Journal of ISOSS
2023 Vol. 9(1), 99-110

IDENTIFICATION OF ASSOCIATED FACTORS TO FATAL AND NON-FATAL ROAD CRASHES: A CASE STUDY OF DISTRICT RAWALPINDI PAKISTAN

Muhammad Kamran Kiani, Muhammad Zakria
and **Muhammad Mushtaq**
Allama Iqbal Open University, Islamabad, Pakistan
Email: kamran.kiyani@aiou.edu.pk
zakria@aiou.edu.pk
muhammad.mushtaq@aiou.edu.pk

ABSTRACT

It is a fact that Fatal and Non- Fatal Road crashes are directly proportional to the increase of population and vehicles on the road. Rawalpindi has become the third densely populated district of Pakistan along with significant increase in road crashes. In this study, the significant factors about fatal and non-fatal road crashes are identified using 19,657 road crashed registered at rescue 1122 during 2017 and 2018 and 1,573 road crashed reported cases to police department during 2013-2017, District Rawalpindi, Pakistan. The analysis revealed that 56.4% of road crashes were because of motorbikes while 32.2% were because of Cars/LTVs. Mostly road crashes occurred during peak hours and the road crash victims belonged to the age bracket ≤ 13 and 50+ Years. The fatal road crashes (%) on clear days is slightly higher than the rainy days. In addition, the Logistic regression was applied and identified the significant variables of fatal road crash based on odds ratio. The Logistic regression parsimonious model correctly classifies the cases by 91.2%. The findings of the analysis may be utilized by district government in formulating a comprehensive road safety policy.

KEYWORDS

Road Crash, Logistic Regression, Wald test, Odds Ratio.

INTRODUCTION

Road Crash refers to an accident involving at least one vehicle and one person fatal or non-fatal within 30 days on a public traffic road accident. The World Health Organization, Global Status Report for Road Safety (2015, 2018) mentioned that more than 1.35 million people die every year in road crashes while 20-50 million suffer due to serious injuries. The road crash is considered the 5th substantial cause of death specifically in developing countries by 2030. Consequently, the reduction in road crash fatality is one of the targets set by UN General Assembly Sustainable Development Goals (SDGs) to halve global road traffic fatalities by 2015. Ministry of Communication-Pakistan (2015) reported that the Road crash fatality in Pakistan is highest than India, Japan, Sri Lanka, UK and USA per 10,000 vehicles due to 95% freight road traffic. In addition, Pakistan road crash fatality is higher than the Europe while in Europe the vehicle damage is higher than Pakistan. Batool et al. (2018) analyzed the information of 461 road crashes district Lahore. Eleven plausible potential factors were considered as explanatory variables. The Logistic regression

technique was applied and concluded that over speeding as well as 2 and 3-wheelers were the most significant factors in most road crashes. Rolison et al. (2018) revealed that use of drugs i.e., alcohol, inexperience drivers, over speeding, road condition and road distractors i.e., cell phone usage, looking kids at the back seats etc. were significant causes behind most of the road crashes in UK. Ahmed (2017) used the logistic regression to model the 212 registered road crashes at directorate-traffic and concluded that the over speeding was the major cause of road crash fatality in Garmian, Iraq. Arain et al. (2017) indicated that 57.30% of injuries were due to fall from heights and 12.5% injuries due to road crash district Rawalpindi whereas 27% did not use the free service of Rescue 1122.Sikdar et al. (2017) analyzed road crash cases occurred in India during 1996-2000 and found that most of the road crash cases were occurred by Cars/LTVs during peak hours. Imran and Nasir (2015) fitted the 3rd degree polynomial curve using the road crash data of Pakistan January 2003 to December 2012 and found that the road crashes are directly proportional to the density of vehicles on road. Karacasu et al. (2013) used the logistic regression and discriminant analysis to classify the fatal and non-fatal road crashes of Eskisehir Province, Turkey. The findings showed that vehicle type, driver's education and road surface played vital role in road crash. Chen et al. (2012) used the logistic regression for the classification of fatal road crash to non-fatal casualties in Victoria, Australia. The findings revealed that the fatal odds ratio is higher at junctions. Sarkar et al. (2011) applied the Logistic regression to Model the risk of Vehicle–Pedestrian fatality Crashes on National Highways, Bangladesh. The study revealed that most of the road crash victims were pedestrians and motor bike riders. Dhakal (2018) concluded that the young bike riders were involved in most of the fatal road crashes in Kathmandu valley, Nepal. Oyedepo and Oluyemisi (2010) explored the causes, magnitude, and financial impact of road crashes for Kenya and found that more than 75% of road crash casualties/victims were of young population. Al-Ghamdi (2002) applied the logistic regression using urban road crash fatality data of Riyadh, Capital of Kingdom of Saudi Arabia and revealed that the fatal odds ratio was very high at road crash junctions, wrong side violations and running on red lights. Tay et al. (2009) identified the contribution of main factors to Hit-and-Run fatal crashes in Singapore and California respectively by fitting logistic regression. Ponnaluri (2012) discussed the fatal road crashes in rural, suburban, and urban part of the district Andhra Pradesh, India and concluded that rural part had high road crash fatality than the urban. Tabibi et al. (2023) identified that the children with attention-deficit/hyperactivity disorder (ADHD) have a high risk of getting road traffic injuries. So, the Pedestrians as well as the children, specifically of age 9-13 years under attention disorder should be extra supervised while crossing the roads. Parenteau and Viano (2022) studied the size and age of drivers who had fatal road crashes during 1998-2020 in the USA. The study revealed that drivers 50+ years of age and having an average weight 80.4+ kg had more fatal road crashes irrespective of the other demographic and socio factors.

Problem Statement

Keeping in view the significance of fatal and non-fatal road crash real life phenomena, the current study was designed to investigate the causes of increased road crash Rawalpindi district than the other cities of Punjab as well as to accomplish the targets 3.6 and 11.2 of SDG "Good Health" and "Sustainable Cities and Communities". The findings of the analysis may also be considered by the district Government in formulating a comprehensive road safety policy.

Data, Study Design and Model Specification

The authentic sources of road crash information in Pakistan are Rescue 1122 and Central Police Office, Pakistan. Originally, 19,657 road crash cases were recorded by Rescue 1122 during 2017 and 2018 and 1573 registered road crashes at Central Police Stations, Rawalpindi district during 2013-2017.The data classified in seven categorical variables i.e., Road Crash (Fatal, Non-Fatal), Victim's age (≤13 Years, 14-49Years, 50+), Vehicle type (Motorbike, 3-wheeler, Car/LTV, PSV/HTV, Pedestrian), Road Crash Cause (Over speeding, Careless, Negligence at U-turn, Wrong Lane Switching, Mechanical Failure), Weather (Clear, Cloudy, Rainy, Foggy), License Status (Yes, No), Driver's age (18-29 Years, 30-50Years, 51+). The road crash variable was considered as binary response variable and the most popular statistical technique i.e., binary logistic regression model was applied for identification and classification purposes.

The mathematically form of the logistic regression model is as under

$$Y_i = \begin{cases} 1, & Fatal\ Road\ Crash \\ 0, & Non-Fatal\ Road\ Crash \end{cases}$$

$$log\left(\frac{\pi}{1-\pi}\right) = logit(\pi) = \beta_0 + \beta_1 X_{1i} + \beta_2 X_{2i} + \cdots + \beta_k X_{ki}$$ (Allison, 2012, PP-17)

RESULTS AND DISCUSSION

This section comprises the description of the data, suitable analysis, interpretation of results and conclusions.

Table 1
Frequency Distribution of Vehicle Type, Road Crash Cause and Nature of Crash District Rawalpindi

Vehicle Type	Over Speeding		Careless -ness		Negligence at U-Turn		Wrong Lane Switching		Mechanical Failure		Total (%)
	Non Fatal (%)	Fatal (%)	Non Fatal (%)	Fatal (%)	Non Fatal (%)	Fatal (%)	Non Fatal (%)	Fatal (%)	Non Fatal (%)	Fatal (%)	
Motorbike	5775 (52.1)	1520 (13.7)	894 (8.1)	2404 (21.7)	163 (2.1)	42 (0.6)	75 (0.7)	23 (0.2)	128 (1.2)	56 (0.5)	11080 (56.4)
3-Wheelers	600 (45.8)	381 (29.1)	52 (4.0)	217 (16.6)	23 (1.8)	21 (1.6)	8 (0.6)	15 (1.2)	5 (0.4)	3 (0.2)	1310 (6.7)
Car/ LTVs	3279 (51.9)	1221 (19.3)	197 (3.1)	1256 (19.9)	124 (2.0)	71 (1.1)	79 (1.2)	8 (0.1)	57 (0.9)	31 (0.5)	6323 (32.2)
PSV/ HTVs	276 (29.2)	207 (21.9)	82 (8.7)	311 (32.9)	9 (1.0)	7 (0.7)	6 (0.6)	18 (1.9)	9 (1.0)	19 (2.0)	944 (4.8)
Total	**9930 (50.5)**	**3329 (16.9)**	**1225 (6.2)**	**4188 (21.3)**	**319 (1.6)**	**190 (1.0)**	**168 (0.9)**	**64 (0.3)**	**199 (1.01)**	**109 (0.6)**	**19657 (100.0)**

- Data Source: Punjab Emergency Service Rescue 1122 during 2017 & 2018, District Rawalpindi
- Over speeding means violation of national Speed limit. Carelessness means driving without observing mandatory road signs, side view mirrors, seatbelt, etc. Negligence at U-Turn and Wrong Lane Switching means ignoring correct Lane marking and opposite traffic.

Table 2
Frequency Distribution of Road Crash time, Victim's Age and Nature of Road Crash District Rawalpindi

Crash Time	Victim's Age	Non-Fatal (%)	Fatal (%)	Total (%)
6am- 11:59am	≤ 13 Years	9(4.89)	175(95.10)	184(3.49)
	14-49 Years	2806(68.00)	1309(32.00)	4115(78.04)
	50+	408(41.89)	566(58.11)	974(18.74)
	Sub Total	**3223(27.21)**	**2050(26.22)**	**5273(26.83)**
12pm-5:59pm	≤ 13 Years	25(7.18)	323(92.82)	348(4.72)
	14-49 Years	3727(64.4)	2063(35.6)	5790(78.56)
	50+	481(39.04)	751(60.04)	1232(16.72)
	Sub Total	**4233(35.74)**	**3137(40.13)**	**7370(37.49)**
6pm-11:59pm	≤ 13 Years	22(12.3)	157(87.7)	179(2.96)
	14-49 Years	3471(68.1)	1628(31.9)	5099(84.27)
	50+	318(41.14)	455(58.9)	773(12.77)
	Sub Total	**3811(32.18)**	**2240(28.65)**	**6051(30.78)**
12am-5:59am	≤ 13 Years	1(5.26)	18(94.74)	19(1.97)
	14-49 Years	522(62.37)	315(37.63)	837(86.92)
	50+	51(47.66)	56(52.34)	107(11.11)
	Sub Total	**574(4.84)**	**389(4.97)**	**963(4.90)**
Total		**11841 (60.24)**	**7816 (39.76)**	**19657 (100)**

Data Source: Punjab Emergency Service Rescue 1122 during 2017 & 2018, District Rawalpindi

Table 1 revealed the frequency distribution of road crash cause and vehicle type. It was observed that in 19,657 road crashes in district Rawalpindi during 2017 and 2018, there were 11,080 road crashes in which motorbikes were involved. Over speeding was the leading cause of road crashes in the district. Whereas maximum fatal road crashes occurred due to carelessness of the driver. Moreover, the road crash cases by Car/LTVs were also not too few i.e., about 32.2% which is the second highest vehicle type. There were also many fatal and non-fatal road crashes due to other causes and vehicle types, but their frequency is less as compared to the said causes and motorbike. When we compare our findings with our neighboring countries like Nepal, India, and Bangladesh we find that Youngsters riding bikes and driving cars were also involved in maximum number of accidents in these countries as well. The findings are consistent with that of the study (Sikdar et al., 2017).

Table 2 describes the frequency distribution of three characteristics i.e., Crash Time, Victim's Age and Nature of Road Crash with the categories 4, 3 and 2 respectively. Out of 19,657 road crash victims, while the remaining 11841 and 7816 were injured and expired respectively. The maximum victims were recorded 5790 within time clock 12pm-5:59pm of age bracket 14-49 years. And during the other time intervals, about 5099, 4115 and 837 victims of the same age bracket were recorded within 6pm-11:59pm, 6am-11:59am and

12am-5:59am respectively. The reported victims of age 50+ were 1232, 974, 773 and 107 during 12pm-5:59pm, 6am-11:59am, 6pm-11:59pm and 12am-5:59am respectively. The WHO's reports on road safety (2013) also indicates that children under 14 years of age were the leading fatal road crash victims around the globe. However, the maximum road crash victims fall in the age bracket 14-49 Years. Almost similar results were found in the study (Dhakal, 2018)

Table 3
Test of Independence of Road Crash and Weather Condition District Rawalpindi

Road Crash	Clear	Cloudy	Rainy	Foggy
Non-Fatal	4625 (4641.3)	667 (679.3)	4291 (4203.6)	2258 (2263.1)
Fatal	3222 (3236.7)	624 (605.9)	2484 (2489.2)	1486 (1496.4)
$\chi^2_{(3)} = 2.799$, P-Value = 0.081				

Data Source: Punjab Emergency Service Rescue 1122 during 2017 & 2018, District Rawalpindi

Table 4
Parameter Estimates of Logistic Regression and Test Statistics

Variables	B	S. E	Wald	df	P-Value	Exp(B)
Crash Time (T)						
(12am-5:59am)	**Ref.**					1.000
6am-11:59am (T_1)	-0.025	0.081	0.09	1	0.761	0.976
12pm-5:59pm (T_2)	-0.179	0.083	4.64	1	0.031	0.836
6pm-11:59pm (T_3)	-0.167	0.082	4.12	1	0.042	0.846
Crash Cause (C)						
(Mechanical Failure)	**Ref.**					1.000
Carelessness (C_1)	2.485	0.154	260.83	1	0.000	**11.996**
Over speeding(C_2)	0.151	0.151	1.00	1	0.318	1.163
Negligence at U-Turn(C_3)	0.467	0.184	6.41	1	0.011	1.594
Wrong Lane Switch (C_4)	0.82	0.198	17.10	1	0.000	2.270
Vehicle Involved (V)						
(3-Wheeler)	**Ref.**					1.000
Bike(V_1)	-0.87	0.068	164.58	1	0.000	0.419
HTV/PSV(V_2)	0.06	0.1	0.36	1	0.049	1.062
LTV/CAR(V_3)	-0.447	0.07	41.07	1	0.000	0.640
Victim's Age (A)						
(14-49 Years)	**Ref.**					1.000
≤13 Years(A_1)	3.237	0.144	505.81	1	0.000	**25.465**
50+ Years(A_2)	0.817	0.047	306.68	1	0.000	**2.263**

Variables	B	S. E	Wald	df	P-Value	Exp(B)
Weather Condition (W)						
(Clear)	**Ref.**					1.000
Cloudy(W_1)	0.187	0.072	6.82	1	0.009	1.206
Fogy(W_2)	-0.64	0.053	147.03	1	0.000	0.528
Rainy(W_3)	-0.305	0.04	58.81	1	0.000	0.737
C1*W3	2.47	0.74	11.14	1	0.001	**11.822**
C2*W3	2.83	1.27	4.97	1	0.003	**16.945**
C1*W1	1.23	1.17	1.11	1	0.000	**3.421**
V1*W3	1.82	1.15	2.50	1	0.001	**6.172**
V2*W2	1.31	1.13	1.34	1	0.005	**3.706**
V3*W3	1.58	1.27	1.55	1	0.007	**4.855**
V1*C2	1.96	1.24	2.50	1	0.001	**7.099**
V1*C4	2.01	1.48	1.84	1	0.000	**7.463**
V2*C3*T3*W2	3.04	1.29	5.55	1	0.002	**20.905**
V1*C1*T1*A1	2.81	1.12	6.29	1	0.000	**16.610**
T2*A1*V1*C4*W3	3.09	1.03	9.00	1	0.002	**21.977**
T1*A1*V3*C3*W2	2.93	1.02	8.25	1	0.003	**18.728**
Intercept	1.13	1.12	1.02			

Hosmer Lemeshow χ^2 = 0.814 > 0.05; Deviance P-value = 0.0021; -2Log Likelihood = 123.1.12 > 0.05; Nagelkerke R^2 = 0.614

Table 3 illustrates the test of association between road crashes and weather. The P-value = 0.081 describes the independence of two attributes i.e., weather and road crash. It may conclude that data do not have sufficient evidence that road crashes occur due to weather conditions. The findings are in consistent with the studies (Batool et al., 2018). To examine the effect of recorded causal variables on the road crash nature i.e., fatal, and non-fatal, the binary logistic regression model was fitted on the available information and the following parsimonious model was found. Table 4 presents the fitted logistic regression model along with test statistics of significant parameter estimates. Factors behind each road crash such as Time (T), Crash Cause (C), and Vehicle involved (V), Victim's Age (A) and Weather Condition (W) were recorded by rescue 1122 and are treated as independent variables. All these factors/variables are of categorical nature, one applicable category in each factor is declared as a reference category for the analysis and interpretation purposes. The chances of fatal road crash due to wrong lane switching while riding a bike in a rainy day during 12pm-5:59pm were 21.977 times more whereas the passenger of age ≤ 13 years (A_1) travelling in Car/LTV vehicle on fogy day during the time 6am-11:59am have had odds 18.728 times more. Similarly, the Carelessness bike rider travelling with victim ≤ 13 years old during the time 6am-11:59am have had fatal road crash odds 16.610 times more to non-fatal. On the other hand, the fatal road crash odd was recorded 20.905 times more while driving the PSV/HTV in foggy weather & exercising the negligence at U-turn during 6pm-11:59pm. The findings indicated that overspeed on motorbike as well as Car/LTV during rain have had fatal road crash odds 7.099 and 4.855 respectively. Carelessness and

over speeding driving in rain have had fatal road crash odds 11.822 and 16.945 times more than non-fatal respectively. Whereas careless driving during cloudy weather, have 3.421 times more chances of fatal road crash than non-fatal. On the other hand, simple cloudy weather has had odds i.e., 1.206 times more chances of fatal road crash as compared to clear weather. The first parsimonious model based on information Rescue 1122 road crash district Rawalpindi is as under: the results agree with that of the study (Malik & Tariq, 2012).

$$\begin{aligned}\log(odds) = {} & 1.13 + 0.817A_2 + 0.187W_1 + 2.47(C_1 \times W_3) + 2.83(C_2 \times W_3) \\ & + 1.23(C_1 \times W_1) + 1.58(V_3 \times W_3) + 1.96(C_1 \times V_1) \\ & + 3.04(V_2 \times C_3 \times T_3 \times W_2) \times 2.81(V_1 \times C_1 \times T_1 \times A_2) \\ & + 1.13((V_3 \times C_3 \times T_1 \times A_1 \times W_2)\end{aligned}$$

Table 5
Frequency Distribution of Road Crash Victims
District Rawalpindi during 2013-2017

Road Crash Victims	Non-Fatal (%)	Fatal (%)	Total (%)
Bike Riders	307 (46.2)	357 (53.8)	664 (42.1)
3-Wheeler	24 (61.5)	15 (38.5)	39 (2.5)
Car/LTV	113 (58.9)	79 (41.1)	192 (12.2)
PSV/HTV	18 (45.0)	22 (55.0)	40 (2.6)
Pedestrian	403 (63.2)	235 (36.8)	638 (40.6)
Total	**865 (55.0)**	**708 (45.0)**	**1573 (100.00)**

Data Source: CPO office District Rawalpindi during 2013-2017, Analyzed in Table 5-7

Table 5 represents the frequency distribution of road crash victims recorded by police department, district Rawalpindi during 2013-2017. It was observed that 42.1%, 40.6% and 12.2% victims were bike riders, pedestrians, and Car/LTV drivers respectively. Out of these percentages, 53.8%, 36.8% and 41.1% fatality belong to the bike riders, pedestrian, and car/LTV respectively. It indicates that a very high % of victims belong to the 2-wheeler, and pedestrian. Overall, approximately 45% of total 1573 victims were fatal and 55% non-fatal respectively.

Table 6
Frequency Distribution of Road Crash Station wise District Rawalpindi during 2013-2017

Station/ Area	FIRs (%)	Victims (%)	Deaths (%)	Injuries (%)	Station/ Area	FIRs (%)	Victims (%)	Deaths (%)	Injuries (%)
Airport	77 (4.9)	110 (4.6)	43 (39.1)	67 (60.9)	Naseer Abad	25 (1.6)	94 (4.0)	28 (29.8)	66 (70.2)
Banni	23 (1.5)	33 (1.4)	10 (30.3)	23 (69.7)	New Town	46 (2.9)	57 (2.4)	15 (26.3)	42 (73.7)
Cantt	29 (1.8)	41 (1.7)	10 (24.4)	31 (75.6)	Pir Wadhai	23 (1.5)	46 (1.9)	12 (26.1)	34 (73.9)
Chontra	77 (4.9)	153 (6.5)	33 (21.6)	120 (78.4)	Wah Cantt	44 (2.8)	62 (2.6)	22 (35.5)	40 (64.5)
City	24 (1.5)	42 (1.8)	11 (26.2)	31 (73.8)	Race Course	41 (2.6)	44 (1.9)	14 (31.8)	30 (68.2)
Civil Lines	94 (6.0)	103 (4.3)	22 (21.4)	81 (78.6)	RA Bazar	16 (1.0)	21 (0.9)	9 (42.9)	12 (57.1)
Gujar Khan	123 (7.8)	179 (7.5)	69 (38.6)	110 (61.4)	Ratta Amral	28 (1.8)	42 (1.8)	22 (52.4)	20 (47.6)
Ganjmandi	14 (0.9)	19 (0.8)	12 (63.2)	7 (36.8)	Rawat	108 (6.9)	143 (6.0)	63 (44.1)	80 (55.9)
Jatli	37 (2.4)	57 (2.4)	21 (36.8)	36 (63.2)	Sadiq Abad	40 (2.5)	42 (1.8)	14 (33.3)	28 (66.7)
Kahuta	116 (7.4)	215 (9.1)	42 (19.5)	173 (80.5)	Sadar Beruni	65 (4.1)	98 (4.1)	33 (33.7)	65 (66.3)
Kallar Syedan	51 (3.2)	80 (3.4)	21 (26.3)	59 (73.7)	Saddar Wah	113 (7.2)	180 (7.6)	72 (40.0)	108 (60.0)
Mandra	67 (4.3)	88 (3.7)	39 (44.3)	49 (55.7)	Taxila	110 (7.0)	157 (6.6)	64 (40.8)	93 (59.2)
Morgah	41 (2.6)	65 (2.7)	19 (29.2)	46 (70.8)	Waris Khan	64 (4.1)	68 (2.9)	20 (29.4)	48 (70.6)
Murree	61 (3.9)	107 (4.5)	41 (38.3)	66 (61.7)	West Ridge	16 (1.0)	25 (1.1)	9 (36.0)	16 (64.0)
Total						**1573 (100.0)**	**2371 (100.0)**	**790 (33.3)**	**1581 (66.7)**

Table 6 revealed that the station wise registered road crashed cases, district Rawalpindi along with victims %, Death % and Injuries %. The registered road crash cases in Gujar Khan, Kahuta, Sadar Wah, Taxila, Rawat, old airport & Chontra were 123, 116, 113, 110, 108, 77 respectively and so on. The minimum cases i.e., 14 were registered in the Ganj mandi area. The findings disagreed with the conclusions of (Ponnaluri, 2012). It might be because of violation of speed limits by careless drivers on a single rural and suburban road in conjunction with the density of bicyclists, motor bikers, pedestrians, LTV/HTV vehicles as well as the domestic and wild animals etc.

Table 7
Parameter Estimates of Logistic Regression and Test Statistics

Variables	B	SE	Wald	df	Sig	Exp(B)
Crash Cause (C)						
Over speeding	**Ref.**					**1.000**
Carelessness (C1)	-1.077	1.38	0.609	1	0.001	0.341
Negligence at U-Turn (C2)	-0.216	0.179	1.456	1	0.03	0.805
Vehicle Type (V)						
3-Wheeler	**Ref.**					**1.000**
Motorbike (V1)	0.123	1.417	0.008	1	0.003	**1.131**
Car/LTV(V2)	0.128	1.215	0.011	1	0.001	0.226
PSV/HTV(V3)	0.019	1.113	0.000	1	0.048	**1.019**
Driver's Age (A)						
30-50 years	**Ref.**					**1.000**
18-29 years (A1)	0.622	1.411	0.194	1	0.039	**1.863**
51+ years (A2)	0.814	1.025	0.603	1	0.001	**2.256**
C1 * V1	-1.103	0.697	2.504	1	0.001	0.332
C1 * V2	0.825	0.47	3.081	1	0.003	**2.283**
C2 * V3	-0.202	0.736	0.075	1	0.003	0.817
C2 * V2	-0.632	0.565	1.251	1	0.002	0.531
C2*A1	0.342	0.361	0.898	1	0	**1.407**
C2*A2	0.315	0.476	0.438	1	0.003	**1.37**
V1*A1*C2	1.001	1.369	0.535	1	0.001	**2.718**
V2*A2*C1	1.364	1.499	0.828	1	0.003	**3.912**
V3*A2*C1	-0.506	1.491	0.115	1	0.002	0.603
V2*A2*C2	1.813	1.156	2.46	1	0.001	**6.127**
V1*A1*C1	1.152	3.624	0.101	1	0.004	**3.165**
Intercept	0.019					

Hosmer Lemeshow χ^2 = 0.0938 > 0.05; Deviance P-value = 0.007; -2Log Likelihood = 12.547 > 0.05; Nagelkerke R^2 = 0.541

Table 7 shows the parameter estimates of fitted logistic regression model on registered road crash data recorded by police stations, District Rawalpindi. The odd ratio corresponding to Careless motorbike driver of age 18-29 years old have 3.165 times more chances of fatal to non-fatal however, a car/LTV driver of age 51+years showing negligence at U-turn have almost double chances or have 6.127 times more chances of fatal to non-fatal. Remarkably, the driver of age 51+ years old has 2.256 times more chances fatal to non-fatal than that of the driver of age 30-50 years old. Correspondingly, the Car/LTV careless drivers of age 51+ years old and negligence motor bikers of age 18-29 years old have odds of 3.912 and 2.718 times more chances of fatal road crash to non-fatal. Similar findings about elderly drivers were found in the research paper (Zhang et al., 2000). The second parsimonious model using FIRs Road crash information, CPO office district Rawalpindi is as under:

$$\log(odds) = 0.019 - 1.077C_1 + 0.128V_2 + 0.019(V_3) + 0.814(A_2) - 0.202(C_2 \times V_3) + 1.001(V_1 \times A_1 \times C_2) + 1.364(V_2 \times A_2 \times C_1) + 1.813(V_2 \times A_2 \times C_2) \times 1.152(V_1 \times A_1 \times C_1)$$

Table 8
Validity of the Classification Logistic Regression Models

Predicted Membership					**Predicted Membership**				
Actual Membership	Non-Fatal		Fatal	**Correct %**	**Actual Membership**	Non-Fatal		Fatal	**Correct %**
	Non-Fatal	**10898**	943	**92.04**		Non-Fatal	**737**	128	**85.20**
	Fatal	581	**7237**	**92.59**		Fatal	58	**650**	**91.81**
Overall Percentage				**92.26**	Overall Percentage				**88.18**
AEPR=7.74%					**AEPR=11.82%**				

Data Source: Rescue 1122 District Rawalpindi Data Source: CPO District Rawalpindi

Table 8 illustrates the actual and predicted membership classification using the fitted logistic regression models. The fitted model correctly classified the objects by 92.59% with only APER (7.74%) for the data rescue 1122 and correctly classified the objects by 88.18% with APER (11.82%) for the data CPO district Rawalpindi. The fitted logistic regression model was found to be almost equally good for both the data sets.

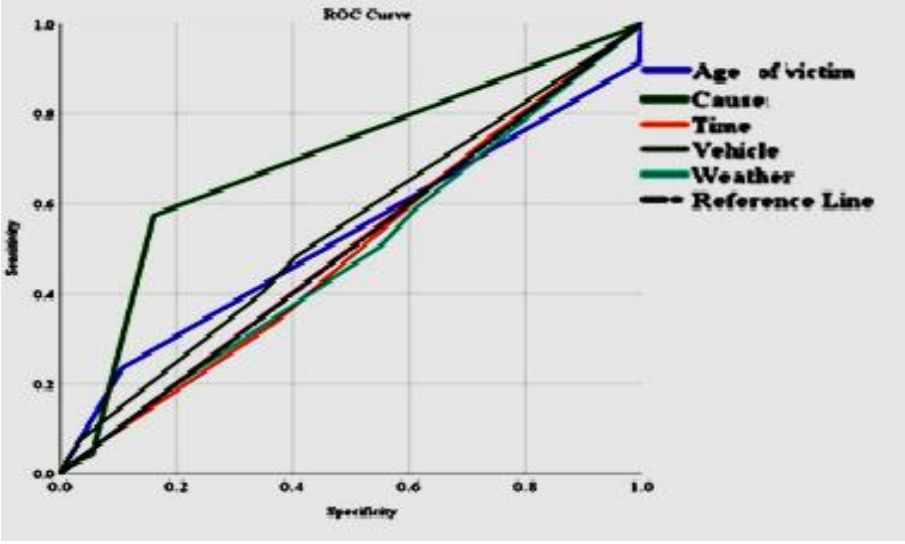

Figure 1: ROC Curve of Fatal Road Crash Recorded by Rescue 1122

Figure 1 revealed that the road crash frequency increased by over speeding, Carelessness at U-Turn and frequent lane switching as well as victim's age as compared to other associated factors i.e., crash time, weather condition and vehicle type etc.

CONCLUSIONS & RECOMMENDATIONS

The findings revealed that Risk of fatal road crashes for pedestrians, as well as for children and elderly people are on the top of the list in district Rawalpindi. Furthermore, the results indicate that the main causes of fatal road crashes were the driver's carelessness, non-observing and disobeying the traffic safety rules throughout the irrespective of the weather conditions. Due to these horrible causes and effects, the road crash chances increased from 16.610 to 21.977 times more than non-fatal. The motorcycle proved to be the most unsafe vehicle in district Rawalpindi especially for children and young bike riders. It indicates that the district needs to take priority considerations and actions for the good health Goal by achieving target 3.6 and 11.2 of SDG(s). It may be in the form of a comprehensive road safety policy aligned with global sustainable development goals. As for the district of developing country with limited resources, the road users may reduce the number of accidents by obeying the safety traffic rules and showing a responsible attitude. The study may be extended for other district of the province as well as of the country.

REFERENCES

1. Ahmed, L.A. (2017). Using Logistic Regression in Determining the Effective Variables in Traffic Accidents. *Applied Mathematical Sciences*, 11(42), 2047-2058.
2. Al-Ghamdi, A.S. (2002). Using Logistic Regression to Estimate the Influence of Accident Factors on accident severity. *Accident Analysis & Prevention*, 34(6), 729-741.
3. Allison, P.D. (2012). *Logistic regression using SAS*: *Theory and application*. SAS institute.
4. Arain, A., Niazi, K., Aatif, M. and Ahmed, W. (2017). Demographic Determinants of Physical Injuries in Rawalpindi: Role of Rescue 1122. *JIMDC*, 6(3), 148-152.
5. Batool, I., Hussain, G., Kanwal, N. and Abid, M. (2018). Identifying the Factors Behind Fatal and Non-Fatal Road Crashes: A Case Study of Lahore, Pakistan. *International Journal of Injury Control and Safety Promotion*, 25(4), 1-7.
6. Bujang, M.A., Sa'at, N., Bakar, T.M.I.T.A. and Joo, L. C. (2018). Sample size guidelines for logistic regression from observational studies with large population: emphasis on the accuracy between statistics and parameters based on real life clinical data. *The Malaysian journal of medical sciences*, 25(4), 122-130.
7. Chen, H., Cao, L. and Logan, D.B. (2012). Analysis of Risk Factors Affecting the Severity of Intersection Crashes by Logistic Regression. *Traffic Injury Prevention*, 13(3), 300-307.
8. Dhakal, K.P. (2018). Road traffic accidents in Kathmandu valley. *Journal of Health Promotion*, 6(1), 37-44
9. Imran, M. and Nasir, J.A. (2015). Road traffic accidents. The Professional Medical Journal, 22(6), 705-709.
10. Karacasu, M., Ergül, B. and Altin, A.Y. (2013). Estimating the Causes of Traffic Accidents Using Logistic Regression and Discriminant Analysis. *International Journal of Injury Control and Safety Promotion*, 21(4), 305-313.
11. Oyedepo, J.O. and Oluyemisi, O. (2010). Accident Prediction Models for Akure-Ondo Carriageway, Ondo State Southwest Nigeria; Using Multiple Linear Regressions. *An International Multi-Disciplinary Journal, Ethiopia*, 4(2), 30-49.

12. Pakistan Breau of Statistics (2017). Provisional province wise population by sex and rural/urban census-2017 Pakistan, (pp. 1-13).
13. Ponnaluri, R.V. (2012). Road traffic crashes and risk groups in India: Analysis, interpretations, and prevention strategies. *IATSS Research,* 35(2), 104-110.
14. Parenteau, C.S. and Viano, D.C. (2022). Size and age of fatal drivers by crash type, vehicle type and gender. *Traffic injury prevention*, 23(11), 1-5.
15. Rolison, J.J., Regev, S., Moutari, S. and Feeney, A. (2018). What Are the Factors That Contribute to Road Accidents? An Assessment of Law Enforcement Views, Ordinary Drivers' Opinions, and Road Accident Records. *Accident Analysis and Prevention,* 115(2018), 11-24.
16. Sarkar, S., Tay, R. and Hunt, J.D. (2011). Logistic Regression Model of Risk of Fatality in Vehicle-Pedestrian Crashes on National Highways in Bangladesh. *Journal of the Transportation Research Board,* 22(1), 128-137.
17. Sikdar, P., Rabbani, A. and Dhapekar, N.K. (2017). Hypothesis of data of road accidents in India-review. International *Journal of Civil Engineering and Technology (IJCIET),* 8(6), 141-146.
18. Tabibi, Z., Schwebel, D.C. and Juzdani, M.H. (2023). How does attention deficit hyperactivity disorder affect children's road-crossing? A case-control study. *Traffic Injury Prevention*, 24(2), 1-6.
19. Tay, R., Barua, U. and Kattan, L. (2009). Factors Contributing to Hit-and-Run in Fatal crashes. *Accident Analysis & Prevention,* 41(2), 227-233.
20. Tay, R., Rifaat, S.M. and Chin, H.C. (2008). A Logistic Model of the Effects of Roadway, Environmental, Vehicle, Crash and Driver Characteristics on Hit-And-Run Crashes. *Accident Analysis & Prevention,* 40(4), 1330-1336.
21. World Health Organization. (2013). Global status report on road safety 2013. Retrieved from:https://apps.who.int/iris/bitstream/handle/10665/44122/9789241563840eng.pdf;jsessionid=06196A393E704F3418F7240D8DB01066?sequence=1
22. World Health Organization. (2015). Global status report on road safety 2015. Retrieved from:http://www.who.int/violence_injury_prevention/road_safety_status/2015/en/
23. Zhang, J., Lindsay, J., Clarke, K., Robbins, G. and Mao, Y. (2000). Factors Affecting the Severity of Motor Vehicle Traffic Crashes Involving Elderly Drivers in Ontario. *Accident Analysis & Prevention,* 32(1), 117-125.