94.2)  270 (4.0)  38 (0.6)  10 (0.1)  74 (1.1) | 6409 (94.6)  241 (3.6)  46 (0.7)  9 (0.1)  71 (1.0) |
| Head Injury  No  Yes | 11590 (65.5)  6098 (34.5) | 4364 (64.6)  2393 (35.4) | 4551 (67.2)  2225 (32.8) |
| Face Injury  No  Yes | 12138 (68.6)  5550 (31.4) | 4518 (66.9)  2239 (33.1) | 4741 (70.0)  2035 (30.0) |
| Extremity Injury  No  Yes | 7588 (42.9)  10100 (57.1) | 2841 (42.0)  3916 (58.0) | 2887 (42.6)  3889 (57.4) |
| Abdominal Injury  No  Yes | 17446 (98.6)  242 (1.4) | 6666 (98.7)  91 (1.3) | 6680 (98.6)  96 (1.4) |
| Chest Injury  No  Yes | 17517 (99.0)  171 (1.0) | 6703 (99.2)  54 (0.8) | 6700 (98.9)  76 (1.1) |
| Spine Injury  No  Yes | 17632 (99.7)  56 (0.3) | 6742 (99.8)  15 (0.2) | 6752 (99.6)  24 (0.4) |
| External Injury  No  Yes | 2608 (38.5)  4168 (61.5) | 2439 (36.1)  4318 (63.9) | 6460 (36.5)  11228 (63.5) |
| Injury Severity score  Less than 16  More than or equal to 16 | 17247 (97.5)  441(2.5) | 6575(97.3)  182 (2.7) | 6624 (97.8)  152 (2.2) |
| Deaths  Survived  Death | 17461 (98.7)  227 (1.3) | 6670 (98.7)  87 (1.3) | 6695 (98.8)  81 (1.2) |

Table 3 shows the unadjusted and adjusted analyses of road traffic deaths. In the unadjusted analyses, the age groups 18-19 years (OR 1; 95% CIs 0.78, 1.28) and 13-17 years (OR 0.93; 95% CIs 0.72, 1.2) did not have significantly different odds of in hospital death compared with the age group 20-24 years.

The odds ratios were higher for both the age groups in the adjusted analysis but the confidence intervals were not statistically significant (OR1.16; 95% CIs 0.72, 1.85 and aOR 1.62; 95% CIs 0.96, 2.69).

Compared to students, motorcyclists who were professionals had higher odds of deaths in both unadjusted (OR 1.46; 95% CIs 1.19, 1.81) and adjusted analysis (aOR 1.54; 95% CIs 1.00, 2.39). There were no statistical significance of day/night, weekday/weekend and winter/summer on deaths. The odds ratios were in opposite directions for midblock crash compared to crash on intersection in unadjusted model versus adjusted model (OR 1.4; 95% CIs 1.15, 1.71 and aOR 0.93; 95% CIs 0.61, 1.45) respectively. There were higher odds of deaths in out of city crashes as well as in some districts where crashes occurred in unadjusted analysis but the effect lowered or became protective in adjusted analysis with no statistical significance. No helmet use was associated with increased odds of death (OR 2.94; 95% CIs 1.36, 8.26) and (aOR 4.51; 95% CIs 0.84, 32.14).

Compared with ambulances, the transfer to hospital in private vehicles was associated with lower odds of death and statistically significant results in both unadjusted (OR 0.07; 95% CIs 0.05, 0.09) and adjusted (aOR 0.26; 95% CIs 0.16, 0.41) analyses. All the hospitals had lower odds of deaths compared to reference hospital; one hospital had very less data and only one in adjusted analysis had statistical significance. There was an inverse relationship between GCS and death, and as GCS decreased the odds increased, both in unadjusted and adjusted analysis. An ISS of 16 or more was associated with increased odds of deaths in unadjusted and adjusted analysis. Both GCS and ISS had statistically significant odds ratios.

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| **Table 3: Univariable and multivariable associations of age group and death (n=31,221)** | | | | |
| **Variables** | **Survived**  **n=**30826 | **Death**  **n=**395 | **Unadjusted OR**  **(95% CIs)** | **Adjusted OR**  **(95% CIs)** |
| Age group  20-24 years  18-19 years  13-17 years | 17461 (56.6)  6670 (21.6)  6695 (21.7) | 227 (57.5)  87 (22.0)  81 (20.5) | 1  1.0 (0.78, 1.28)  0.93 (0.72, 1.2) | 1  1.16 (0.72, 1.85)  1.62 (0.96, 2.69) |
| Gender  Male  Female | 30758 (99.8)  68 (0.2) | 395 (100.0)  0 (0.0) | 1  0 (0, 0.01) | 1  0.00 (0.00, 39.05) |
| Profession  Student  Professionals | 13564 (44.0)  17262 (56.0) | 138 (34.9)  257 (65.1) | 1  1.46 (1.19, 1.81) | 1  1.54 (1.00, 2.39) |
| Time of the day  Daylight  Night | 16717 (54.2)  14109 (45.8) | 207 (52.4)  188 (47.6) | 1  1.08 (0.88, 1.31) | 1  1.37 (0.94, 2.00) |
| Days of the week  Weekday  Weekend | 20305 (65.9)  10521 (34.1) | 259 (65.6)  136 (34.4) | 1  1.01 (0.82, 1.25) | 1  0.95 (0.64, 1.40) |
| Season  Winter months  Summer months | 9287 (30.1)  21539 (69.9) | 112 (28.4)  283 (71.6) | 1  1.09 (0.88, 1.36) | 1  1.45 (0.96, 2.22) |
| Road Structure  Intersection  Midblock | 8555 (27.8)  22271 (72.2) | 85 (21.5)  310 (78.5) | 1  1.4 (1.11, 1.79) | 1  0.93 (0.6, 1.45) |
| District  Central  East  Kemari  Korangi  Malir  South  West  Out of city | 7670 (24.9)  4871 (15.8)  1460 (4.7)  3206 (10.4)  1694 (5.5)  9252 (30.0)  1787 (5.8)  886 (2.9) | 64 (16.2)  52 (13.2)  43 (10.9)  63 (15.9)  43 (10.9)  84 (21.3)  22 (5.6)  24 (6.1) | 1  1.28 (0.88, 1.85)  3.53 (2.37, 5.2)  2.36 (1.66, 3.35)  3.04 (2.05, 4.48)  1.09 (0.79, 1.51)  1.48 (0.89, 2.36)  3.25 (1.98, 5.14) | 1  1.00 (0.45, 2.22)  0.65 (0.21, 1.93)  1.06 (0.46, 2.43)  1.31 (0.55, 3.01)  0.98 (0.44, 2.19)  0.99 (0.37. 2.37)  1.15 (0.45, 2.87) |
| Helmet use  Yes  No | 1121 (3.6)  29705 (96.4) | 5 (1.3) 390 (98.7) | 1  2.94 (1.36, 8.26) | 1  4.51 (0.84, 32.14) |
| Patient transfer vehicle  Ambulance  Police  Private  Public  Others | 7412 (24.0)  54 (0.2)  22909 (74.3)  402 (1.3)  49 (0.2) | 309 (78.2)  4 (1.0)  67 (17.0)  14 (3.5)  1 (0.3) | 1  1.78 (0.54, 4.37)  0.07 (0.05, 0.09)  0.84 (0.46, 1.39)  0.49 (0.03, 2.24) | 1  0.70 (0.04, 6.46)  0.26 (0.16, 0.41)  0.90 (0.32, 2.30)  0.23 (0.00, 13.95) |
| Hospital  1  2  3  4  5 | 11479 (37.2)  8439 (27.4)  776 (2.5)  27 (0.1)  10105 (32.8) | 198 (50.1)  93 (23.5)  10 (2.5)  0 (0.0)  94 (23.8) | 1  0.64 (0.5, 0.82)  0.75 (0.37, 1.34)  0 (0, 19.99)  0.54 (0.42, 0.69) | 1  0.68 (0.36, 1.26)  0.05 (0.02, 0.12)  0.00 (0.00, 195536.21)  0.94 (0.48, 1.84) |
| GCS Score (%)  13 to 15  9 to 12  6 to 8  4 to 5  3 | 29336 (95.2)  1218 (4.0)  182 (0.6)  41 (0.1)  49 (0.2) | 54 (13.7)  24 (6.1)  17 (4.3)  8 (2.0)  292 (73.9) | 1  10.7 (6.48, 17.16)  50.74 (28.08, 87.4)  106 (44.38, 225.85)  3237.38 (2186.13, 4903.91) | 1  1.94 (1.04, 3.53)  3.57 (1.70, 7.28)  6.38 (2.20, 17.29)  602.26 (365.76, 1011.74) |
| Injury Severity score  Less than 16  More than or equal to 16 | 30351 (98.5)  475 (1.5) | 95 (24.1)  300 (75.9) | 1  201.78 (158.1, 259.69) | 1  33.51 (20.48, 55.21) |

Table 4 shows unadjusted and adjusted associations of age group with severe injury (ISS => 16). The age group 18-19 years was associated with higher odds of severe injury (unadjusted OR 1.08; 95% CIs 0.91, 1.29, and aOR 1.23; 95% CIs 0.95, 1.60) while the odds are lower for age group 13-17 years (OR 0.9; 95% CIs 0.74, 1.08 and aOR 0.84 95% CIs 0.63, 1.13). All these associations of age with severity of injuries were without statistical significance

Motorcyclists who were professionals had higher unadjusted and adjusted odds with no statistical significance. Darkness versus daylight (OR 0.86; 95% CIs 0.74, 0.99 and aOR 1.08; 95% CIs 0.88, 1.33) and summer versus winters (OR 0.89; 95% CIs 0.77, 1.04 and aOR 1.06 95% CIs 0.86, 1.32) while weekend had higher unadjusted and lower adjusted odds (OR 1.03; 95% CIs 0.89, 1.2 and aOR 0.99; 95% CIs 0.80, 1.22) for severe injuries. Midblock crash was associated with higher odds of severe injuries in unadjusted as well as adjusted analysis (OR 2.02; 95% CIs 1.67, 2.46 and aOR 1.60; 95% CIs 1.24, 2.08). Two districts had higher odds in unadjusted analysis but turned lower odds when adjusted with statistical significance. No use of helmet had lower odds of severe injuries in unadjusted analysis (OR 0.87; 95% CIs 0.62, 1.26) and higher adjusted odds ratio (aOR 2.70; 95% CIs 1.67, 4.47). Transfer to hospital through private vehicles had lower odds of severe injuries (OR 0.07 95% CIs 0.06, 0.08 and aOR 0.32, 95% CIs 0.25, 0.40). Hospital had statistically significant odds ratios in both unadjusted and adjusted analysis; two hospitals had lower while other two had higher odds of severe injuries. Low GCS had linear relationship with severe injuries in unadjusted analysis and also had higher adjusted odds with statistical significance.

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| **Table 4: Univariate and Multivariable association of Injury severity with age of young motorcyclists (n=31,221)** | | | | |
| **Variables** | **ISS less than 16**  n = 30446 | **ISS more than or equal to 16**  n = 775 | **Unadjusted ORs**  **(95% CIs)** | **Adjusted ORs**  **(95% CIs)** |
| **Age groups**  20-24 years  18-19 years  13-17 years | 17247 (56.6)  6575 (21.6)  6624 (21.8) | 441 (56.9)  182 (23.5)  152 (19.6) | 1  1.08 (0.91, 1.29)  0.9 (0.74, 1.08) | 1  1.23 (0.95, 1.60)  0.84 (0.63, 1.13) |
| Gender  Male  Female | 30378 (99.8)  68 (0.2) | 775 (100.0)  0 (0.0) | 1  0 (0, 0) | 1  0.00 (0.00, 0.18) |
| Profession  Student  Professional | 13367 (43.9)  17079 (56.1) | 335 (43.2)  440 (56.8) | 1  1.03 (0.89, 1.19) | 1  1.01 (0.80, 1.28) |
| Time of the day  Daylight  Night | 16476 (54.1)  13970 (45.9) | 448 (57.8)  327 (42.2) | 1  0.86 (0.74, 0.99) | 1  1.08 (0.88,1.33) |
| Days of the week  Weekday  Weekend | 20059 (65.9)  10387 (34.1) | 505 (65.2)  270 (34.8) | 1  1.03 (0.89, 1.2) | 1  0.99 (0.80, 1.22) |
| Season  Winter months  Summer months | 9147 (30.0)  21299 (70.0) | 252 (32.5)  523 (67.5) | 1  0.89 (0.77, 1.04) | 1  1.06 (0.86, 1.32) |
| Road Structure  Intersection  Midblock | 8515 (28.0)  21931 (72.0) | 125 (16.1)  650 (83.9) | 1  2.02 (1.67, 2.46) | 1  1.60 (1.24, 2.08) |
| District  Central  East  Kemari  Korangi  Malir  South  West  Out of city | 7615 (25.0)  4793 (15.7)  1436 (4.7)  3174 (10.4)  1667 (5.5)  9185 (30.2)  1762 (5.8)  814 (2.7) | 119 (15.4)  130 (16.8)  67 (8.6)  95 (12.3)  70 (9.0)  151 (19.5)  47 (6.1)  96 (12.4) | 1  1.74 (1.35, 2.23)  2.99 (2.19, 4.03)  1.92 (1.46, 2.51)  2.69 (1.98, 3.62)  1.05 (0.83, 1.34)  1.71 (1.2, 2.38)  7.55 (5.7, 9.96) | 1  0.64 (0.43, 0.97)  1.35 (0.79, 2.28)  0.53 (0.34, 0.82)  0.70 (0.44, 1.10)  0.94 (0.62, 1.43)  1.25 (0.77, 2.01)  1.14 (0.71,1.83) |
| Helmet use  Yes  No | 1094 (3.6)  29352 (96.4) | 32 (4.1)  743 (95.9) | 1  0.87 (0.62,1.26) | 1  2.70 (1.67, 4.47) |
| Patient transfer vehicle  Ambulance  Police  Private  Public  Others | 7109 (23.3)  51 (0.2)  22843 (75.0)  394 (1.3)  49 (0.2) | 612 (79.0)  7 (0.9)  133 (17.2)  22 (2.8)  1 (0.1) | 1  1.59 (0.66, 3.3)  0.07 (0.06, 0.08)  0.65 |0.41, 0.98)  0.24 (0.01, 1.08) | 1  2.44 (0.70, 7.00)  0.32 (0.25, 0.40)  0.96 (0.52, 1.69)  0.59 (0.02, 5.04) |
| Hospital  1  2  3  4  5 | 11366 (37.3)  8413 (27.6)  562 (1.8)  21 (0.1)  10084 (33.1) | 311 (40.1)  119 (15.4)  224 (28.9)  6 (0.8)  115 (14.8) | 1  0.52 (0.42, 0.64 )  14.57 (12.02, 17.64)  10.44 (3.81, 24.55)  0.42 (0.33, 0.52) | 1  0.49 (0.35, 0.68)  10.44 (7.64, 14.26)  1.15 (0.26, 5.33)  0.42 (0.29, 0.61) |
| GCS Score (%)  13 to 15  9 to 12  6 to 8  4 to 5  3 | 29228 (96.0)  1021 (3.4)  88 (0.3)  25 (0.1)  84 (0.3) | 162 (20.9)  221 (28.5)  111 (14.3)  24 (3.1)  257 (33.2) | 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  12.75 9.93 16.39  102.81 70.88 149.27  90.53 47.00 172.41  404.57 296.42 557.31 |

**Discussion**

Our study shows that the age of motorcyclists is not significantly associated with severe injury or in hospital death. Type of vehicle that transports patients and hospital where they get treatment were associated with severity of injuries and deaths. Helmet use, mid-blocks and district of city where crashes occurred are also associated with severity of injuries.

The effect size of both age groups 17-18 and 13-17 years show higher odds of death compared to 20-24 years and age 13-17 years have higher odds than age 17-18 years. However, with severity of injuries as outcome, age 17-18 shows higher odds of severe injuries as opposed to age 13-17 years which has lower odds. The association of age is uncertain due to confidence intervals that are compatible with both protective and harmful associations with the outcomes. Our hypothesis that young drivers in early years of obtaining license might be more associated with severe injuries or deaths did not hold statistical significance however higher odds indicative of the same direction as of our hypothesis.

Age was used in our study as proxy of experience in driving. Although we did not know actual period of their driving experience. We also did not know whether our study participants had driving license. The legal age to obtain license in Pakistan is 18 years but many underage drivers start driving earlier than that as the enforcement of road safety laws is weak.(15, 32) The previous study in New Zealand showed different result motorcyclists 15-19 years are at an increased risk of injury compared with older riders more than 25 years.(33)

Prehospital and hospital care are important components of trauma care. In our setting, the ambulances are primarily carrier vehicles for patients without any paramedics /prehospital care. The overall usage of these ambulances is low around 9% in Karachi.(34) The usage of these ambulances is more for injuries in Pakistan and the odds of dying for patients brought in ambulances is seven times more than for non-ambulance patient.(34) In our setting we had three public tertiary care hospitals and two private hospitals. Almost 98% of study patients were enrolled from three public hospitals. Our study result showed difference in care as odds were lower for deaths in hospital which is private. While odds of same hospital is higher for severe injuries. The two public hospitals have lower odds of severe injuries. Another publication from same database used for this study reported hospital as the determinant of survival after road injury of any road user after adjusting for age, type of injury, injury severity, and time since injury and mode of transport.(35)

These hospitals are located in three districts and geographical spread is not very diverse across city of 3780 kilometers square. It is situated not more than 11 km at maximum to each other. Some of the districts have lower odds of severity of injuries. One such district has public tertiary care hospital that is included in this paper that showed lower odds of severity. Odds of midblock crashes are higher for severity of injuries. Previous study also showed that crashes in intersections involving children and adolescents have slighter injury outcomes.(36) Another study showed front seated passengers in cars had higher odds of severity of injuries.(37) Low speed in intersections could be reason for less severity than mid- block crash.

Helmet use is known to reduce head injury by 69% and death by 42%. In our study, no helmet use by motorcyclists has higher odds of severe injuries with statistical significance but higher odds of deaths with no use of helmet have overlapping confidence interval. However paper from same data showed decrease likelihood of death with helmet use in all age motorcyclists irrespective of driver or passenger. As we discussed above, survival is dependent on many other factors including hospital care and severity. Lack of resources, high volume, lack of treatment protocols and limited audit of quality of care are some of the barriers in hospitals. Helmet use is very low in our country due to many reasons such as tropical weather, lack of safety and lenient enforcement.(38, 39) Our study did not show significant odds of night time, weekends and season however another paper from the same database that included all age motorcycle riders and passengers’ analysis showed higher odds of fatal injuries. Their eligibility criteria and the way they categorized season and time were different than ours.(15) Another paper from another city of Pakistan reported weekday crashes of motorcycles had higher likelihood of fatal injuries.(32)

We believe lot can be done to prevent unlawful acts of driving such as underage driving or driving without a license. Motorcycle is transport for low and lower middle class so underage driving might be due to need within a family. The society of Pakistan is conservative and woman driving a motorcycle is very rare. The women use motorcycle as passengers, sit with legs on one side as deemed modest way of sitting. In such households sometime underage boys drive motorcycle to help commute women of the house. In addition, there is the thrill of driving as well as a teenager. There is a need to debate how to make laws that are easy to follow in local context such as early licensing age with mandatory helmet use and licensing test for new riders should with mandatory helmet possession to encourage safety. The emphasis on quality and timely provision of trauma care systems that include prehospital care.

Limitations: Missing data was a challenge and we missed around 15, 000 entries however the analysis of this study would contribute to literature of young road users. The details related to license was not available so age groups based on our assumptions related to license according to legal age could be misclassified. For example adolescent 18 years old might not receive license despite of legal age.

Conclusion: The age groups of young motorcyclists that were based on legal driving age and driving experience is not associated with increased risk of road deaths or severity of injuries but underage driving .has high volume in Pakistan. Helmet use, road structure, transporting vehicle, hospital, district of crash, GCS were related to deaths and injury severity.

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