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Evaluation of the influencing factors and causes of pedestrian crashes at both intersections and along roadways using Regression Analysis: *A case of Nekemte, Ethiopia*

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Abstract: *One of the inputs for the economic development of a country is the expansion of the road network, which is important for the transportation of people and freights from place to place. With this expansion, the occurrences of road traffic accidents in terms of pedestrian crashes are increasing in all parts of the world from time to time killing the lives of many people and damaging properties. This problem is growing at an alarming rate in sub-Saharan African countries like Ethiopia. Therefore, this study aims to assess the influencing factors and Contributing Causes of pedestrian crashes at both intersections and along roadways using Regression Analysis. The study area was conducted in the East Wallaga Zone, Nekemte town of Ethiopia in Oromia National Regional State, as a part of our research work. The pedestrian crash data recorded between September, (2008) to January 2011 were collected from the Nekemte traffic police office and used for regression analysis. Besides, a field survey was made to observe the road segments with high pedestrian volume and pedestrian crashes were selected by using a purposive sampling Technique. This research study found that there was a significant increase in terms of the number of deaths occurring due to pedestrian crashes as a result of the increase in the coverage of road crashes and their consequences. The major causes of pedestrian crashes include Pedestrian and road characteristics, land use, light and weather conditions, crash location, and speed. The result showed that Road condition, Human factor, shoulder, carriageway, roadways, and Volume of traffic have a strong correlation with pedestrian crashes occurring while driver skill and age of the driver have a low correlation with road traffic accidents.*

Keywords: *Crashes, pedestrian crashes, pedestrian volume, prediction, traffic safety.*

I. INTRODUCTION

Road safety has recently been considered one of the greatest issues in road safety management worldwide. Due to the influencing factors from various aspects, pedestrian crashes cause a lot of loss in the economy and people's happiness. It is reported that around 1.35 million people die in the world each year due to road traffic accidents and Due to insufficient attention to Pedestrian safety [1]. Pedestrian crashes constitute major health, economic, and developmental challenges of developing countries, Morley adversely affected sub-Saharan African Countries [2]. In 1999, for instance, 750,000-880,000 people died in road traffic crashes of which, about 85% of these occurred in developing countries [3], and in 2002 an estimated 1.2 million people were killed in road traffic crashes [4]; 90% of the traffic crashes occurred in low and middle-income countries of which Sub-Saharan countries had faced the highest fatality rate (28.3 per 100,000 population), which is substantially higher than any continent in the world [5].

Walking is the most traditional mode of transportation and can carry a high risk of injury or death on many of our Nation's streets and highways. Motor vehicles only have been around for about a century, but during that comparatively short time, they often have made walking hazardous, each year from 1998 to 2007, an average of approximately 4,800 pedestrians were killed and 71,000 pedestrians were injured in the United States traffic crashes. During these 10 years, pedestrians represented approximately 11.5 percent of all pedestrian crash victims [6]. Pedestrian safety is a critical issue in the United States, but pedestrian fatalities are even more common in many

developing countries. The total mortality was 622 in 2008 and 933 in 2009 accounting for a 50% increase. From these, we can conclude that pedestrian crashes in developing countries are a major health problem and need an immediate solution that reduces the fatality, injury, and property damage happening due to the problem of road safety.

Similar to the other sub-Saharan Regions, a road traffic accident in Ethiopia is increasing occasionally. For example, on research conducted in Addis Ababa from 2001 to 2008, it increased from 9.27% to 13.9% with a typical pick in 2006, which was 15.1% [7].

Pedestrians walking on the road are a unique travel mode as it provides many health benefits for individual pedestrians, in Auditions. It also enforces the lowest adverse externalities to the transportation network. However, pedestrians are the most vulnerable road users, often due to the lack of enough protection and poor facility design, leading to higher pedestrian exposure. Vehicle-pedestrian crashes are an important traffic safety concern because it has a pattern of unique certainty and high severity levels. The 2017 National Household Travel Survey estimated that about 16% of the United States population (around 5% increases from 2009 National Household Travel (NHT survey estimates) walked on their travel day for different reasons. Over the last several years, pedestrian crash rates in Ethiopia have been consistently ranked amongst the highest in the country, through the nation; a lot of emphasis has been put on intersection crashes. Intersection crashes are typically geocoded more accurately than other crashes because they are explicitly associated with intersections as part of the crash attributes, Midblock crashes are segment oriented and studies have shown that for the most part, most analysis is done on an intersection-to-intersection basis using very long segments.

II. LITERATURE REVIEW

Global crash statistics

The pedestrian crash is one of the causes of the death of people and has been ranked as one of the leading causes of death in the world. Millions of people are killed each year. Every day, thousands of people are killed and injured on the road by crashes. It is the leading cause of death, disabilities, and hospitalization, severe socioeconomic costs, across the world. According to (WHO), it has been estimated that pedestrian crashes (PCs) take the lives of nearly 1.3 million each year, as a result, nearly 3500 people die each day. Besides, the people who suffer serious injuries including disability are about 20 to 50 million worldwide.

The factor that causes pedestrian crashes

The causes of traffic accidents are the road, the driver, the road user, the vehicle, and environmental factors. According to [5], studies from the American and British reports; accidents occurred 57% due to driver factor, 27% due to the combined roadway and driver factor, 6% combined vehicles and driver factor,3% a combination of the road, drivers, vehicles,2% vehicle factor,1% combined of vehicle and road user factor. Road network in Africa is expanding fast, and similarly, maintenance standards are improved resulting in the safety standard of the road. However, in Nekemte town, due to a lack of training in the subject area, the contribution of roads and environment to pedestrian crashes is underestimated. Some examples of how a reduction in crashes and crash severity may be achieved include:

1. The behavior of humans;
2. The condition of the roadway/environment;
3. The design and maintenance of technology including vehicles, roadway, and environment technology;
4. The provision of emergency medical treatment, medical treatment technology, and post-crash rehabilitation;
5. The exposure to travel, or level of transportation demand.

Walking at Night

Pedestrian crash risk at night is higher than in the daytime due to the lower conspicuity of pedestrians this is exacerbated by the tendency for pedestrians to judge themselves as being more visible than at night. One study shows that driver's ability to recognize pedestrians at night is degraded such that pedestrian fatalities may rise seven times higher at night than daytime Most pedestrians in developed countries can afford to buy retroreflective clothing which is both available and has been demonstrated to enhance visibility at night but such clothing is neither commonly available nor affordable in DCs. Besides, most locations in developed countries with high pedestrian traffic have sufficient street lighting to facilitate the visibility of pedestrians at night and thereby reduce road crashes whereas the same does not apply as widely in DCs.

Effects of Cross-section Elements on Pedestrian Crashes

studied the effect of road cross-section elements on pedestrian crashes; roadway cross-section encompasses features on the travel portion of the road used by pedestrians and the roadside. Accordingly, the design of the cross-section element influences the safety of the roadway. The portion of the road cross-section normally used for pedestrian and vehicle travel may serve multiple purposes, including future expansion and recovery room for an uncontrolled pedestrian.

Besides, types and descriptions for the most common elements of roadway cross-section were given in the following ways; Width of the lane, number of lanes, shoulder width, pedestrian sidewalk, Median width, and Median type.

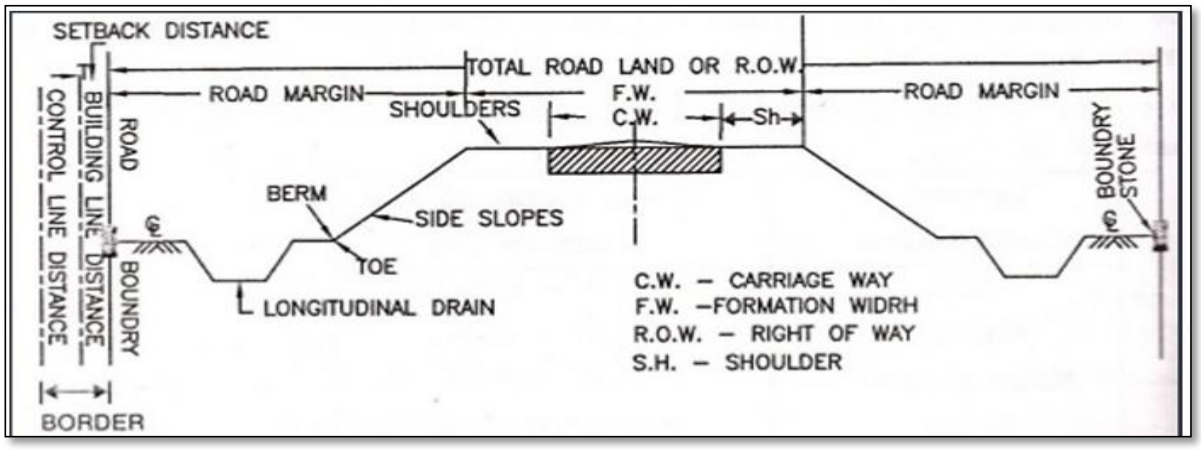


Figure 1. Roadway Cross-sectional Elements.

Alcohol and its influence on Driving or Walking

Like speed, alcohol influences the risk of pedestrian involvement in a pedestrian crash and the increased severity of consequent injury Consumption of alcohol leads to a higher probability of pedestrian crashes since alcohol slows reaction time impairs perception and decision-making, reduces attention, and decreases visual acuity. It should be noted that these impairments to performance apply equally to drivers or pedestrians consuming alcohol before, or whilst driving or walking and contribute to vehicle-pedestrian crashes.

Table 1: Stopping and Passing sight Distance in relation to design (Ethiopian Roads Authority, 2002).

Design Speed (Km/h)	Coefficient of Friction(f)	Stopping sight distance(m)	Passing sight Distance(m)
20	0.42	20	160
30	0.40	30	217
40	0.38	45	285
50	0.35	55	345
60	0.33	85	407
70	0.31	110	482
85	0.30	155	573
100	0.29	205	670

Regression Analysis

Regression analysis is a statistical technique that is very useful in the field of engineering and science in modeling and investigating relationships and impact (Positive and Negative) between two or more variables (dependent and independent variables, factors, and parameters).

The method of regression analysis is used to develop the line, Table, curve, or graphs, which provides the best fit through a set of data points. This basic approach is applicable in situations ranging from single linear regression to more complex and sophisticated nonlinear multiple regressions. The best-fit model could be in the form of a linear, parabolic, or logarithm trend. A linear relationship is usually practiced in solving different engineering problems because of its simplicity.

In this research work, an attempt is made to apply Multiple linear logistic, Binary regression, Probit regression Modeling, and logit Regression modeling Analysis to characterize Pedestrian crash characteristics and contributing causes using a Statistical approach. The statistical software program (SPSS) has been used in regression analysis to find the Effect of each crash's characteristics and parameters on the pedestrians. Several techniques can be used to judge the pedestrian crash characteristics and contributing causes on pedestrian may, adequacy of the regression model, some of which are a standard error(Ɛ), R-squared value (R2), R-adjusted, and the P-value. The value of R2 is always between 0 and 1 because R is between -1 and +1, whereby a negative value of R indicates a relationship inversely, and positive values imply a direct relationship. Confidence in the result indicates in terms of significant value(P), the correlation was considered significant if (p) is zero or 5 percent different from zero.

III. METHODS/ FLOW OF THE STUDY

A descriptive research Method and analytical design approach has been used in this study. The descriptive type of research is considered to be an appropriate method to investigate the status, causes, and countermeasure of pedestrian crashes, and it has to be analyzed for different pedestrian crashes along the intersection and at roadway mid-block along the study area. The field observational survey will be conducted to obtain a more exact and larger sample of pedestrian crashes while walking and crossing the road, attitudes, perceptions of facilitators, and barriers concerning this behavior.[8]

The sample population was taken out from all districts found in the Nekemte town while the method of sampling used, is a purposive sampling technique. From this perspective, the population is the target group to be studied in a particular place while the sample is a part of the population. From this nature of the work, pedestrians move from one place to another place.

Variables considered for the analysis

Table 2: Variables with their Code and Factors

Set	Factor	Variable	Code	Measure
Pedestrian Characteristics	Pedestrian-related causes	Pedestrian under the influence (PUI), pedestrian failed to yield the right of way (Ped FTYROW), pedestrian disobeyed traffic control (Ped DOTCD), handicapped pedestrian, a pedestrian walking along the roadway, pedestrian crossing.	1	Nominal
			2	
Driver characteristics	Driver-related causes	Driver under the influence (DUI), Driver failing to yield the right of way, Driver disobeying traffic control, careless driving, speeding, Aggressive Driving.	1	Nominal
			2	
Environmental Characteristics	Weather	Clear	1	Nominal
		Reverse	2	
	Time of day	Daytime	1	
		Nighttime-lightened	2	Nominal
		Night time-not lightened	3	
Location Characteristics	Presence of Crosswalk	No	1	Nominal
		NA (Along with roadway crash)	2	
		Yes	3	
	Presence of sidewalk	No	1	Nominal
		NA (crossing crash)	2	
		Yes	3	
	Type of control	No control	1	Nominal
		Control sign	2	
		Signal control	3	
	Crash Location	Intersection	1	Nominal
		Mid-block	2	

Crash Characteristics	Crash type	Left turn	1	Nominal
		Right turn	2	
		Through	3	
	At-fault party	Driver	1	Nominal
		Pedestrian	2	
	Injury severity	None	1	Ordinal
		Possible	2	
		Minor	3	
		Major	4	
		Fatal (within 30 days)	5	

Correlation using Regression Analysis

Regression is the statistical process used for evaluating the relationship between variables. The regression analysis has many techniques for modeling the statistical equation and analysis of several variables, which is focused, on the relationship between a dependent variable and independent variables. Regression analysis is a statistical technique used to describe relationships among variables.

The simplest case to examine is one in which a variable Y, referred to as the dependent or target variable, may be related to one variable X, called an independent or explanatory variable, or simply a regression.

If the relationship between Y and X is believed to be linear, then the equation for a line may be appropriate:

$$Y = \beta 1x + \beta 2X + \varepsilon$$

When the Multiple regression Model explains Y using more than one independent variable $Y=\beta 0+ \beta 1X1+ \beta 2X2+\ldots\ldots \beta pXp+\varepsilon$

Where $\beta 0, \beta 1, \beta 2 \ \beta p$ are the parameters, and ε is the random error.

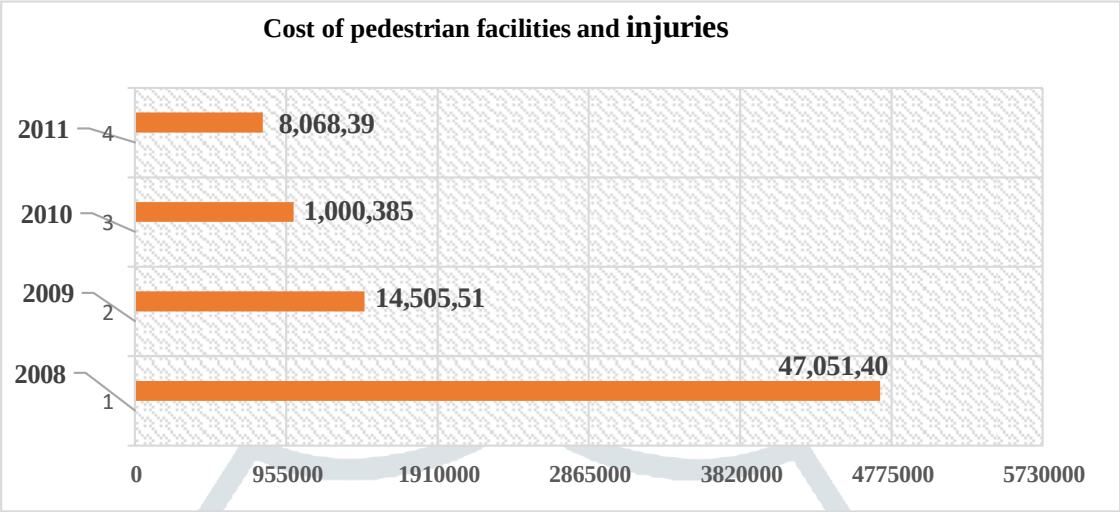
In simplest terms, the purpose of regression is to try to find the best-fit line or equation that expresses the relationship between Y and X.

IV. RESULT AND DISCUSSIONS

The result Cost of the Pedestrian Crash as Property Damages:

As it is described in the figure below, the analysis shows that the number of fatalities is not- constant over the 4 years at intersections However, a higher number of fatal crashes occurred at midblock locations (16.5%) compared to (7%) at intersections

Figure 2: Cost of pedestrian facilities and Injuries



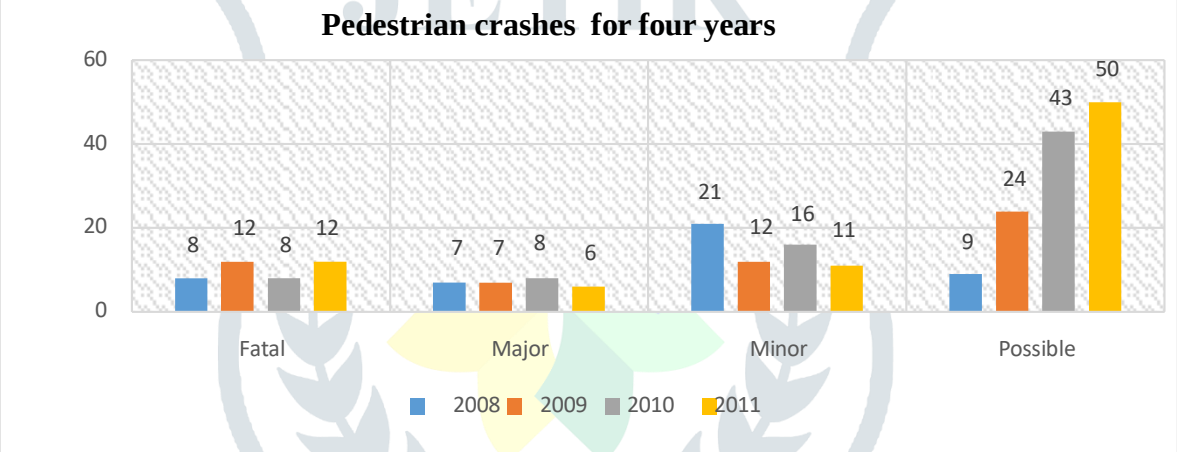


Figure 3: Result of Injury severity by year and location

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Result of the Lighting Condition on pedestrian's movement

Lighting conditions are also, one of the factors for pedestrian crashes. Pedestrian crashes at intersections occurred most frequently during daylight; in contrast, the majority of pedestrian crashes along the roadway occurred during nighttime with or without street lights.

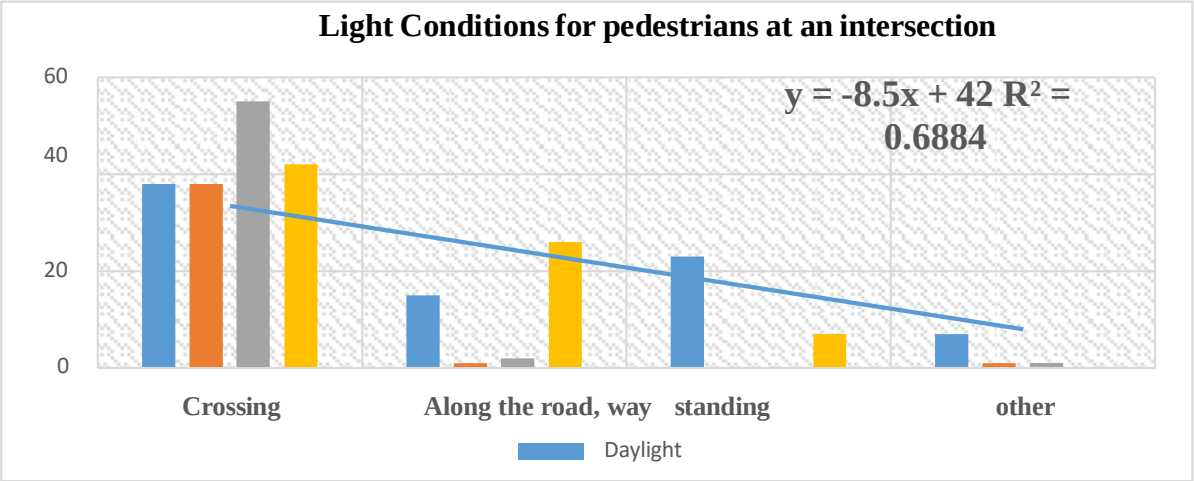


Figure 4: Light Conditions for pedestrians at an intersection

Result of Injury severity by year and location

Result of the Pedestrian crashes at intersections.

Three Main Types of pedestrian crashes at intersection points

1. Crashes involve right-turning vehicles, and they account for 30 percent of all analyzed crashes at intersections.
2. Crashes that involve left-turning, and account for 14 percent of all analyzed pedestrian crashes.

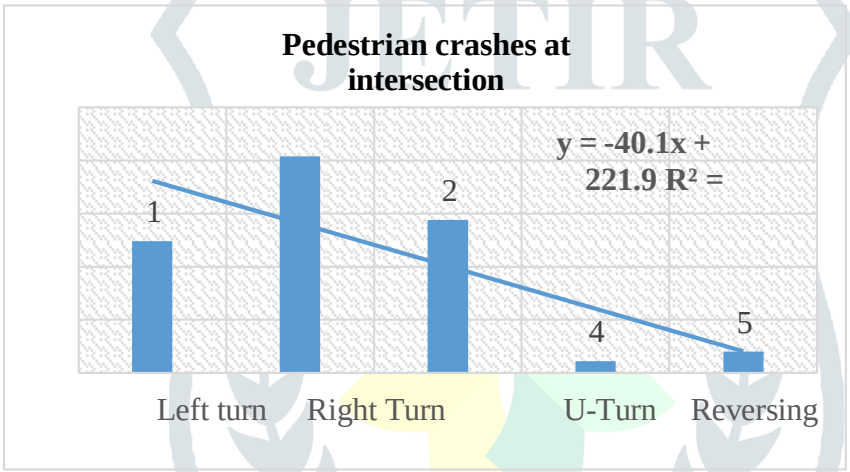


Figure 5: Pedestrian crashes at intersection

Result of the Models Analysis and Results

The probability expression of the multinomial logistic regression is:

- The regression model is
- Data about *x* and *y* are obtained from a sample.
- From the sample of values of *x* and *y*, estimates *b*0 of β0 and *b*1 of β1 are obtained using the least squares or another method.
- The resulting estimate of the model is

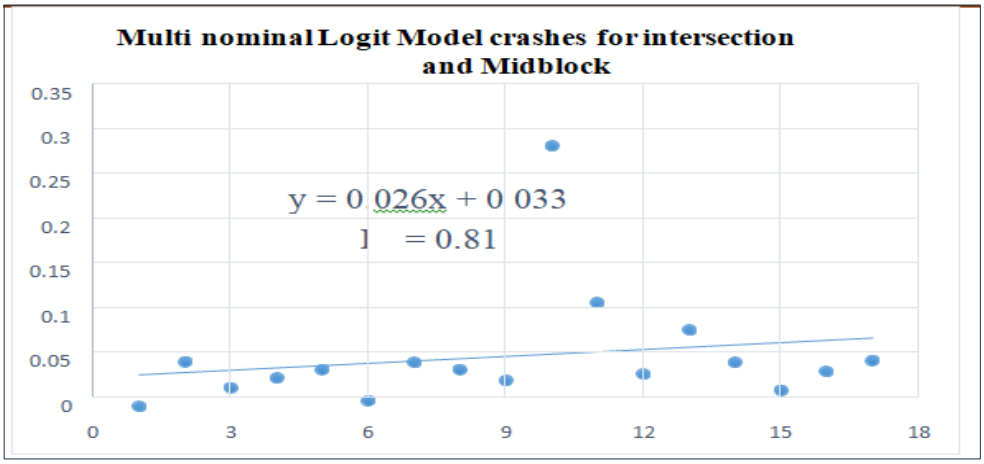


Figure 6: Multinominal Logistic crashes for intersection & Midblock

Statistical Evaluations of Multinomial Logistic Regression Output

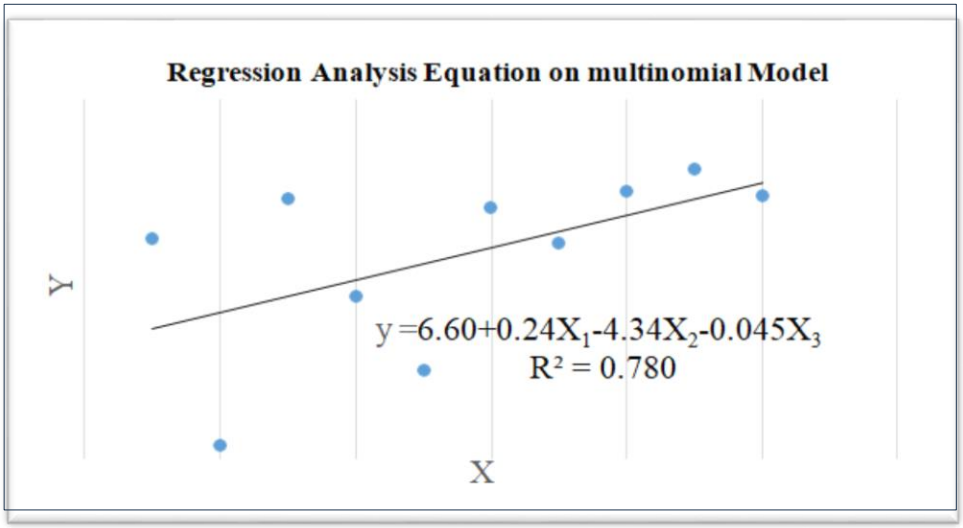
The More general and appropriate test is the likelihood ratio test. It assesses the significant impacts of individual parameters on pedestrian crashes at both intersections and roadways. The likelihood ratios test shows a chi-square distribution. The chi-square statistic is the difference in -2 log-likelihoods between the final model and a reduced model. The likelihood ratio test statistics is

$X^2 = -2\ [LL\ (\beta R) - LL((\beta U)]$.

Table 3: Statistical Evaluation

Parameter Estimates								
Factors		**B**	**Std. Error**	**df**	**Sig.**	**Exp(B)**	**95% Confidence Interval for Exp(B)**	
							Lower Bound	Upper Bound
RT	Speed	2.135	2.656	0	.026	.656	1.56	3.656
	Dist Driv	-3.62	7.097	1	.038	1.132	.000	1.034
	Carele Driv	3.271	1.825	1	.001	29.025	4.779	36.604
	Aggre Driv	0.520	1.779	1	.070	1.682	.051	54.990
	DUI	-1.534	.000	1	.032	.001	.053	.001
TH	Speed	2.001	32.453	0	.002	0.539	1.099	1.034
	Dist Driv	2.019	11.753	1	.960	2.099	.000	4.656
	Careless Dri	3.44	60.912	1	.028	1.710	.000	1.040
	Aggressive	2.066	80.086	1	.002	4.000	.702	2.043
	DUI	3.350	31.359	1	.002	3.257	.335	1.034

V. RESULT OF THE MODEL VALIDATION EQUATION.



From The Table above left-turn crashes were more likely to occur with aggressive driving compared to right-turn crashes. The chance of right-turn crashes not caused by aggressive driving is higher than when compared to left-turn crashes. The probability of right turn and through crashes is higher when a pedestrian is found to be at midblock crossings which are rarely controlled.

Figure 7: Modal Regression analysis Equations when vehicles movies with a Left Turn in the Reference category

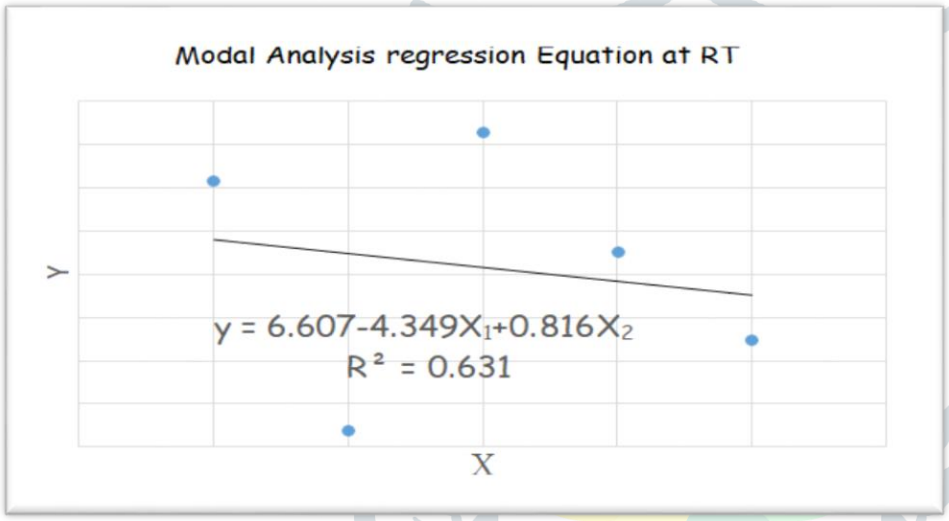


Figure 8: Modal Equations when vehicles movies Right Turn Left turn is the Reference category.

Countermeasure for reducing pedestrian exposure to vehicular traffic Reducing vehicle speeds

- ✓ Reducing pedestrian exposure to vehicular traffic: There are several specific engineering measures to ensure that. Most of these measures involve separating pedestrians from vehicles or reducing traffic volume: building usable sidewalks/footpaths
- ✓ Reducing vehicle speeds: One of the most effective ways to improve pedestrian safety is to reduce the speed of vehicles.
- ✓ Improving pedestrian visibility: A high percentage of pedestrian collisions and deaths occur due to low lighting conditions.
- ✓ Traffic law enforcement: Traffic laws affecting pedestrian safety are largely aimed at controlling pedestrian and driver behavior at intersections, crossings, and other locations.
- ✓ Improving vehicle design for pedestrian protection: Motor vehicles have become increasingly safer for occupants, due to improvements in vehicle design. Until recently, vehicle design incorporated few features to protect pedestrians
- ✓ Providing care for injured pedestrians: The primary goal in pedestrian safety should be to prevent road crashes from happening in the first place.

VI. CONCLUSIONS AND RECOMMENDATIONS

Conclusions

For intersection-related crashes, it was found that left turn, right turn, and moving vehicles struck crossing pedestrians.
At mid-block locations, major crash types were through moving vehicles hitting pedestrians crossing and walking along the roadway. The evaluated factors affecting pedestrian crashes were classified into four major categories; Location characteristics(e.g. intersection, Midblock, type of control, presence of crosswalk, the prescience of sidewalk), Pedestrian factors(e.g. pedestrian under influence, failure to yield to the right of way), Driver/vehicle characteristics(e.g. Driving under influence, failed to yield to the traffic control device, aggressive driving), and Environmental-related characteristics(e.g. weather condition, road surface conditions and time of day) were among the factors studies.

Recommendations

Based on a deep understanding of the main causes of pedestrian crashes, low-cost engineering was proposed. On existing situations or identified causes, improvement was suggested.

- The pedestrian crashes in Nekemte town occur during the day rather than at nighttime. Hence, the traffic policies should be assigned properly to control traffic safety condensation and pedestrian volume in the daytime rather than at night.
- Redesign or construct the improper traffic control devices, traffic signs, and shouldering of way, and develop road infrastructure (road lights and marking, sign inventory like speeds limit).
- Road Safety Audit surveys should be done for short intervals to observe changes in the road structure and equipment as well as the road environment.
- Training should be provided to traffic officers on how to use GPS to specify where pedestrian crashes have occurred and the data can easily be used to map and take countermeasures in the Pedestrian crash risk areas.
- Strict traffic police implementation and speed control.
- Giving training regards traffic laws for both pedestrians and drivers regularly & Providing pedestrian sidewalks and zebra marks.

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