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Identification of crash prone areas in Ethiopia

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Research Article

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Identification of crash prone areas in Ethiopia

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Key findings

- The situation of roads traffic crash in Ethiopia is very serious both in terms of severity and frequency of occurrence
- Speed is one of the governing factors that make the driver to be the leading causes of crash.
- Among different types of collision, overturning collision and vehicle pedestrian collision are occurring more frequently

Abstract

Motor vehicle ownership in Ethiopia is 1 vehicle per 145 populations; however, on average 14 people per day die on Ethiopian roads due to traffic crashes. In the 8 years from 2008-2016, estimated economic costs of traffic crashes in Ethiopia of 3.155 billion ETB (~A$84.8 million), The aim of this study was to identify the main causes of traffic crashes in federal roads and to recommend possible countermeasures. Both primary and secondary data were used. Crash blackspots were identified using the Flamish government formula and crash frequency method. The results of crash rate and crash severity index show that, the traffic crash is very severe; the crash severity index of up to 55 and crash rate of 3.5 Mvkm (million vehicle kilometre). The main causes of traffic crashes were speeding, not giving priority for pedestrian, not giving priority for vehicle, following too close, lack of traffic sign, poor pedestrian behaviour and driver error. Human factors, particularly driver behaviour accounts up to 82 percent of all crashes. High number of crashes occurred during good weather conditions (87%), on good asphalt (95%) and with vehicles which have no defect (84%). Collisions with pedestrians (45%) and overturning collisions (45%) were the leading types of collision. Installing rumble strips to control for speeding, providing traffic hazard light to prevent run off crashes, installing traffic sign to providing information for driver and pedestrian, creating awareness, improving sight distance and modernising crash data recording system minimize the accident occurrence.

Keyword

Crash severity, Black spot, Traffic crash, over speeding
Clinical trial number: not applicable

Introduction

According to the World Health Organisation, over 1.1 million people are killed in road crashes globally each year [1] [2] [3]. Given the fact that more cars are driven on the streets of the developed countries than the undeveloped, one may easily assume that the number of people killed per car would be higher in developed nations [4]. However, compared to high income countries, per vehicle fatality rate is significantly higher in low- and middle-income countries.

Despite having low road network density and vehicle ownership, Ethiopia has a relatively high crash record, over 5,118 people killed annually [5]. Data obtained from Federal Transport Minister shows the number of motor vehicles

in Ethiopia reached 831,265 in 2017, whereas the total number of populations was estimated at 106,399,924, which bring 1 vehicle per 128 population, a small vehicle ownership rate compared to high income countries.

In Ethiopia, road traffic crash has been one of the top ten causes of death. In 2013, the number of people killed by a road traffic crash was equivalent to those who died due to malaria which is 9th cause of death [6]. Among the most prominent factors, human factor of which drivers' errors take the lion's share of the blame. [7] [8] argued that most safety studies have been based upon a person-centred approach and stresses the role of human error in traffic crashes is not limited to loss of life only; it also has a great impact on economic and social activities. When we see the economic impact of traffic crashes, from 2008 to 2016 in Ethiopia losses were about 3.155 billion ETB (~$84.8 million). Resources that could have been used to construct more than 158km asphalt road, assuming 20,000,000 ETB per km. Therefore, traffic crashes are becoming the key public health and development challenges of the country, so this calls for studies, to put effective measures to prevent traffic crashes [9] [10].

This study is conducted by collect traffic crash data occurred in non-built-up area (road segments which are out of the urban area) for the three years and accessing their current situation regarding to traffic crash. After collection of data the research proceeds to identify the causes of crash and finally forwards remedial measures.

Method

Source of Data

Data for the research were collected using both primary and secondary sources. The primary data were obtained from questioner, interview and field survey, whereas the secondary data were collected from:

- Traffic Police office of the study road
- Ethiopian Road Authority/ERA
- Federal Police Commission and Transport Minister

To obtain detail information the three-year traffic crash data were collected from each Wereda found in the study roads.

Sample population

Population of the study for this research includes Federal asphalt road sections which have high traffic crash records. These road sections were selected based on the traffic crash data record. Using the Ethiopian road authority road network classification first crash per km length is determined. Next roads having extreme value of crash per km length is selected. Based on the crash per km length, surface condition, traffic volume, road length and other criteria the sample populations are selected.

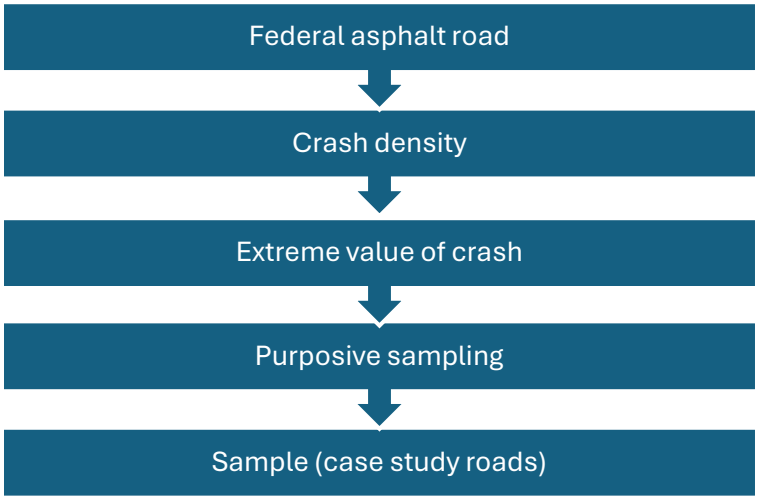


Figure 1 Sample selection procedure

Hence, the nature of traffic crash in urban and rural area are different, the study focus road segments which are out of the urban area.

Data analysis

The questioner and interview were done to strength the secondary data obtained from traffic office and to obtain information for identification of black spot. The selection of method of black spot identification is based on available data. For this research the Flamish government formula, which is stated below, and crash frequency method is used to identify black spot location.

Flemish government formula First, site where in the last three years three or more crashes have occurred is selected. Then, a site is considered to be dangerous when its priority value (P), calculated using the following formula, equals 15 or more:

P = X + 3*Y + 5*Z, where
X = total number of light injuries
Y = total number of serious injuries
Z = total number of deadly injuries

Result and Discussion

Crash rate

Crash rate was defined as number of crashes that occur at a given site during a certain time period in relation to exposure (million vehicle miles of travel). Crash rate relates traffic crash with different parameters such as AADT, length of the road, and exposure. It is obtained by dividing annual crash for annual exposure or row and multiply with one million. Doing so, a maximum of 3.5 and a minimum of 1 crash rate were obtained.

Based on obtained result, a vehicle has a 3.5 in a million chance of being involved in a crash for every mile travelled on Asella-Bekoji road segment.

When we say the number of death injury, serious injury and slight injury it doesn't mean the number of people dead or injured, but the number of crashes. The chart below indicates the total number of crash and the number of people injured due to this crash for each road.

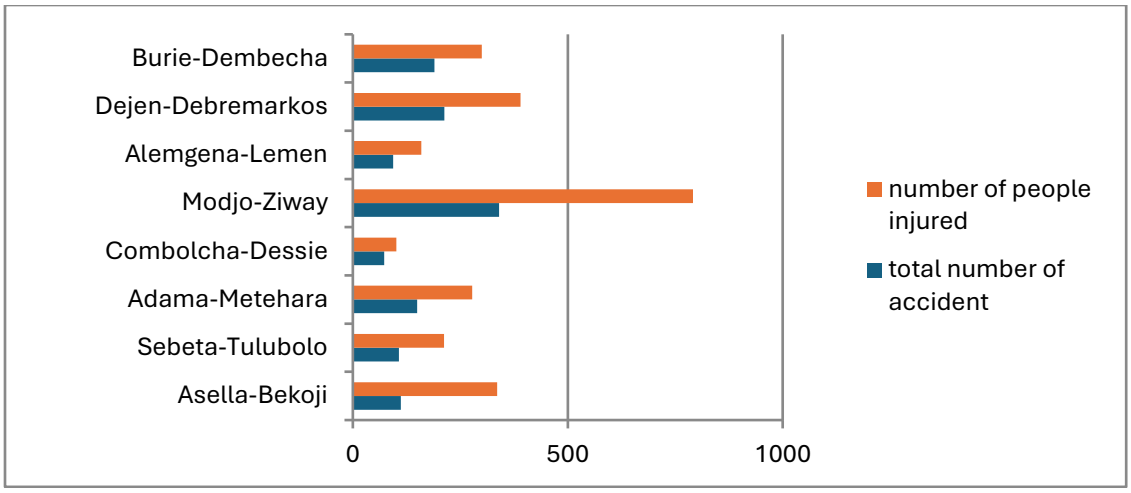


Figure 1. Total number of crashes and people injured

In all study roads number of people injured are greater than total number of crashes; that means at least 2 peoples were injured from single crash.

Crash severity index for the study road

Crash Severity Index: measures the seriousness of a crash. It is defined as the number of persons killed per 100 crashes. It is obtained by dividing number of people died for the total number of crash and multiplies by 100.

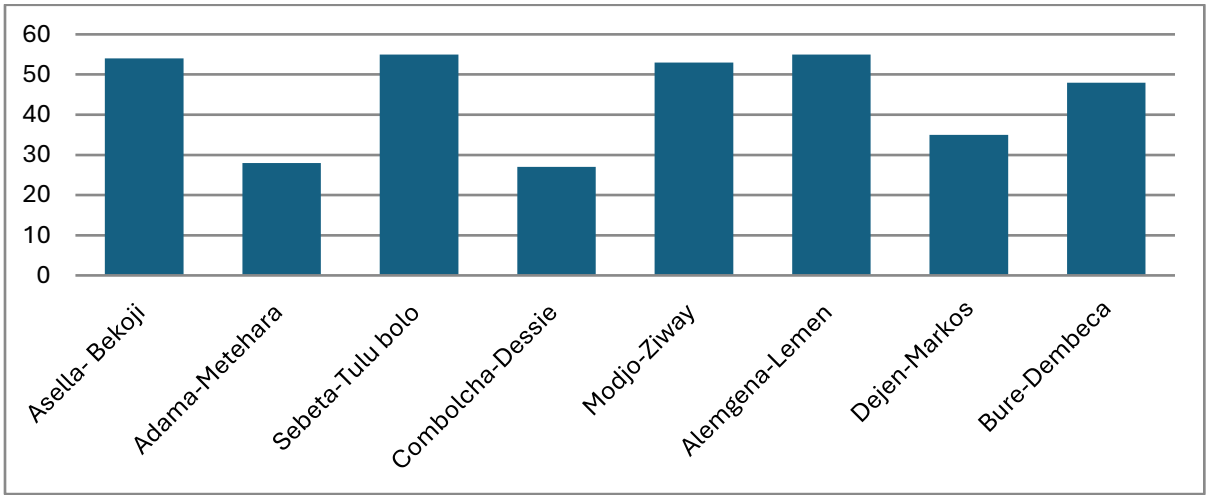


Figure 3. Severity of crash in the study road

The above figure implies how sever the traffic crash in the study road. In average 54 people in Asella – Bekoji road, 28 people in Adama - Metehara road, 55 people in Sebeta-Tulu bolo road, 27 people in Combolcha-Dessie road, 53 people in Modjo-Ziway, 55 people in Alemgena-Lemen road, 35 people in Dejen-Markos road and 48 people in Bure-Dembeca road died from 100 crashes. When we see in the whole country, in average from 100 crashes only 12 people died, this implies the severity of traffic crash in the above road is very high.

When we observe the proportion of crash for death injury, serious injury and slight injury; in all study roads the percentage of death injury is greater than serious and slight injury. See chart below.

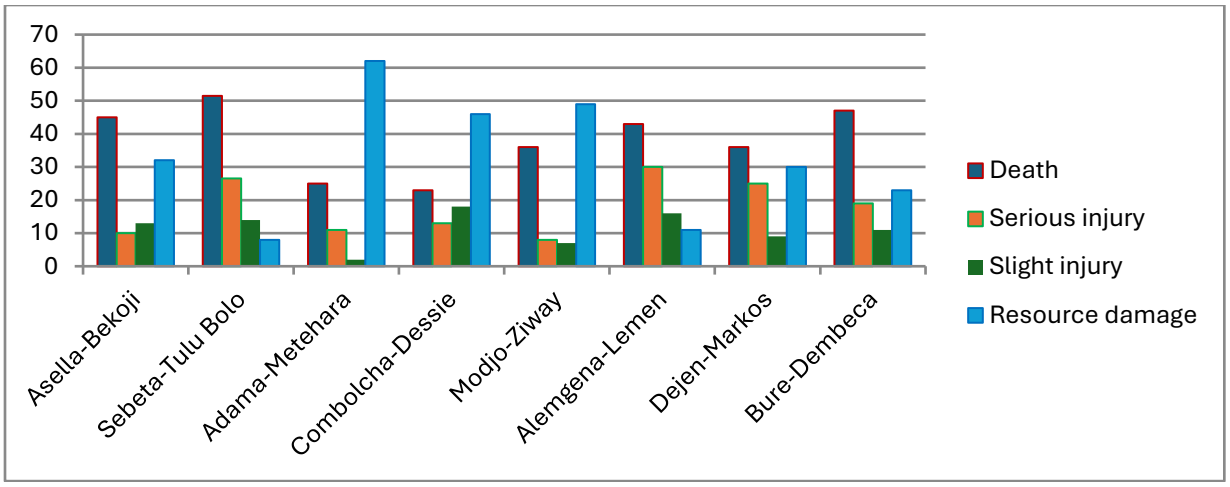


Figure 4. The proportion of crash with respect to death, serious injury, slight injury and resource damage

The crash severity index and the proportion of crash implies severity of crash in rural area is very high than urban area, hence this study is focused on road segments out of the urban area. Different studies done in Addis Ababa indicate that the percentage of crash for death injury is very small compared to slight and serious injuries, unlike the study roads. Majority of the crash happen in urban area results resource damage. The result of data analysis shows, this difference is observed as result of the following facts.

Due to low enforcement and absence of speed controlling mechanism, over speeding and not wearing seatbelt is common problem in all study roads (roads out of the urban area). An increase in average speed is directly related both to the occurrence of a crash and to the severity of the crash. Wearing seatbelt has a high potential for crash severity reduction. The results of the research done in 11 countries show that; the average effectiveness of Seatbelt at preventing fatal injuries was 47.1% [6].

Trends of Traffic Crash in the Study Roads

Except Sebeta Tulu Bolo and Combolch Dessie roads the trend of traffic crash shows increasing. In Sebeta Tulu Bolo and Combolch Dessie roads there is a slight decrement in number of crash.

When we see the trends of traffic crash in Sebeta -Tulu Bolo and Combolcha- Dessie road, there is a slight decrement in the number of crash. As it was observed in data collection there was some intervention made by Sebeta – Tulu Bolo road traffic police at identified black spots, after intervention the number crash is decreasing to some extent.



Figure 5. Hazard location after long tangent at Sebeta-Tulu Bolo. Intervention made at Sebeta – Tulu Bolo road (traffic hazard light).

Traffic hazard light is very effective if it is implemented in the location where run off crash has occurred frequently. To see the effectiveness of a treatment or traffic hazard light in Sebeta –Tulu Bolo road Crash modification factor was calculated. Crash modification factor (AMF) = number of crashes after treatment divided by number of crashes before treatment

AMF= 35/42

AMF= 0.83

From this it is possible to calculate percentage of reduction in the number of crashes. Percentage of reduction in the number of crashes is obtained by multiplying number of crashes before treatment by one minus crash modification factor.

Percentage of reduction = (1-AMF) *100 = (1- .83) =17 %

There are 7 black spots in which run off crash are dominated in Sebeta –Tulo Bolo road. 17% reduction of crash is obtained by applying traffic hazard light at three black spots; if traffic hazard light was installed in all (7) black spots, it reduces the total crash by 40% using cress cross calculation. The trends of traffic crash in Sebeta –Tulu Bolo road tell us treating black spot has high potential for traffic crash reduction.

For the case of Combolcha – Dessie Road, even if, it is not comfortable for vehicle occupant the construction of speed breaker reduces traffic crash significantly. There is several speed breakers constructed on this road, however there is different problems on the constructed speed breaker.

Observed problem on Combolcha – Dessie Road speed breaker

- vehicle occupant discomfort
- damage to vehicle
- Excessive delay (a well-designed speed breaker is recommended to reduce speed up to 25 km/hr),
- fuel consumption due to acceleration and deceleration

A speed breaker is effective if it is constructed by keeping standards and with proper signage; otherwise, it may be the causes of crash. As per the road crash report 2014, in India a total of 4726 lives were lost due to crashes at speed breakers on National Highways. The Indian Road congress (IRC) recommends speed breaker having a dimension of

width 3.7 meter, height 0.1 meter and radius of 17 meter. It is better to study the impacts of speed breaker provision for traffic crash

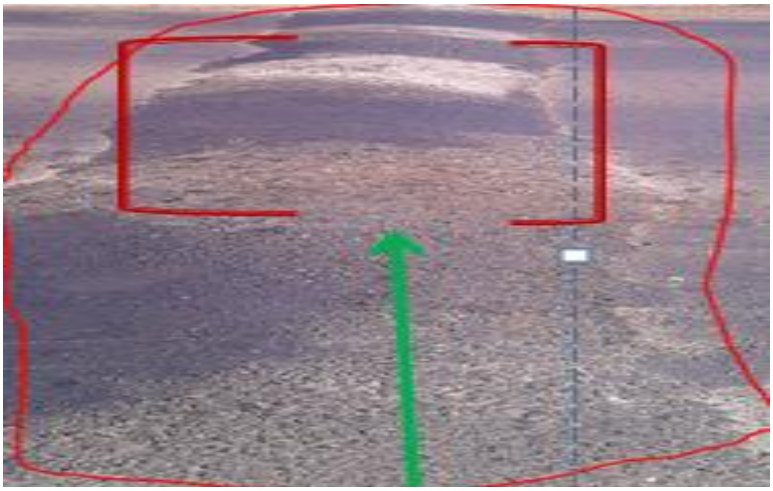


Figure 6; Unsuitable speed breaker on Combolcha – Dessie road

There should also a proper signage before and after speed breaker to indicate the presence of speed breaker.
Road characteristics and weather condition

High number of crashes is registered during good weather condition, on good asphalt and dry road condition for all study roads.

Why high crashes happen on good asphalt?

Most of the study roads are designed and constructed to achieve high level of service (riding quality), without implementing road safety action (speed limit, wearing seatbelt) and traffic calming measures. The road without speed controls and traffic calming measures, invites the driver to choose more than design speed, in distress asphalt





the road limit operating speed. As a result roads with high levels of pavement roughness and distress will contribute low crash, regardless of riding quality and vehicle damage.

Figure 7; Sample photo of traffic crash on good asphalt collected during field survey

Vehicle factor

Vehicle type and number of traffic crashes

To identify types of vehicles causing high number of crashes, crash data were collected with the types of vehicles. To simply the analysis, using the ERA vehicle classification the vehicles are classified under 8 groups. These are Car, Land Rover, Small Bus, Large Bus, Small Truck, Medium Truck, Heavy Truck and Truck Trailer. All types of vehicles are categorized under these groups. Since the vehicle exposure or AADT by vehicle type affects the types of vehicles causing high number of crash the analysis considers the types of vehicles causing high number of crashes together with their exposure in each study roads.

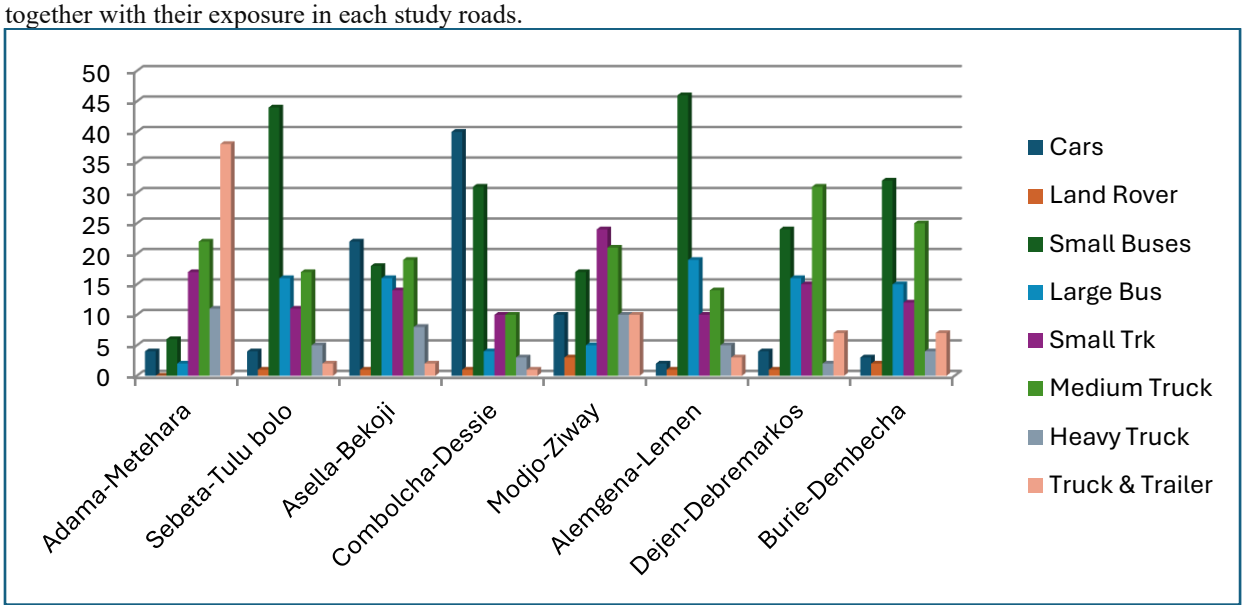


Figure 8; Percentage of traffic crash by Vehicle type causing the crash

The above chart shows types of vehicle causing high number of crash for each study roads separately. Regardless of their exposure from the chart small bus and medium truck causes high percentage of the total crash.

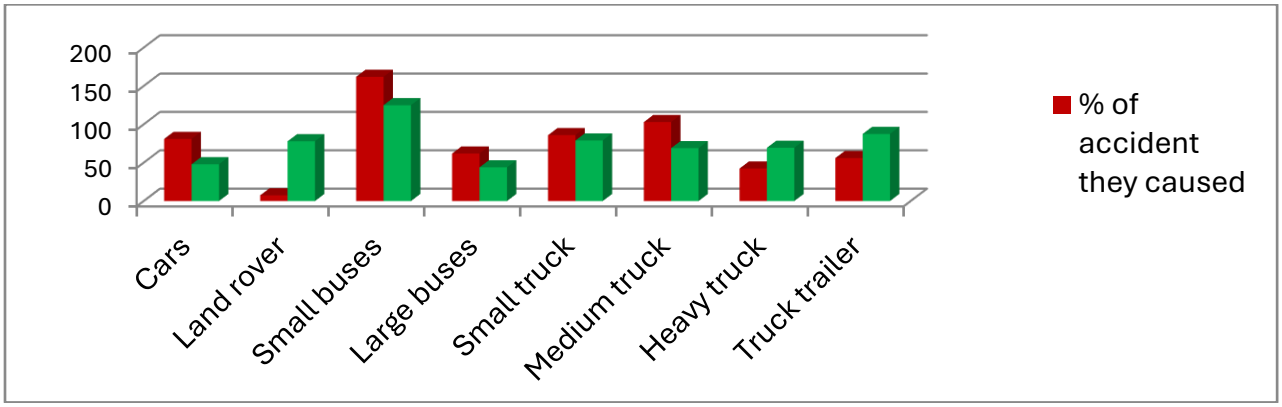


Figure 9; Vehicle exposure and traffic crash they causes

From the above chart the red colour indicates percentage of crash caused by each vehicle types, and the green colour indicates vehicle exposure in each road. Small bus, medium truck, large bus and small truck cause high percentage of crashes. Hence the percentage of crash they caused is greater than their exposure. Fatigue, driving long distance without rest alcohol, following too close incompetence of the drive are the main causes for truck crash. From small bus vehicle having 12 passenger seats is the main causes of crash. Over speeding and in appropriate overtaking are the main reasons for crash happening with these types of vehicles.

Therefore, Small bus, medium truck, large bus and small truck are the focus area for police maker.

Vehicle service year and vehicle defect analysis result indicates vehicle problem causes very small amount of crash. In general vehicle is not the main causes of crash compared to other factors. But it not to mean defect vehicles cannot cause crash; in single crash there are multiple factors that aggravate the effects of the crash, even if they are not the main factors.

Types of Vehicle Collisions and Traffic Crash

The main types of collision identified are; in front collision, front and back collision, front and side collision, side to side collision, overturning collision, collision with pedestrians and collision with animal.

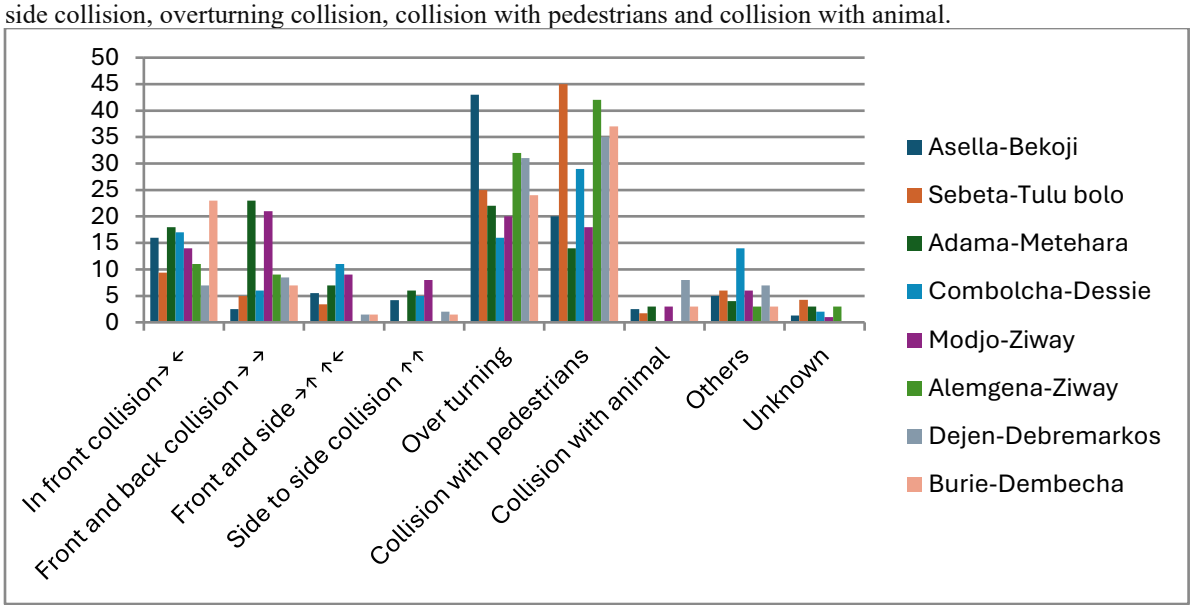


Figure 10; Types of vehicle collisions and traffic crash

Overturning collision, collision with pedestrian and in front collision is the main types of collision causing high number of crashes. They are different factors for overturning collision, vehicle pedestrian collision and in front collision.

Overturning collision; Severity of the crash in the study road was very high; this is mainly due to over speeding. Speed is the governing factor for overturning of vehicle. As it is observed from secondary data, and interview conducted for traffic police, over speeding is the main problem of traffic crash. This is why overturning collision is become dominant types of collision.



Figure 11; Hazard location after long tangent in Asella-Bekoji in which over turning crash is dominated

Collision with pedestrian

Not giving priority for pedestrian and vehicle were the root causes for pedestrian Collision, especially in school and religious area. The effect of pedestrian collision depends on operating speed. For example changing operating speed from 50 km/hr to 60 km/hr increases the probability of pedestrian collision death by 30%. Similarly increasing the operating speed beyond 80km/hr increases the probability pedestrian collision death by 100% (European commission for road safety).

Head on collision: - in appropriate overtaking and absence of center line are the main causes for head on collision. Most of the roads in rural area are not maintained regularly, especially road marking. In the absence of road center line it is difficult for driver to keep their lane, as a result the uses the opposite lane. Center line rumble strip is effective for head on collision.

Traffic Crash Prone Area in the Sampled Population

The process of eliminating or improving crash black spots in a road network is composed of several activities, as illustrated in the figure 10 below (black spot manual 2001).

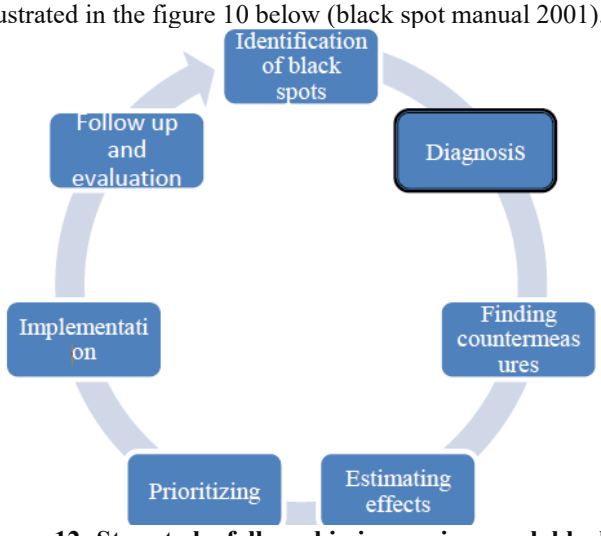


Figure 12; Steps to be followed in improving crash black spots in a road network Source of data: Black spot manual, 2001

Asella – Bekoji road

The selection of method of black spot identification is based on available data. For this research the Flamish government formula and crash frequency method is used to indentify black spot location.

Table 1. Identified black spot location on Asella –Bekoji road

Black spot name	Easting	Northing
Lemmu ketema	0841182- 0840819	0524713 - 0524785
Cefa negesso	0835731 - 0835230	0527755 - 0527658
Cibaa Mikael dildiyi akababi	0827626 - 0827303	0528334 - 0528667
Calalaka wenz	0822060 - 0821887	0527936 - 0527568
Dosha atana tera	0874794 - 0874697	0514111 -0514049
Bilalo primary school	0869481 -0867455	0514054 - 0514956
Alemu wefco	0872917 -0871711	0513363 - 0513268
Burkitu school	0861510 - 0860615	0516042 - 0516496
Ashebeka wenz	0852419 - 0851992	0516985 - 0517244
Gusha goba lenca	0848709 - 0848451	0518912 - 0518977

More than 60% of the total crashes were happen in these identified ten black spots. Therefore, treating or applying mitigation measures for those black spots can reduce the crashes significantly. Doing the same procedure for all study roads the following black spot locations were identified together with their GPS coordinates.

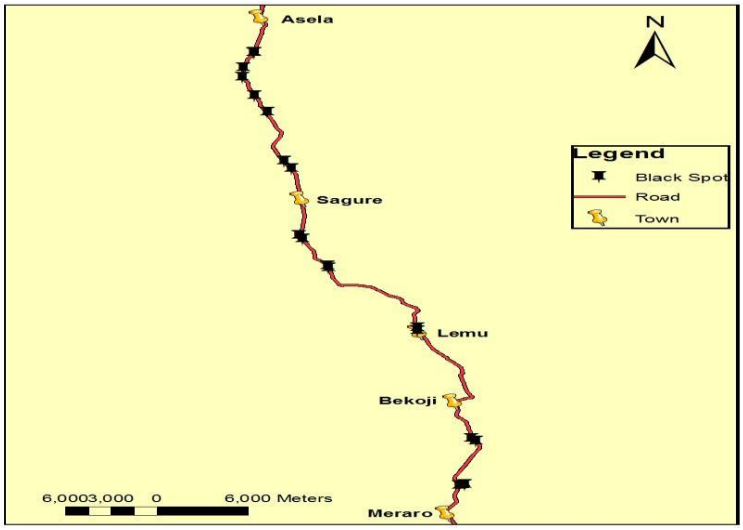


Figure 13; Location of identified black spots on Asella – Bekoji road using GIS software
Adama – Metehara road

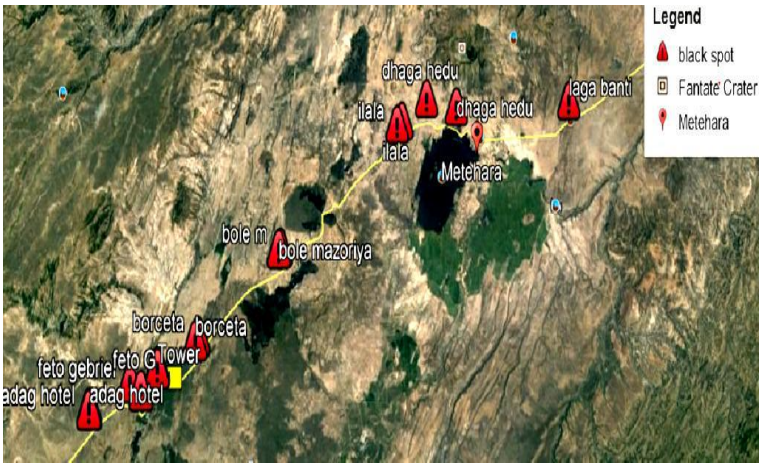


Figure 14; Location of identified black spots on Adama - Metehara road using Google earth

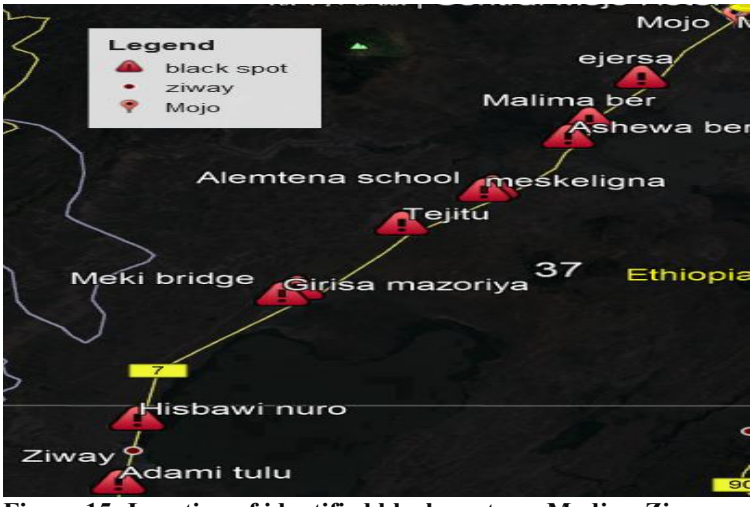


Figure 15; Location of identified black spots on Modjo - Ziway road using Google earth

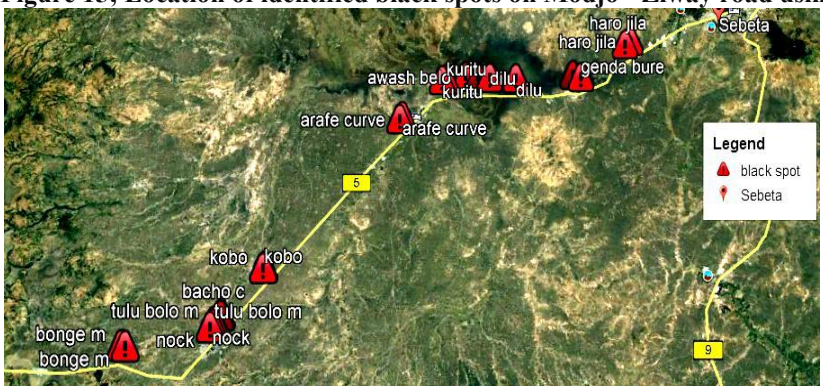


Figure 16; Location of identified black spots on Sebeta-Tulu Bolo Dejen – Debre Markos road



Figure 17; Location of identified black spots on Dejen – Debre Markos road using Google earth
Bure – Dembecha road



Figure 18; Location of identified black spots on Bure – Dembecha road using Google earth

Summarised Causes of Traffic Crash in Black spot Area and Number of Crash They Cause in Percent

The following are the causes of crash identified by traffic police together with the number of crashes they cause. The data shows most of the causes are due to driver fault.

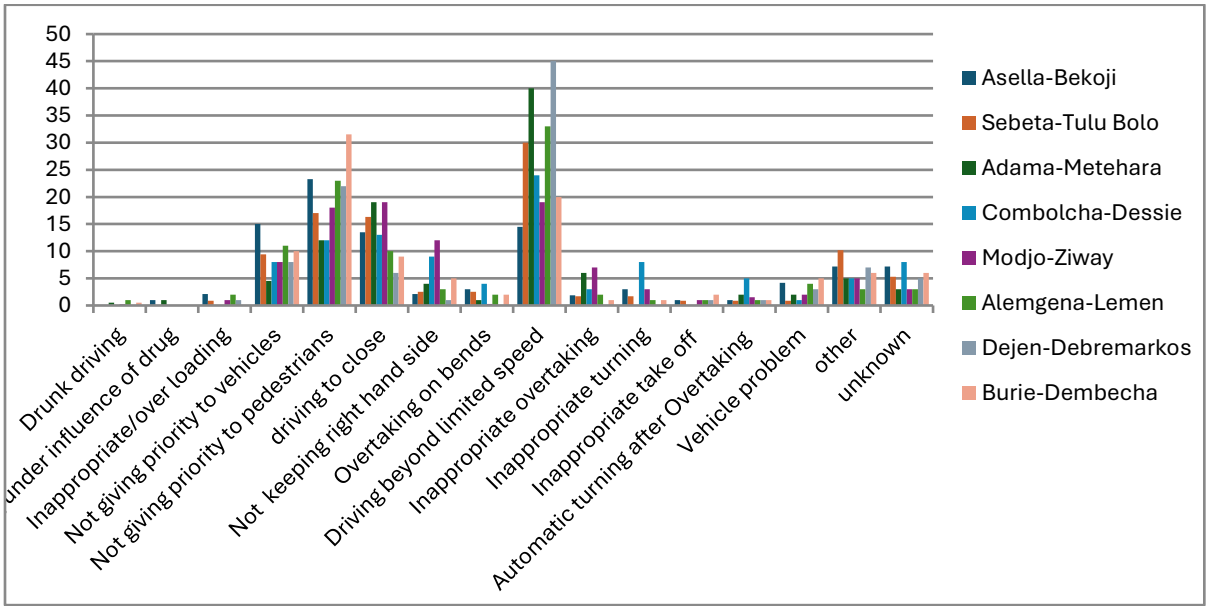


Figure 19; Causes of traffic crash and percentage of crash they cause

Driving beyond limited speed, not giving priority for pedestrian, not giving priority for vehicle and driving too close are the top causes of crash.

Conclusions

The situation of roads traffic crash at the national level is very serious both in terms of severity and frequency of occurrence. Speed controlling and wearing of seatbelt are critical to reduce the Severity and rate of the crash.

- From results of data analysis, the main causes of crash are;
    - Over speeding
    - Not giving priority for pedestrian,
    - Not giving priority for vehicle,
    - Driving too close,
    - Not keeping right side,
    - Poor pedestrian and driver behaviour

Speed is one of the governing factors that make the driver to be the leading causes of crash. Physical speed controlling measure is effective to reduce vehicle speed, which plays a vital role in crash severity reduction. Majority of the crashes are registered on good asphalt, during good weather condition and on good (dry) road condition. Absence of safety actions implementation and traffic calming measures are the main causes for crashes happen on good asphalt.

Among different types of collision, overturning collision and vehicle pedestrian collision are occurring more frequently; together they account more than 50% of the total crashes.

Absence of lane marking, speed limit post, pedestrian facilities, warning sign, and sigh distance problem with difficult roadside environment, were the common problems identified within the black spot. Providing traffic hazard light at black spot location were effective measures to reduce run off and lane departure crash at minimum cost.

Recommendation

- The policy maker should have to work hard on road safety action implementation such as speed limits, pedestrian safety and speed control measures.
- Construct rumble strips, traffic hazard light and speed breaker at identified black spots. Shoulder rumble strips have reduced run-off road type crashes by 20 to 72 percent with benefit cost ratio of 5:1 to 20:1 Source Washington State Department of Transportation.
- Maintenance of road marking and traffic sign continuously is significant.
- It is better to use modern technology that help at least to reduce the crash levels due to over speeding, such as speed measuring instrument (speed radar), and alcoholic test throughout the country.
- Providing separated pedestrian way and assigning traffic police (student traffic police) especially in school and religious area may be appropriate for those study roads.
- Creating awareness for pedestrian through social media (TV and radio), providing traffic safety education programs in all schools or adding traffic crash course on a curriculum (so that road safety for children and teenagers can be achieved through educational programs) reduce this problem.
- Creating different association such as, ERA driver association etc and providing safety training through established association to improve driver's capacity.
- The traffic police should have to modernize the crash data recording system. Poor recording system of crash data and lack of modern technology used to control the traffic flow should be improved. The traffic crash data should be recorded with exact location, if possible, with their GPS coordinates, this simplifies black spot identification.
- The government should update road safety policy on speed limits and pedestrian priority.
- Finally Ethiopian Road authority/ERA should implement the proposed mitigation measures on the identified black spot.

- Roads that are registering crashes repeatedly or black spots might have some sort of design problems. Roads with design problems should be corrected through reengineering works.

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Availability of data and materials

All necessary data were included in this manuscript.

Declarations

Ethics approval and consent to participate

Not applicable.

Consent for publication

Not applicable.

Competing interests

The author declares that there are no competing interests.

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