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ROLE OF ROAD GEOMETRY ON ROOAD ACCIDENTS IN UASIN GISHU AND BUNGOMA COUNTIES IN KENYA

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ABSTRACT
Road accidents in the Transport Industry are a threat to public health and national development in many developing countries. It contributes to poverty by deaths, injuries, disabilities, grief, lost of productivity and material damages. This study was undertaken at Uasin-Gishu and Bungoma counties, with specific focus on Uasin-Gishu (UGC) County Hospitals, Bungoma County Hospitals, (BCH), Eldoret Police Station, Bungoma Police Station, County's department of Transport / accidents and some road terminus in Uasin-Gishu and Bungoma counties. The study sought to establish the effects of Geometry and environmental factors to accident. The results obtained in this study, can be used by the road safety and county authorities for planning and evaluating road safety measures. The methodology and procedure for data collection was based on both qualitative and quantitative approach. Interviews, focus group discussions, observations and review of secondary data, were used in data collection accordingly. Statistical analyses of data were done by descriptive. Statistics employing the measures of central tendencies, frequency distributions, difference between a set of observed frequencies and a corresponding expected frequency.. The road accident rate per hundredth vehicle kilometers was found to be significantly related to the physical characteristics of the road geometry, such as junctions per kilometer, surface irregularity and road width..

I. INTRODUCTION
Road accidents in transport industry are one of the leading causes of death and disability worldwide. They account for more than 1.2 million deaths—3.6% percent of the global mortality burden (WHO 2009). It is also estimated that in 2004, Road accidents in transport industry injuries (RATIs) contributed to 2.7% percent of the total disability-adjusted life years (DALYs) lost globally, a proportion that is expected to rise to 4.9 percent by the year 2030 and position as the third leading contributor to the global burden of disease (WHO, 2008).

Road transport is the basic mode of transportation for goods and passengers in Kenya; taking care of 90% of National freight tonnage and 95% of the transport volume. Despite the fact that the development of road systems and transport is an important factor in socioeconomic development, accidents in Transport industry account for high death rates in the country and pose a threat to public health and developmental progress (Down, 1997). Many of these roads have "evolved" from the original muram roads, rather than being properly designed for modern motor vehicles. They often contain many sub-standard curves out of character with the surrounding environment, as well as a lack of passing opportunities. Both the motoring public and road authorities have identified these as major concerns that need to be identified and ultimately remedied (MoT, 2006a).

Statement of the Problem
Road accidents in transport industry in Kenya are expected to increase because of increase in number of vehicles on roads; these will result in increased road accidents and fatality rates in these settings (Chandran et al. 2010). Kenya, has seen a sharp increase in the number of registered motor vehicles over the past two decades—from 1.4 motor vehicles per 100 people in 1985 to 2.7 motor vehicles per 100 people in 2007 (WHO, 2009). Road usage has correspondingly also gone up for every type of vehicle (Wang et al, 2009). Motorcycle use in Kenya has also significantly increased over the last decade. The literature review has addressed the major factors that enhance road accidents to take place. The issue of road geometry features has not been adequately addressed as reason for these road accidents.
Hence this study was set to identify risk factors of road accidents as related to the impact of geometry and environmental features of the road. Therefore this study sought to answer the questions do the road geometry and environmental features of the road are adequate reasons for perpetual road accidents in Kenya especially in Uasin-Gishu and Bungoma counties?

Research objectives
To determine the relationship between road geometry, environmental features and road accident rates on roads.

Research questions
What roles do the road geometry and environmental features play in road accidents?

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Significance

The study has revealed the effects of road Geometry and environmental features to possibility of road accidents. The findings obtained can be used by the road safety authorities for planning and evaluating road safety measures. The results can also be used to develop interventions to mitigate Transport industry accidents in Uasin Gishu and Bungoma counties.

Scope

The study was conducted in Uasin Gishu County and Bungoma Counties. It focused on roads in Uasin Gishu county, urban roads based in Eldoret Town. It further focused on roads in Bungoma County and the urban roads in Bungoma Town. The impacts of road geometry and environmental features in relations to road accidents, the target populations were Traffic police officers, Health workers, county Heads of transport, drivers of PSV vehicles, drivers of private vehicles, Motor bike riders, lorry/ tractor drivers, pedestrians, driving schools and opinion leaders in Uasin Gishu and Bungoma Counties.

II. LITERATURE REVIEW

Accidents in transport industry

Accident factors are conditions or actions that accompany a accident, whether or not they are determined to have contributed to the occurrence of the accident. Factors that are determined to have actually contributed to the occurrence of the accident are considered causes. An accident may be attributed to more than one cause. Geometric factors: width of lanes, width of shoulders, road curvature, number of lanes, other features and obstacles, etc. Environmental factors: weather condition, road condition, light condition, time of day, day of the week. Traffic factors: collision type, speed related, traffic volume, speed limit. The reason is based on the view of (Holt-Jensen, 2001), which emphasis that geography exists among other reasons to study evaluation in phenomenon from place to place.

Overview of the road accidents

The road accidents in transport industry are a global health problem and its magnitude is worrying in both the developed and developing world (WHO, 2009). Approximately 3,300 lives are lost everyday due to road accidents globally, with an estimated 20-50 million of people sustaining injuries annually (Mock CM, Arreola-Risa C, Quansah R 2009). The injuries sustained in transport industry are the leading killer of the most economically productive group who are in age bracket of 15years to 25 years, in the world (WHO, 2009).

The total traffic deaths reported in the following countries in 2007, global motorcycle mortality rates were highest in Thailand, Cambodia, Indonesia, Malaysia, France, USA and México at 70, 63, 61, 58, 25, 11, and 6% respectively (Odero, 2003). In the countries of East African, two-wheel automobiles have recently become a popular mode of public transport, and statistics have revealed that motor cycle accidents are claiming many lives (Mamboleo et al, 2011). In 2007, 16% of Rwanda’s total road accidents in transport industry deaths were due to motorcycles accidents, whereas in Uganda and Tanzania, 7% of the total deaths were attributed to motorcycle accidents (Odero, 2003).

Highway Geometric Factors

Width of Lanes and Shoulders

In the study carried out by Wang et al., 2011 which looked at nearly 5000 km of two-lane highways found that road accidents, head-on collisions, and side-swipe collisions were related to the road width parameters. They observed that greater width of lanes, greater width of shoulders, less hilly terrain, lower vehicle density, and a smoother roadside were correlated with fewer traffic accidents. According to Yang et al., 2011 the greater width of roads, better road surface finish, fewer hills, and fewer side roads were correlated with a lower traffic accident rates. A study was conducted to identify whether it is safer to widen lane or shoulder for a fixed total width, using geometric, traffic, and accident data for almost 52,000 miles of roadways from Pennsylvania and Washington State and it was found that there is a slight benefit to increase lane width for a fixed total width (Gross et al., 2009). However, benefits were noticed if total paved width, lane width, and shoulder width were increased individually. In a number of studies where shoulder data is available for use in the accident model, it was found to be a significant factor affecting traffic injury severities (Yang et al., 2011).

Vertical Alignment (Grades)

Petzman and Sam, (2008) examined 2,225 accidents between 1988 and 1993 on a 61 km long section of I-90 near Seattle, Washington. They had the information on the road grade for this road section, and were able to analyze the frequency of various types of accidents in light of the road geometry. A study by Zhu et al., 2010 also found that steep roadways contribute to a greater likelihood of traffic accidents. Petzman et al (2008) points out those vertical curves in the form of sags were not a major problem because they did not obscure or limit driver’s vision, but hill crests, on the other hand, limited the sight distance. Accidents were also associated with downhill sections of roads (Wang etal., 2011). A number of previous research efforts have identified roadway grade as a significant factor in the determination of injury/accident severity (Zhu et al., 2010).

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Horizontal Alignment (Curves)

Highway curves have been identified as one of the most significant geometric factors that affect fatal and injuries accidents on highways (Zhu et al., 2010)). For example, a study by Eustace et al., 2011 found that a significant majority (more than 70%) of traffic accidents that occurred on curved sections of roads were either fatal or caused injuries. In addition, they note that for accidents that occurred on curved sections, approximately half of them were associated with ice or wet road surfaces. This is despite the fact that far fewer vehicle miles are logged in such conditions (Roy and Dissanayake, 2011).

Number of Lanes

In a study conducted by Kononov et al. (2008) it was observed that increasing the number of lanes causes an increase in number of vehicles changing lane as traffic jam (number of vehicles per kilomter) increases, which results in increased traffic accidents. Mergia et al. (2013) study showed that increased number of lanes on freeway mainlines and ramps increase the chance of severe injuries at freeways' merging locations. However, a study by Liu and Subramanian (2009) held that roadways with fewer lanes (one or two lanes) tend to have a relatively higher likelihood of being locations of run-off-road accidents when compared with roadways with more than two lanes. The currents tudy was set to determine relationship of geometry of road and road accidents.

Impacts of road geometry

Al-Haji, G., and Asp, K., (2007) examined the associations between open road geometry (on both single and dual carriageways) and injury accident rates in the European States, in order to assess the road safety implications of more flexible design standards. In particular, horizontal radius, gradient, and sight distance were considered. These attributes were determined for 100-m sections of road, with over 30km of single carriageway (typically 9-10m wide) road examined, away from intersections and frontage development. Clearly defined and highly statistically significant associations were found on single carriageways. Accident rates increased with decreasing horizontal radii less than 500m and with increasing downhill gradients. There was a less significant increase in accident rate with decreasing sight distance, partly because sight distance was also correlated to horizontal radius.

Lamm *et al* (2000) provides a comprehensive summary of various German studies investigating the relationship between various road design parameters and accident rates on two-lane rural roads. Some of the factors found to be related to higher accident rates were:

i. Narrow pavement widths (especially < ~6m)
ii. Smaller horizontal curve radii (especially < ~300-400m)
iii. Higher Curvature Change Rates for curves; as defined below
iv. Vertical grades > 6% (particularly downgrades)
v. Limited forward sight distances (especially < ~100m)
vi. Small ratio between the radii of the current curve and the preceding curve (especially < ~0.2)
vii. The lack of spiral transition curves for curves of < ~300m radius

The dominant factor was Curvature Change Rate (CCR), which is defined as the rate of angular deflection per length of curve. For a purely circular curve, this can be defined as:

$$CCR = /\frac{180x\ 103}{\pi R}\ (\text{degrees/km}) \qquad (1)$$

$$CCR = /\frac{180x\ 103}{\pi R}\ \text{X}\ \{\text{Lr1/2R +Lc/Rr2/2R}\}\ \frac{\{\text{Lr1/2R +Lc/Rr2/2R}\}}{\pi(Lr1+Lc+Lr2)}\ \text{degrees/km} \qquad (2)$$

Where R = Circular curve radius

R = Circular curve radius (m)

LC = Length of circular curve (m)

LT1, *LT2* = Length of preceding and succeeding transition elements (m)

Lamm *et al* (2000) found that curves with CCRs > ~180 deg/km (~320m circular radius) had considerably higher accident rates; at 720 deg/km the accident rate was five times higher than at 180 deg/km.

Environment Factors

Environmental factors that may influence the occurrence and severity of traffic accidents such as light condition, weather condition, day of the week, time of day, and roadway condition have been extensively investigated in various previous studies such as;(Eustace et al., 2011), (Mergia et al., 2013), found that single vehicle accidents were more likely to occur during the night, and multiple vehicle accidents were more likely to occur during the daytime. Roy and Dissanayake (2011), evaluated the frequency of accidents during various times and dates in 1990 in Honolulu. The study indicated that more accidents occurred on Fridays and Saturdays.

Buildup environment and the occurrence of road accidents

The buildup environment can influence the occurrence of road accidents in a locality. The Planning of road construction to help in development should take into account the width of the road and the layout of the junctions (Eustance et al 2011). Whether black spots will be improved or not rest on the shoulders of the state and further more regional or local authorities. The availability of the better roads side facilities for pedestrians and safer crossing points to reduce traffic risk accidents is the duty of the authorities at different level. The existence of traffic laws and effectiveness with which they are enforced is largely the sole reserve of the ruling government (Eustance et al, 2011). The power and readiness to focus on transport and accident risk as an economic problem and poverty problem in addition to a public health problem is the duty of the government. The state attitudes towards

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road accidents will determine the sort of attentions the problem will receive. This is a question of economic development and the availability of recourses, priority and the overall risk leveling the society in developing countries (Mulvaney, et al, 2006).

III. MATERIALS AND METHODS

Study site

Uasin Gishu County

Uasin Gishu County is a county in the rift valley province of Kenya. It has a total of 894,179; 202291. Households and covers an area of 3, 3452, SQ.KM. The population density is 267Q KM and 50% of the population lives below the poverty line (Kenya Mpya, 2012).

These high lands rise sharply from the western edge of the Rift Valley, and the highest points are the Cherangany hills (3450m) and Mau summit (3090). Between these highland masses the level of the western highlands drops at an average of 2200m. Eldoret lies at an altitude of 2084 meters above the sea level (Cheserek et al, 2012).

Bungoma County

Bungoma County is a county in the former Western Province of Kenya. It has a Total Population of 1,375,063 and covers an area of 3,032.2 square KM. The Population density is 453.5 people per Square. KM and 53% of the population lives below the poverty line (Sindani, 2011).

Study population

The targeted population for the study Comprised, Four wheeled Vehicles drivers (PSV), Two wheeled vehicles(PSV) drivers, Pedestrians in Uasin-Gishu and Bungoma Counties, Victims of accidents in hospitals facilities in Uasin Gishu county (HF in Eldoret) and Hospital facilities in Bungoma county (Health facilities in Bungoma). Health workers at Health facilities in Uasin Gishu, and Bungoma traffic police officers, and Major driving schools in Uasin-Gishu and Bungoma counties.

The five rural roads shall be selected for studies are as follows for every county:

i. Curved roads at least four points/ places
ii. Straight road at least four points/ places
iii. Sharp corners at least four points/ places
iv. Downhill/Uphill at least four points/ places

Research Designs

The study employed survey, correctional and summative evaluation research designs. This enabled the researcher to collect both qualitative and quantitative data. Research

Sampling Strategy

The data were generated from both primary and secondary sources. For primary data, questionnaires, Interview schedules and focus group discussion were used.

Multi-stage sample size was determined by use of Fisher's (2004) formula for selecting the respondents at household level.

Data collection

The primary data was obtained by Interview with key informers, questionnaires, observation and focus group. In the process of understanding risk factors that contribute to accidents in Transport industry at Uasin-Gishu and Bungoma Counties, the unit of analysis for an in-depth understanding of life experience of accident victims in relation to safety measures undertaken by the Uasin-Gishu and Bungoma Counties authority to improve health and system risks in their respective counties as shown in the table below

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Table 3.1 b. Primary data collection of Uasin Gishu and Bungoma counties

Person injury on road accidents/hundredths per kilometers/ per annum (on bases of i. Average road width (M), ii. Vertical curvature, iii. Horizontal curvature deg/km, iv. Surface irregularity mm/km, v. Junctions in KM)	20	Observation
Person injury on road accidents/hundredths per kilometers/ per annum (on bases of i. Average road width (M), ii. Vertical curvature, iii. Horizontal curvature deg/km, iv. Surface irregularity mm/km, v. Junctions in KM, vi. Sight distance(m)	20	Observation
Person injury on road accidents/hundredths per kilometers/ per annum (on bases of i. Average road width (M), ii. Vertical curvature, iii. Horizontal curvature deg/km, iv. Surface irregularity mm/km, v. Junctions in KM, vi. Sight distance(m))	20	Observation

Table 3.2 c. Primary data collection of Uasin Gishu and Bungoma counties

Parameter values for Bungoma & Uasin Gishu i. Average width, ii. vertical curvature(m/km) iii. Horizontal curvature(m/km), iv. Surface irregularity (mm/km), v. Irregularity(mm/km), vi. junctions/km	20	Observation
Environmental risk factors for road accidents i. Wet slippery roads, ii. Fog/ Mist, iii. Muddy roads, iv. Gravel road	20	Observation
Road geometry (UGC & BC i. Curved grade, ii. Curved level, iii. Straight grade road	20	Observation

Secondary Data

In the study the secondary source of data which were collected in the field is the review of hospital records of patients admitted to the hospital as accident victims of all accidents happened in Uasin-Gishu and Bungoma counties from 2008 to 20013, Accidents records from the traffic police officers in Uasin-Gishu and Bungoma traffic police offices and Accidents records from departments of Uasin-Gishu and Bungoma Counties. The method involved the search of information in records, published books, journals, maps, dissertation, newspapers as well as available government policy document.

Reliability and validity of Data instruments

The data were generated from both primary and secondary sources. For primary data, questionnaires, Interview schedules and focus group discussion were used. The data were recorded and tabulated in tables for analysis.

Validity

To test the validity of the instrument, pilot studies were conducted in 50 motor vehicles psv and 40 road users. The aim of a pilot study was to assess the clarity of the wording of the questionnaires, interview schedule, focus group discussion guide and

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observation check list and items which failed to meet the anticipated data were discarded. A pilot study is important in testing the validity of the instruments and clarity of language (Kothari (2005).

Reliability

To test the reliability of instruments the researcher was used the test re-test method. Test re-test reliability was used to establish the correlation co-efficient. The reliability was ascertained by first assigning values to the items in the questionnaires for purposes after it had been administered. The items were split into two equal halves using odd versus even plan. The reliability co-efficient for the half items were estimated using the Pearson product correlation formula. To obtain the self-correlation of the whole questionnaire using the reliability of the half, an estimate were made using spearman Brown prophesy formula. The piloting was done in Kakamega County. The questionnaires were tested in Kakamega provisional hospital and Lugari District hospital.

Data analysis processes

Table 3. 5 Data Analysis of UGC & BC

Sn	Specific objective; To	Measurable variables/ indicator	Research Design	Methods of Analysis
	determine the effects of Geometry and environmental features	Curved roads, i. straight roads, ii. sharp corners, road safety signs, iii. traffic laws, iv. Vegetations, v. visibility, sites	correlation	Descriptive statistical and Regression

In the study seeking to determine risk factors associated with accidents in transport industry in Eldoret and Bungoma Counties, the researcher adopted correlation designs. This enables researcher to assess the degree of association or relationship that exists between two or more variables. Thus it was an attempt to measure the relationship between risk factors and road accidents in transport industry.

Limitations of the study

The field work came under some constraints such as

i. Those who were not seriously injured and decided to go away without reporting at any police station or hospital their records Were not be found.
Solution: The eye witness were used to give account of the road accident

i. At the hospital some accident forms were missing information on age of the victim, time of accident, type of the vehicle and direction on which the vehicle was going.
Solution: Only those forms with all required information were used in the research

ii. Only a few accidents were occurred during the study time, therefore types of injuries for analysis were very few.

Solution: Used majorly the ones on record

Assumptions.

The research considered the following assumptions:

i. It was assumed that the records at hospitals were available.
ii. The traffic police were to avail the data as required.
iii. The target motors drivers and pedestrians were cooperative in giving the data

The drivers of private and PSV vehicles both Two and four wheel were to be cooperative

IV. RESULTS AND DISCUSSION

The results of regression analysis

The results of the simple regression analysis

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Table 4.13 a. Simple Regression Analysis Results Bungoma County

Independent variable	Regression Constant -a	Regression Coefficient-b	Correlation Coefficient- R	t value	Level of Statistical significance
Average width (m)	3.9162	-0.2480	0.1502	-0.6282	Not sig at 10%
Vertical curvature(m/km)	2.2840	0.0020	0.0140	0.0600	Not sig at 10%
Horizontal Curvature (deg/Km)	1.7668	0.0266	0.5640	2.8200	Sig at 5%
Surface irregularity(mm/km)	1.1831	0.0002	0.3979	1.7903	Sig at 10%
Junctions per Kilometer	1.6849	1.2474	0.6961	4.0060	Sig at 5%

The 't' value is the ratio of the regression coefficient to the standard error and was used to test whether the relationship was statistically significant. That is; were unlikely to have occurred by chance. The tables indicate the relationships which were found to be significant at the 5% or 10% level. (That is to say that there is only a 5% probability that the relationship could have occurred by chance). Considering many factors affecting road accidents rates, a relationship found significant at the 10% level in this study could be considered satisfactory. The correlation coefficient r is also given. The value r^2 provides a measure of the proportion of variability in y that is accounted for by variability in the appropriate x value. For instance in Bungoma County, junctions per kilometer was found to be the most significant independent variable. The r^2 value of 0.49 indicates that 49% of the variation in road accidents rate is explained by variation in the number of junctions per kilometer alone.

In both counties the most significant parameter of those considered in this study was found to be the number of junctions per kilometer. The correlation between the junctions and the road accident rate was greater on the Nairobi-Malaba road and other roads in Bungoma County, than in Uasin-Gishu County but as can be seen from Figure 4, the ranges were quite different in the two counties. In Bungoma where there were never more than two junctions per kilometer an addition of one junction per kilometer was associated with an increase in the road accidents rate of over one road accident per hundredth vehicle-kilometers. In Uasin-Gishu County, where there were often as many as 8 junctions per kilometer, an increase of three junctions per kilometer would increase the road accident rate by one road accident per hundredth vehicle-kilometers. On the Uasin-Gishu County 'A' roads, road width was a significant factor, the wider the road the lower the road accident rate. On the Nairobi-Malaba road, there was very little variation in the road width and the small amount of variation (Table 4.2.3b) has not provided a significant relationship with road accident rate.

Table 4.13 b. Simple Regression Analysis Results For Uasin Gishu County

Independent variable	Regression Constant A	Regression Coefficient B	Correlation Coefficient r	T value	Level of Statistical significance
Av width (m)	7.6655	-0.8414	0.4802	2.8441	Sig at 5%
Vertical curvature (m/km)	2.6963	-.0030	0.0346	0.1794	Not sig at 10%
Horizontal Curvature (deg/Km)	2.3648	0.0010	0.1224	0.6403	Not sig at 10%
Surface irregularity(mm/km)	0.7745	0.00035	0.3643	2.10	Sig at 5%
Ave. sght distance (m)	3.1755	-0.oo40	0.1324	0.6940	Not sig at 10%
Junctions per Kilometer	1.1080	0.3050	0.4847	2.8795	Sig at 5%

In both counties the surface irregularity was related to the road accident rate: the rougher the road the higher the number of road accidents per hundredth vehicle-kilometers. In Uasin-Gishu the relationship was statistically significant at the 5% level whereas in Bungoma it was significant at the 10% level. Again, in Uasin-Gishu County, the range was greater than in Bungoma. The effect of

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surface irregularity was very similar in both counties; an improvement in roughness of 2000 millimeters per kilometer was associated with a reduction in the road accident rate of 0.8 road accident per hundredth vehicle-kilometers per annum.

In Bungoma the horizontal curvature was found to be significantly related to the road accident rate, a decrease of 35^0 per kilometer reducing the road accident rate by one road accident per hundredth vehicle kilometers.

In Uasin-Gishu County neither horizontal curvature nor sight distance was found to be a significant factor. This is a somewhat unusual result since the range of horizontal curvature is much greater in Uasin-Gishu County than it is in Bungoma County.

Interpretation

The road accident rate per kilometer per annum was found to be significantly related to the vehicle flow whereas the rate per hundredth vehicle kilometers was found to be significantly related to the following physical characteristics of the road geometry,

i. Junctions per kilometer,
ii. Surface irregularity and
iii. Road width.

The road accident rates in Uasin-Gishu and Bungoma Counties were found to be consistently greater for similar values of vehicle flow and geometric design.

Results

The Junctions per kilometer, Surface irregularity and Road width are the major factors of the road geometry design that contribute to road accidents in BC and UGC.

The road accident rates per hundredth per annum was found to significantly related to the physical characteristics of the road geometry which are, Junctions per kilometer, Surface irregularity and Road width.

Results on sections on roads in Bungoma County

Nairobi –Malaba, BG-Chwele-Kitale, BG-Bokoli, Kimilili Kitale, Bungoma-Mumias, Bungoma town road networks.

Table 4.14 Person injury road accidents

Section No	Person injury road accidents/hundredths ver-kilometers/ annun	Average road width(m)	Vertical curvature m/km	Horizontal curvature deg/km	Surface Irregularity Mm/km	Junctions in Km
1	2.90	6.10	10.00	19.42	2200	0.66
2	2.14	6.10	1.34	4.59	2200	0.39
3	2.30	6.10	0	0.73	29030	1.43
4	2.79	6.10	5.2	12.54	3164	0.63
5	3.51	6.10	14.4	35.53	29086	0.43
6	1.64	6.10	14.4	40.74	2986	0.56
7	2.79	6.10	14.4	16.98	3208	0.32
8	2.64	6.10	15.0	2.08	3208	0.35
9	1.06	6.10	15.0	31.5	3203	0.12
10	2.8	6.10	14.1	1.19	3208	0.43
11	2.39	6.10	2.60	50.7	3208	0.32
12	1.85	7.10	5.55	53.79	1533	0.17
13	4.57	7.00	8.84	12.73	1533	1.94
14	1.92	7.00	5.57	4.78	1533	0.12
15	1.30	7.00	4.43	7.22	1533	0.26
16	1.51	7.00	5.03	38.90	1533	0.21
17	1.88	7.00	13.00	38.90	1533	0.31
18	1.64	7.00	1.89	10.42	1533	0.56
19	2.26	7.00	11.10	30.44	1388	0.56

Results for sections of roads in Uasin- Gishu

Nairobi – Malaba, Eldoret Kapsapet road, Eldoret –Iten, Eldoret Nziwa road, Eldoret- Kitale road

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Table 4. 15 a Person injury road accidents

Section No	Person injury road accidents/hundredths per-kilometers/ annun	Average road width(m)	Vertical curvature m/km	Horizontal curvature deg/km	Surface Irregularity Mm/km	Sight distance(meters)	Junctions in Km
1	2.10	7.30	2.43	25.40	2824.8	237.22	4.80
2a	3.00	6.90	3.27	47.70	3883.4	209.50	6.63
2b	1.90	6.10	12.41	134.41	4900.9	126.54	6.81
3a	3.70	6.10	9.29	102.86	4800.9	146.36	7.71
3b	3.70	5.80	35.93	274.16	5106.5	96.34	8.31
4a	2.50	6.20	51.36	322.42	4555.5	106.71	4.83
4b	1.30	6.70	19.10	130.62	4364.3	139.65	5.87
5a	1.00	6.30	8.93	111.12	3118.5	168.64	2.50
5b	3.00	5.60	7.56	124.66	4600.8	133.25	3.17
6	6.10	5.50	8.09	184.66	4963.6	127.760	8.18
8	2.80	6.20	11.23	19963	4253.9	122.00	5.39
9	1.60	6.40	1.77	97.95	3800.6	163.75	3.74
10y	1.90	6.50	14.73	148.32	4868.9	134.78	3.11
10z	2.20	6.60	6.08	106.71	3307.7	169.54	4.60
11y	1.80	5.90	11.31	133.04	4679.7	131.74	4.48

Table 4.15 b Person injury road accidents

Section No	Person injury road accidents/hundredths per- kilometers/ annun	Average road width(m)	Vertical curvature m/km	Horizontal curvature deg/km	Surface Irregularity Mm/km	Sight distance(meters)	Junctions in Km
11z	3.40	5.20	20.94	249.63	4965.6	110.38	7.16
12	1.50	5.10	12.79	273.04	6100.0	1101.38	3.26
13y	1.90	5.40	11.50	243.48	5810.7	105.82	6.49
13z	4.00	5.10	15.68	339.57	6035.9	95.43	4.52
14y	3.00	4.10	18.89	250.75	4727.0	92.08	5.74
14z	3.20	4.10	18.89	250.75	4727.0	92.08	5.74
15	5.00	5.40	15.58	138.32	5454.4	135.69	4.41
16	2.20	5.60	29.79	368.32	4934.0	80.48	8.00
17x	1.10	6.70	8.87	161.18	4317.0	117.69	2.82
17y	0.90	7.60	22.31	38.32	2188.0	149.44	4.34
17w	1.20	6.00	39.56	423.60	6085.2	68.59	1.16
17z	3.40	5.50	29.62	346.34	6984.1	71.94	3.87
18	2.60	5.40	40.87	232.42	5942.3	96.95	2.61

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Variation in parameter values

Table 4. 16 Variations in parameter values for Bungoma County

Parameter	Maximum	Minimum	Mean	Standard Deviation
Average width(m)	7.50	6.90	6.50	0.500
Vertical curvature(m/km)	15.01	0	7.91	5.41
Horizontal curvature(deg/km)	53.80	0.72	20.0	17.33
Surface irregularity(mm/km)	3307	1487	2625	770.5
Junctions/ Km	1.94	0.11	0.49	0.460

Table 4.17 Variations in parameter values for Uasin Gishu County

Parameter	Maximum	Minimum	Mean	Standard Deviation
Average width(m)	7.5	4.96	6.0	0.68
Vertical curvature(m/km)	51.35	1.76	17.26	12.33
Horizontal curvature(deg/km)	423.6	25.3	193.4	102.86
Surface irregularity(mm/km)	6991.2	2193.0	193.4	102.86
Junctions/ Km	8.32	1.16	5.01	1.86
Average sight distance (m)	237.3	68.5	126.9	37.60

In Terms of Road Geometry

What factors do you think facilitate the occurrence of road Accidents in Uasin-Gishu / Bungoma counties?

Table 4. 19 Road Geometry factors

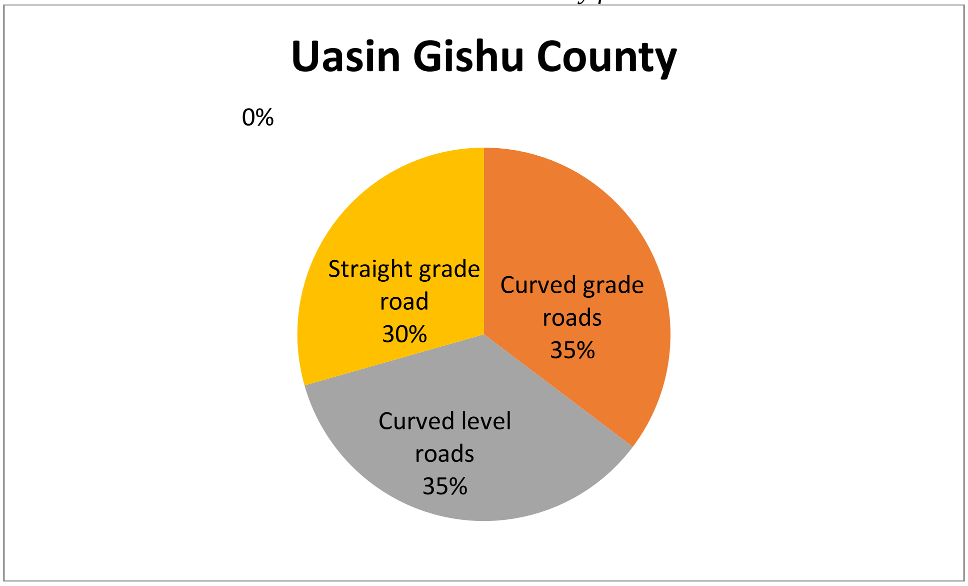

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Figure 4.19 Road Geometry factors-Uasin Gishu County

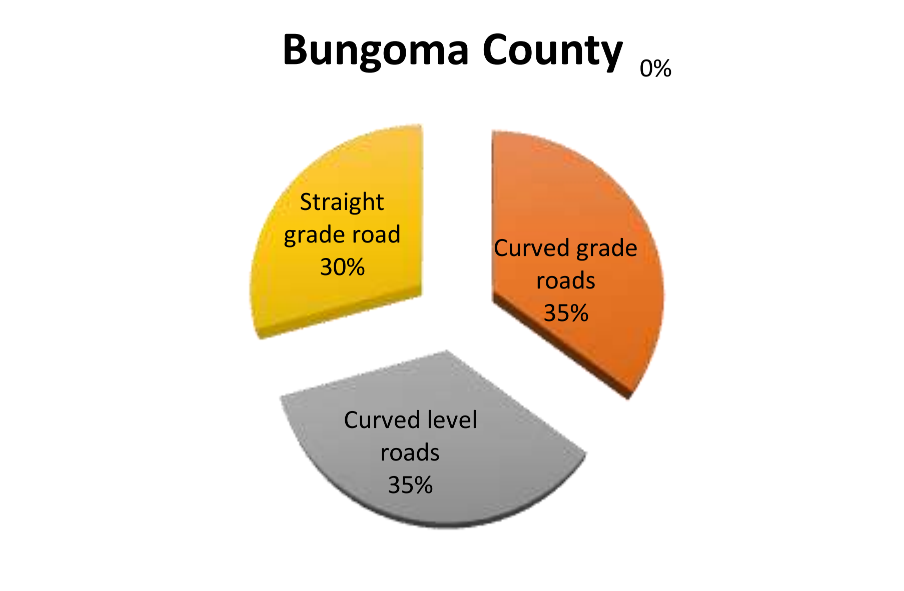

Figure 4.20 Road Geometry factors-Bungoma County

NB:
'na' stands for negative attitude
'pa' stands for positive attitude

V. CONCLUSIONS

The road accident rates in Uasin-Gishu and Bungoma Counties were found to be consistently greater for similar values of vehicle flow and geometric design. From data obtained from various sources in Bungoma and Uasin-Gishu County, it has been shown that, using multiple regression analysis to relate the Road accident rates on roads in these counties to certain geometrical design, characteristics of the road. In Bungoma, the road accident rate per hundredth vehicle-kilometers was significantly related to the number of junctions per kilometer, the horizontal curvature, the vertical curvature and the surface irregularity.
In Uasin-Gishu County, it was found to be related to road width, and junctions per 'kilometer. The road Engineers and physical planners may wish to use these regression equations in other counties to obtain estimates of changes in road accident rate following given road improvements where traffic and road conditions are similar to those described here. But since the equations derived are different Bungoma and Uasin-Gishu counties it would be difficult to decide which equation to use. Where conditions were similar to those on the Nairobi-Malaba road, the equation derived from the Bungoma county data would appear the most appropriate since same road pass through the two counties. Similarly, where there were extremes of horizontal and vertical curvature and surface irregularity the equation derived for Uasin-Gishu County may be most appropriate. But there was little variation in road width on the Nairobi-Malaba road and this did not appear to be a significant parameter, whereas in Uasin-Gishu County it was the most important parameter. Hence where a road was being widened as the construction was going on; it might be difficult to decide which equation was the most appropriate equation to use particularly if conditions were similar to those on the Nairobi-Malaba road. The other factors which are involved are road user behavior and vehicle condition and maintenance.

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