

Road User Vulnerability in Traffic Accidents, Featuring Full Day Data Collection – Comprehensive MACRO Analysis Study for the City of Karachi, Pakistan

* Syed Faraz Jafri, ** Khawaja Sheeraz, *** Kamran Khan, **** Zubair Iqbal Rao, and *****Asif Abbasi

Abstract — It is an undoubted truth that the system of transportation planning is associated with the key parameters of traffic safety. This focuses the implementation of designed policies and standards. The relationship between road traffic accidents and applied infrastructure facilities is proportional. This imparts the available geometric design considerations, pavement structure, environmental, human and vehicle contributory factors. Traffic accidents are also affected on various 24hrs timings of the day and classified as dawn, daylight, dusk and dark in different research studies. Each time of the day has its own characteristics featuring with the driver performance, site detection, visual acquaintance and information provided for decision sight distance.

Accidents occurring in various timings with respect to different types of road users are presented in this research. Possible root causes with significant recommended measures are the extensive dimensions of this research study. On the whole, three years data record is utilized in the analytical part as well. For the sake of reason, macro analysis tools and techniques are used in order to justify the results. The results are also formulated highlighting responsible factors and liaison with the accidents carried out in morning and dark.

Index Terms — Accident, Day, Karachi, Safety, Vulnerability, Vehicle Inspection System, Illumination, Glare

I. INTRODUCTION

Road traffic injuries are also a major cause of orthopedic and mental disabilities. Poor communities are on vulnerable side in association with the medical catastrophes in comparison to those experienced by economically settled communities. The specific problems faced by poor families may include health issues and less education with the lack of awareness. The safety objective and the efficiency objective run in parallel. A few explanations about some parts of the accident assessment are available. It is useful to judge the prime reasons of the human deaths and wounds caused by the collisions on roads. Many factors can be blamed for the occurrence of a traffic accident. For example, non-obedience to traffic rules, lack of enforcement of the traffic laws, wrong behavior of drivers and pedestrians, inadequate repairs of roads, the use of unfit vehicles etc. Out of these, any single issue is not the main reason behind accidents. Usually, two or more than two factors become the joint cause of an accident.

For the reduction in frequency of traffic accidents, two-approach corrective actions can be applied, viz.,

- 1) By means of efficient geometric design of roads (i.e., providing large radius curves, adequate super-elevation, broad shoulders, wide footpaths, etc.)
- 2) By means of safe vehicle designs (i.e., increasing vehicle's weight, raising vehicle's energy absorption capacity, providing safety airbags, enhancing the brightness of head-lights, providing additional fog-lights, providing Anti-Lock Braking System, etc.) and also by implementing an efficient vehicle inspection system [1].

One of the main causes of a traffic crash for the road user is inappropriate road vision or sight obstruction. Due to budget constraints and less infrastructure facilities, the stated problem is observed especially in Pakistan.

II. OBJECTIVES

The research is focused on following areas:

- 1) Design the time set criteria and quantify number of crashes
- 2) Application of micros and macros approaches
- 3) Way forward measures in connection to the calming measures and situational concepts.

III. ACCIDENT POTENTIAL AND SAFETY MEASURES

Accident prevention is generally transformed with the strategy of applied design and safety principles for new road construction and updating and existing road. The factor is also responsible on the focused traffic management. Impact studies in this connection are of great importance, involving the re-checking of the designs of these projects, so as to exclude any problematic feature that might have been involved. Identically contrast was arranged with the help of collected data. This is also helpful in installing any other or available traffic control device on emergency basis [2]. Any safety measure designed will ensure the past and present data record while the application will be installed for temporary period until the effective impact study is achieved.

* Department of Civil Engineering, Sir Syed University of Engineering & Technology, Karachi. sfaraz@ssuet.edu.pk, engr_sfjafri@hotmail.com

** Department of Civil Engineering, Sir Syed University of Engineering & Technology, Karachi. khawajasheeraz@gmail.com

*** Department of Civil Engineering, Sir Syed University of Engineering & Technology, Karachi. kamran_khan85@hotmail.com

**** Department of Civil Engineering, Sir Syed University of Engineering & Technology, Karachi. engr_zubairao@hotmail.com

***** Department of Civil Engineering, Sir Syed University of Engineering & Technology, Karachi. aabbasi@ssuet.edu.pk

IV. A STUDY OF THE TIME SET CRITERIA FOR ROAD CRASH

Dawn, Daylight, Dusk and Dark timings are whole 24-hour day time set criteria for the occurrence of an accident and the situation of an accident is also dependent on the discussed parameter. Apart from that, collision avoidance can be achieved by having a transparent outlook of the core sources. For understandable research control, a subsequent time set criteria has been designed as follows:

- 1) Dawn (early morning): 6 – 9 am
- 2) Daylight (Sun causing glare): 10 am – 5 pm
- 3) Dusk (sunset timings): 6 – 9 pm
- 4) Dark (from night to early morning): 10 pm – 5 am

In the actual circumstances, the ruling factors that cause a collision to happen are: the eye tendency to recover from the effect of glare caused by the sunlight or the opposite vehicle's headlights, and the inadequate lightening available for the travelers at the night time. Insufficient illumination may be due to the non-functional headlights of vehicles and street lights as well. All these problems are indirectly connected with the highlighted duration of incidents. The incidents are also explained with the sunrise and sunset for a reader. One study suggests that the accidents in which the sleepiness of the driver is the governing factor, mostly occur during the first few hours after the sunrise. The early morning timings are also critical for the drivers who are under-age and over-age, because the drivers in both that age brackets usually have the effect of fatigue in the beginning hours of the day [3].

V. A CASE STUDY OF THE RTIR&PC (ROAD TRAFFIC INJURY RESEARCH & PREVENTION CENTER)

The growing trend of vehicle ownership in the city of Karachi is seriously increasing the number of minor and major accidents. The factors for these accidents include pavement distresses, inadequate illumination, glare recovery issues, animal movement on roads, horizontal or vertical curve effects, overtaking sight distance problems, high speeding, reckless driving, etc. A few of the reported accidents were investigated by the authorities, which resulted into the participation of indirect road furniture issues that depend on the variations of traffic flow during 24 hours. An effort is being made by a center known as RTIR&PC, that stands for "Road Traffic Injury Research and Prevention Center". The data of this research is also taken from the Center's records. The Center is responsible for the collection of traffic accident data, as received for different trauma centers, and then analyzing the data from several aspects.

RTIR&PC is located at the JPMC (popularly known as Jinnah Hospital) [4]. The Center continuously collects the injury data in its present condition as well. This research was initiated in September 2006. The data collected by the Center from 2007 to 2009 was acquired and has been presented in the pages that follow. The data of road traffic accidents was obtained from the trauma departments of five major hospitals

of Karachi, namely JPMC (commonly known as Jinnah Hospital), ASH (commonly known as Abbasi Shaheed), CHK (commonly known as Civil Hospital), LNH (commonly known as Liaquat National) and AKUH (commonly known as Agha Khan Hospital) through a comprehensive and monitored injury observation program. Research Assistants were deployed at these five hospitals, who manually collected the required data. For appropriate analysis, the accidents are divided into three major classes, i.e., Minor Accidents (in which an accident victim is given treatment at the hospital and discharged in a relatively shorter duration), Serious Accidents' (in which the injured person is formally admitted in the hospital for full treatment), and Fatal Accidents (in which injured patient expires before or after arrival at the hospital). Similarly, the persons using roads are classified as Rider / Pillion Rider (traveling on a motor bike or scooter), Driver (driving a 3 or more wheel vehicle), Passengers (accompanying the Driver in a vehicle), and Pedestrians (walking on foot). The accidents are divided into four time zones of a day (as discussed above) for the investigation of time dynamic characteristics of accidents. A thorough analysis is done after this data classification part.

The darker stage of the twilight and the night time are considered to have similar effects on the probable occurrence of accidents. Both these are awful timings due to the factors like less illumination and slow glare recovery process, resulting into increased number of fatal road crashes. These two critical causes are discussed in detail in the analytical section of this research paper. A hypothesis is related to these two grave aspects and a correlation is recommended which is a main point of the paper. The scheme has been designed in a way that is ultimately related to the result of collision prevention system. Giving due consideration to the above stated two dreadful timings of the day, the data of 2007 to 2009 has been used to describe the pattern of fatal accidents in the time slot from 8 pm to 4 am, thereby grouping the dusk and dark timings together.

VI. OLD AGE DRIVING AND DARK DEATH TOLL

The accident study illustrated that the severity of collisions in the case of old age drivers is enormous in comparison to the other age groups of the population [5]. Old drivers cause higher number accidents at roundabouts, even in the broad daylight. Mostly, the older drivers have the tendency to drive in the day time, in order to avoid night accidents. But they are likely to be involved in the glare recovery action of the sunlight during the day and they also face the reflection / refraction issues in between eyesight and sunlight. Discussion is also done as to how the information has to be provided for processing, i.e., either the basis should be the low luminance, or the low/high contrast targets. The available perception reaction time methodologies for different types of road users are applicable to check the planned idea [6].

VII. SIGHT PERCEPTION OF ROAD USERS IN COMPARISON TO THE DECISION SIGHT DISTANCE (DSD)

A driver should have the ability to take maneuvering action whenever a target comes in his way, like for example, any moving / stationary vehicle, any object like a tree, building, footpath etc., or any traffic related device like a signal, light pole, sign board, etc. The acuteness of the driver's vision is connected with the sharpness of his/her PIEV Time on seeing an object, obstacle, vehicle, pedestrian, etc. [7,8]. A driver tends to be blindfolded when the sunlight directly hits his/her vehicle's windscreen [9]. The blinding effect of sunlight magnifies due to the presence of dirt, dust, smudge etc. on the windscreen, because particles or stains refract the sunlight, thereby intensifying its adverse effect. This is a very prominent problem in Karachi due to the city's declining environmental conditions. Glare recovery action also intensified due to the opposite vehicle's headlight effects during the dusk and night timings.

VIII. DATA ESSENTIALS WITH JUSTIFICATIONS (RTIR&PC)

The data below is presented on the lines of designed time set criteria. It concludes that almost 80% of the accidents occurring during the timings of dusk and dark, inflict minor injuries. It also figures out that nearly the same percentage of accidents involving minor injury take place in the daylight, which is a higher value in comparison to the minor injury accidents occurring in the morning, despite the fact that the traffic flow rate is higher in the morning than daylight. The data shown below is of the year 2008 only.

Table I
Severity of Injuries During Different Timings of the Day [4]

Injury Severity	Dawn (percentage)	Daylight (percentage)	Dusk (percentage)	Dark (percentage)
Minor	73	80	78	79
Serious	22	17	19	18
Fatal	5	3	03	03
Total	100	100	100	100

The two focused elements for the readers are Inadequate Illumination and Glare Recovery Action. Table 2 below shows the accident figures caused by these two critical factors. Inadequate illumination is often the governing factor in the accidents caused during dusk and dark timings. The glare recovery action is related to the sunlight and the opposite car headlight issues. These two grave factors discussed on the data available for 3 years, are the key points of the research study showing, that there could be technical advancements and intelligent transportation system, supported by the real scenario. These include vehicle activated signs, signal synchronization and detective control systems. In this connection, the Command and Control Center functioning in Karachi, must play a vital role by its available resources and technical expertise, which is a big achievement for the city of Karachi.

Table II
Serious Accidents Caused by the Two Critical Factors

Critical Factor	Serious Accidents In		
	2007	2008	2009
Inadequate Illumination	369	344	234
Glare Recovery Action	0	14	8

IX. MICROS AND MACROS (DATA ANALYSIS)

Macros provide much broader spectrum to the investigators for the designing and analysis of experiments. Micro Analysis illustrated above is followed by Macro Analysis. Simple data modeling is carried out for Micro Analysis, while that is to be synchronized with the Analysis of Variance (ANOVA) as macros.

Normally, the macro analysis is synchronized on one parameter only and the analysis is carried out without duplication. The noise and strangeness of the data is searched, if the difference has to be calculated. The approach of ANOVA is applied on the data of fatal road accidents caused in the time slot from 8 pm at night to 4 am in the morning. Generally that type of a macro analysis is carried out so as to fully expose the situation and formulate better results for the accident data of night time, given below. The combined timings of dusk and dark are considered while doing the correlation and regression analysis. The 3-year data collected during the time slot under consideration, is given below.

Table III
Fatal accidents during the dusk and dark timings in combination [4]

Timing Slot	Fatal Accidents In The Year		
	2007	2008	2009
8 pm to 10 pm	96	143	144
10 pm to 12 am	69	98	66
12 am to 2 am	32	62	75
2 am to 4 am	25	43	37

F-Ratio is the main parameter in the analysis. The "Sum of Squares (SS) and the "Degree of Freedom" (DF) form the basis of the F-Ratio. The SS and DF are independent variables that are based on the ranks of "within" and "between" the groups of analysis.

$$F - Ratio = \frac{Var\ Between\ Treatments}{Var\ Within\ Treatments} \quad (1)$$

$$Var\ Between\ Treatments = \frac{SS\ Between\ Treatments}{DF\ Between\ Treatments} \quad (2)$$

$$Var\ Within\ Treatments = \frac{SS\ Within\ Treatments}{DF\ Within\ Treatments} \quad (3)$$

On the basis of only one parameter and without data duplication, the inference of ANOVA is used on the data shown above. Following results appeared:

A. Results for Between Groups

Sum of Squares = 2162.667
 Degree of Freedom = 2
 MS = 1081.333
 F-Ratio = 0.636619
 P-Value = 0.551326
 F Critical = 4.256495

B. Results for Within Groups

Sum of Squares = 15287
 Degree of Freedom = 9
 MS = 1698.556

According to the results of ANOVA, the obtained value of F-Ratio is lower than the Critical value of F-Ratio. This is because the enforcement plans used for certain major roads for the avoidance of collisions during the timings of dusk and dark, are not real. The results change much, if the data duplication is not allowed, as shown below:

C. Results for Rows

Sum of Squares = 14179.67
 Degree of Freedom = 3
 MS = 4726.556
 F-Ratio = 25.61048
 P-Value = 0.000808
 F Critical = 4.757063

D. Results for Columns

Sum of Squares = 2162.667
 Degree of Freedom = 2
 MS = 1081.333
 F-Ratio = 5.859121
 P-Value = 0.038832
 F Critical = 5.143253

During the period of three years under consideration, accidents are included in the same time slots linked with the provision of amenities and conveniences. That results into the improvement of the F-Ratio (i.e., the obtained value of F-Ratio is greater than the critical value of F-Ratio). It is very much understandable that while the scenario is changing from dusk to dark, the drivers and pedestrians can see the targets more visibly, resulting into the reduction of road crashes in that specific year. In other words, the road users are viable to take supportive measures as satisfied with the existing infrastructure facilities. When the same time slots are compared with the linked columns (i.e., the yearly data) the results obtained are totally un-grouped. The obtained value of F-Ratio is less than the critical value of F-Ratio.

In analytical hypothesis, some sustaining action maneuvers are required, which increase the chances of fatal accidents occurring at night. This type of strategy is the advanced level for a traffic engineering program or for producing better impact studies.

X. INVOLVEMENT OF ROAD USERS AND THEIR DANGER IN THE ACCIDENTS CAUSED DURING THE COMBINED TIME SLOTS OF DUSK AND DARK

Age factor is one of the most prominent issues impairing the efficiency of driving skills. There is a big difference in the resulted outcomes of novice and old age drivers [10]. Older drivers have slower reaction time creating more hazards of improper night vision and response or recovery time. Glare is not only concerned with the night vision based on headlight sight distance, but it is also related to the sunlight glare, the phenomenon is based on the reflection and refraction of light.

Apart from old age drivers, the old age pedestrians also have the problems like less hearing, slower walking speed and shorter attention spans. Separate policies should be formulated for all the categories and types of road users, thereby creating a balance between the road situation and users' rights.

A transport policy framework should be prepared on priority basis for the guidance of old age drivers and pedestrians, simultaneously recording the traffic accidents during the time slots of dusk and dark, with the help of associated training strategies or awareness programs. In the present and aggregative situation of Karachi, vehicle contributory factors, the road infrastructure and the human beings should be strongly bonded together in a relationship. The criteria will ensure the basis pattern of three E's of traffic engineering, i.e., Engineering, Education, and Enforcement.

XI. STRONG AND VIGILANT SUPPORTIVE ACTION FOR ROAD SAFETY IN TECHNICAL TERMS

Appropriate guidance should be provided to the driver on the road network and in a smarter way. Technical advancements include intelligent transportation systems, driver information systems and pavement detection systems. All the methodologies are governed with the basic need of the available data, road network layout as a communicator and strict enforcement applicability. Traffic control devices and traffic signage plan must be designed, keeping in view the considerations of advanced traffic engineering ways. Any facility that is planned to be installed, should focus on the detailed traffic modeling, as per the desired guidelines. Detective Message Signs should be preferred over the ordinary Warning Signs because the former can ensure a variety of multiple messages. Above all, the advancement in connection to the use of variable colors in calming devices and markings, must be incorporated.

XII. CONCLUSION AND RECOMMENDATIONS

As per the facts and figures of the entire research study, following corrective measures are synchronized for the policy makers:

- Need of a particular control and calming device should be the preliminary stage
- Valuable short term and long term measures should be proposed, ensuring economical solutions
- Proper training to the road users should be given more priority, looking at the traffic situation of Karachi
- Solving the issue of inadequate illumination should also be prioritized. The problem might be addressed to with the solar lightening system, in a way to have functional street lights
- The area of vehicle inspection system should be strong. The desired guidelines should be developed in coordination with the manufacturing companies and the concerned partners
- Driving license should be issued under a strict policy, incorporating a written test, a practical driving test and a thorough medical checkup of the driver
- All road users should get an equal importance for both their rights and responsibilities. Certain standards are available for the design of vehicles and the design of roads and associated infrastructure. But unfortunately, the standards for road users are lacking
- On the available data and supportive methodologies, impact studies should be carried out for the forecasting purposes.

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