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Summary report for research entitled with causes and remedial measures of traffic accident in federal roads

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Abstract
Despite having low road network density and vehicle ownership, Ethiopia has a relatively high accident records. Data obtained from Federal Transport Minister shows the vehicle ownership in Ethiopia is 1 vehicle per 145 populations; however on average 14 people per day died in Ethiopian roads due to traffic accident. Ethiopia losses 3.155 billion ETB from subsequent resource damage within 8 years (2008 to 2016) due to traffic accident, which constructs more than 158km asphalt road. This study is carried out to identify the main causes of traffic accidents in federal roads and to recommend possible countermeasures. To achieve the objective of the research both primary and secondary data were used. The secondary data was obtained by collecting the three year traffic accident record starting from 2015/16 – 2017 /18 which occurs within the selected road section. Using non random sampling Asella-Bekoji, Adama-Metehara, Sebeta- Tulubolo, Combolcha-Dessie, Modjo-Ziway, Alemgena- Lemen, Dejen-Debremarkos and Bure- Dembecha road were selected as sample population. To identify the black spot the Flamish government formula and accident frequency method were used. The results of accident rate and accident severity index shows that, the traffic accident is very sever; the accident severity index of up to 55 and accident rate of 3.5 Mvkm (million vehicle kilometer) was obtained. Based on analysis, the main causes of traffic accident are; over speeding, not giving priority for pedestrian, not giving priority for vehicle, following too close, lack of traffic sign, poor pedestrian behavior and incompetency of the driver. Human factors, particularly driver behavior accounts up to 82% of the total accident. High number of accident occurred during good weather condition (87%), on good asphalt (95%) and with vehicles which have no defect (84%). Overturning collision and collision with pedestrian were the leading types of collision, they results up to 43 and 45% of the total accident respectively. Generally common problems were identified within black spot location. Installing rumble strips to control over speeding, providing traffic hazard light to prevent run off accident, installing traffic sign to providing information for driver and pedestrian, creating awareness, making road safety policy and enforcement, improving sight distance and modernizing accident data recording system is recommended based on observed problems.

Keywords: Road traffic accident, black spot, accident cause, mitigation measure

Introduction
Road traffic accidents are those accidents that occur on a way or Street open to public traffic, result in one or more persons being killed or injured, and at least one moving vehicle was involved"(economic commission for Europe, 2013). It includes collision between vehicles, vehicles and animals, vehicles and pedestrians or vehicles and stuck obstacle (Safe Carguide, 2004 sited by Girmay Giday, 2014) [17]. With the rapid increase in the population, advancement in industry, development and expansion of modes of transport and movement, traffic accident is increasing from time to time. 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 (Tesfalem Hailu, 2010) [33]. 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 accident record, over 5118 people being dead annually (Federal Police report, 2018). Data obtained from Federal Transport Minister Show's number of vehicle in Ethiopia reaches 831265 in 2017, whereas the total number of population was estimated at 106,399,924, which bring 1 vehicle per 128 populations (too small vehicle owner ship compared to developed nation).

In Ethiopia, road traffic accident has been one of the top ten causes of death. For example, in 2013, the number of people killed by road traffic accident was equivalent to those who died due to malarial (which is 9th cause of death) throughout the country (The Centers for Disease Control and Prevention, 2013). Among the most prominent factors, human factor of which drivers' errors takes the lion's share of the blame. Fikadu, 2015 [12] argued that most safety studies have been based upon a person approach and stress the role of human error in the production of 75-90% of accidents.

Road traffic deaths and injuries has therefore been the key public health and development challenges of the country and will continue to adversely affect the livelihood of community and the economy of the country unless effective measures are taken to control the problem.

Method

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 accident data from 2015/16 – 2017/18 were collected from each Wereda found in the study roads.

Population of the Study and Sample population

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

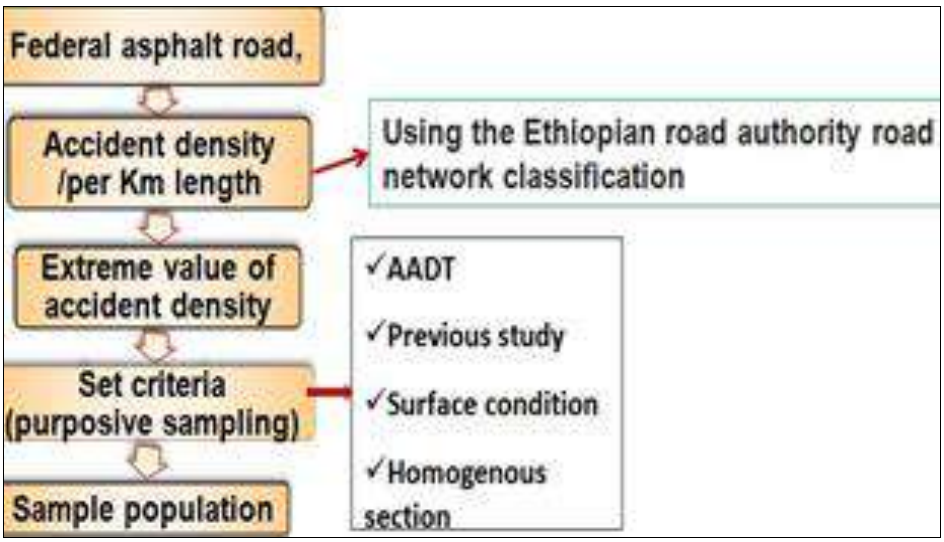

Fig 1: Sample selection procedure

Using the above procedure, Modjo-Ziway, Adama-Metehara, Sebeta-Tulubolo, Combolcha-Dessie, Asella-Bekoji, Alemgena-Lemen, Dejen - Debre markos, and Bure - Dembeca roads are selected as sample population. Hence, the nature of traffic accident in urban and rural area are different, the study focus road segments which are out of the urban area.

Method of Analysis

After all necessary data are collected from the site visit, from the interview and secondary data, the research proceeds to analyze the collected data. 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 accidents 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

Accident Rate

Accident rate is the best indicator of traffic accidents. It is 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). Accident rate relates traffic accident with different parameters such as AADT, length of the road, and exposure. It is obtained by dividing annual accident (row 6) for annual exposure [(row 2*row3*365) or row 4*365] and multiply with one million. Doing so, a maximum of 3.5 and a minimum of 1 accident rate were obtained.

Table 1: Accident rate for the study roads

Road name								
Asella - Bekoji		**Sebeta-Tulu Bolo**	**Adama-Metehara**	**Combo lcha-Dessie**	**Modj o-Alemg Ziway**	**ena-Lemen**	**Deje n-Markos**	**Bure-Dembeca**
Parameter								
Average AADT	1523	4921	5121	3084	4895	6247	1607	1578
Length (mile)	30	30.5	48.5	14	51	23	55	50
exposure	45690	150090.5	243247.5	43176	249645	143681	88385	78916.67
Annual expo.	16676850	54783033	88785338	15759240	91120425	52443565	32260525	28804583
Accident/ yrs	55	39	135	46	211	36	71	64
Accident rate	3.5	1	2	3	1	1	2.2	2.3

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

The total number of accident registered with in the study period: The total number accidents registered during the study period 2015/16 to 2017/18 in the study roads were shown in the table below.

Table 2: Total number of accident registered with in the study period

Road name	**Adama - Metehara**	**Asella-Bekoji**	**Sebeta-Tulu Bolo**	**Combolcha-Dessie**	**Modjo-Ziway**	**Alemgena -Lemen**	**Dejen-Markos**	**Bure-Dembeca**
Total accident	396	165	117	138	631	106	213	190

The above mentioned figure indicates the number of accidents, that means the number of people dead or injured were too much. Single accident causes some people to be dead, some to be injured. The total number accidents registered in the whole road during the study period 2015/16 to 2017/18 were 1956 accidents within 302 mile 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 it is to mean number of accident that results death or injury accidents. The chart below indicates the total number of accident and the number of people injured due to this accident for each road.

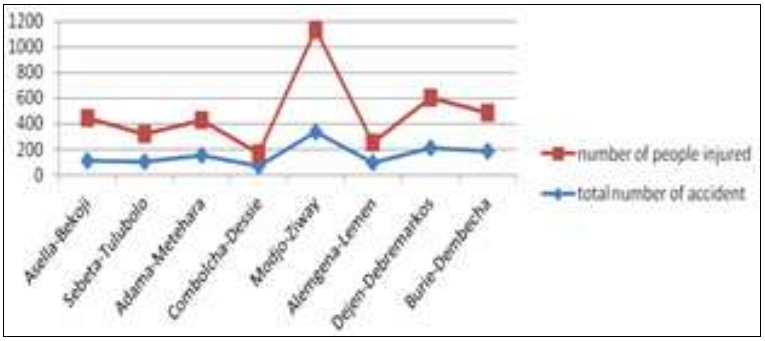

Fig 2: Showing Total number of accident and people injured

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

Accident severity index for the study road: Accident Severity Index**:** measures the seriousness of an accident. It is defined as the number of persons killed per 100 accidents. It is obtained by dividing number of people died for the total number of accident and multiplies by 100.

Table 3: Severity of accident in the study road

Year	**Accident severity index**							
	Asella-Bekoji	**Adama-Metehara**	**Sebeta- Tulu bolo**	**Combolcha-Dessie**	**Modjo-Ziway**	**Alemgena-Lemen**	**Dejen-Markos**	**Bure-Dembeca**
2015/16	58	30	52	21	55	63	33	49
2016/17	51	32	48	21	53	55	32	51
2017/18	52	22	63	43	50	47	41	44
average	54	28	55	27	53	55	35	48

The above table implies how sever the traffic accident 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 accidents. When we see in the whole country, in average from 100 accidents only 12 people were died, this implies the severity of traffic accident in the above road is very high.

When we observe the proportion of accident 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.

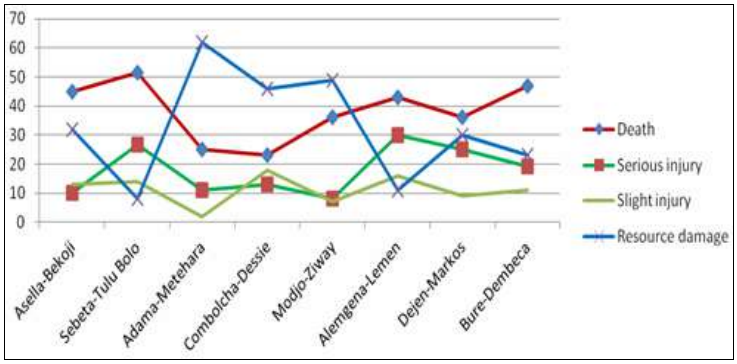

Fig 3: The proportion of accident with respect to death, serious injury, slight injury and resource damage

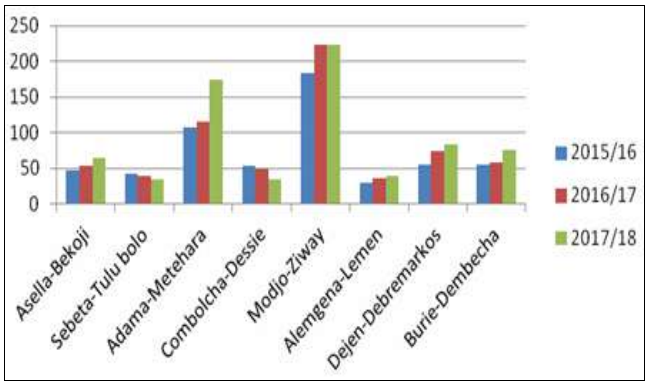

Fig 4: Trends of traffic accident in the study road

The accident severity index and the proportion of accident implies severity of accident 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 accident for death injury is very small compared to slight and serious injuries, unlike the study roads. Majority of the accident 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 an accident and to the severity of the accident. Wearing seatbelt has a high potential for accident 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% (Road safety observatory 2019).

Trends of Traffic Accident in the Study Roads

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

When we see the trends of traffic accident in Sebeta -Tulu Bolo and Combolcha- Dessie road, there is a slight decrement in the number of accident. 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 accident is decreasing to some extent.

Hazard location after long tangent at Sebeta-Tulu Bolo

Fig 5: 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 accident is occur frequently. To see the effectiveness of a treatment or traffic hazard light in Sebeta – Tulu Bolo road Accident modification factor was calculated.

Accident modification factor (AMF) = number of accident after treatment divided by number of accident before treatment

AMF= 35/42 AMF= 0.83

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

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

There are 7 black spots in which run off accident are dominated in Sebeta –Tulo Bolo road. 17% reduction of accident 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 accident by 40% using cress cross calculation. The trends of traffic accident in Sebeta – Tulu Bolo road tell us treating black spot has high potential for traffic accident reduction.

For the case of Combolcha – Dessie road, even if, it is not comfortable for vehicle occupant the construction of speed breaker reduces traffic accident significantly. There is a number of speed breaker 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 accident. As per the road accident 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 meter, height 0.1 meter and radius of 17 meter. It is better to study the impacts of speed breaker provision for traffic accident

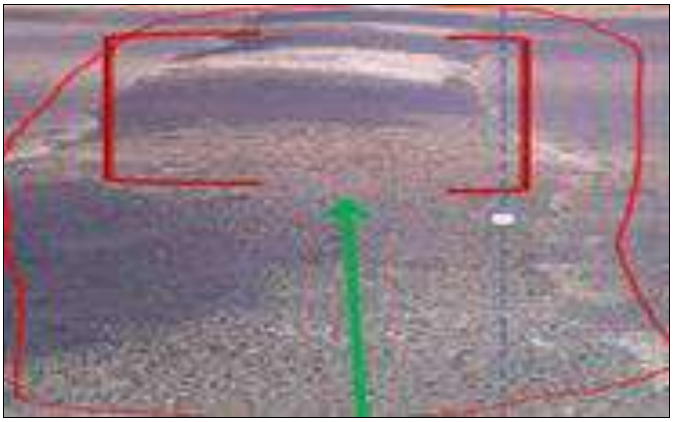

Fig 6: Unsuitable speed breaker on Combolcha – Dessie road

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

Accidents and Contributory Factors

The main identified contributing factors of traffic accidents are human factor (driver and pedestrian), vehicle factor, and road and weather factor. Among the above listed contributing factors, human factor particularly driver behavior cause majority of the accident. (See figure below). By nature traffic accidents occur as a result of combination of factor, even if driver is the main factor, they are other factors which contribute for the occurrence of accident and aggravate the effect of accident.

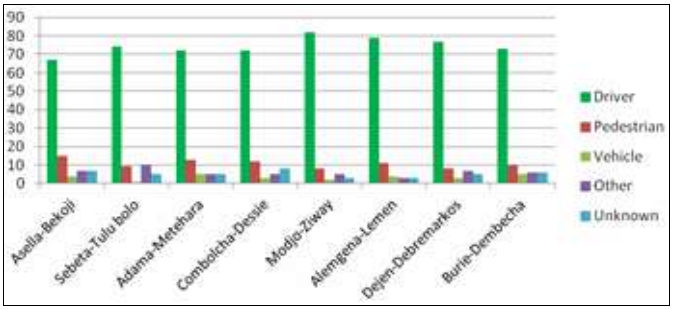

Fig 7: Indicates contributing factor for traffic accident

As the secondary data and reviewed literature indicates, the main contributing factors of traffic accidents are human factor (driver and pedestrian), vehicle factor, and road and weather factor. When we say 67% of the total accidents in Asella - Bekoji road were contributed by driver, it doesn't mean driver were the sole causes of this accident, but they are other factors which contribute for the occurrence of accident and aggravate the effect of accident. By nature traffic accidents occur as a result of combination of factor.

Driver Characteristics

The main problem that makes drivers to be the leading causes of accidents is;

- Over speeding which contributes up to 40%
- Not giving priority for pedestrian

Pedestrian behavior was the second contributing factor for the occurrence of traffic accident next to driver behavior. Not giving priority for vehicle was one of the main causes for pedestrian related traffic accident. Vehicle factor causes insignificant amount of the total accidents.

Fig 8: Traffic accident due to driver problem

Age of Drivers Vs Numbers of Accidents

The road traffic accidents caused by the driver also depends on the driver's age and their efforts. Several studies have showed that the age of drivers have a greater impact over the occurrence of road traffic accident/RTA.

This is due to the fact that, the age of drivers affects their;

- Driving behavior,
- Concentration and
- Sense of responsibility

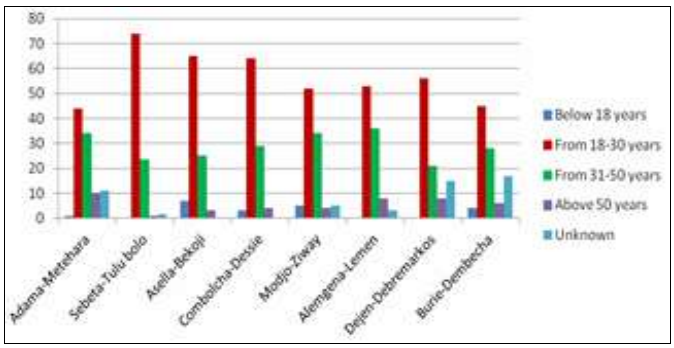

Fig 9: Traffic accident in relation to driver age

The driver age classification is based on Ethiopian federal police commission driver age classification.

Most of the time accidents are caused by the driver in the age range of 18- 30 years. Drivers found in the age between 18 and 30 in the Sebeta - Tulubolo road are 3 times more frequently involved in road traffic accident than drivers aged 31 to 50. Overconfidence, risk taking behavior, lack of experience, drunk driving, and others behaviors can place young drivers in more hazardous situations than other drivers. This age group is most active in the economy of the country.

Road characteristics and weather condition

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

Table 4: Shows traffic accident in relation to road characteristics and weather condition

Road name	Accident on Good asphalt in %	Accident on dry road in %	Accident on Good weather in %
Asella-Bekoji	80	89	76
Sebeta-Tulu Bolo	87.3	87.3	77
Adama- Metehara	94	97	87
Combolcha- Dessie	79	85	78
Modjo-Ziway	95	96	70
Alemgena- Lemen	90	86	77
Dejen-Debre Markos	95	98	95
Bure-Dembeca	86	98	98

Why high accidents 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 accident, regardless of riding quality and vehicle damage.

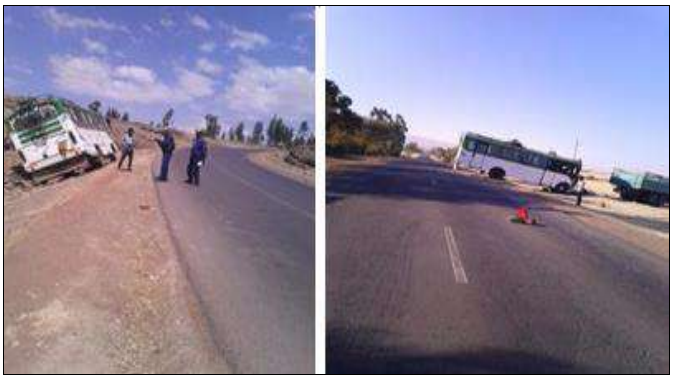

Fig 10: Sample photo of traffic accident on good asphalt collected during field survey

Vehicle factor

Vehicle type and number of traffic accident

To identify types of vehicle causing high number of accident, accident data were collected together with the types of vehicle. 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 vehicle are categorized under these groups. Since the vehicle exposure or AADT by vehicle type affects the types of vehicle causing high number of accident the analysis considers the types of vehicle causing high number of accident together with their exposure in each study roads.

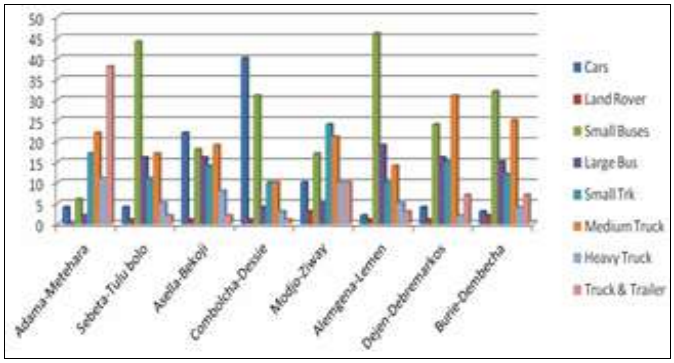

Fig 11: Percentage of traffic accident by Vehicle type causing the accident

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

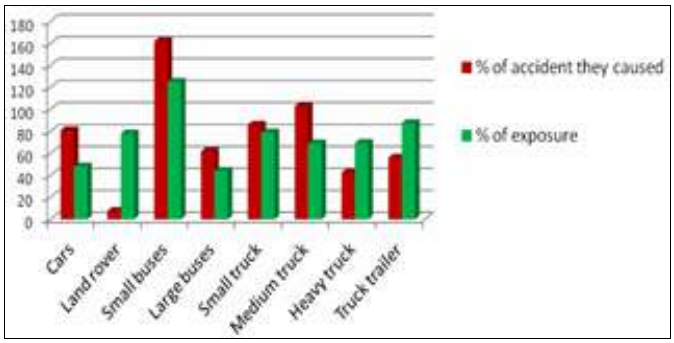

Fig 12: Vehicle exposure and traffic accident they causes

From the above chart the red color indicates percentage of accident caused by each vehicle types, and the green color indicates vehicle exposure in each road. Small bus, medium truck, large bus and small truck cause high percentage of accidents. Hence the percentage of accident 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 accident. From small bus vehicle having 12 passenger seats is the main causes of accident. Over speeding and in appropriate overtaking are the main reasons for accident happening with this types of vehicle. Therefore Small bus, medium truck, large bus and small truck are the focus area for police maker.

Vehicle service year and traffic accident

When service life of the vehicles is increased, the reliability of them to travel longer distance gets less and less. Therefore, the accidents it can result will be increase. The part of the vehicle depreciates from time to time, and reduces its speed and other important conditions. However the result of data analysis shows that vehicles having service year of 2 -5 years causes high number of accidents.

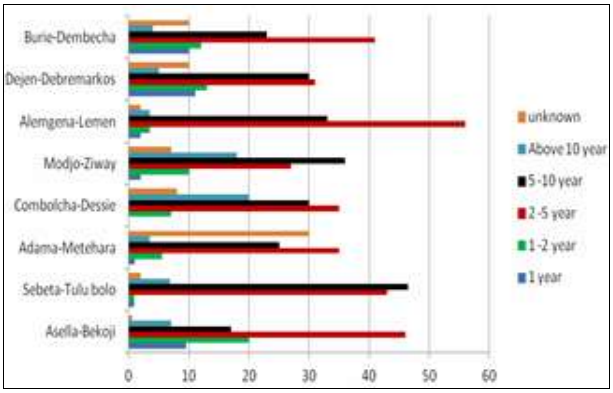

Fig 13: Vehicle service year and traffic accident

Vehicles having a service life between two – five years cause high percentage of accident. Secondly vehicle having a service life of five – ten cause high accident.

Vehicle defect and traffic accident

The largest share of accident in the study roads are caused by vehicles which have no defect. Defected vehicles caused the smallest share of total accident

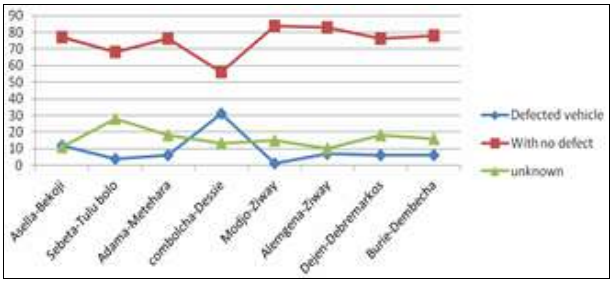

Fig 14: Vehicle defect and traffic accident

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

Types of Vehicle Collisions and Traffic Accident

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.

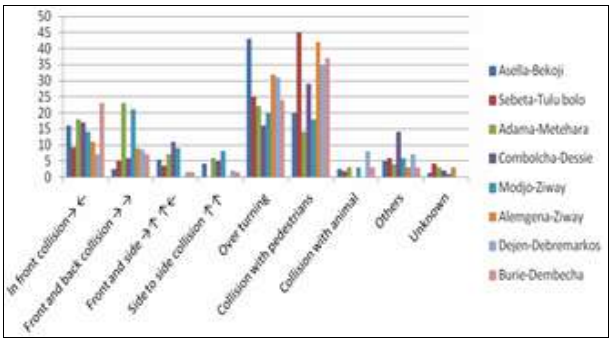

Fig 15: Types of vehicle collisions and traffic accident

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

Overturning collision

Severity of the accident 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 accident. This is why overturning collision is become dominant types of collision.

Fig 16: Hazard location after long tangent in Asella- Bekoji in which over turning accident 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.

Summarized Causes of Traffic Accident in Black spot Area and Number of Accident They Cause in Percent

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

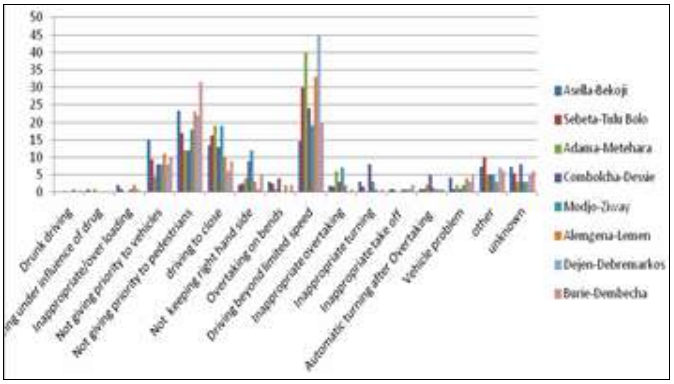

Fig 17: Causes of traffic accident and percentage of accident they causes

Conclusion and recommendation

Conclusion

The situation of roads traffic accident 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 accident.

From results of data analysis the main causes of accident are;

- Over speeding,
- Not giving priority for pedestrian,
- Not giving priority for vehicle,
- Driving too close,
- Not keeping right side,
- Poor pedestrian and driver behavior

However, the above factors are not the sole causes of traffic accident; by nature traffic accident results from a combination of factors. For example if speed is the main causes of accident, the road side environment, lane width (road geometry), road surface, road infrastructure, vehicle condition, weather condition and etc aggravates the effects of accidents. In general traffic accident has no single cause.

Speed is one of the governing factors that make the driver to be the leading causes of accident. Physical speed controlling measure is effective to reduce vehicle speed, which plays a vital role in accident severity reduction. Majority of the accidents 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 accidents 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 accidents. Absence of lane marking, speed limit post, pedestrian facilities, warning sign, and sigh distance problem with difficult road side 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 accident at minimum cost.

In genera in this research, adequate accident data together with their location and traffic data were collected to achieve the stated objectives. However, this data was not obtained simply; it was very tedious and time taking. The data recording system was not comfortable to extract data needed for the research. Recording accident data with soft copy was not cultured in most of the traffic police. In addition to this since Traffic Police Officers had many tasks and were usually out of their offices, it was difficult to get them.

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.

Traffic calming measures, such as traffic sign, play a very important role in changing driver behavior over time and using them is useful for pedestrian protection.

Maintenance of road marking and traffic sign continuously is significant.

It is better to use modern technology that help at least to reduce the accident 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 accident 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 accident data recording system. Poor recording system of accident data and lack of modern technology used to control the traffic flow should be improved. The traffic accident 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. Traffic police have to practice consistent and well-oriented enforcement with respect of all road users. Visible enforcement against few risky drivers would mean educating others who see what is happening, from breaking the same laws.

Finally Ethiopian road authority/ERA should implement the proposed mitigation measures on the identified black spot. Roads that are registering accidents repeatedly or black spots might have some sort of design problems. For example sight distance, narrow shoulders, narrow bridges, lack of accurate pedestrian walking-ways, difficult road side environments (side slope and back slope) etc. are some of problems observed in the study roads. Therefore, roads with design problems should be corrected through reengineering works.

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