iJRASET
International Journal For Research in
Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 10 Issue: II Month of publication: February 2022

DOI: https://doi.org/10.22214/ijraset.2022.40116

Accident Analysis and Method Comparison of Finding Black Spots on M-2(Lahore-Islamabad) Motorway, Pakistan

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Abstract: The purpose of this research is to locate the black spot on the Lahore-Islamabad Motorway and investigate the elements that contribute to traffic accidents (M2). The National Highways and Motorway Police (NHMP), Pakistan, provided 10 years of road accident data for this research. A total of 375 kilometres of M-2 were included in this study's database of sixteen hundred fifty two traffic accidents. Time, sector, beat, severity, casualty, severity index, weather, and other variables are taken into account while analysing the 2010-2020 crash data for M-2. The accident patterns and trends on various road segments have been analysed. Cars (50 percent), trucks (15 percent), buses (eight percent), and Hiace (seven percent) are the most susceptible vehicles (7 percent). More than two-thirds of accidents are caused by reckless driving (28%) or sleeping at the wheel (27%) or tyre bursts (11%) or mechanical faults (8%) or slick roads (5%) or incorrect pedestrian crossings (5%). (4 percent). In both Europe and Asia, several methodologies are used to identify problem areas. An overview of the approaches employed in Austria, Belgium, and India is presented in this work. Kallar Kahar (Salt Range) was classified as a "black spot" as a consequence of these approaches due to the large number of accidents that occur there (223 km, 224 km, 225 km, 229 km, 234 km, 195 km, and 283 km). Vehicle braking failure is the leading cause of car accidents. Because human error is a key component in car accidents, teaching drivers about traffic safety via traditional and new media may help reduce the number of collisions. Alarms and tyres monitoring gauges are advised to prevent mishaps caused by sleeping and tyre rupture.
Keywords: Road Traffic Accidents, Traffic Safety, Black Spots, Motorway, Dozing alarms.

I. INTRODUCTION

The development of a country's road network is one of the most essential aspects in its economic and social growth. For a country with a huge population, Pakistan needs a wide range of modes for transport, including air and land. The road network is the sole mode of transportation capable of providing door-to-door service and reaching all corners of the globe. That's why building and maintaining our country's transportation network is so critical. The country's road system is well-established. In compared to other means of transportation, highways carry about 92 percent of all passenger and freight traffic with a current road density of 0.32 kilometres per square kilometre. Due of its high utility, public transit relies on it heavily.[1]

The primary goal of transportation networks is to move people and commodities in a safe, convenient, and efficient manner. Road safety is the most crucial and fundamental part of the transportation system, since road traffic accidents may have a negative impact on an individual's social and economic well-being, as well as resulting in a country's loss of GDP. According to a World Health Organization (WHO) report, road traffic accidents are the eighth (eighth) major cause of mortality worldwide. Road traffic accidents cost low- and middle-income nations like Pakistan 3% of their annual GDP, according to the World Health Organization. The overall amount of development aid that poor nations get from all across the globe is almost double that amount. Road accidents in Pakistan cost the country's economy roughly 3% of GDP. According to a World Health Organization (WHO) report, road traffic-related accidents are the eighth biggest cause of mortality worldwide. Road traffic accidents claim the lives of more than 1.35 million people each year, and injure an additional 50 million. This means that every day, 3700 people are killed on the roads throughout the globe. For children and young adults ages 5 to 29, road traffic accidents are the most common cause of mortality. [2].

Transportation safety is a long-standing concern of the engineers, who are always looking for ways to improve the system. The safety of transportation has become a grey area as a result of socio-economic and human issues and calls for more attention from highway safety management. Third-world nations are increasingly turning to freeway management, which places a focus on fixing safety concerns in order to build the public's confidence in the nation's expensive highway infrastructure. As a result, accidents play a critical role and may be used as a gauge for the safety of any roadway.

After the installation of highways in Pakistan, transportation engineers and managers confront new issues in roadway safety. Because of the high-speed dynamics involved, highway management necessitates more precise attention to safety hazards. Since poverty and poor literacy rates have made mechanical transportation inefficient, it is vital for a transportation manager to come up with the most suitable solutions in the most real-time situations. It has been decided that Islamabad–Lahore Motorway (M-2) is the best option for analysing the causes of accidents, taking into account all relevant factors in Pakistan's current situation. So Approximately 4,087 (43.18%) of all traffic accidents in Pakistan between 2010 and 2020 resulted in death; the remaining 5,377 (56.82% of all accidents) were nonfatal.

This means that on average, 26 people die on Pakistan's roads every day, according to the Pakistan Bureau of Statistics for the years 2020-2021 [3].

There has been a 282% rise in the number of fully enlisted engines from 2010 to 2020, with an average annual increase of 28.16 percent, according to the Pakistan Economic Overview 2020-2021. Every year, Pakistan is plagued by road traffic accidents and the resulting loss of life and property damage, which is a major problem. Despite several efforts, the situation on the roads has deteriorated fast and is already at a catastrophic point. As a first step in making Pakistan's roads safer, we need to thoroughly study the data on road traffic accidents in order to determine the most common causes of accidents, and then implement preventative measures in order to avoid those causes.[4]

This research has a two-dimensional impact. To begin, it investigates the possible causes of the greatest number of collisions on M2. Road accidents are also affected by environmental, mechanical, human, road geometry, and accident timing characteristics. In order to minimise the number of car accidents, it is vital to pinpoint the contributing variables and devise countermeasures that address the most pressing issues in road safety. As a second step, the identification of black spots on the road network serves as the basis for a comprehensive traffic safety programme that aims to enhance road safety conditions in the region. According to prior study, a black spot is any site where the number of accidents is larger than the number of accidents in comparable road locations (i.e., within the same region or on the same road). To find the best answer, we want to investigate how and where a countermeasure to prevent traffic accidents might be implemented. To do this, we'll employ various methodologies from across the globe to identify the black spots on highways.

II. LITERATURE REVIEW

There are almost 885,000 deaths from road accidents annually and total causalities number goes up to 10 million. Studies done by WHO show that road accidents account for 2.5% of total deaths. But in age group of 5-44 years, it is as high as 10% and is among six leading causes of death. Motor vehicle accidents rank first among all total accidents throughout the world [5].

A study conducting on a regional basis showed that the Asia-Pacific region has the greatest share of road deaths which is 44%, whereas the region has only 16% of total registered vehicles. They further observed that between 1987-1995 period road deaths increased by 40% in the Asia- Pacific. Conversely, road deaths fell by about 10% in developed countries. World Health Organization published a report on Global Status on Road Safety.

Comparing both the Global Status report on Road Safety published in the years 2013 and 2018 it is observed that annual deaths from RTAs increased from 1.24 million to 1.35 million globally witnessing a nearly 9% increase in the annual RTA deaths. Moreover, during the period 2013 to 2018 fatality rate remained the same which are 18 deaths per 100,000 population. The number of vehicles increased globally from 1.9 to 2.1 billion during the same period hence death rate per registered vehicle declined and in 2016 it is reported to be around 64 deaths per 100,000 registered vehicles compared to the 70 deaths in the year 2013. Although statistics suggest that the severity of RTAs is reducing but progress varies significantly from different areas of the world. [6].

Any location or site that shows an accident possible that is expressively high when associated with some ordinary accident possible resulting from a set or group of similar location is known as Black spot. At a specific place, usually, the number of road accidents or accidents will differ extensively on yearly basis, even though if traffic, road plan or layout is same. In mathematical relations, highway accidents at distinct locations are infrequent, casual, multifactor events. The accident black spot mentions to a segment or section of a road viewed as a high-risk place or location for vehicle accidents [7].

Another description of black spot is that in which any site or location which have length 100m and during the last five year, 4 injuries accidents have been noted. The numerical meaning of the accident black spot depends on the evaluation and assessment of the number of recorded accidents to the usual number for a similar category of site and location. As an example, taken a junction, it is considered as a black spot, if the noted Figure of a road accident in a definite period is more than the normal figure of accidents for this sort of junction [8].

A task of improving sites in existing road system, having problems, through alterations of geometric design elements and environmental features is called Black spot safety work. More specifically, it targets specific sites, intersections and road sections which have surprisingly high number of casualties, often called black spots. Above mentioned phases are further described in sections below [9].

1) Targeting black spots on the highway network.
2) Prioritizing the black spots to treat with safety improving measures.
3) Before and after studies of the effect of treatment.

Furthermore, following four approaches are used to reduce crashes by applying engineering treatments [9]:

a) Single sites or black spots-treating specific sites or short sections of road;
b) Route action-applying known remedies on a route with an abnormally high crash rate;
c) Area-wise action-applying several treatments over a wide area; and

Mass action-applying a known remedy to locations with common crash problems or causal factors.

However, merely crash history, identification of black spots and prioritizing them cannot be relied upon, local knowledge about site and accidents trends should also be used along with statistical information.

There are two basic national data system that are maintained by the National Highway Traffic Safety Administration (NHTSA). The Fatality Analysis Reporting System (FARS) responsibility is to record all fatal accidents in country. Accident reports filed by police in case of fatal accidents is the primary source of information. The second system is the General Estimates System (GES) which is more general system and includes information on all types of accidents on highways like fatal, injuries and property damage only (PDO) [10].

The accident studies are fundamentally different as compare to other traffic parameters because of the infrequent and random times and places of accident occurrence. All accident data comes primarily from police. All basic information is incorporated in this data. The system of gathering, storing and recovering this information is usable and its well-organized form is an absolute requirement. This accident data is required to meet a wide range of purposes, including but not limited to [10]:

- To identify locations where high or unusual number of accidents occur, also called black spots.
- Detailed functional evaluations of these black spots in order to find accident causes.
- To develop a statistical model using factors related to accidents, so as to have an idea about general accident trends, common factors related to casualties and driver profiles.
- To develop a procedure that help identification of hazardous locations before occurrence of large number of accidents.

The data is collected in the form of reports filled by police officer who is present on the accident location. Police reports generally contain fatal or serious injuries, minor injuries and PDO’s are not reported frequently. Data collected by police is one of the most reliable sources of information. Police reports are approximately filed for 50% of the total accidents [10].

A comprehensive and consistent RTAs data is necessary for justifiable transport safety policy and health sector. Analysis of data collection system in Pakistan revealed that usually accidents which involve minor injuries or PDO are underreported, people report only major or fatal accidents. Further details show that young people reported at a very less rate to both police and Punjab Emergency Response Service (PERS) at rate of 17% and 50% respectively. Underreporting is observed mostly in case of non-fatal accidents and young people, the reason may be carelessness of this age group people and people do not take non-fatal accidents very seriously [11].

III. PROBLEM STATEMENT

In Pakistan, road safety is a major concern. Accidents caused by road traffic are the eighth largest cause of mortality worldwide, according to a report from the World Health Organization (WHO). According to figures from the World Health Organization, road traffic accidents cost low- and middle-income nations like Pakistan 3% of their annual GDP. About 3% of Pakistan's GDP is spent on traffic accidents each year. Accidents caused by road traffic are the eighth biggest cause of mortality in the world, according to a report from the World Health Organization (WHO). There are more than 1.35 million people who die and 50 million who are wounded in road traffic accidents every year, which means that 3700 people die on the highways every day. The greatest cause of mortality for children and young people aged 5 to 29 is road traffic injuries. In the last ten years, from 2010 to 2020, Pakistan experienced an average of 9,464 traffic accidents, with 4,087 (43.18 percent) resulting in death and the remaining 5,377 (56.82 percent) resulting in injury.

This means that on average, 26 people died every day on Pakistani roads as a result of traffic accidents [12]. For a long time, transportation experts have been concerned about safety and have worked tirelessly to improve the system's security. In emerging nations, this issue is growing at an alarming pace because of the need for high-speed Internet and other considerations. The issue, however, isn't given the attention it deserves in emerging nations, such as Pakistan As a matter of urgency, those who occupy positions of authority in this area must acknowledge this situation as a health catastrophe and implement appropriate measures to deal with it. In Pakistan, the injury-to-fatality ratio is 2.2:1 compared to 10-15:1 in affluent nations. Even in a developed nation like Pakistan where 25,000 to 30,000 people are killed every year in road accidents, it is essential to do research into the causes of these incidents and devise ways to prevent them. Pakistan is building additional roadways, and a research like this one will assist to reduce the risk of accidents and deaths [12].

IV. OBJECTIVES

The main objectives of this study are:

1) Find out black spots & suggest the workable optimum solution.
2) Method comparison to identify the black spots and find best suitable method at local condition.
3) To analyse the cause of black spots at M-2.
4) Suggest the best possible solution to improve the safety factor of M-2.

V. STUDY AREA

The National Highway and Motorway Police (NH&MP), which is in charge of collecting and organizing accident data, provided the crash data for the M-2 expressway (M-2). A site with an unusually high number of accidents should do extensive research and analysis to identify the factors that may be contributing to the incidents, and then take steps to enhance workplace safety as a result of the findings. If the site is classified as a "high accident" area, thorough information is needed to understand how accidents occur at each individual place on the site. In order to retrieve the NH&MP gear, a fantastic mischance report form was designed to include all the necessary details about the incident. Often it is done in two steps, Manual Record and Computerized Record. Engineers then perform analysis on these locations in order to develop countermeasures to reduce problems and improve safety.

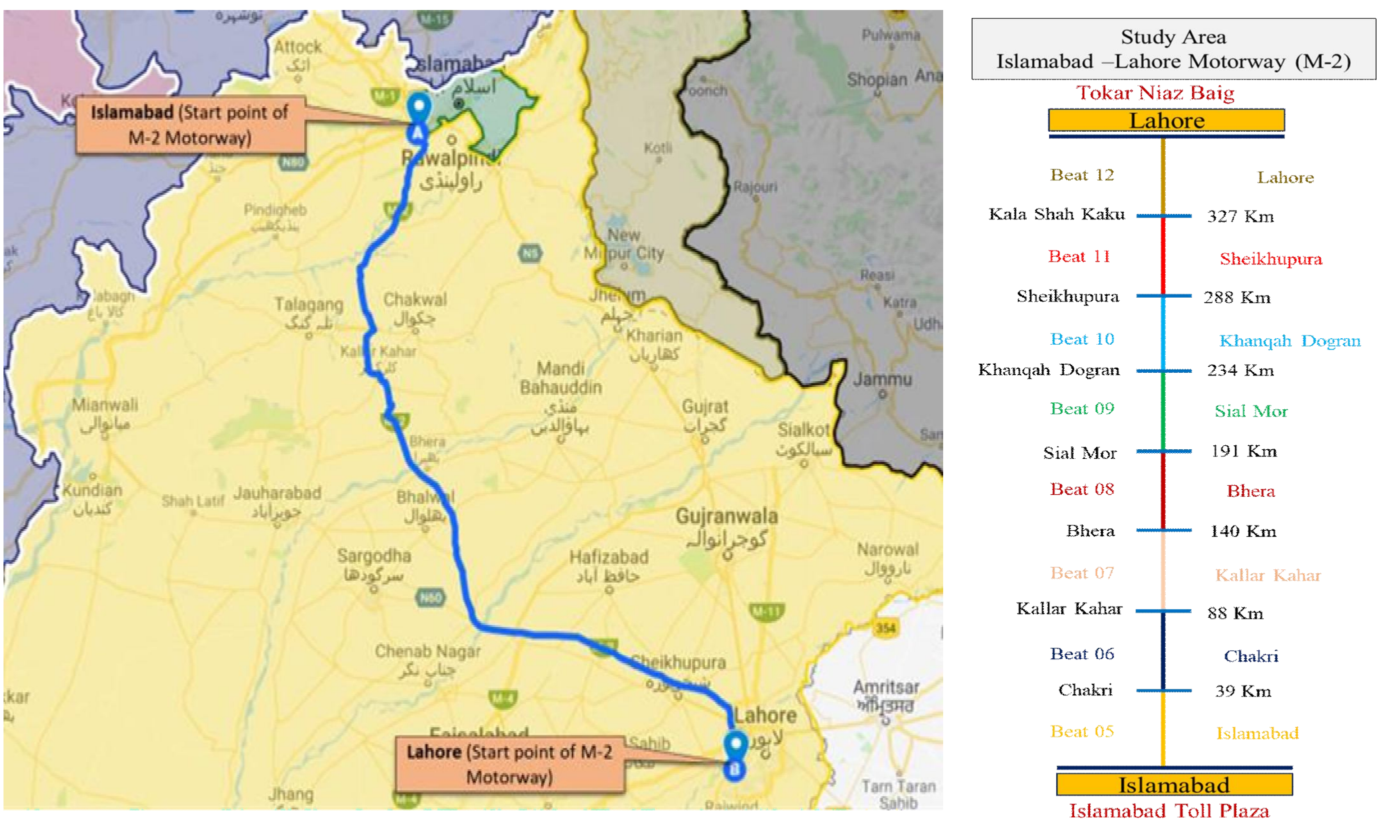

Fig. 1 Alignment Map of Study Area (M-2 Motorway)

ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 10 Issue II Feb 2022- Available at www.ijraset.com

VI. DATA DESCRIPTION

NHMP, Pakistan's National Highways and Motorway Police (NHMP), has provided the research data for M2 accidents from 2010 to 2020. It was possible to use more current data since it came in a standard format. Excel was used to sort the data by contributing variables, time of day, and year. It is difficult to conduct a thorough analysis of road accident reports in Pakistan since they are often produced in text form. In Pakistan, accident reports contain information on the date, time, and location of the incident, as well as the severity of the accident, the kind of vehicle involved, the number of people wounded or killed, and any contributing circumstances. It is essential that accurate, detailed, and trustworthy information on traffic accidents be gathered in order to take the necessary precautions.

VII. DATA ANALYSIS

A. Time Wise Analysis

Accident's data collected for Islamabad – Lahore motorway M- 2 have been analysed using Statistical and MS excel software to determine the time-wise distribution of accidents on M-2 which also helps in the determination of yearly, monthly, hourly analysis of data and to determine the time of day and factors which causes more accidents Firstly, the accident is summarized based on time such that yearly, monthly, daily, hourly, and according to day/night. Accident frequencies are calculated and are shown on the graph in the preceding sections.

B. Year Wise Analysis

In the case of Yearly Analysis ten years of data from 2010-2020 are used. The accident's frequencies are calculated and shown on the graph. The overall trends are inspected based on the years. The figure shows the year-wise accidents analysis. 2015 is the year with the greatest number of accidents cases on M-2 having a frequency of 272.

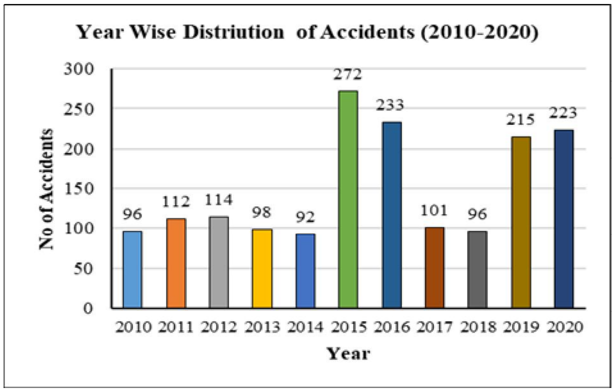

Fig. 2 Year wise distribution of Accidents on M-2 (2010-2020)

C. Month Wise Analysis

Accidents are also summarized based on month-wise. The total number of accidents is calculated in each month for the total ten years such that in the case of January, the total number of accidents for the year 2010 - 2020 are obtained and shown on the graph similarly the whole procedure is repeated for all twelve months of the year. Figure shows the month-wise accidents analysis. From the figure, it is clear that on motorway M-2 most accidents occurred in the month July is 169 (10.20%) while least accidents occurred in January are 105 (6.40%).

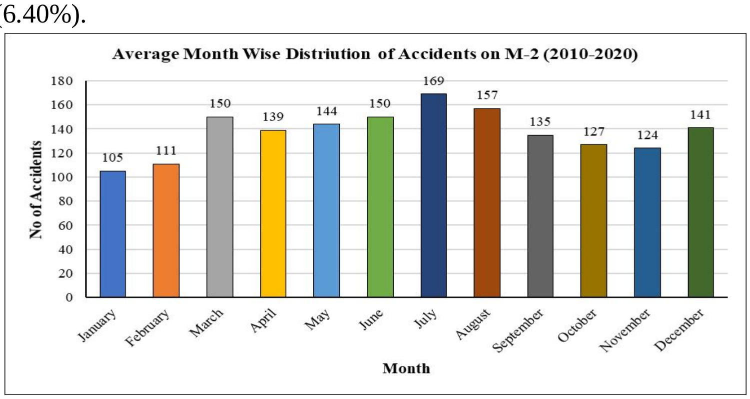

Fig. 3 Month-wise distribution of Accidents on M-2 (2010-2020)

D. Day Wise Analysis

Accident data have been analyzed by day-wise for ten years from 2010 to 2020 which helps in the identification of a particular day with the high number of accidents. Identification of the peak day will help in determining the factors associated with the reoccurrence of accidents on that particular day. The figure shows the total number of accidents that occurred in the last ten years on each day of the week. The figure shows that the maximum number of accidents that occurred on Sunday which are 265 (16%) followed by Tuesday with the frequency of 245 (14.80%)

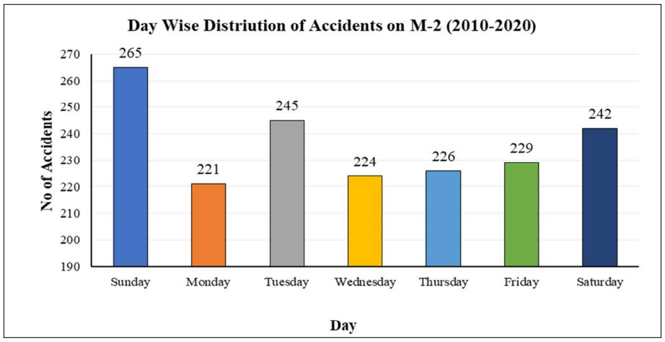

Fig. 4 Day wise (Average) distribution of Accidents on M-2 (2010-2020)

The figure shows the day-wise analysis of accidents from the year 2010 to 2020 based on accidents severity. It can be observed from the figure that the maximum number of fatal accidents occurred on Sunday (99) followed by Tuesday (97), while in case of non-fatal accidents Sunday and Friday are on top with frequency of 166 and 161 respectively.

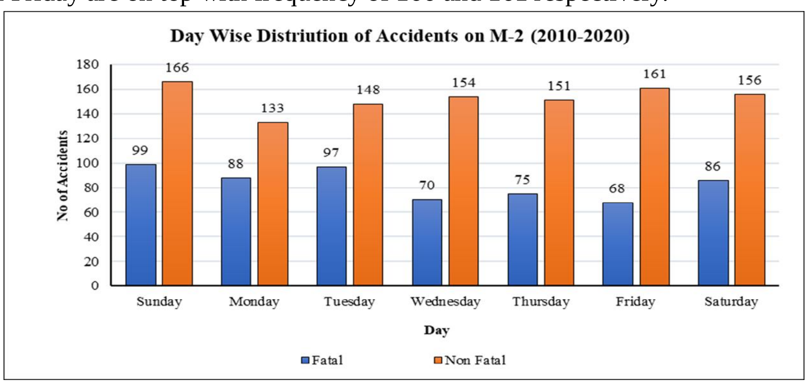

Fig. 5 Day wise (Average) distribution of Accidents on M-2 (2010-2020) for fatal and non-fatal accidents

E. Day/night wise analysis

The accident's data analyses has been carried out day and night. The day is observed from 0600 hours (morning) to 1800 hours (evening) and night from 1800 hours (evening) to 0600 hours morning. Day/night analysis are carried out for Motorway M-2 for the last 10 years' accidents data. The figure shows the day/night analysis of accidents data which shows that 52% of accidents occurred during day time while 48% of accidents occurred during night time.

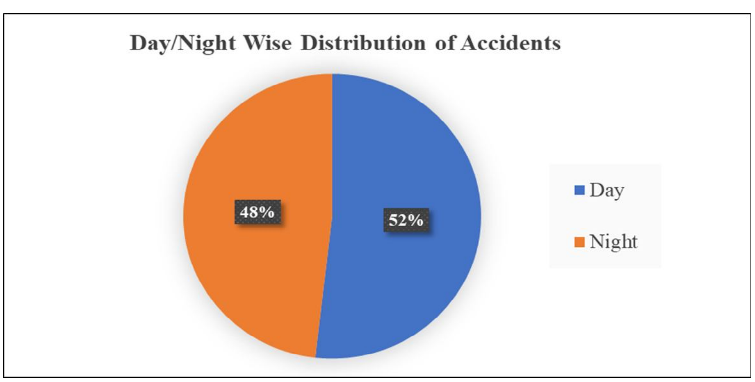

Fig. 6 Day wise (Average) distribution of Accidents on M-2 (2010-2020) for fatal and non-fatal accidents

The figure shows the analysis of accidents data based on day and night for M-2 from year 2010 to 2020. It can be observed from the figure that maximum accidents occurred during the year 2015 with 143 accidents during daytime and 129 accidents during night-time.

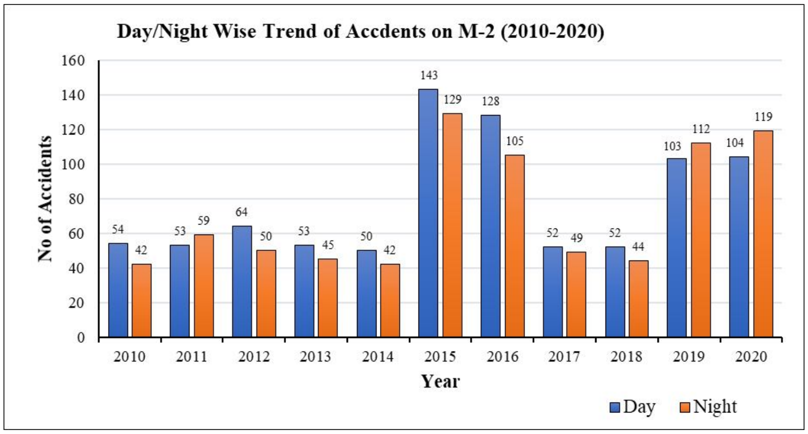

Fig. 7 Day/Night wise (Average) distribution of Accidents on M-2 motorway (2010-2020)

F. Beat wise analysis

Islamabad – Lahore motorway M-2 is composed of 8 beats. Accidents data from the year 2010 to 2020 has been analyzed according to beats. The frequency of accidents is found for all beats and compare the beats to know which beats cause a greater number of accidents. On Motorway, the most frequent accident occurring beat is 07 which starts from Kallar Kahr to Bhera, and it has a total length of 52 km. This area consists of salt range so mostly accidents are higher in this beat. The figure shows the distribution of accidents on Motorway beats.

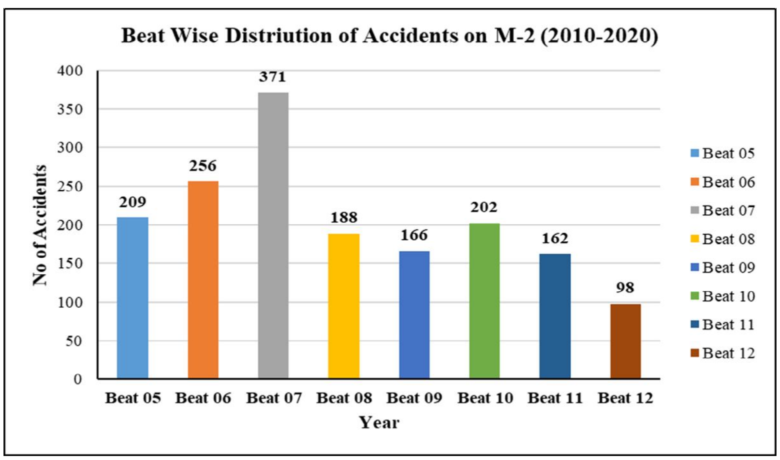

Fig. 8 Beat wise percentage distribution of Accidents on M-2 motorway (2010-2020)

Figure shows beat wise distribution of the number of accidents, it can be observed from the figure that the maximum number of accidents 371 occurred on beat 07 from the year 2010 to 2020, while a smaller number of accidents occurred on beat 12 which is the last portion of motorway M-2 from Kala shah Kaku to Lahore.

G. Severity index wise analysis

The severity index (SI) is defined as the number of people who died per accident. It can be calculated by dividing the total number of fatalities by the total number of accidents. The severity index is widely used as a statistical parameter for describing the severity of the relative accident. It can be observed from the figure below that the maximum severity index has been calculated for the year 2017 with an SI of 0.584 which means that 0.584 fatalities occurred per accident in the year 2017 while the least number of severity index observed for the year 2015 which is 0.246 despite that maximum number of accidents occurred during the year 2015 this shows that the maximum number of accidents in the year 2015 are non-fatal as shown in table 1.

Table I
Severity Index analysis of accidents data for M-2 motorway from year 2010 to 2020

Year	Fatal	Non-Fatal	Total	Severity Index
2010	38	58	96	0.36
2011	39	73	112	0.348
2012	48	66	114	0.421
2013	36	62	98	0.367
2014	35	57	92	0.380
2015	67	205	272	0.246
2016	78	155	233	0.335
2017	59	42	101	0.584
2018	37	59	96	0.385
2019	68	147	215	0.316
2020	78	145	223	0.350

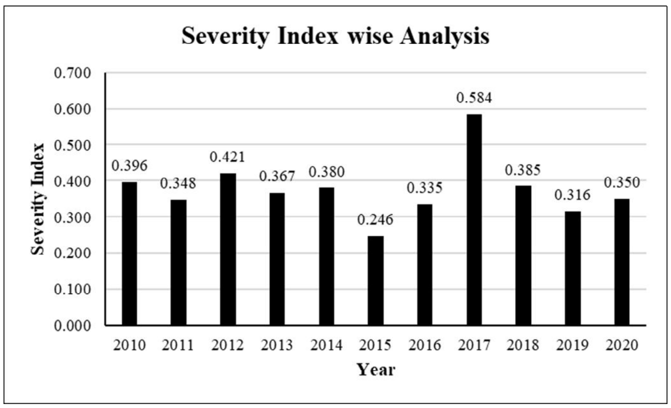

Fig. 9 Severity index wise Analysis of Accidents data on M-2 for each year (2010-2020)

H. Direction Wise Analysis

The direction of Motorway M-2 is represented by two ways such that Alpha and Bravo. Alpha represents the direction from Islamabad to Lahore (M-2 South) while Bravo represents the direction from Lahore to Islamabad (M-2 North). As per the analysis of accidents data from the year 2010-2020, the accidents that occurred in the Alpha direction are 38%, and in the Bravo direction are 62%. The accident in the Bravo direction is greater as compared to the Alpha direction. Mechanically there is a certain limit up to which a vehicle can sustain pressure and temperature after those brakes fail. Certain critical lengths are also followed that a slope can have a certain length after those vehicles cannot keep control. Bravo direction has more accidents only because of Northbound lane has problems of climbing that heavy vehicle finds difficult to climb in Kallar Kahar section and having sharp curves. The figure shows the distribution of accidents on Alpha and Bravo direction of Motorway M-2.

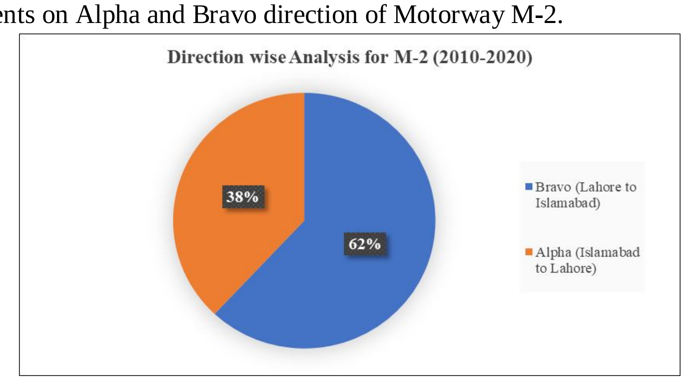

Fig. 10 Direction wise percentage distribution of Accidents data on M-2 motorway (2010-2020)

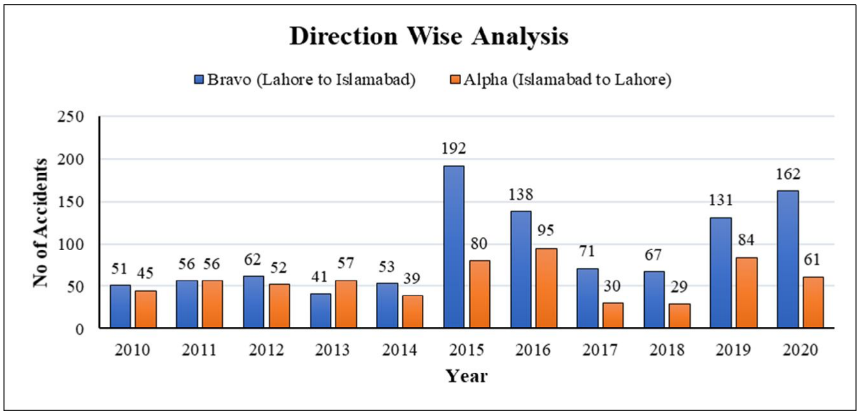

Fig. 11 Direction wise Analysis of Accidents data on M-2 for each year (2010-2020)

I. Accident Severity Wise Analysis

Severity-wise analysis includes fatal, non-fatal, and property damage only. Fatal are those accidents in which at least one person died, non-fatal are those accidents in which people are not dead but are injured. Property damaged accidents are those accidents in which there are neither people dead nor injured but only loss occurs in the form of property like a public or private property. The public property contains damage of Traffic Control Devices, Traffic Lights, road construction, etc. private property includes damage to vehicles, etc. Composition of fatal, non-fatal, and property damaged are found for ten years (2010-2020) for motorway M-2. On Motorway the composition of accidents is fatal 35%, non-fatal 53% and Property damaged are 12%.

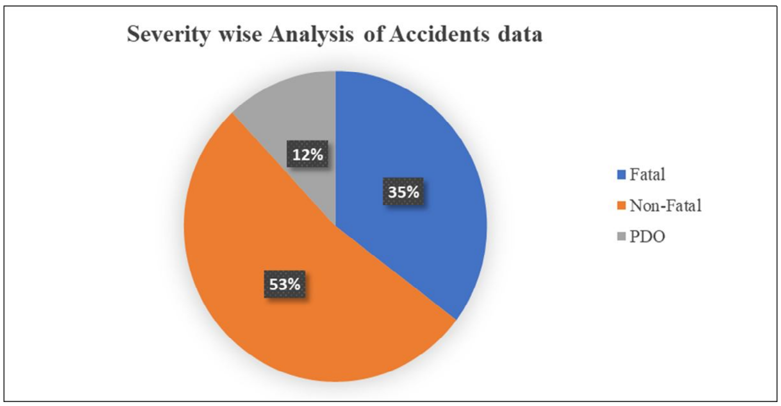

Fig. 12 Accident's severity wise Analysis of Accidents data on M-2 for each year (2010-2020)

The figure below also shows the frequency of accidents severity on Motorway M-2 for the years 2010 to 2020.

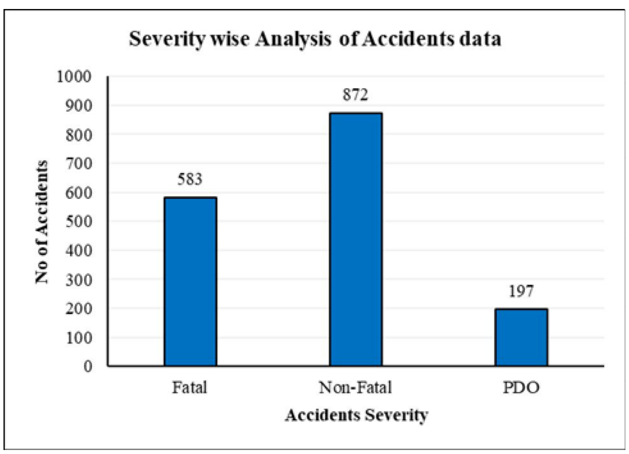

Fig. 13 Frequency distribution of accidents based on Severity of accidents (2010-2020)

J. Casualty Wise Analysis

Casualty-wise analysis means analysis based on the number of people dead and injured throughout the study duration (2010- 2020). The frequency of all the people dead and injured are calculated and are presented in the figure. Accident data were analysed to calculate the year with a maximum number of fatal and non-fatal accidents. On Motorway M-2 the total number of people dead is 583 and injured is 842 out of a total 1652 accidents while the remaining 197 are property damage only. The figure also shows that the maximum number of fatal accidents (47) occurred during the daytime are in the year 2016 while the maximum number of non-fatal accidents (38) occurred during nighttime in the year 2020. The figure also shows that the maximum number of non-fatal accidents (113) during daytime occurred in the year 2015 while the maximum number of non- fatal accidents (81) occurred during nighttime in the year 2019 and 2020.

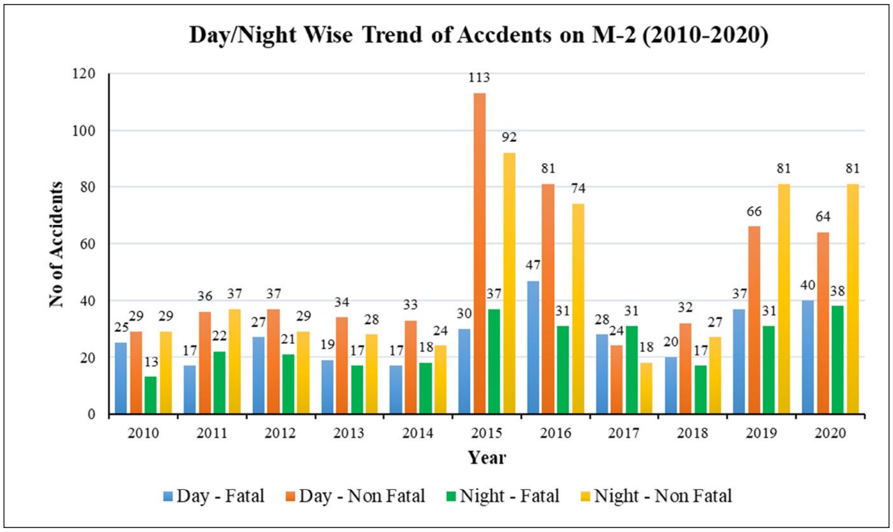

Fig. 14 Causality wise analysis of accidents for M-2 motorway for each year based on day and night (2010-2020)

K. Accident cause wise analysis

Accidents data for M-2 have been analysed based on cause of the accident. Accidents are happened due to many reasons which are discussed here. In this study accidents are analysed based on the following reasons. The various causes that are considered here are: Careless Driving, Dozing at Wheel, Tire burst, Mechanical fault, Slippery Road, Improper Crossing by Pedestrian, Over Speeding, Brake Failure, Other Reason, and Drunk Driver etc. After analysis it is concluded that mostly accidents occur on motorway is due to Careless Driving (28%), dozing at Wheel (27%), Tire burst (11%), Mechanical fault (8%), Slippery Road (5%), Improper Crossing by Pedestrian (5%), Over Speeding (5%), Brake Failure (4%) etc.

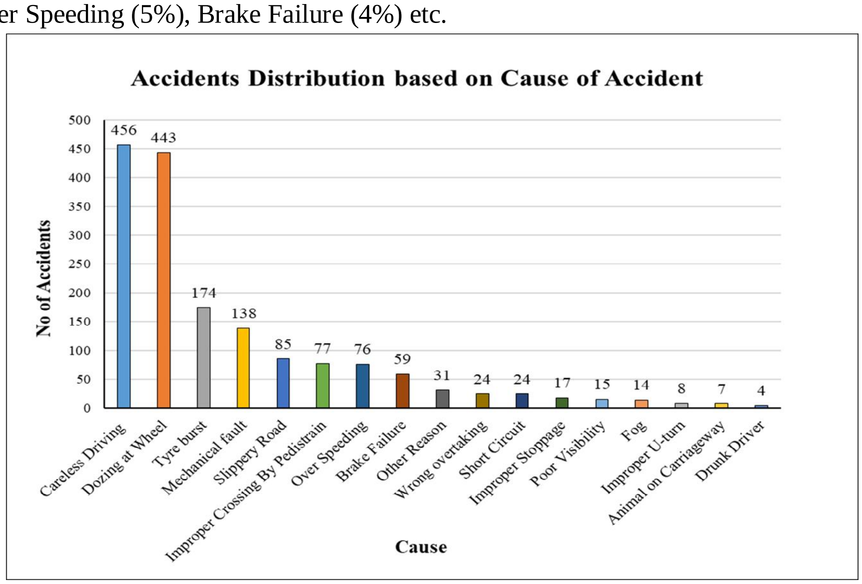

Fig. 15 Frequency distribution of accidents on M-2 motorway based on cause of the accident (2010-2020)

L. Collision Type Wise Analysis

Accident data are also analysed based on collision type of accidents to know which type of collision is more vulnerable to accidents on motorway M-2. Accidents frequencies for different collision types involved in accidents have been calculated for all ten years of data (2010-2020). These values are then compared to find out which collision type causes more accidents. It has been observed from analysis of data that 27% of accidents occurred due to Nose to tail collision type, 24% due to roll over, 17% due to hit from the rear side, 5% due to vehicle turned turtle, etc. The figure shows the frequency of the number of accidents based on collision type.

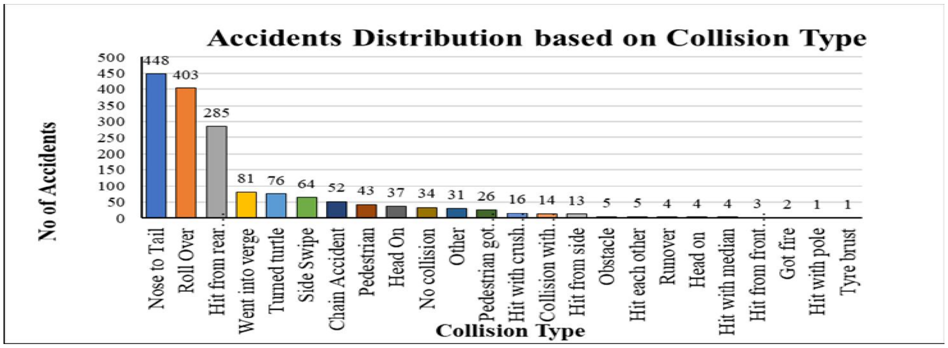

Fig. 16 Frequency distribution of accidents on M-2 motorway based on cause of the accident (2010-2020)

VIII. BLACK SPOT IDENTIFICATION METHODS

Following methods are used to identify the Blackspots:

A. Austria method

When it comes to Austrian road construction and maintenance guidelines (RVS 1.21), which was released in November 2002, the term "black patches" is used. Black spots and dangerous places are designated in accordance with this guideline based on their reported crash history [13]. A black spot must meet one of the following two conditions:

1) More similar injury accidents within 3 years and a relative coefficient Rk of at least 0.8. The value of this coefficient is calculated as follows:

a) R_K =U/ (0.5 + 7xl0-5xAADT)

b) Where:

c) AADT = Annual Average Daily Traffic [vehicles/24 hours]

d) U = Number of injury accidents within 3 years

e) AADT=26000 (M-2 Year 2021)

2) At least 5 accidents (including property damage only) of similar type within one year. Since 1995 property damage accidents are not recorded in Austria, hence black spot management primarily relies on the first definition.[13]

Table II

Top 10 blackspot location identified by Austria method

Beat	KM	Accidents	AADT	R_k
Beat-07	223	16	26000	6.90
Beat-07	224	15	26000	6.47
Beat-07	225	14	26000	6.03
Beat-06	283	12	26000	5.17
Beat-07	229	12	26000	5.17
Beat-06	287	10	26000	4.31
Beat-05	350	9	26000	3.88
Beat-07	234	9	26000	3.88
Beat-08	195	9	26000	3.88
Beat-09	149	9	26000	3.88

Table II presents top 10 blackspot location identified by Austria method. The top most blackspot location is KM 223 of beat 07 which has R_k value of 6.90 and sixteen (16) accidents are involved.

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 10 Issue II Feb 2022- Available at www.ijraset.com

B. Flanders Method

When defining a "black spot" for traffic accidents, the following criteria are used in Flanders: According to police records cited by Geurts (2006):

Those locations where three or more accidents have happened in the past three years are chosen for further investigation. The following formula determines if a location is unsafe when its priority (S) score is 15 or above.[13]

$$S = LI + 3SI + 5DI$$

1) The total number of minor injuries is designated as LI.
2) Injury severity index (SI) (For each patient who is hospitalized for more than 24 hours)
3) Injuries that result in death (Each casualty that died within 30 days after the accident)

There are "dark spots" in the three years of accident data.

Table III
top 10 blackspot location identified by Flanders method

Beat	KM	Accidents	Total No of Deaths	Total No of Major Injuries	Total No of Minor Injuries	S=LI+3SI+5DI
Beat-10	100	8	9	13	2	86
Beat-08	175	6	13	6	2	85
Beat-11	41	8	6	18	0	84
Beat-07	229	12	8	12	4	80
Beat-07	224	15	8	11	3	76
Beat-07	223	16	13	0	10	75
Beat-07	225	14	10	3	10	69
Beat-06	295	6	2	18	1	65
Beat-06	281	7	4	14	2	64
Beat-06	283	12	3	11	12	60

Table 3 presents top 10 blackspot location identified by Flanders method. The top most blackspot location is KM 100 of beat 10 which has S value of 86 with eight (8) accidents involved. Thirteen (13) major injuries and sixteen (16) minor injuries are also recorded.

C. Accident Severity Index (ASI) Method

The Accident Severity Index (ASI) was generated based on the information gathered. Based on severity, blackspots were selected and road safety study was conducted in the most dangerous areas. For this strategy, death or injury accidents at a site are given more weight than those that cause simply property damage. Accident Severity Index (ASI) measures a location's danger without considering its actual dimensions. The equation shown below was employed.[14]

$$ASI = N_f W_f + N_s W_s + N_m W_m$$

The equation was applied to each site and the results were analysed. The hotspots were then rated based on the severity values that had been obtained. The locations were organised according to the severity of the situation.

TABLE IV
Top 10 blackspot location identified by Accident Severity Index (ASI) method.

KM	Fatal (N_f)	Major Injury (N_s)	Minor Injury (N_m)	ASI Formula
223	9	-	6	60
229	7	3	2	53
224	6	3	2	47
225	6	1	6	45
195	7	-	1	43
41	5	3	-	39
100	4	3	1	34
23	5	1	-	33
234	4	1	3	30
149	4	-	4	28

Table 4 presents top 10 blackspot location identified by Accident Severity Index (ACI) method. The top most blackspot location is KM 223 of Beat 7 which has ASI value of 60 with nine (9) fatal injuries and six (06) minor injuries involved.

IX. RESULTS AND DISCUSSIONS

The National Highway Traffic Safety Administration's (NHTSA) data was used to identify accident black areas. There were three methodologies used to assess existing data: the Austria approach, the Flanders method, and the Accident Severity Index (ASI). Accident black areas were investigated, and the sites and causes of accidents were discovered. The greatest RK value in Austria is (6.90) and the lowest RK value is (3.88) among the top ten black spots. In the previous three years, there have been 16 incidents at 223 kilometres, nine of which have resulted in fatalities and seven of which have resulted in non-fatal injuries. In the previous three years, there have been 15 incidents at 224 kilometres, six of which resulted in fatalities and nine of which resulted in non-fatal injuries. In the previous three years, there have been 14 incidents at 225 km, six of which have resulted in fatalities and eight of which have resulted in non-fatal injuries. At a distance of 100,175,41 kilometres, the highest severity values (S) according to the Flemish approach are 89,85,84. At 100 kilometres, there were 9 fatalities, 13 serious injuries, and 2 minor injuries. At 175 kilometres, there were 13 fatalities. More weight is given to fatal and serious injuries than to property damage in a severity index technique. These are the ASI values at 223,229, 224 that are the highest. Kallar Kahar, a hilly location near Islamabad, is the source of M2's predominantly black blotches. With its many twists and steep hills, the Kallar Kahar area is anything from flat. There were more incidents in this area because of the steep slopes, which might lead to brake failure. The occurrence of crashes in a 1 km segment was used to identify black patches quantitatively. As a result of the salt range mountainous area's slope and radii curve concerns as well as road traffic crashes caused by braking failure, the greatest RK values were reported at 223km, 224km, 225km, 228km or 229km. Due to a steep 7 percent grade and a severe horizontal curve, the brakes failed on the uppermost black spot region.

X. CONCLUSION

There have been an increasing number of traffic deaths and injuries in the previous two decades, therefore road safety has become a hot topic. The vast majority of car accidents might have been avoided if only common sense had prevailed. Road collision injuries are mostly foreseeable, and numerous effective solutions exist. With the cooperation of several government agencies, an integrated approach to road safety may result in a significant drop in road accidents. Proper road design and traffic management, higher vehicle standards, and effective law enforcement are all part of the integrated strategy. This study revealed that human conduct while driving the vehicle was the major factor to a road traffic accident, but the environment and the vehicle were also contributors. Accidents with a high severity index increased in number as a result of an increase in the number of collisions. Compared to other months and days, July and Sunday had a larger number of traffic accidents. Nighttime has a higher rate of traffic accidents than daytime. Dozing drivers are more likely to be involved in car accidents early in the morning than at other times. Figures from a study on the severity of traffic accidents suggest that deadly collisions outnumber non-fatal ones. When compared to other types of accidents, rollovers and nose-to-tail impacts were the most common. Dozing at the wheel and reckless driving were two of the most common causes of traffic jams on the roads. In contrast to foggy and overcast weather, dry weather was associated with the majority of traffic incidents. Straight roads have the most complex road geometry compared to curves and gradients. Passenger automobiles were the most often involved in traffic accidents as the primary cause of injury or death. The salt range was found to be the most dangerous and full of trouble spots. With its many twists and steep hills, the Kallar Kahar area is anything from flat. There were more incidents in this area because of the steep slopes, which might lead to brake failure. Illegal pedestrian and animal crossings have led to the discovery of more black spots in the vicinity of both cities. In light of the findings and recommendations, it is suggested that pedestrian and animal underpasses be built near densely populated areas, that speed calming techniques be improved, that rumble strips be installed, that seatbelts be worn, that dozing alert alarms be installed, that tyre inspection devices be installed, that public awareness campaigns be launched, and that seatbelts be worn.

XI. RECOMMENDATIONS

Several ideas have been put out to help reduce the number of accidents on certain highways. Blind curves must be made wider in order to improve vision on both sides of the bends and prevent road traffic accidents on certain sections of road. It is critical that the rear-view mirror is not impeded in any manner. For several identified trouble sites, the following solutions were proposed: speed limit signs, cat eyes and road reflectors, road humps, increased setback distance at the intersection, delineators and retro-reflective markers, and curve indications. It might be a good idea to put maintenance checkpoints at various points along the roadways. Accidents caused by drowsy driving are the most common. Drivers should be made aware of the dangers of sleepy driving by conducting awareness programmes and advising them to get at least eight hours of sleep before getting behind the wheel.

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Volume 10 Issue II Feb 2022- Available at www.ijraset.com

The most traffic accidents occur as a result of poor vehicle condition. A vehicle should not be driven until it is mechanically and technically sound. Before hitting the road, make sure the vehicle's essential functions, such as the headlights, battery level, oil level, tyre pressure, windshield defogger, and wiper blades, are all in working order. Drivers are advised not to drive for more than four hours at a time. Building rest facilities at the appropriate intervals would help alleviate weariness and sleepiness for drivers. On straight sections of the road, the installation of rumble strips every 10 kilometers or 20 kilometers prevents sleepy driving. To keep the driver engaged, the rumble strip produces some vibration and a distinctive sound. The use of a lane departure warning system may also help to cut down on drowsy driving. It is possible to put this warning system in a car and alert the driver if the line is being changed. According to this research, unskilled driving is also a substantial contributor to road accidents. According to experts, driving license should be issued only to those who meet tight criteria. To prevent road accidents, Pakistani drivers must pass a thorough driving exam after receiving sufficient driving instruction, which has already been shown to be a crucial factor among Pakistani drivers. A driver operating without a valid driver's license would be subject to harsh penalties and fines. In order to better communicate with drivers, authorities should put up enormous posters with updated signs and laws. The study of traffic accidents involves a wide range of components, making it a difficult subject to master. There must be a thorough explanation and proper formatting of the country's road accident reports in order to conduct statistical and spatial analysis in the future. If you want to make road accident reports more important to traffic officers, you should provide training sessions for traffic officers. This law would aid in identifying and addressing the major contributing factors to car accidents in order to minimise the number of people killed or injured on the country's roads.

XII. LIMITATIONS OF THE STUDY

A case study of Pakistan's Lahore-Islamabad (M-2) motorway was used to demonstrate the analysis of traffic crashes with black patches. According to the research, conclusions cannot be generalized to the whole nation since each city has a unique population, traffic, and environmental makeup.

XIII. ACKNOWLEDGMENT

The authors thank the Taxila institute of transportation engineering for providing a research oriented environment and NHMP for providing the accidental data for the study period.

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