Research Journal of Mathematics and Statistics 7(4): 53-59, 2015
ISSN: 2042-2024, e-ISSN: 2040-7505
© 2015 Maxwell Scientific Publication Corp.
Submitted: May 27, 2015 Accepted: July 14, 2015 Published: November 25, 2015

Research Article

The Effect of Road Traffic Fatality Rate on Road Users in Ghana

Christian A. Hesse and John B. Ofosu
Department of Mathematics and Statistics, Faculty of Social Studies, Methodist University College, Ghana

Abstract: In this study, we shall consider the annual distribution of the rates of road traffic fatalities per 100 casualties on road users in Ghana. The rate of road traffic fatalities per 100 casualties is called *road traffic fatality index.* Data on road traffic casualties, fatalities and fatality indices (F. I.) by road users and by regions, from 2010 to 2013, will be used. Using published road traffic accident data from the National Road Safety Commission of Ghana, a two-factor factorial design and analysis of variance of the effect of a road user class with 7 levels of factor and the effect of a geographical region with 10 levels of the factor shall be considered. The interaction between the two factors shall be considered. The result will show that, different road user classes have different effects on the road traffic fatality index and also that, there are significant differences in fatality index rates among the 10 regions of Ghana. We shall also discover that, there is significant interaction between road user class and geographical region. A multiple comparison test, using Fisher's Least Significance Difference (LSD) method, shall be conducted to determine which pairs of road user fatality index means are significantly different. The study will show that, there are significant differences in road traffic fatality indices (fatality per 100 casualties) among various road users and also in the ten regions of Ghana. The risk of dying in a road traffic accident among pedestrians and cyclists are both significantly higher than those of other road users. The LSD shows that there is no significant difference between fatality indices of pedestrians and cyclists. The risk of dying in a road traffic accident among pedestrians and cyclists are both significantly higher than those of other road users, recording an average rate of 33.9 and 31.78 deaths per 100 casualties, respectively.

Keywords: Fatalities and casualties, road traffic

INTRODUCTION

According to the National Road Safety Commission (NRSC) of Ghana, in 2013, about 2 240 persons were killed and 13 001 were injured in road traffic accidents in Ghana. Road users in Ghana can be classified under the following eight categories: pedestrians, car occupants, goods vehicle occupants, bus/mini-bus occupants, motorcyclists, pick-up occupants, cyclists and others. The NRSC has reported that pedestrians are the road users with the highest risk of death in road traffic accidents in Ghana. In 2013, the vulnerable road users in Ghana (pedestrians, bus/mini-bus and car occupants), according to the NRSC report, constitute about 72% of road users killed on the roads, with pedestrians alone being about 41%. Compared to year 2012, NRSC reported that there has been a 3.3 percentage drop in the fatality share of pedestrians (from 41.5% in 2012 to 38.2% in 2013) and a 2.0 percentage drop in that of bus occupants. There was a reduction of 21.9% in pedestrian fatalities and a reduction of 23.8% in bus occupant fatalities from year 2012 to year 2013.

Based on NRSC report, motor-cyclist fatalities in road traffic accidents continue to follow an upward trend. Statistics released by NRSC on road traffic accidents in Ghana show that the proportion of motor-cyclist fatalities in the total number of road traffic fatalities increased from 2.7% in 2001 to 14.2% in 2011 and increased again to 14.5% in 2012 and now is at 17.0% in 2013. The report indicated that motorcycle fatalities of 17.0% have now strongly overtaken car occupant fatalities (11.5%), though we have 10 times more cars involved in crashes than motorcycles. Compared to 2012, motorcycle fatalities in 2013 reduced marginally by 0.6%. Motor-cyclist fatalities, according to NRSC, increased by 634% compared to a reduction of -4% for pedestrians from 2001 to 3013. The increasing use of motor-cycles as taxis (popularly known as Okada) and the non-use of helmets by both riders and pillion riders may have contributed to the rising trend of motor-cyclists fatalities.

Several studies have shown that a pedestrian in a road traffic accident, is at a greater risk of being severely injured. Oxley *et al*. (2004) reported that older pedestrians and cyclists are vulnerable road users, comprising a substantial proportion of all road fatalities

Corresponding Author: Christian A. Hesse, Department of Mathematics and Statistics, Faculty of Social Studies, Methodist University College, Ghana
This work is licensed under a Creative Commons Attribution 4.0 International License (URL: http://creativecommons.org/licenses/by/4.0/).

world-wide. Oxley *et al*. (2004) stated that pedestrian fatalities constitute between 20 and 30% of road fatalities, while cyclist deaths range from 2% in Australia to 10% in Denmark, Belgium, Germany and Sweden to 23% in the Netherlands.

Evans (2000) analyzed driver death rates per capita, per licensed driver and per mile driven in relation to driver age and sex and also analyzed the death rates of pedestrians in relation to the age and sex of the drivers involved in the crashes in which they

Table 1: Road user class by fatality, casualty and fatality index for 2010 and2011

	Persons Killed	Casualties	Fatality Index	Persons Killed	Casualties	Fatality Index	Persons Killed	Casualties	Fatality Index	Persons Killed	Casualties	Fatality Index	Persons Killed	Casualties	Fatality Index	Persons Killed	Casualties	Fatality Index
	Greater Accra						Northern						Brong Ahafo					
	2011			2010			2011			2010			2011			2010		
Pedestrian	245	1176	20.8	231	1388	16.6	17	41	41.5	20	40	50.0	82	231	35.5	57	153	37.3
Car Occupant	30	931	3.2	56	1032	5.4	2	58	3.4	13	76	17.1	45	344	13.1	33	311	10.6
Goods Veh. Ocpts	13	163	8.0	19	155	12.3	13	74	17.6	21	250	8.4	38	170	22.4	29	175	16.6
Bus/Mini-Bus	46	951	4.8	60	1008	6.0	57	357	16.0	15	263	5.7	52	444	11.7	21	464	4.5
Motorcyclist	49	389	12.6	31	460	6.7	20	75	26.7	13	75	17.3	57	214	26.6	20	104	19.2
Pick-Up Ocpts	7	110	6.4	8	139	5.8	7	66	10.6	22	90	24.4	3	56	5.4	1	59	1.7
Cyclist	16	62	25.8	18	98	18.4	6	14	42.9	7	11	63.6	17	42	40.5	5	25	20.0
Other	1	11	9.1	1	13	7.7	1	4	25.0	3	7	42.9	3	13	23.1	3	11	27.3
Total	407	3793	10.7	424	4293	9.9	474	3614	13.1	20	40	50.0	297	1514	19.6	169	1302	13.0
	Ashanti						Upper East						Upper West					
	2011			2010			2011			2010			2011			2010		
Pedestrian	211	776	27.2	193	753	25.6	15	24	62.5	13	26.8	23.0	6	16	37.5	11	17	64.7
Car Occupant	45	692	6.5	58	721	8.0	2	27	7.4	3	7.1	7.5	0	23	0.0	5	25	20.0
Goods Veh. Ocpts	38	286	13.3	32	289	11.1	1	12	8.3	4	14.0	11.6	1	8	12.5	2	7	28.6
Bus/Mini-Bus	120	1428	8.4	97	1587	6.1	1	21	4.8	1	7.8	5.6	8	45	17.8	3	42	7.1
Motorcyclist	40	267	15.0	38	183	20.8	26	67	38.8	13	19.9	15.6	32	96	33.3	25	57	43.9
Pick-Up Ocpts	8	113	7.1	15	164	9.1	2	31	6.5	0	7.4	7.9	0	13	0.0	1	27	3.7
Cyclist	8	39	20.5	11	33	33.3	7	15	46.7	11	28.6	30.6	3	9	33.3	7	8	87.5
Other	4	13	30.8	10	22	45.5	0	0	-	0	20.0	26.6	0	0	-	0	0	0.0
Total	474	3614	13.1	454	3752	12.1	54	197	27.4	13	13.6	11.7	50	210	23.8	11	17	64.7
	Central						Eastern						National Fatality Index					
	2011			2010			2011			2010			2011			2010		
Pedestrian	101	346	29.2	98	422	23.2	98	346	28.3	109	438	24.9	26.8			23.0		
Car Occupant	28	450	6.2	14	347	4.0	44	488	9.0	50	614	8.1	7.1			7.5		
Goods Veh. Ocpts	12	93	12.9	11	92	12.0	33	242	13.6	20	224	8.9	14.0			11.6		
Bus/Mini-Bus	44	502	8.8	29	575	5.0	37	1006	3.7	54	1017	5.3	7.8			5.6		
Motorcyclist	12	82	14.6	8	86	9.3	22	113	19.5	13	81	16.0	19.9			15.6		
Pick-Up Ocpts	2	48	4.2	2	51	3.9	6	102	5.9	3	73	4.1	7.4			7.9		
Cyclist	4	25	16.0	4	19	21.1	8	31	25.8	7	26	26.9	28.6			30.6		
Other	0	4	0.0	1	3	33.3	0	3	0.0	3	10	30.0	20.0			26.6		
Total	203	1550	13.1	167	1595	10.5	248	2331	10.6	259	2483	10.4	13.6			11.7		
	Volta						Western						National Fatality Index					
	2011			2010			2011			2010			2011			2010		
Pedestrian	45	128	35.2	50	194	25.8	78	262	29.8	71	280	25.4	26.8			23.0		
Car Occupant	14	194	7.2	19	222	8.6	41	315	13.0	20	269	7.4	7.1			7.5		
Goods Veh. Ocpts	7	68	10.3	8	74	10.8	12	88	13.6	13	85	15.3	14.0			11.6		
Bus/Mini-Bus	37	460	8.0	24	381	6.3	25	280	8.9	21	427	4.9	7.8			5.6		
Motorcyclist	20	140	14.3	32	161	19.9	35	130	26.9	17	89	19.1	19.9			15.6		
Pick-Up Ocpts	9	34	26.5	0	53	0.0	2	50	4.0	3	35	8.6	7.4			7.9		
Cyclist	3	21	14.3	10	32	31.3	8	22	36.4	12	30	40.0	28.6			30.6		
Other	4	22	18.2	0	6	0.0	2	5	40.0	0	0	0.0	20.0			26.6		
Total	139	1067	13.0	50	194	25.8	203	1152	17.6	71	280	25.4	13.6			11.7		

Table 1 (Cont): Road user class by fatality, casualty and fatality index for 2012 and 2013

	Persons Killed	Casualties	Fatality Index	Persons Killed	Casualties	Fatality Index	Persons Killed	Casualties	Fatality Index	Persons Killed	Casualties	Fatality Index	Persons Killed	Casualties	Fatality Index	Persons Killed	Casualties	Fatality Index
	Greater Accra						Northern						Brong Ahafo					
	2013			2012			2013			2012			2013			2012		
Pedestrian	196	960	20.4	333	1441	23.1	26	52	50.0	5	14	35.7	64	167	38.3	66	178	37.1
Car Occupant	65	880	7.4	54	808	6.7	5	39	12.8	7	47	14.9	16	279	5.7	30	256	11.7
Goods Veh. Ocpts	13	74	17.6	15	139	10.8	27	218	12.4	10	79	12.7	25	128	19.5	17	117	14.5
Bus/Mini-Bus	28	675	4.1	55	986	5.6	52	292	17.8	42	215	19.5	38	266	14.3	55	496	11.1
Motorcyclist	43	411	10.5	56	512	10.9	20	103	19.4	26	71	36.6	42	207	20.3	40	199	20.1
Pick-Up Ocpts	7	69	10.1	8	114	7.0	2	46	4.3	2	26	7.7	1	44	2.3	3	30	10.0
Cyclist	8	60	13.3	14	75	18.7	7	10	70.0	7	12	58.3	5	23	21.7	6	25	24.0
Other	3	40	7.5	0	15	0.0	1	26	3.8	0	0		10	25	40.0	4	7	57.1
Total	363	3169	11.5	535	4090	13.1	140	786	17.8	99	464	21.3	201	1139	17.6	221	1308	16.9
	Ashanti						Upper East						Upper West					
	2013			2012			2013			2012			2013			2012		
Pedestrian	172	486	35.4	188	739	25.4	18	31	58.1	15	24	62.5	8	23	34.8	19	42	45.2
Car Occupant	56	463	12.1	39	581	6.7	1	15	6.7	2	27	7.4	1	20	5.0	0	18	0.0
Goods Veh. Ocpts	34	185	18.4	43	258	16.7	0	2	0.0	1	12	8.3	12	59	20.3	2	15	13.3
Bus/Mini-Bus	67	883	7.6	89	1323	6.7	0	2	0.0	1	21	4.8	8	41	19.5	13	60	21.7
Motorcyclist	54	222	24.3	56	266	21.1	31	95	32.6	26	67	38.8	39	125	31.2	24	90	26.7
Pick-Up Ocpts	2	59	3.4	5	73	6.8	2	8	25.0	2	31	6.5	2	21	9.5	1	11	9.1
Cyclist	7	23	30.4	10	49	20.4	5	24	20.8	7	15	46.7	2	6	33.3	12	21	57.1
Other	14	51	27.5	2	9	22.2	0	0	-	0	0	-	0	1	0.0	0	0	-
Total	406	2372	17.1	432	3298	13.1	57	177	32.2	54	197	27.4	72	296	24.3	71	257	27.6
	Central						Eastern						National Fatality Index					
	2013			2012			2013			2012			2013			2012		
Pedestrian	64	217	29.5	90	315	28.6	78	279	28.0	107	453	23.6	28.5			25.8		
Car Occupant	21	296	7.1	35	395	8.9	32	473	6.8	37	477	7.8	7.7			7.9		
Goods Veh. Ocpts	11	70	15.7	21	114	18.4	17	103	16.5	46	234	19.7	16.9			16.6		
Bus/Mini-Bus	70	307	22.8	33	415	8.0	33	705	4.7	89	910	9.8	9.1			8.6		
Motorcyclist	19	103	18.4	18	86	20.9	16	125	12.8	24	156	15.4	19.6			19.0		
Pick-Up Ocpts	6	40	15.0	6	52	11.5	3	51	5.9	4	81	4.9	7.3			7.6		
Cyclist	9	20	45.0	3	14	21.4	6	23	26.1	8	33	24.2	25.5			28.1		
Other	0	3	0.0	1	3	33.3	12	54	22.2	1	1	100	20.3			22.0		
Total	200	1056	18.9	207	1394	14.8	197	1813	10.9	316	2345	13.5	15.2			14.6		
	Volta						Western						National Fatality Index					
	2013			2012			2013			2012			2013			2012		
Pedestrian	58	166	34.9	39	126	31.0	42	165	25.5	63	250	25.2	28.5			25.8		
Car Occupant	13	168	7.7	13	140	9.3	8	196	4.1	27	331	8.2	7.7			7.9		
Goods Veh. Ocpts	5	74	6.8	3	22	13.6	30	114	26.3	22	95	23.2	16.9			16.6		
Bus/Mini-Bus	23	322	7.1	25	211	11.8	10	136	7.4	25	301	8.3	9.1			8.6		
Motorcyclist	35	153	22.9	15	146	10.3	24	104	23.1	48	160	30.0	19.6			19.0		
Pick-Up Ocpts	1	28	3.6	1	19	5.3	3	31	11.0	5	50	10.0	7.3			7.6		
Cyclist	3	16	18.8	0	5	0.0	3	11	8.0	11	29	37.9	25.5			28.1		
Other	4	9	44.4	0	2	0.0	0	8	0.0	1	4	25.0	20.3			22.0		
Total	142	936	15.2	96	671	14.3	120	765	15.7	202	1220	16.6	15.2			14.6		

were killed, using data from years 1994 through 1996. Evans reported that an 80-year old male driver has a 121% higher death rate per licensed driver and a 662% higher death rate per mile driven than a 40-year-old male driver and reported similar patterns for females. However, when analyzing the rate of pedestrian fatalities in relation to driver age, Evans reported that on a per-driver basis, 80-year-old drivers of either sex were less likely than 40-year-old drivers to be involved in crashes fatal to pedestrians. When analyzed on a per-mile-driven basis, 80-year-old drivers had higher rates of involvement in crashes fatal to pedestrians than did 40-year-old drivers; however, the elevation was smaller than the elevation in their own death rates.

Table 1 shows the distribution of road user class by fatality, casualty and fatality indices (F. I.) from 2010 to 2013, where F. I. refers to the number of road traffic fatalities per 100 casualties. The data used in this study were obtained from the National Road Safety Commission (NRSC) of Ghana.

The F. I. is required for characterization and comparison of the extent and risks of traffic fatality between different road users. It can be seen (Table 1) that, nationally, the F. I. increased from 23.0 to 28.5 among pedestrians from 2010 to 2013, whilst that of car occupants increased marginally from 7.5 to 7.7 over the same period. In very simple terms, these changes imply that the chance of at least one casualty dying as a result of road traffic accident has increased over the period. It can also be observed that, over the 4 year period, the cyclist continues to be the road user with the highest national fatality rate, more especially at the northern part of the country (Northern, Upper East and Upper West regions). For instance, in 2010, about 88% of all cyclists in the Upper West region who were involved in road traffic accidents lost their lives while 64% of cyclist casualties died in the Northern region. This may be due to the fact that cyclists in Ghana don't usually use crash helmets when riding.

In this study, therefore, we propose the use of a two-factor factorial design and analysis of variance to determine if there are significant differences in road traffic fatality index rates among road user classes and also that, if there are significant differences in fatality index rates among the 10 geographical regions of Ghana. The interaction between road user class and geographical region in Ghana shall also be considered. Analysis of variance is well covered in several books, including those of Cochran and Cox (1957), Cox (1958), Fisher (1966), Kempthorne (1952), Montgomery (2001) and Ofosu *et al*. (2014).

MATERIALS AND METHODS

In this section, we consider an experiment involving the following 2 factors:

A: The effect of a road user class on road traffic fatality index in Ghana.

B: The effect of a geographical region on road traffic fatality index in Ghana.

We assume that there is an interaction effect between the two factors. This means that the effect of road user class depends on the level of geographical region and vice versa. Our main objective is to determine if there are significant differences among the various road users in Ghana and to investigate if there is significant interaction between the factors *A* and *B*. Road user class is investigated at 7 levels, while geographical region is investigated at 10 levels. The experiment is replicated 4 times (4 years). Table 2, extracted from Table 1, gives the data arrangement for a two-factor factorial experiment, with observations in each cell being the F. I. of a road user class in a specified geographical region over the 4 year interval (2010 to 2013).

We wish to test the following hypothesis:

- There are no differences in road traffic fatality index among the road user classes;
- Geographical region has no significant effect on fatality index;
- The road user class and region do not interact. using a 0.05 level of significance.

The model for this experiment is:

$$y_{ijk} = \mu + \alpha_i + \beta_j + (\alpha\beta)_{ij} + \varepsilon_{ijk} \begin{cases} i = 1, 2, ..., 7 \\ j = 1, 2, ..., 10 \\ k = 1, 2, ..., 4 \end{cases} \quad (1)$$

where,

y_{ijk} = A typical observation (road traffic fatality index)
μ = The overall mean effect
a_i = The effect due to the i^{th} road user class
β_j = The effect due to the j^{th} geographical region
$(a\beta)_{ij}$ = The joint effect of the road user class at i^{th} level and the effect of geographical region at j^{th} level
ε_{ijk} are independent $N(0, \sigma^2)$:

$$\sum_{i=1}^{7} \alpha_i = \sum_{j=1}^{10} \beta_j = \sum_{i=1}^{7} \sum_{j=1}^{10} (\alpha\beta)_{ij} = 0. \quad (2)$$

Total uncorrected sum of squares = 156 267.56. The computation for the various sums of squares are then given by:

$$SST = \sum_{i=1}^{7} \sum_{j=1}^{10} \sum_{k=1}^{4} y_{ijk}^2 - \frac{y_{\dots}^2}{280} = 156\,267.56 - \frac{5231.8^2}{280} = 58\,511.38,$$

$$SSA = \frac{1}{40} \sum_{i=1}^{7} y_{i\cdot\cdot}^2 - \frac{y_{\dots}^2}{280} = \frac{1}{40}\left(1355.9^2 + 322.7^2 + \dots + 1271^2\right) - \frac{5231.8^2}{280} = 27\,147.41,$$

$$SSB = \frac{1}{28} \sum_{j=1}^{10} y_{\cdot j\cdot}^2 - \frac{y_{\dots}^2}{280} = \frac{1}{28}\left(334.1^2 + 447.4^2 + \dots + 501.5^2\right) - \frac{5231.8^2}{280} = 27\,147.41,$$

$$SSE = \sum_{i=1}^{7} \sum_{j=1}^{10} \sum_{k=1}^{4} y_{ijk}^2 - \frac{1}{4} \sum_{ij} t_{ij}^2 = 156\,267.56 - \frac{1}{4}\left(81.1^2 + 113.6^2 + \dots + 122.3^2\right) = 13\,535.19,$$

$$SSAB = SST - SSA - SSB - SSE = 10\,133.26,$$

where,

SST = The corrected sum of squares
SSA = The sum of squares due to road user class
SSB = The sum of squares due to geographical region
SSAB = The sum of squares due to the interaction between road user class and geographical region
SSE = The residual sum of squares

The computations are summarized in Table 3.

RESULTS AND DISCUSSION

Let C_i denote the effect of the i^{th} level of road user class on road traffic fatality index. We wish to test the null hypothesis $H_0 : C_1 = C_2 = \dots = C_7 = 0$ against H_1: at least one $C_i \neq 0$. The test statistic is $F = \frac{\text{road user class mean square}}{\text{residual mean square}}$. *F* has the *F*-distribution with 6 and 210 degrees of freedom when H_0 is true. We reject H_0 at significance level 0.05 when the computed value of *F* is greater than $F_{0.05,\, 6,\, 210} \approx 2.10.$. Since 70.20>2.10, we reject H_0 at 0.05 level of significance. We conclude that different road user classes have different effects on the road traffic fatality index.

Table 2: Data arrangement for the two-factor factorial experiment

		Geographical region									
		Greater Accra 1		Ashanti 2		Northern 3		Brong Ahafo 4		Upper East 5	
Road User Class	Pedestrian 1	16.8	81.1	35.4	113.6	41.5	177.2	38.3	148.2	62.5	206.1
		20.8		25.4		50		37.1		23	
		20.4		27.2		50		35.5		62.5	
		23.1		25.6		35.7		37.3		58.1	
	Car Occupant 2	3.2	22.7	6.5	33.3	3.4	48.2	13.1	41.1	7.4	29
		5.4		8		17.1		10.6		7.5	
		6.7		6.7		12.8		11.7		7.4	
		7.4		12.1		14.9		5.7		6.7	
	Goods Veh. Ocpts 3	17.6	48.7	18.4	59.5	12.4	51.1	19.5	73	0	28.2
		10.8		16.7		12.7		14.5		8.3	
		12.3		11.1		8.4		16.6		11.6	
		8		13.3		17.6		22.4		8.3	
	Bus/Mini-Bus 4	4.8	20.5	8.4	28.8	16	59	11.7	41.6	4.8	15.2
		6		6.1		5.7		4.5		5.6	
		5.6		6.7		19.5		11.1		4.8	
		4.1		7.6		17.8		14.3		0	
	Motorcyclist 5	10.5	40.7	24.3	81.2	19.4	100	20.3	86.2	32.6	125.8
		10.9		21.1		36.6		20.1		38.8	
		6.7		20.8		17.3		19.2		15.6	
		12.6		15		26.7		26.6		38.8	
	Pick-Up Ocpts 6	6.4	44.2	7.1	26.4	10.6	163.3	5.4	52.8	6.5	45.9
		5.8		9.1		24.4		1.7		7.9	
		13.3		3.4		70		21.7		25	
		18.7		6.8		58.3		24		6.5	
	Cyclist 7	13.3	76.2	30.4	104.6	70	234.8	21.7	106.2	20.8	144.8
		18.7		20.4		58.3		24		46.7	
		25.8		20.5		42.9		40.5		46.7	
		18.4		33.3		63.6		20		30.6	
	Total	716.6		441.6		407.3		501.5		5231.8	

		Geographical region										
		Upper West 6		Central 7		Eastern 8		Volta 9		Western 10		Total
Road User Class	Pedestrian 1	34.8	182.2	29.2	110.5	28	104.2	35.2	126.9	25.5	105.9	1355.9
		45.2		29.5		23		25.8		25.2		
		64.7		23.2		24.9		31		25.4		
		37.5		28.6		28.3		34.9		29.8		
	Car Occupant 2	0	25	6.2	26.2	9	31.7	7.2	32.8	13	32.7	322.7
		20		4		8.1		8.6		7.4		
		0		8.9		7.8		9.3		8.2		
		5		7.1		6.8		7.7		4.1		
	Goods Veh. Ocpts 3	20.3	74.7	15.7	59	16.5	58.7	6.8	41.5	26.3	78.4	572.8
		13.3		18.4		19.7		13.6		23.2		
		28.6		12		8.9		10.8		15.3		
		12.5		12.9		13.6		10.3		13.6		
	Bus/Mini-Bus 4	17.8	66.1	8.8	44.6	3.7	23.5	8	33.2	8.9	29.5	362
		7.1		5		5.3		6.3		4.9		
		21.7		8		9.8		11.8		8.3		
		19.5		22.8		4.7		7.1		7.4		
	Motorcyclist 5	31.2	135.1	18.4	63.2	12.8	63.7	22.9	67.4	23.1	99.1	862.4
		26.7		20.9		15.4		10.3		30		
		43.9		9.3		16		19.9		19.1		
		33.3		14.6		19.5		14.3		26.9		
	Pick-Up Ocpts 6	0	22.3	4.2	34.6	5.9	20.8	26.5	41.1	4	33.6	485
		3.7		3.9		4.1		0		8.6		
		9.5		15		5.9		3.6		11		
		9.1		11.5		4.9		11		10		
	Cyclist 7	33.3	211.2	45	103.5	26.1	103	18.8	64.4	8	122.3	1271
		57.1		21.4		24.2		0		37.9		
		33.3		16		25.8		14.3		36.4		
		87.5		21.1		26.9		31.3		40		
	Total	716.6		441.6		405.6		407.3		501.5		5231.8

Table 3: ANOVA table

Source of variation	Sum of squares	Degrees of freedom	Mean square	F
Road user class	27147.41	6	4524.57	70.20
Region	7695.51	9	855.06	13.27
Interaction	10133.26	54	187.65	2.91
Residual	13535.19	210	64.45	
Total	58511.38	279		

Table 4: Mean road traffic fatality index for road user classes in Ghana

Road User Class	Pedestrian	Car Occupants	Goods Veh. Occupants	Bus/Mini-Bus	Motorcyclist	Pick-Up Occupants	Cyclist
Mean fatality index	33.90	8.07	14.32	9.05	21.56	12.13	31.78

Let R_j denote the effect of the j^{th} level of geographical region on the road traffic fatality index ($j = 1, 2, \ldots, 10$). We wish to test the null hypothesis H_0 : $R_1 = R_2 = \ldots = R_{10} = 0$ against H_1 : at least one $R_j \neq 0$ The test statistic is F = geograpgical region mean square/residual mean square. F has the F-distribution with 9 and 210 degrees of freedom. We reject H_0 at significance level 0.05 when the computed value of F is greater than $F_{0.05,\ 9,\ 210} \approx 1.88$. Since 13.27, the computed value of F, is greater than 1.88, we reject H_0 at the 5% level. We conclude that different regions have different effects on the road traffic fatality index.

Here, we wish to test the null hypothesis H_0 all $(CR)_{ij} = 0$ against H_1: at least one $(CR)_{ij} \neq 0$ The test statistic is $F = \frac{\text{interaction mean square}}{\text{residual mean square}}$. F has the F-distribution with 54 and 218 degrees of freedom when H_0 is true. We reject H_0 at significance level 0.05 when the computed value of F is greater than $F_{0.05,\ 54,\ 210} \approx 1$ Since 2.91, the computed value of F, is greater than 1, we reject H_0 at the 5% level. We conclude that there is interaction between road user class and the type of region.

Multiple comparisons: Since the analysis of variance indicates that road user class means differ significantly, it is of interest to make comparisons between the individual road user class means to discover the specific differences.

Over the years, several methods for making multiple comparisons have been suggested. Duncan (1951, 1952, 1955) has contributed a considerable amount of research to the subject of multiple comparisons. Other multiple comparison methods in use are those proposed by Tukey (1949, 1953), Newman (1939), Keuls (1952) and Scheffé (1953, 1959). The advantages and disadvantages of the various multiple comparison methods are discussed by Bancroft (1968), O'Neill and Wetherill (1971), Daniel and Coogler (1975), Winer (1971) and Ofosu *et al*. (2014). Daniel (1980) has prepared a bibliography on multiple comparison procedures.

The oldest multiple comparison method and perhaps the most widely used, is the least significant difference method of Fisher, who first discussed it in the 1935 edition of his book "The design of experiments". To use this method, we first calculate the Least Significant Difference, (LSD), for the given data. This is given by:

$$LSD = t_{\frac{1}{2}\alpha,\ 210}\sqrt{\frac{2MSW}{n_0}}, \quad (3)$$

where, $\alpha = 0.05$, $n_0 = 40$ $t_{\frac{1}{2}\alpha,\ 210} = 1.960$ and $MSW = 64.45$ (Table 3). This gives $LSD = 3.52$. Table 4 shows the mean fatality index for each of the road user class in Ghana.

We then compare the observed difference between each pair of means to the *LSD*. If the observed difference is greater than 3.52, we conclude that the road traffic fatality indices of the two road user classes are significantly different. For example, from Table 4, it can be seen that, the observed difference between the mean fatality indices for pedestrian and motorcyclist is (33.90-21.56) = 12.34. Since 12.34 is greater than 3.52, we conclude that there is a significant difference between the road traffic fatality indices for pedestrian and motorcyclists. It is obvious that the road traffic fatality index for pedestrians is significantly greater than that of other road users except for cyclists. This means that, the risk of dying in a road traffic accident among pedestrians and cyclists are both significantly higher than those of other road users, recording an average rate of 33.9 and 31.78 deaths per 100 casualties, respectively.

CONCLUSION

In the previous section, we found that, there are significant differences in road traffic fatality indices (fatality per 100 casualties) among various road users and also among the ten geographical regions of Ghana. The risk of dying in a road traffic accident among pedestrians and cyclists are both significantly higher than those of other road users. This points to the fact that more and more people as a proportion of the recorded number of casualties, are being killed through road traffic accidents among these two categories of road users.

The encroachment on pedestrian walkways and footbridges and some roadways has limited pedestrian space along the corridor and the linked roads and thereby increasing the risk of pedestrians being injured or killed in road traffic accidents. Many storeowners make use of the space in front of their stores, including the pedestrian walkways, to showcase their stock. The lack of safeguarded pedestrian space on sidewalks along major roads and the lack of safe zebra crossings have also aggravated this risk.

There is the need for pedestrian-friendly flyovers to aid in crossing major highways. Adanu (2004) asserts that, in order for Accra to develop a sustainable transport system, it must increase its use of public transit (metro buses) and Non-Motorized Transport (walkways for pedestrians and cycling ways for bicyclists).

Bicycling as a form of transport is environmentally friendly and relatively cheap compared with other forms of transport. It also promotes healthy exercise. Reports demonstrate that a sizeable portion of Accra's population utilize this form of transport. Ghana's *National Transport Policy*, in 2008, recognizes the need for a strong Non-Motorized Transport component to the country's overall transportation development, highlighting these reasons. We need to develop the appropriate infrastructure (such as bicycle paths, free and open sidewalk) and safety measures (including motorists' recognition and respect for pedestrians and bicyclists) and legal protections for non-motorized transport. As a country, there is the need to formulate policies that will:

- Foster a safer regime for use of non-motorised transport
- Create better conditions for pedestrians
- Foster greater use of bicycles

An extensive study on bicycle use among the urban poor in Nima and Jamestown of Accra (Turner *et al*., 1995) highlighted the general negative attitudes within certain communities toward cyclists. Healthy transport, as described by Banister (2008), requires separating people and traffic, with separate routes and space for pedestrians and cyclists. Investment in separate, dedicated infrastructure for cyclists could reduce these negative attitudes and the risk environment for cyclists. As well, promoting bicycle use as a transport mode requires addressing the cultural and community perceptions of bicycling use in different ethnic communities (Turner *et al*., 1995).

REFERENCES

Adanu, S.K., 2004. The need for changes in urban planning: Case study of Accra capital city of Ghana. Proceeding of the 40th ISoCaRP Congress.

Bancroft, T.A., 1968. Topics in Intermediate Statistical Methods. Iowa State University Press, Ames, Iowa.

Banister, D., 2008. The sustainable mobility paradigm. Transp. Policy, 15: 73-80.

Cochran, W.G. and G.M. Cox, 1957. Experimental Designs. 2nd Edn., John Wiley and Sons, New York.

Cox, D.R., 1958. Planning of Experiments. John Wiley and Sons, New York.

Daniel, W.W., 1980. Multiple Comparison Procedures. A Selected Bibiography. Vance Bibliographies, Monticello, III.

Daniel, W.W. and C.E. Coegler, 1975. Beyond analysis of variance: A comparison of some multiple comparison procedures. Phys. Ther., 55: 114-150.

Duncan, D.B., 1951. A significance test for difference between ranked treatments in an analysis of variance. Verginal J. Sci., 2: 171-189.

Duncan, D.B., 1952. On the properties of the multiple comparison tests. Verginal J. Sci., 3: 50-67.

Duncan, D.B., 1955. Multiple range and multiple F-tests. Biometrics, 11: 1-42.

Evans, L., 2000. Risks older drivers face themselves and threats they pose to other road users. Int. J. Epidemiol., 29: 315-322.

Fisher, R.A., 1966. The Design of Experiments. 8th Edn., Hafner Publishing Company, New York.

Kempthorne, O., 1952. The Design and Analysis of Experiments. John Wiley and Sons, New York.

Keuls, M., 1952. The use of the studentized range in connection with an analysis of variance. Euphytica, 1: 112-122.

Montgomery, D.C., 2001. Design and Analysis of Experiments. 5th Edn., John Wiley and Sons, New York.

Newman, D., 1939. The distribution of the range in samples from a normal population in terms of an independent estimate of standard deviation. Biometrica, 31: 20-30.

Ofosu, J.B., C.A. Hesse and F. Otchere, 2014. Intermediate Statistical Methods. EPP Books Services, Accra.

O'Neill, R. and G.B. Wetherill, 1971. The present state of multiple comparison methods. J. R. Stat. Soc. B, 33: 218-241.

Oxley, J., B. Corben, B. Fildes and M. O'Hare, 2004. Older vulnerable road users – Measures to reduce crash and injury risk. Report No. 218, Monash University Accident Research Centre.

Scheffé, H., 1953. A method for judging all contrasts in the Scheffé, H. (1950) Analysis of variance. Biometrika, 40: 87-104.

Scheffé, H., 1959. Analysis of Variance. Wiley and Sons, New York.

Tukey, J.W., 1949. Comparing individual mean in the analysis of variance. Biometrics, 5: 99-114.

Tukey, J.W., 1953. The Problem of Multiple Comparisons. Princeton University, Ditto.

Turner, J.M., M. Greico and E.A. Kwakye, 1995. Subverting sustainability? Infrastructural and cultural barriers to cycle use in Accra. Proceeding of the 7th World Conference on Transport Research, Sydney, Australia.

Winer, B.J., 1971. Statistical Principles in Experimental Design. 2nd Edn., McGraw-Hill, New York.