Identifying Hazardous Location, Predicting the Crash and Providing a Countermeasure on Rural Truck Road

Abebe Biress*, Ashenafi Aregawi

Department of Surveying Engineering, Mekelle University, Tepi bushira, Ethiopia

Research Article

Received: 01-Aug-2022, Manuscript No. JET-22-001-PreQc22; **Editor assigned:** 04-Aug-2022, Pre QC No. JET-22-001 -PreQc-22 (PQ); **Reviewed:** 18- Aug-2022, QC No. JET-22-001- PreQc-22; **Revised:** 25-Aug-2022, Manuscript No. JET-22-001 -PreQc-22 (R); **Published:** 01-Sep-2022, DOI:10.4172/2319-9857.11.5.004.

***For Correspondence:** Abebe Biress, Department of Surveying Engineering, Mekelle University, Tepi bushira, Ethiopia

E-mail: **abebebiress@gmail.com**

Keywords: Countermeasure; Empirical bayes estimate; Excess hazardous road segments; Safety performance function;

ABSTRACT

The main aim of this thesis was evaluating the statuses of a mid-block section of the rural truck road in Awi zone and recommended countermeasures at selected hazardous locations after identifying the causes of the crash.

Currently, the issue of traffic safety has become the most considerable concern throughout the world. Especially, the issues that have done the dynamic growth of traffic crash day today, Geometric and traffic control features and traffic volume effect main input variables in the Empirical Bayes method used affect the developing countries including Ethiopia. According to the Awi zone police commission report, road traffic crashes in the study area (20016-2018), 212 crashes observed.

The study uses empirical Bayes method to identify hazardous locations on the mid-block section of the road. The method also includes safety performance function at base condition and site condition approved in HSM and these methods presented mid-block section of the road. In addition to that, the result shows among the segmented 123 parts of the road 32-road segments identified as hazardous locations. This identification of hazard locations indicates that these sections need urgent attention to diagnose, prioritize, evaluate and give effective solutions to reduce road traffic crash and increase the safety performance of the road. Possible solutions have used traffic-controlling devices, modification of geometric design parameters.

INTRODUCTION

Road traffic crash death and injures observed in the world, it was estimated that over 1.3 million people died each year on the world road because of the road traffic crash. According to studies by WHO, more than 3,200 people are killed and over 130,000 injured in traffic, crash every day around the world. The vulnerable road users' means pedestrians, cyclists and motorcyclists mostly affected by this problem. The trends of road traffic crashes become increasing in the last decades that is why the researchers to think of this problem and find possible causes and precautionary measures to prevent road traffic crashes from happening. Roadway, traffic control devices and roadside features of the highway mainly affected by human, vehicular and environmental factors. The other factor that affects the safety of the highway was the geometric design features of the roads and associated features, which have a noticeable effect on the road traffic crash. These inquiries have led to study road traffic crash related to geometric design features and other criteria of the road which are mandatory to study the safety of the highway. This paper combines so many road traffic crash data, geometric design feature data, and volume data of traffic, traffic control device data and previous research by different researchers [1].

In developed and developing countries, the losses of resources and economy affected by road traffic crash, due to that, they are considered as the main criterion for road safety. The three basic aspects of transport humans, roads and vehicles, were the primary factors in the crash. The human factor seems to be the dominant cause of crash compared to the others. However, the number of crashes can be seriously reduced if the road design factor has evaluated better and highway design has made correctly. When considering the population figures, developing countries in Sub-Saharan Africa have the highest frequency of various crashes worldwide.

Much of the research on highway safety has focused on different factors, which affect roadway safety. The factors have categorized as traffic characteristics, road geometrics, road surface condition, weather, and human factors. Previous research has shown that geometric design inconsistencies, operations (traffic mix, volume, and speed), environment, and driver behavior were the common causes of the crash. Most of the studies have shown the influence of various geometric design variables, traffic volume, and traffic control devices selectively on the occurrence of crashes and have concluded that not all variables have the same level of influence in all places.

In Africa over 80% of goods and people were transported by roads, while in Ethiopia road transport accounts for over 90% of all the inter-urban freight and passenger movements in the country [2].

Road traffic crashes pose a significant weight in Ethiopia, as was the case for other developing countries because Ethiopia was one of the developing countries in the world and road has the major transport system. Recently, Ethiopia has become one of the fastest growing non-oil producing economies in the world.

MATERIALS AND METHODS

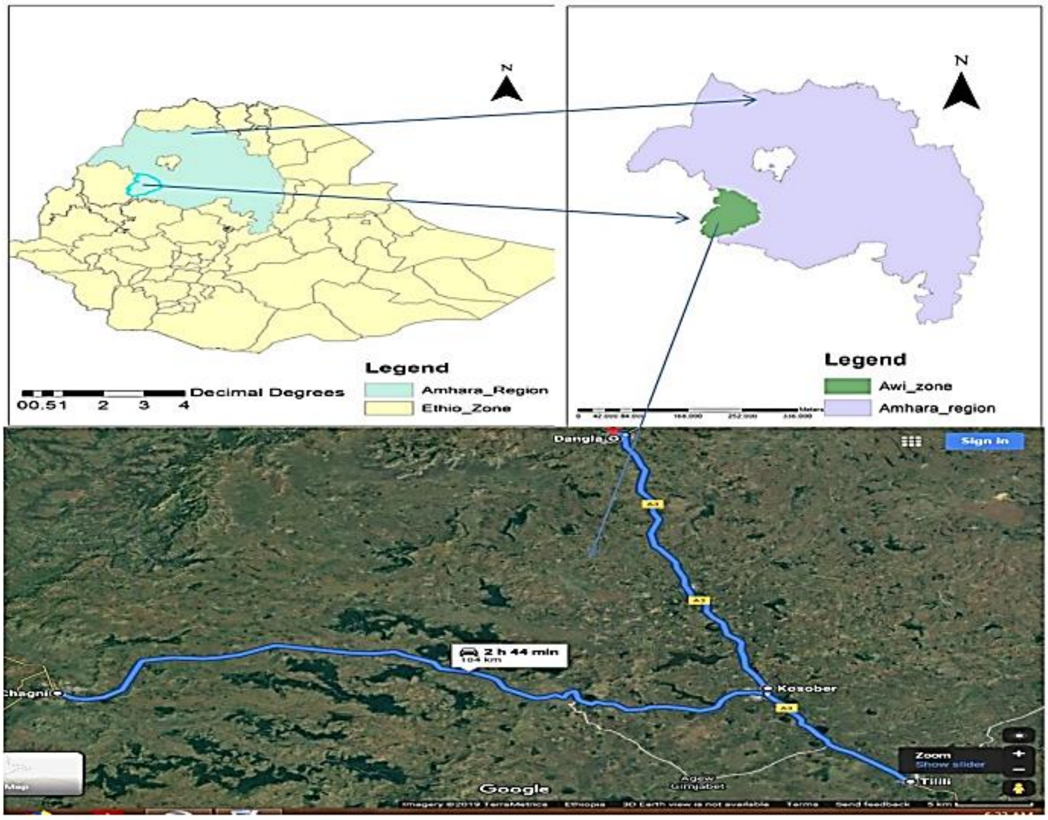
The major aim of this thesis was predicting and estimating the crash by using the empirical Bayes method that will be used to identify the hazardous location using the geometric features, traffic control features and volume of traffic in rural main roads of the Awi zone. In addition, it aims to identify the contributing factors and develop the most appropriate countermeasures of the hazardous locations, that occur due to the inappropriateness of geometric and traffic control features of the road.

Hence, the study was primarily, executed for the identification of hazardous locations due to the cumulative effect of geometric features of the rural main road, which have a 102 km length in rural, area of the site. The entire methodology that was adapted for accomplishing the objective of the research was based on data collection, analysis of collected data, identification of the hazardous location, site investigate the identification of the most affecting geometric features of the road segment. Elimination of non-significant factors, then by using empirical Bays model evaluating each of the road parts and providing the countermeasures.

We used a 25 ms speech window with mel-cepstral and 32 ms window with wavelet features, due to specific decomposition structure. The mother wavelet chosen for continuous transform in signal decomposition was the Morlet wavelet. The mother wavelet chosen for discrete transform [3,4] with 28 filter length. The stride is set to 10 ms for all extraction methods to ensure a fair comparison. The Decision Tree Ensemble also termed the Random

Forest method was used. A random forest is a meta estimator that fits a number of decision tree classifiers on various sub-samples of the dataset and uses averaging to improve the predictive accuracy and control over-fitting. The sub-sample size is the same as the original input sample size and the samples are drawn with replacement. Quality of split is measured by "gini" denoting Gini Impurity [5,6]. Max depth of the tree is set at 500. Maximum features to be used for prediction are sqrt (n features). The minimum number of samples required to be at a leaf node is set at 3. A split point at any depth will only be considered if it leaves at least 3 training samples in each of the left and right branches. The minimum number of samples required to split an internal node is set at 5. 400 estimators are used which denotes the number of trees in the forest. Model is kept similar to the three feature extraction methods to test the performance (Figure 1).

Figure 1. Research area. **Note:** ( ) Amhara_Region; ( ) Ethio_Zone; ( ) Awi_Zone; ( ) Amhara_Region.



Road segment selection criteria

It is a rational means to divide the road into intersections and road segments based on traffic safety management because the problems and the treatments are different for intersections and road segments (Table 1).

The main reasons for the selection of segment were:

1. The availability of better crash database at the respective police stations compared to intersection part of the road,
2. The potential openness of the segment road networks to the occurrences of the frequent number of a crash.
3. Due to its large coverage of the road segment in the research area.

Table 1. The study of the road network.

Street name	Street classification as per ERA	Total length (Km)
Kosober to Burie	Truck	20.529
Kosober to Dangla	Truck	39.777
Kosober to Chagni	Truck	42.114
Total	Truck	102.42

The analysis of intersection should include all crashes that occur within the specified radius of 250 ft from the center of the intersection. Driveway crash occurring within 250 ft or 76 meter from the center of the intersection should be included in the count of intersection crashes. Illustrates the influence zone of an intersection.

Different road features were there in the selected road segment. Where road layout comprises straight road section, horizontal and vertical curves while geometric features encompass various types and sizes of median width, shoulder, U-turn, lane width, lane number, etc [7-9].

The identification of contributing factors and selection of countermeasure

The countermeasure selection has been made by evaluating the Potential for Safety Improvement (PSI) if appropriate countermeasures are applied. Countermeasures have been targeted a particular crash type or contributing factors. The contributing road and traffic control factors were identified through exhaustive fieldwork, in-depth analysis of historical crashes, from the model indication that is any variation from the base model. Therefore, the countermeasures selection and implementation depend on the recommendation of the HSM, site observation and the detailed analysis of each road segment in the result analysis part.

According to HSM, the recommended contributing factors and countermeasures in rural two-way two-lane roads existed in the appendix.

Accordingly, crashes on the roadway segment commonly observed were listed in the HSM. Thus, is vehicle rollover, opposite direction sideswipe head-on sideswipe, single-vehicle run off the road.

Depending on this and other similar conditions HSM generalizes the following contributing factors on the rural truck two-way two-lane roads, thus, are the inadequacy of the base model developing geometric features and traffic control features, inadequate pavement marking, excessive speed, poor delineation, poor visibility, etc. Moreover, the recommended treatments or countermeasures suggested by HSM and other manuals of the roadways, recovering the fault parameters of the road geometric features, traffic control features and other contributing factors to the normal condition.

RESULTS

Primarily this section presents with a detailed analysis of data sources. The primary data analysis dealt with computation and organization of data acquired from the site investigation survey such as geometric features, traffic control features. Whereas the secondary analysis dealt with detail analysis of crash patterns along with the study, area means in the identification of hazardous locations like that of crash data, traffic volume data. Accordingly, identification of contributing factors and the countermeasures of the hazard location also discussed and provide.

Analysis of collected data

As it was explained in chapter three, data were collected from primary and secondary data sources. Besides, the entire analysis of the thesis was performed by analyzing the gathered data step by step and the requirement of the models.

Crash Modification Factors (CMF)

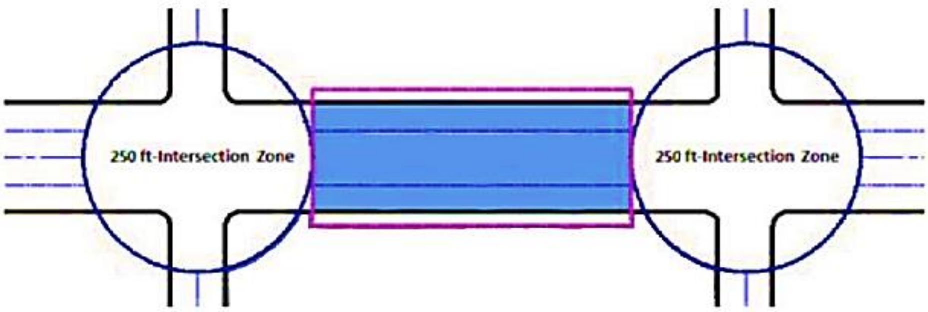
The CMFs for geometric design and traffic control features of rural two-lane two- way roadway segments are presented in consecutive parts below as it elaborated in 3.8 part of this thesis. These factors used to account for the variation between the base condition and the local site conditions. In case there are 11, CMF applied in these modification processes.

Hazardous road segments

According to the selected performance measure and detail procedure described in the methodology part, hazardous road segments and the corresponding performance measure value were estimated. The identification of dangerous road segments was based on the value of the excess. EB- adjusted crash greater than the crash with CMF and CF as stated in the methodology part having the value negative road segment means the road segment is not hazardous and if the value is positive indicates the rod segment is said to be not normal or hazardous. Therefore, when the excess expected crash frequency value became greater than zero, a site experiences more crashes than expected otherwise a site experiences fewer crashes than expected. For example, segment K-CH 134 has experienced 1.58 crashes per year more than the expected threshold value, which can be expected from such types of roads. Hence, there will be the potential to reduce an equal number of crashes per year with minor improvements along this segment. Accordingly, based on excess values it is possible to identify the hazardous road segments ranking road sites based on excess value [10,11].

The identified dangerous road segments in the above section were ranked according to their excess values. The one that has ranked at the left has a high potential to reduce the number of crashes compared to the other road sites in the ranked list after treatments will be applied. This implied that the higher the value of excess in the ranked list of dangerous segments the more K-CH134 dangerous compared to the other sites in the list. Segment, which was ranked in the first position, in the rural two-lane two-way main road reference population, has a potential for reducing the average crash frequency by 1.5807 crashes per year (i.e. around 10.14% of total the excess number of crashes in the study area). Therefore, Segment K-CH134 would be ranked in the first position as compared to other segments according to the highest excess expected crash frequency. Similarly, segment K-CH122, which took the second place, has the potential for reducing the average crash frequency by 1.21 crashes per year (which contributed around 7.8 of a total excess the number of crashes in the study area). On the other hand, if segment K-CH52, which was ranked in the last position (i.e. ranked in 32 positions), is treated it has a potential for reducing the average crash frequency by 0.00454 crashes per year. This is the reason why the prioritization of individual sites was made within a reference population (Figure 1).

Figure 1. Influence zone of an intersection.



Data collection

Previous research studies were reviewed to attend the stated objectives of the research. The provided literature gives institutions to the ways of data collection, problems encountered and means of solving it and the background knowledge about road safety becomes sufficient, gives solutions after identifying the problems. The knowledge and experiences gained in the literature review helped the writer of this paper, identifying the efficient, effective and most appropriate method of study approach on stated goals.

During the fieldwork of data collection, different types of data gathered thus were road traffic crash data, traffic volume data, road geometric data, traffic controlling data, and roadside data [12].

Crash data's

The data of road traffic crash were collected from different responsible bodies like woredas and zonal police commissions in this case five woredas, and one zone was the source of data. According to the analysis of crash Statistics Guide by Permit Writers Workshop (2002), crash data for the most recent one up to two year was normally used and generally sufficient for the interpretation of the sites. The study by other researchers also frequently used. The three year statistical data and from one year to five year was used to identify the hazard location of the road segment.

Traffic volume

Traffic volume data are the most important factors in the analysis of the road, which means, it is the base to calculate the different design criteria like AADT.

The number of studies indicates that the influence of traffic volume. In this research, the AADT was used in predicting and estimating a crash, identification of hazardous locations and the data were taken from Ethiopian roads authority and the data collected by the manual method of collection in seven consecutive days of the week including the night. The collected data were as shown in the table below (Table 2).

Table 2. ERA standard vehicle classification.

Vehicle code	Types of vehicles	Description
1	Small cars	Passenger Cars, Minibuses (up to 24-passenger seats), Taxis, Pick-ups, and Land Cruisers, Land Rovers, etc.
2	Buses	Medium and large size buses above 24 passenger seats
3	Medium trucks	Small and Medium-sized Trucks including tankers up to 7 tons load
4	Heavy trucks	Above 7 tons load 5 Articulated trucks with trailer or semi-trailer and Tanker Trailers

Geometric feature data's

Geometric feature data were frequently, caused by a traffic crash as stated in the literature part. In addition to that, these data were used in the crash prediction model analysis. Many studies as stated by different scholars and books. Thus on the account of literature reviews, subjective engineering judgment, geometric features of the selected road network were presumed to be the prevalent traffic crash causative factors.

By using the checklist prepared, the characteristics of each parameter listed were collected individually in the segment by excluding the intersections and its effect as stated in the above part of the discussion. Thus, indicating the most affecting variables in road traffic crash according to the above- stated reasons and HSM approves this way of analysis.

CMF1r-Centerline rumble strips

Centerline rumble strips are installed on undivided highways along the centerline of the roadway, which divides opposing directions of traffic flow. Centerline rumble strips are incorporated in the roadway surface to alert drivers who unintentionally cross, or begin to cross, the roadway centerline. The base condition for centerline rumble strips is the absence of rumble strips.

CMF2r-Passing lanes

The base condition for passing lanes is the absence of a lane (i.e., the normal two-lane cross-section). The CMF for a conventional passing or climbing lane added in one direction of travel on a rural two-lane two-way highway is 0.75 for a total crash in both directions of travel over the length of the passing lane from the upstream end of the lane addition taper to the downstream end of the lane drop tape.

CMF3r-Automated speed enforcement

Automated speed enforcement systems use video or photographic identification in conjunction with radar or lasers to detect speeding drivers. These systems automatically record vehicle identification information without the need for police officers at the scene [14].

DISCUSSION AND CONCLUSION

Depending on the methods used that is empirical Bayes method, out of 123 road segments, this study identifies 32 of them are singled out as hazardous road segments and ranked based on their excess number of expected crashes. The study also found that in total around 16 excess crashes can be expected from the identified 32 dangerous sites other crashes were occurred due to other cases and predicted crashes.

Out of 32 ranked dangerous segments, eleven of them are found to be the worst sites because they contributed around 69% of the total excess expected crash frequencies. In the identification of hazardous locations, the base model the site condition models are incorporated step by step to achieve the designed objectives.

The identifying hazardous locations can also divide into different groups for the implementation and allocation of resources'; priority of implementation for the countermeasures.

This study also found the major contributing road and traffic factors along with the most dangerous segments, include: Sharp horizontal curves after a long tangent, a high number of non-motorized traffic and pedestrians directly access the road at a place where the road passes through village settlement, poor coordination of horizontal and vertical alignments, terrain type, lane and/or shoulder width, the presence of curves n both side of the tangent.

Accordingly, simple and cost-effective countermeasures such as the provision of the warning sign with recommended speed, road surface marking, construction of painted guardrail outside the curve, provision of rumble strips, and others are proposed in order to reduce the excess number of the crash. Therefore, implementation of the identified countermeasures for the worst road segment especially, those included in the first category of group rank will be vital to reducing the excess number of the crash.

ACKNOWLEDGMENT

First, I would like to thank my Almighty Lord, God and His Holy Mother, St. Mary, in a matchless and eternal way. Secondly, I am very pleased to express my deepest gratitude and appreciation to my advisor Ashenafi Aregawi (Ph.D.) for his prodigious help and positive suggestions throughout the study execution. I am also thankful to the staff of Civil engineering, Road and transportation; my grateful thanks are also extended to the staff of Ethiopian Roads Authority Debre Markos Aouragodana branch and Awi zone police departments of the five woredas. Moreover, I would like to present my special and sincere gratitude to my whole family members, my father Biress Taye, my mother Genet Amare, my brothers, and my sisters. Finally, my honorable appreciation and thanks go to my colleagues and best friends for their valuable contribution, advise, support and motivation staring from the commencement to the completion of the research.

REFERENCES

1. Daubechies I. Orthonormal bases of compactly supported wavelets. Comm Pure Appl Math. 1988;41:909-996.
2. Livingstone SR, et al. The Ryerson audio-visual database of emotional speech and song (ravdess): a dynamic, multimodal set of facial and vocal expressions in north American english. PLOS ONE 2018;13: e0196391.
3. Mallat S. A wavelet tour of signal processing. Academic Press, San Diego. 1999.
4. Modic R. Comparative wavelet and MFCC speech recognition experiments on the Slovenian and English speechdat 2. NOLISP. 2003.
5. O'Shaughnessy D. Speech communication: human and machine. Addison-Wesley publishing company. 1987:568.
6. Dash SK, et al. DWT-based feature ex-traction and classification for motor imaginary EEG signals. CSMB.2016.
7. Shegokar P, et al. Continuous wavelet transform based speech emotion recognition. 2016.
8. Tran H, et al. Proposed combination of PCA and MFCC feature extraction in speech recognition system. 2015;2:697-702.
9. Abdulhafedh A, et al. Road traffic crash data: an overview of sources, problems, and collection methods. J Transp Technol. 2017;7:206.
10. Lawless M, et al. Road safety inspection guidelines. ireland's international trade and transport connections (No. 573). ESRI Working Paper. 2017.
11. Terefe M, et al. Identifying and ranking dangerous road segments a case of hawassa-shashemene-bulbula two-lane two-way rural highway, Ethiopia. J Transp Technol. 2018;8:151-174.
12. Gebremedhin S, et al. Magnitude of road traffic accident-related injuries and fatalities in Ethiopia. PLOS ONE. 2019;1-10.