International Journal of Engineering Technology Science and Research
IJETSR
www.ijetsr.com
ISSN 2394 – 3386
Volume 4, Issue 9
September 2017

Pedestrian Safety on Indian Roads – A Review of Recent Studies

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ABSTRACT

Pedestrians are one of the most Vulnerable Road User in India. In terms of pedestrian crashes on a worldwide scale over 4,00,000 pedestrians are killed every year and over 10,000 pedestrians are killed on Indian roads. In most regions of the world this epidemic of road traffic injuries is still increasing. Road traffic accidents are a major but neglected global problem, requiring concerted efforts for effective and sustainable prevention. A comprehensive approach is required for improving road safety of pedestrians and reducing the causalities on the roads. In the similar direction this study tends to figure out various studies carried out in the world related to pedestrian safety on roads. This study is an attempt to find out the most critical factors responsible for pedestrian safety and to devise methods which would provide solution for the same.

Keywords :*Road accidents, pedestrian safety, Critical factors.*

INTRODUCTION

Pedestrians are most vulnerable in a traffic accident. Currently in Bangalore, more than 50% of the fatalities on the road involve pedestrians. Hence improving conditions for the safety of the pedestrians should be of utmost concern for local urban planners, engineers, municipal administrators.

As the road accident prediction studies involve various complex systems namely the human, road, vehicle and all other environmental factors, it is vital to develop dynamic simulation model to understand the interactions between the various complex systems.

Road accidents are imposing considerable social and economic burdens on the victims, and various direct and indirect costs. Road accidents are essentially caused by improper interactions between vehicles, and other road users or roadway features. The situation that leads to improper interactions could be the result of the complex interplay of a number of factors such as pavement characteristics, geometric features, traffic characteristics, road users, behaviour, vehicle design, driver’s characteristics and environmental aspects. Thus, the whole system of accident occurrence is a complex phenomenon.

ROAD SAFETY SCENARIO

Every day thousands of pedestrians are killed and injured on roads. Men, women or children walking, biking or riding to school or work, playing in the streets or setting out on long trips, will never return home, leaving behind shattered families and communities. Millions of people each year will spend long weeks in hospital after severe crashes and many will never be able to live, work or play as they used to do. Road traffic injuries constitute a major public health and development crisis, and are predicted to increase if road safety is not addressed adequately.

The World Health Organization (WHO) and the World Health Assembly has been concerned with this issue for a long time. Among other international organizations, the United Nations Economic Commission for Europe, the United Nations Development Fund and the United Nations Children's Fund, have all stepped up their road safety activities over the past decade.

Over 1.2 million people die each year on the world's roads, and between 20 and 50 million suffer non-fatal injuries. In most regions of the world this epidemic of road traffic injuries is still increasing. A comprehensive approach to improving road safety and reducing the death toll on their roads is much required. Low income and medium income group countries have higher road traffic fatality rates (21.5 and 19.5 per 100000 populations, respectively) than high-income countries (10.3 per 100000). Over 90% of the world's fatalities on the roads occur in low-income and middle-income countries, which have only 48% of the world's registered vehicles.

The economic cost of road traffic crashes is enormous. Globally it is estimated that US$ 518 billion is spent on road traffic crashes with low- and middle-income countries accounting for US$ 65 billion – more than these countries receive in development assistance. But these costs are just the tip of the iceberg. For everyone killed, injured or disabled by a road traffic crash there are countless others deeply affected? Many families are driven into poverty by the expenses of prolonged medical care, loss of a family breadwinner, or the added burden of caring for the disabled.

In low-income countries and regions – in Africa, Asia, the Caribbean and Latin America – the majority of road deaths are among pedestrians, passengers, cyclists, users of motorized two wheelers, and occupants of buses and minibuses. The leading casualties in most high-income countries, on the other hand, are among the occupants of cars. However, when it comes to comparative fatality rates (deaths for any measure of exposure) for all users in the traffic system, these regional differences disappear. Nearly everywhere, the risk of dying in a road crash is far higher for vulnerable road users – pedestrians, cyclists and motorcyclists than for car occupants.

THE SOCIAL AND ECONOMIC COSTS OF ROAD TRAFFIC INJURIES

In economic terms, the cost of road crash injuries is estimated at roughly 1% of gross national product (GNP) in low-income countries, 1.5% in middle income countries and 2% in high-income countries. The direct economic costs of global road crashes have been estimated at US$ 518 billion, with the costs in low-income countries – estimated at US$ 65 billion – exceeding the total annual amount received in development assistance. Furthermore, the costs estimated for low-income and middle-income countries are probably the significant underestimates. Using more comprehensive data and measurement techniques, the estimated annual costs (both direct and indirect) of road crash injury in European Union (EU) countries alone, which contribute 5% to the global death toll, exceed €180 billion (US$ 207 billion). For the United States of America, the human capital costs of road traffic crashes in 2000 were estimated at US$ 230 billion. If comparable estimates were made of the direct and indirect economic costs of road crashes in low-income and middle-income countries, the total economic cost globally of road crashes would be likely to exceed the current estimate of US$ 518 billion.

Road crashes not only place a heavy burden on national and regional economies but also on households. In Kenya, for example, more than 75% of road traffic casualties are among economically productive young adults. Despite the large social and economic costs, though, there has been a relatively small amount of investment in road safety research and development, compared with other types of health loss. There exist, however, well-tested, cost-effective publicly-acceptable solutions to the problem. Funding for interventions, though, even in many countries most active in road safety – all of whom have targets for further reductions in casualties – has been scarce

In short, current road safety efforts fail to match the severity of the problem. Road travel brings society great benefit, but the priceless society is paying for it is very high. Road safety policies in India must focus on the following issues to reduce the incidence of road traffic injuries: pedestrians and other non-motorist in urban areas; pedestrians, other non-motorists, and slow vehicles on highways; motorcycles and small cars in urban areas; over-involvement of trucks and buses; night-time driving; and wrong way drivers on divided highways.

The next portion of the proposal will highlight the significant studies conducted on the area which helped the researcher to find gap analysis and frame suitable objective of the study.

LITERATURE REVIEW

Pedestrian safety is a problem all over the world. Each year numerous pedestrian die or get severely injured in traffic accidents. The majority of accidents occur in urban areas. The reason for this is the constant interaction between vehicles and pedestrian. Accidents come with a great cost for the victim and for the society. Speed plays a central role in traffic safety, more and more traffic researchers come to that conclusions. The present section presents the past studies related to the study.

Pei et.al. (2012), studied the effect of exposure and speed on crashes in Hong Kong. Results indicated a positive correlation between speed and crash risk when distance exposure is considered, and negative when time exposure is used. However, speed was found positively associated with the injury severity [1].

Mustakim and Fujita (2011), developed accident predictive models based on the data collected at rural roadway, Federal Route 50 Malaysia. Multiple non-linear regression method was used. The result verified that, the existing number of major access points, without traffic light, rise in speed, increasing number of AADT, growing number of motorcycle and motorcar and reducing the time gap are the potential contributors of increment accident rates on multiple rural roadway. National Cooperative Highway research program, NCHRP, TRB, US, has done a very exhaustive work to suggest multivariate models were lane width, shoulder width, no of intersections and number of horizontal curves were considered as significant variables [2].

Mohan (2011) analyzed the data reported by Asian countries and demonstrated that a few high income countries have unreliable statistics, and on the other hand a few low income countries were able set up good data collection systems. Overall and road user specific fatality rates do not have a high correlation with country income levels. The reasons for this are not known. In the absence of more reliable data and identification of risk factors for each country, it is not possible to give very specific country based countermeasures for road safety. It would be adequate at present to focus on measures that have international validity and are known not to have negative side-effects [3].

Charles (2010) claimed that as automobile transportation continues to increase around the world, bicyclists, pedestrians, and motorcyclists, also known as Vulnerable Road Users (VRU), will become more susceptible to traffic crashes, especially in countries where traffic laws are poorly enforced. Several countries, however, are employing innovative strategies to ensure that road users can more safely navigate the urban landscape. The research addressed the potential countermeasures and strategies for improving pedestrian safety from an international perspective [4].

Najamuddin and Parida (2004) from their study claimed that pedestrians are the main victim of fatal accidents. Nearly 90 % of the total fatalities in our country occur on rural roads while only 10 percent occur on urban roads. Traditional planning is greatly biased to the motorized modes of transport, even though every road users is a pedestrian at some stage of journey. The problem had always been realized but efforts are mostly negligent. Therefore, the researchers suggested the need to address it within an integrated system of roads, road users and vehicles. The researchers also claim that Pedestrian traffic safety needs to be addressed within an integrated system of roads, road users and vehicles. In comparison to developed countries the traffic accident characteristics and nature of accidents are considerably different in India. To enhance the road safety condition, a large number of strategies can be employed. Traditional planning is greatly biased to the motorized modes of transport. A comprehensive traffic and transport study focuses on large public transport system and undermines the importance of operating a safe pedestrian transport network. Although a number of urban transport studies have been completed in India still pedestrian facilities have not received their due emphasis [5].

Kumar and Kulkarni (2010) through their research said that Pedestrians are neglected because they make no noise. They go quietly findings their ways in prevailing chaos. A recent study conducted in Indian Cities states that more than 20% of the road accidents involve pedestrian. Hence safety of pedestrian is a basic step to create safer city. A report entitled “Road Safety in India: Challenges and Opportunities” March 2009 states that road traffic fatalities have been increasing at about 8% annually for the last ten years. About 60% of all fatalities in urban areas belong to pedestrians. Hence pedestrian safety is a challenge for transport planners, traffic engineers, town planners, urban local bodies and policy makers to make city safer [6].

Anthaput and Got (2012) acclaimed that in the age of rapid motorization, the pedestrian has been left far behind. Huge investments are directed towards building infrastructure for motorized modes, while little or no planning is provided to non-motorized modes of travel such as walking and cycling, which have been the traditional modes of travel. Increased urban sprawl, improved economic conditions and neglect of pedestrian facilities have all led to increase in the number of motorized vehicles, which have resulted in our cities with high levels of pollution, congestion, road accidents, social inequality, poor mobility, and deterioration of quality of life. Asian cities are set to explode with over 55% of population projected to live in them by 2030. This poses a huge challenge to the concept of sustainability and livability [7].

Kouabenan and Guyot (2004) used three methods to analyze 55 reports of actual pedestrian accidents randomly selected from police records in the Ivory Coast. Each method revealed a particular aspect of pedestrian accident causation according to accident severity. An analysis of the spontaneous causal explanations given by the involved persons made it clear that pedestrians and drivers explain accidents in a defensive way by stressing factors that tend to incriminate the other party. In the conclusion, we point out the utility of an approach that combines several methods of accident analysis and we consider some ways to improve the use of accident reports for prevention purposes [8].

Steve Mark (2001) studied the increasing concern with the growing number of pedestrians struck by motor vehicles. The research addresses vehicles with bumpers at a pedestrian's thigh height, such as vans and sport utility vehicles. The goal of the research was to predict upper leg form forces due to bumper impacts and analyze bumper system concepts for minimizing these forces [9].

Naughton and Cate (2001), studied an approach to a solution to conflicts of interest posed by new pedestrian safety requirements are presented here. The effects of various design parameters on pedestrian safety and the resulting influence on other requirements were examined. Computer Aided Engineering (CAE) techniques are used extensively for this work, in order to determine the sensitivity of the behavior of front-end systems to design and material characteristics. Finally an overall approach to solutions is presented, involving a theory of stiffness distribution to meet the pedestrian safety requirements, while continuing to address the current needs [10].

Yoshiuki, Mizuno and Hirotoshi Ishikawa (2001), studied the IHRA pedestrian working group has conducted investigation and analysis on the current status of pedestrian accidents in the IHRA member countries. The researchers collected the accident data that occurred by 1999, then unified the formats of the accident data and established a dataset that makes it possible to make comparison with each other. As per the status of pedestrian accidents, three parts of the pedestrian’s body have the highest priority for protection, the child and adult heads, and the adult lower leg/knee. The study further suggested that It was deemed necessary to conduct validation study of the test procedures through actual tests using sample vehicles and to explore the car feasibility level prior to the use of the test methods in legislation [11].

Patel, Kartha, Mehta (2010) studied the road traffic accidents on selected highways and town/village roads of Sabarkantha district, Gujarat was conducted for the period of one year (from January 2002 to December 2002), during this period, total 512 event of road traffic accidents were recorded in the district, It is observed that the Pedestrian accident (37.78%) dominates overall the other types of accidents. Among the 193 events of Pedestrian accident, 158(81.87%) were non-fatal and 35(18.13%) fatal. The maximum number of events (62.69%) took place during daytime and 37.31% of events took place during dark hours. Analysis also shows that highest number of events (35.23%) took place on town/village roads [12].

Sharma and Iyer (2011), used Head Injury Criteria (HIC) prediction for pedestrian impact analyses during early stages of vehicle development is a challenge for designers and Computer Aided Engineering (CAE) analysts because of minimal geometry information for the hood. This research proposes a HIC prediction tool based on statistical analysis of simulation data from an initial CAE simulation. The HIC prediction tool will be used for pedestrian head impacts on hoods to aid in hood design and under hood components packaging which comprehends pedestrian protection variables. Pedestrian impact HIC performance is a function of various contributing factors like hood thickness, material, deformation space, and also proximity to attachment locations. These parameters have been studied separately and then checked for their combined sensitivity to HIC. With shortened development time, said tools may enable more robust analytical prediction [13].

Mohan (2011) discussed that WHO released a global status report on road safety: time for action in July 2009. He analyzed the data reported by Asian countries. The report demonstrates that a few high income countries have unreliable statistics, and on the other hand a few low income countries are able set up good data collection systems. Therefore, all countries should be able to set up reasonable data reporting systems given the right policies. Overall and road user specific fatality rates do not have a high correlation with country income levels. The reasons for this are not known. In the absence of more reliable data and identification of risk factors for each country, it is not possible to give very specific country based countermeasures for road safety. It would be adequate at present to focus on measures that have international validity and are known not to have negative side-effects [14].

Sharma and Landge (2012) studied that pedestrians are one of the Vulnerable Road User, have become more susceptible to traffic crashes with the rapid growth of motor vehicles in India. In terms of pedestrian crashes on a worldwide scale over 4, 00,000 pedestrians are killed every year and over 10,000 pedestrians are killed on Indian roads. To date, only limited research has been undertaken to develop the accident prediction model for pedestrian accidents. The research focus on pedestrian crash prediction model on Indian Rural Highway (NH-6). Accident data collected between 2005-09 over a stretch of 100 km of road length are used for modeling. The Negative Binomial method was used to model the frequency of accident occurrence. The Akaike Information Criterion (AIC) is used to measure the relative goodness of fit. The candidate set of explanatory variables are: Total Traffic volume (AADT), Lane width (LW), Shoulder width (SW), and access density (AD). It is observed that access density, Shoulder width and Lane width have significant impact on pedestrian safety [15].

Singh & Suman (2012) selected a stretch of NH-77 from Hajipur to Muzaffarpur. The accidental data was collected for last eleven years, 2000-2010 from the Police Stations where FIR was lodged. The collected data were analyzed to evaluate the effect of influencing parameters on accident rate. Heavy vehicles like truck are involved in maximum number of accidents on the selected stretch. It was estimated that a heavy vehicles is involved in almost 48% accidents followed by two-wheelers 16%, car 12% and bus10%. There was no definite trend for monthly variation in accident on a study section but the accidents in month of July and January are generally higher. Accident rate in terms of number of accidents per km-year increases with traffic volume. But the accidents rate in terms of number of accident per million-vehicle kilometer-year (MVKY) decreases with increase in traffic volume. Accident rate per MVKY increases during the study year, whereas both injury and fatality rate per MVKY show a declining trend over the study period. The developed model for accident prediction represents that the number of accidents per-km-year increases with AADT and decreases with improvement in road condition [16].

Mannering, Shankar and Haddock, (2012), emphasized on an alternative approach to this problem views vehicle accident rates (accidents per mile driven) directly instead of their frequencies. Viewing the problem as continuous data instead of count data creates problem in that roadway segments that do not have any observed accidents over the identified time period create continuous data that are left-censored at zero. Past research had appropriately applied at obit regression model to address this censoring problem, but this research has been limited in accounting for unobserved heterogeneity because it has been assumed that the parameter estimates are fixed over roadway-segment observations. Using 9-year data from urban interstates in

Indiana, this paper employs random-parameters tobit regression to account for unobserved heterogeneity in the study of motor vehicle accident rates. The empirical results show that the random-parameters tobit model outperforms its fixed-parameters counterpart and has the potential to provide a fuller understanding of the factors determining accident rates on specific roadway segments [17].

Mountain, Fawaz and Jarrett (1996) with a purpose of developing and validating a method for predicting expected accidents on main roads with minor junctions where traffic counts on the minor approaches were not available. The study was based on data for some 3800 km of highway in the U.K. including more than 5000 minor junctions. The high ways consisted of both single and dual-carriageway roads in urban and rural areas. Generalized linear modeling was used to develop regression estimates of expected accidents for six highway categories and an empirical Bayes procedure was used to improve these estimates by combining them with accident counts. Accidents on highway sections were shown to be a non-linear function of exposure and minor junction frequency. For the purposes of estimating expected accidents, while the regression model estimates were shown to be preferable to accident counts, the best results were obtained using the empirical Bayes method. The latter was the only method that produced unbiased estimates of expected accidents for high-risk sites [18].

Kalokota, Seneviratne (1994) *classified a*pproximately 2.5 million miles or 63 percent of the highways in U.S., as two-lane rural highways, and 50 percent of fatalities occur on these highways. This report is based on a study aimed at modeling the influence of the geometric design variables on traffic accidents on two-lane rural highways. It was found that the exposure in terms of distance travelled (length of road section) is the most significant variable in the empirical models developed in the present case. Contrary to previous findings, horizontal curvature and cross-section were found to have rather negligible effects on accident occurrence.The main findings of the study were, disaggregation of data by type of roadway section (curved or tangent) does not improve model predictability. Models developed in the present case are temporally and spatially transferable by updating parameters using Bayesian statistics whereas previously developed models are not [19].

Ameen and Naji (2001) tried to identification of the causes of road accident fatalities is becoming more important with the growth of technology, population, number of vehicles and the need for their use. Many authors have addressed the problem in the past but no universal findings have been obtained. The problem tends to be different under different environments and for different geographical regions. The research also developed a model for the analysis and forecasting of road accident fatalities in Yemen considering data restrictions. The proposed data has a particular structure of accident occurrence that has not been reported in any existing research using data in other countries. The available data for the period 1978–1995 is used to build models to understand the nature and extent of the causes of fatalities. Part of the data is used for model building and part of it for test purposes. The issues of correlation and causality have been addressed and multiple co linearity is investigated and dealt with. Two alternative models are proposed based on both statistical grounds and that of practicality in viable decision making [20].

Shankar, Mannering, and Barfield (1995) explored the frequency of occurrence of highway accidents on the basis of a multivariate analysis of roadway geometries (e.g. horizontal and vertical alignments), weather, and other seasonal effects. Based on accident data collected in the field, a negative binomial model of overall accident frequencies is estimated along with models of the frequency of specific accident types. Interactions between weather and geometric variables are proposed as part of the model specifications. The results of the analysis uncover important determinants of accident frequency. By studying the relationship between weather and geometric elements, this paper offers insight into potential measures to counter the adverse effects of weather on highway sections with challenging geometries [21].

Karlaftis and Golias (2002) revisited the question of the relationship between rural road geometric characteristics, accident rates and their prediction, using a rigorous non-parametric statistical methodology known as hierarchical tree-based regression. The goal of this study was twofold; first, it develops a methodology that quantitatively assesses the effects of various highway geometric characteristics on accident rates and, second, it provides a straightforward, yet fundamentally and mathematically sound way of predicting accident rates on rural roads. The results show that although the importance of isolated variables differs between two-lane and multilane roads, 'geometric design' variables and 'pavement condition' variables are the two most important factors affecting accident rates. Further, the methodology used in this paper allows for the explicit *prediction* of accident rates for given highway sections, as soon as the profile of a road section is given [22].

Hiselius (2004) estimated the relationship between accident frequency and the traffic flow empirically treating the hourly traffic flow in two different ways, as consisting of homogenous vehicles and as consisting of cars and lorries. Rural roads in Sweden were studied using Poisson and Negative Binominal regression models. It is found that important information is lost if no consideration is taken to differences between vehicle types when estimating the marginal effect of the traffic flow. The accident rate decreases when the traffic flow is treated as if homogeneous. However, when cars are studied separately the result suggests that the accident rate is constant or increases. The result with respect to Lorries is reversed, indicating a decreasing number of accidents as the number of Lorries increase [23].

Amoros, Martin, Lafont and Laumon (2008) from their study conducted in France and in many developed countries, confirmed that the reporting of fatalities is almost complete but the reporting of non-fatal casualties is rather low. It is moreover strongly biased. Valid estimates are needed. Methods: Using the capture–recapture method on police data and on a road trauma registry covering a large county of 1.6 million inhabitants, we estimate police under-reporting correction factors that account for unregistered casualties. These correction factors are then applied to the nation-wide police data, with standardization on under-reporting bias factors. Results: In 2004, whereas the police report 108 727 non-fatally injured, the estimation yields 400 200. Over the 1996–2004 study period, the average annual estimated incidence is 871/100 000 for all injured (3.4 times the police incidence), 232/100 000 for hospitalized, 103/100 000 for seriously injured (2.2 times the police incidence) and 12.6/100 000 for casualties with long-term major impairment. The incidence of seriously injured is 11.3/100 000 for pedestrians, 9.5/100 000 for cyclists, 36.3/100 000 for motorized two-wheel users and 42.5/100 000 for car users. The estimated incidences were much higher than the police-based ones. This changes the scale of the road injuries issue. The risk of suffering a major impairment from a road crash is equal to the risk of being killed. Motorized two-wheel users experience a large burden of traffic casualties, much larger than that indicated by police data. The approach used can be reproduced in other countries, if an additional medical registration exists [24].

Karlaftis and Tarko (1998)emphasized that panel data sets were becoming readily available and increasingly popular in safety research. Despite its advantages, panel data raises new specification issues, the most important of which is heterogeneity, which have not been addressed in previous studies in the safety area. Based on a county accident data set, the present analysis extends prior research in a significant direction. There was an explicit effort to control for cross-section heterogeneity that may otherwise seriously bias the resulting estimates and invalidate statistical tests. Because common modeling techniques such as the fixed and random effects models, developed to account for heterogeneity, are impractical for count data, this study uses cluster analysis to overcome this. First, observations are disaggregated into homogeneous clusters. Then, separate negative binomial models including a time trend factor are developed for each group. The results clearly indicate that there are significant differences between the models developed, and that separate models describe data more efficiently than the joint model [25].

Milton, Shankar and Mannering (2008) from their study projected thatmany transportation agencies use accident frequencies, and statistical models of accidents frequencies, as a basis for prioritizing highway safety improvements. However, the use of accident severities in safety programming has been often been limited to the locational assessment of accident fatalities, with little or no emphasis being placed on the full severity distribution of accidents (property damage only, possible injury, injury)—which is needed to fully assess the benefits of competing safety-improvement projects. In this paper we demonstrate a modeling approach that can be used to better understand the injury-severity distributions of accidents on highway segments, and the effect that traffic, highway and weather characteristics have on these distributions. The approach we use allows for the possibility that estimated model parameters can vary randomly across roadway segments to account for unobserved effects potentially relating to roadway characteristics, environmental factors, and driver behavior. Using highway-injury data from Washington State, a mixed (random parameters) logit model is estimated. Estimation findings indicate that volume-related variables such as average daily traffic per lane, average daily truck traffic, truck percentage, interchanges per mile and weather effects such as snowfall are best modeled as random-parameters—while roadway characteristics such as the number of horizontal curves, number of grade breaks per mile and pavement friction are best modeled as fixed parameters. Our results show that the mixed logit model has considerable promise as a methodological tool in highway safety programming [26].

Wang, Quddus, Ison (2011) confirmed that accident prediction models (APMs) have been extensively used in site ranking with the objective of identifying accident hotspots. Previously this has been achieved by using a univariate count data or a multivariate count data model (e.g. multivariate Poisson-lognormal) for modeling the number of accident sat different severity levels simultaneously. This paper proposes an alternative method to estimate accident frequency at different severity levels, namely the two-stage mixed multivariate model which combines both accident frequency and severity models. The accident, traffic and road characteristics data from the M25 motorway and surrounding major roads in England have been collected to demonstrate the use of the two-stage model. A Bayesian spatial model and a mixed logit model have been employed at each stage for accident frequency and severity analysis respectively, and the results combined to produce estimation of the number of accidents at different severity levels. Based on the results from the two-stage model, the accident hotspots on the M25 and surround have been identified. The ranking result using the two-stage model has also been compared with other ranking methods, such as the naïve ranking method, multivariate Poisson-lognormal and fixed proportion method. Compared to the traditional frequency based analysis, the two-stage model has the advantage in that it utilizes more detailed individual accident level data and is able to predict low frequency accidents (such as fatal accidents). Therefore, the two-stage mixed multivariate model is a promising tool in predicting accident frequency according to their severity levels and site ranking [27].

Lee, Roesler, Harvey and Ibbs (2002) through their study concluded that many urban concrete pavements in California need to be reconstructed, as they have exceeded their design lives and require frequent maintenance and repair. Information is needed to determine which methodologies for pavement design, materials selection, traffic management, and reconstruction strategies are most suitable to achieve the objectives of California Department of Transportation's long-life pavement rehabilitation program. For developing construction productivity information for several construction windows, a case study was performed on a Caltrans concrete rehabilitation demonstration project near Los Angeles on Interstate-10, where 20 lane-km was successfully rebuilt using fast setting hydraulic cement concrete with one weekend closure for 2.8 lane-km and repeated 7- and 10-h night time closures for the remaining distance. The concrete delivery and discharge controlled the overall progress. In terms of the number of slabs replaced per hour, the 55-h weekend closure was 54% faster than the average night time closure. An excellent traffic management strategy helped to reduce the volume of traffic during the weekend closure and minimize the traffic delay through the construction zone [28].

Flueler and Seiler (2003) through their research asserted that risk-based regulation seeks to make law more efficient as well as more transparent. It aimed to replace prescriptive, deterministic regulations by goal-oriented, probabilistic regulations, based on the criteria of cost-effectiveness and limitation of individual risks. The overall goal was to achieve more safety at less cost. The project 'Risk-Based Regulation' (1996–99) was intended to evaluate the feasibility of the approach from both technical and legal perspectives in the Swiss context. Nine case studies were carried out: storage and management of explosives (both military and civil), occupational safety, non-occupational accident prevention (mainly road accidents), fire protection, transportation of dangerous goods, waste disposal (conventional toxic landfills and radioactive repositories), and nuclear (reactor) safety. The research summarizes final results of the case studies and draws general conclusions on the possibilities and limitations of implementing a risk-based approach. Its findings should be useful in formulating standardized approaches as envisaged by the European Commission under the heading of a ‘Compass for Risk Analysis’ (EC-JRC, 2000), and the safety guidelines of the so-called ‘Swiss Agency for Technical Safety’ (SATS), a new institution to be set up in Switzerland to integrate all federal regulatory bodies dealing with technical risk [29].

Katz (2004) through his study found that the environmental load of fibre-reinforced polymer (FRP) reinforced pavement was compared with that of steel reinforced pavement. Replacing steel bars with FRP bars can lead to changes in the concrete mix and pavement structure at the erection stage, to a reduced need for maintenance activities related to steel corrosion, and to different recycling opportunities at the disposal stage. The current study examined all of these variables. The environmental load of FRP reinforced pavement was found to be significantly lower than that of steel reinforced pavement. This result was mainly from the fact that FRP reinforced pavement requires less maintenance, its cement content and concrete cover over reinforcement can be reduced, and the reinforcement itself generates a smaller environmental load [30].

Lindenmann, Burger, Laube and Partl (2006) confirmed that year more than 1000 pedestrians are injured in accidents on pedestrian crossings in Switzerland. The accidents often occur in darkness, twilight or poor visibility during rain at locations without sufficient public-street lighting because vehicle drivers notice the pedestrian crossing too late or overlook it altogether. Pedestrian crossings can be made significantly easier for vehicle drivers to recognize at night and in poor visibility by means of HMB reflectors. When crossing sites are made more conspicuous with high horizontal retro-reflecting markers, the readiness to stop increases. The reflectors can thus contribute to improving road safety at pedestrian crossings. This new low-cost measure has a wide range of applications. The new reflector system is currently gaining ground in Switzerland and several other European countries [31].

In India safety policies must focus on issue concerning safety of VRUs, especially Pedestrians which constitutes to minimum 40-50% of total road users and their interaction with trucks, tractors, buses and cars three/two wheeler etc. is highly unavoidable due to mixed traffic scenario in India. The situation even worsens due to more technologically and advanced vehicle launching day by day, driven by drivers with a little traffic education, using relatively very less advanced roadways and enforcement systems. Developed nations such as the United States, Canada, Australia, and those in Europe have made progress in pedestrian safety in recent years. India is experiencing growth in terms of economic development and motorization and now the time has come to begin addressing pedestrian's safety needs to a larger extent.

FURTHER STUDY IN THE LINE OF RESEARCH

From the literature review it can be very clearly seen that it’s very important to study and find out the contributing factors responsible for pedestrian accidents further remove them. The basic factors which are extracted from the review of literature, that cause pedestrian causalities /accident are Driver condition, Vehicle condition, Road condition, Road users other than the motorist such as bicyclist, rickshaw, and stray animals etc and Environmental factors The basic objective of study is to reduce the pedestrians’ accidents on Indian Roads. These objectives can be achieved by studying the pedestrian behaviour along and across and unsignalised) Indian roads and the pedestrian-vehicular interaction on the Indian roads.

Therefore, there is a need to study urban as well as non-urban sections of highways in India, to identify the significant factors of accidents and to develop a predictive model for the same. The study would also assess the pedestrian safety of Indian roads and recommend suitable improvement.

All the road sections of Sonipat City are selected for research work. Further a detailed data of road features and accident data from record of traffic police (FIRs), NHAI and Government Departments and other concerned agencies will be rigorously collected. This data will be categorised and analysed to determine the various significant factors leading to fatal accidents on Indian roads. Further SPSS software would be used to develop accident prediction model for selected road sections.

METHODOLOGY FOR EXECUTION OF THE STUDY

This section of the proposal describes the research design for the study i.e. the various sources of data, sample size, methodology as well as research software. The purpose is to have a clear idea about the research process.

SOURCE OF DATA FOR THE STUDY

For traffic volume data on selected road stretches from NHAI and other government offices like PWD are contacted. The FIR data of vehicle accidents was collected from various police headquarters and police stations. This will be a significant source of data.

Geometric features of various roads will be checked in Sonipat district. Physical dimensions, surface texture, total length of the section etc were noted down. They affect a lot in deciding the pedestrian view towards a pedestrian safety facility on roads.

CONCLUSION

The research paper presents an exhaustive review on pedestrian safety while delineating critical factors why this study is necessary. This study also offers the blueprint of an empirical study based on statistical tools and technique and multi vitiate analysis to figure out the accident prediction model which will help the researcher to exactly know the important factors leading to pedestrian accidents and devise scientific methods to prevent them. Identifying effective factors on pedestrian accidents and providing pedestrian accident prediction models can help to improve pedestrian safety and prevent pedestrian accidents on roads. Some models were shown to estimate pedestrian crashes on roads during the research. Among models including: linear regression, Poisson and negative Binomial to choice the best pedestrian accident prediction model from studied models with conducted trials on them that can define characteristics of pedestrian accidents in the finest way, negative binomial due to less dispersion, more correlation and logical answer between Poisson and linear regression were considered more appropriate. Methods described in the former section can help to improve pedestrian safety and decrease pedestrian accidents after finding effective factors and providing pedestrian accident prediction model on roads under study.

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