ANALYSIS OF THE REGIONAL DISTRIBUTION, PATTERNS AND FORECAST OF ROAD TRAFFIC FATALITIES IN GHANA

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

Abstract

Road traffic fatalities (RTFs) in Ghana have adverse effect on the dependency ratio and economic growth in the formal sector of the economy. To analyse the pattern of road traffic deaths in Ghana, fatalities of road traffic accidents by age group from 2001 – 2010 were obtained. Using published road traffic accident statistics from the National Road Safety Commission of Ghana, the pattern of RTF in the ten (10) geographical regions in Ghana was obtained, using moving average analysis. The pattern of the road traffic fatality data displays 10 distinct yearly cycles over a 10-year period, with the underlying trend showing a steady marginal increase overall, as well as in each particular region.

Based entirely on the moving average trend of the past data, the values of the number of RTFs are projected for each of the 10 geographical regions. The number of road traffic fatalities in Ghana are predicted to rise from 1 986 in the year 2010 to 3 526 in the year 2030, an increase of about 77.5%. This finding is consistent with one of the key findings on global trends and projections presented in the *World report on road traffic injury prevention*, which revealed that road traffic deaths are predicted to increase by 83% in low-income and middle-income countries.

Keywords: Fatality, Trend and Forecast

1. Introduction

Data provided by the National Road Safety Commission (NRSC) of Ghana, showed that, in 2010, a total of 1 986 people died from road traffic accidents. This means that, on the average, about 6 people died daily on Ghana's roads. About 21% of road traffic deaths occured in Ashanti region of Ghana, where 5 178 140 people or 19% of Ghana's population live and own about 16% of vehicles in Ghana, as at 2010. Eastern region had the highest mortality rate, with 11.6 deaths per 100 000 population. This was followed closely by the Central region with 9.8 per 100 000 population. These two regions accounted for more than 30% of all road traffic death rates in Ghana. Greater Accra Region, with more than 60% of registered vehicles and the highest population density in Ghana, recorded the lowest average rate of 5.8 fatalities/100 accidents. Out of every 100 road traffic accidents in the Northern region, about 41 victims of the casualties die. Thus the risk of dying from road traffic injury is highest in the Northern Region, followed closely by the Upper West region with a rate of about 30 fatalities/100 accidents which shows no significant disparity with that of the Upper East and the Brong-Ahafo regions.

According to the *World report on road traffic injury prevention* (Penden et al., 2004):

- 1.2 million people died as a result of road traffic accidents. This means that, on average, 3 242 people died daily on the world's roads.
- 20 million to 50 million people were injured or disabled in road traffic accidents.
- Road traffic injuries were the 11th leading cause of death worldwide and accounted for 2.1% of all deaths globally. Furthermore, these road traffic deaths accounted for 23% of all injury deaths worldwide.
- 90% of road traffic deaths occurred in low-income and middle-income countries, where 5 098 million people or 81% of the world's population live and own about 20% of vehicles in the world.
- The WHO, African Region, had the highest mortality rate, with 28.3 deaths per 100 000 population. This was followed closely by the low-income and middle-income countries of the WHO, Eastern Mediterranean Region, at 26.4 per 100 000 population (Table 1.1). Countries in the WHO, Western Pacific Region, and the WHO, South-East Asia Region, accounted for more than half of all road traffic deaths in the world.

The key findings on global trends and projections, presented in the *World report on road traffic injury prevention* (Penden et al., 2004) are summarized below:

- The number of road traffic injuries has continued to rise in the world as a whole, but there has been an overall downward trend in road traffic deaths in high-income countries since the 1970s, and an increase in many of the low-income and middle-income countries.

- Road traffic injuries are predicted to rise from the tenth place in 2002, to the eighth place by 2030, as a contributor to the global burden of diseases.
- Road traffic deaths are predicted to increase by 83% in low-income and middle-income countries (if no major action is taken), and to decrease by 27% in high-income countries. The overall global increase is predicted to be 67% by 2020, if appropriate action is not taken.

In a study of injury-related mortality among adolescents, Ohene et al. (2010) discovered that drowning (submerging and suffocating in water) and road traffic accidents, are the leading causes of injury-related, mortality based on data collected from Korle-Bu teaching hospital. They recommended appropriate injury reducing interventions to facilitate a decrease in these preventable deaths. According to Odero et al. (1997), road traffic accident victims tend to stay longer in the hospital than average patients.

In this paper, we analyse the pattern and then forecast the occurrence of road traffic fatalities in Ghana. Table 1 shows the regional distribution of road traffic fatalities in Ghana, from 2001 to 2010. A cumulative total of 29 954 deaths were recorded during the period. It can also be seen that, during the year 2010, the highest regional number of road traffic fatalities of 454 deaths was recorded in Ashanti region, followed closely by Greater-Accra region, which recorded 424 deaths, and then the Eastern and Brong-Ahafo regions with 259 and 169 recorded deaths, respectively. These four regions alone contributed 65.7% of all the road traffic fatalities in Ghana.

Table 1: Annual Distribution of Road Traffic Fatalities by Region

Year	Greater Accra	Ashanti	Western	Eastern	Central	Volta	Northern	Upper East	Upper West	Brong-Ahafo	Total
2001	240	379	135	279	206	152	66	34	17	152	**1660**
2002	169	359	121	346	215	130	71	44	20	190	**1665**
2003	232	377	138	263	188	152	138	53	35	140	**1716**
2004	299	577	158	325	234	167	131	68	24	202	**2185**
2005	313	315	154	299	183	122	97	79	30	192	**1784**
2006	335	388	143	216	184	169	112	44	21	244	**1856**
2007	407	463	150	280	190	145	105	69	27	207	**2043**
2008	385	416	169	294	150	179	95	59	36	155	**1938**
2009	429	469	144	343	246	140	113	54	40	259	**2237**
2010	424	454	157	259	167	143	114	45	54	169	**1986**
Total	**5010**	**6204**	**2440**	**5064**	**3312**	**2238**	**1488**	**832**	**427**	**2939**	**29954**
Mean	**16.7**	**20.7**	**8.1**	**16.9**	**11.1**	**7.5**	**5.0**	**2.8**	**1.4**	**9.8**	**100**

Fig. 1, on the next page, shows the graph of the distribution of road traffic fatalities on the vertical axis against the ten (10) independent administrative/geographical regions of Ghana on the horizontal axis over the 10-year period from 2001 to 2010. The trend of the graph over the interval of time is obvious. It displays 10 distinct yearly cycles over the 10-year period, with the underlying trend showing a steady marginal increase overall, as well as in each particular region. The graph appears to follow almost identical pattern in the corresponding regions over the successive 10-year cycles. The 10 independent geographical regions in Table 1 represent the regional variations in a yearly cycle. The data shows a significant regional effect with the cycle peak over Ashanti region and trough in the Upper East region. Since a definite periodicity for the occurrence of road traffic fatality in the 10 regions can be established from the above data, it follows that the change in conditions of road traffic fatality can be anticipated to some degree of precision.

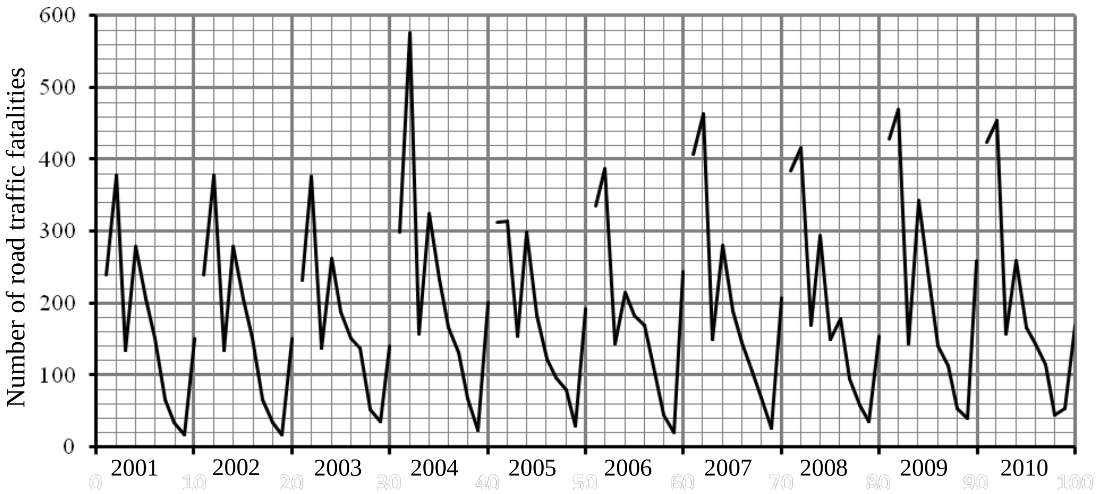

Fig. 1: A graph of the distribution of the data in Table 1

2. The model

The actual number of road traffic fatality value, may be modelled by:

Actual value = Trend + Regional variation

or $Y = T + R$. ………………………………………………...........(1)

2.1 The trend

Since the pattern in Fig. 1 shows a significant regional effect on fatality, the moving average technique is used in extracting the trend. The data is road traffic fatalities in distinctly 10 independent geographical regions of Ghana over yearly cycle. We therefore need a 10-value moving average trend. Table 2 shows the 10-value centred moving average (t) together with the corresponding actual data values (y).

Table 2: Centered 10-value moving averages of the data in Table 1

n	*y*	*t*	***n***	*y*	*t*	***n***	*y*	*t*	***n***	*y*	*t*
1	240		**26**	152	175.0	**51**	335	181.0	**76**	179	196.0
2	379		**27**	138	188.3	**52**	388	184.1	**77**	95	200.9
3	135		**28**	53	199.3	**53**	143	183.1	**78**	59	202.3
4	279		**29**	35	203.4	**54**	216	180.9	**79**	36	203.5
5	206		**30**	140	208.8	**55**	184	183.0	**80**	155	210.7
6	152	162.5	**31**	299	211.9	**56**	169	189.2	**81**	429	213.6
7	66	157.9	**32**	577	212.3	**57**	112	196.6	**82**	469	212.5
8	34	156.2	**33**	158	212.7	**58**	44	200.7	**83**	144	213.2
9	17	158.9	**34**	325	212.9	**59**	21	204.2	**84**	343	213.1
10	152	162.7	**35**	234	215.4	**60**	244	207.7	**85**	246	218.5
11	169	162.0	**36**	167	219.2	**61**	407	206.8	**86**	140	223.5
12	359	161.2	**37**	131	206.8	**62**	463	205.3	**87**	113	222.5
13	121	161.9	**38**	68	193.5	**63**	150	206.2	**88**	54	222.4
14	346	162.6	**39**	24	192.0	**64**	280	207.7	**89**	40	218.8
15	215	164.6	**40**	202	188.2	**65**	190	206.2	**90**	259	210.7
16	130	169.7	**41**	313	183.4	**66**	145	203.2	**91**	424	206.9
17	71	173.7	**42**	315	179.4	**67**	105	199.8	**92**	454	207.1
18	44	175.5	**43**	154	178.3	**68**	69	198.4	**93**	157	206.7
19	20	172.2	**44**	299	179.1	**69**	27	200.0	**94**	259	206.9
20	190	166.7	**45**	183	178.9	**70**	207	198.7	**95**	167	203.1
21	232	166.4	**46**	122	179.5	**71**	385	198.4	**96**	143	
22	377	170.9	**47**	97	184.3	**72**	416	199.6	**97**	114	
23	138	174.7	**48**	79	187.4	**73**	169	198.6	**98**	45	
24	263	175.9	**49**	30	182.7	**74**	294	198.6	**99**	54	
25	188	174.1	**50**	192	178.6	**75**	150	196.4	**100**	169	

Fig. 2 shows a graph of the original data with the trend superimposed. It can be seen that, there is approximately a constant marginal increase in the trend values. That is, the trend values are approximately linear.

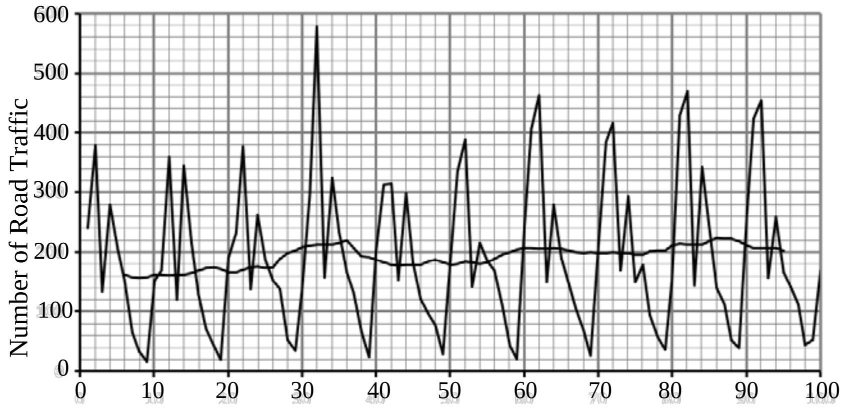

Fig. 2: Trend superimposed on the graph of the data

In order to obtain a formula for the estimation of trend values for future number of occurrence of road traffic fatalities, we use the least square regression model of the form

$$t_n = \beta_0 + \beta_1 n + \varepsilon_n, \quad n = 6, 7, \ldots, 95, \quad \ldots\ldots(2)$$

where t_n is the trend value for the n^{th} observation and the error terms $\varepsilon_6, \varepsilon_7, \ldots, \varepsilon_{95}$ are assumed to be normally and independently distributed with mean 0 and variance σ^2. β_0 and β_1 are parameters to be estimated. It can be shown that the maximum likelihood estimates of β_0 and β_1 are given by (see Ofosu et al., 2013)

$$\hat{\beta}_0 = \bar{t} - \hat{\beta}_1 \bar{n}, \quad \ldots\ldots(3)$$

where $$\hat{\beta}_1 = \frac{\sum_{n=6}^{95} n t_n - \frac{1}{90}\left(\sum_{n=6}^{95} t_n\right)\left(\sum_{n=6}^{95} n\right)}{\sum_{n=6}^{95} n^2 - \frac{1}{90}\left(\sum_{n=6}^{95} n\right)^2} \quad \ldots\ldots(4)$$

$$= \frac{S_{nt}}{S_{nn}}, \quad \ldots\ldots(5)$$

$$\bar{n} = \frac{1}{90}\left(\sum_{n=6}^{95} n\right), \quad \bar{t} = \frac{1}{90}\left(\sum_{n=6}^{95} t_n\right)$$

$$S_{nt} = \sum_{n=6}^{95} n t_n - \frac{1}{90}\left(\sum_{n=6}^{95} n\right)\left(\sum_{n=6}^{95} t_n\right), \quad \ldots\ldots(6)$$

and $$S_{nn} = \sum_{n=6}^{95} n^2 - \frac{1}{90}\left(\sum_{n=6}^{95} n\right)^2. \quad \ldots\ldots(7)$$

The fitted or estimated regression line is

$$\hat{t}_n = \hat{\beta}_0 + \hat{\beta}_1 n. \quad \ldots\ldots(8)$$

The $\hat{t}_n$ values are the predicted trend values. Thus, based on the data in Table 2 and the given equations, the maximum likelihood estimates of β_0 and β_1 are $\hat{\beta}_0 = 165.805$ and $\hat{\beta}_1 = 0.52895$, respectively.

The significance of the regression relationship can be assessed by using analysis of variance techniques to test the null hypothesis H_0: $\beta_1 = 0$ against the alternative hypothesis H_1: $\beta_1 \neq 0$. The sum of squares due to linear regression is given by

$$SSR = \frac{S_{nt}^2}{S_{nn}} = 16\,994.7.$$

The total corrected sum of squares is given by

$$SST = S_{tt} = \sum_{i=6}^{95} t_i^2 - \frac{1}{90}\left(\sum_{i=6}^{95} t_i\right)^2 = 29\ 605.4.$$

Therefore, the residual sum of squares is $SSE = SST - SSR = 12\ 610.7.$ The calculations can be summarized in the following ANOVA table.

Table 3: Analysis of Variance table of the data in Table 2

Source of variation	Sum of squares	Degrees of freedom	Mean square	F
Linear regression	16994.7	1	16994.7	118.593
Residual	12610.7	88	143.3	
Total	29605.4	89		

The test statistic for testing H_0 against H_1 is $F = \frac{\text{regression mean square}}{\text{residual mean square}}$. When H_0 is true, F has the F-distribution with 1 and 88 degrees of freedom. We reject H_0 at significance level 0.05 if the computed value of F is greater than $F_{0.05,\,1,\,88} \approx 3.95.$ Since 118.593, the calculated value of F, is greater than 3.95, the test is significant at the 5% level. There is therefore enough evidence to conclude that there is a linear relationship between the expected value of t and n. Thus, equation (8) can be expressed as

$$\hat{t}_n = 165.805 + 0.52895n. \quad \text{.......................................(9)}$$

Table 4 shows the estimated trend values, $\hat{t}_n$, from Equation (9), the residuals from the regression trend $e_n = y_n - \hat{y}_n$ and the standardized residual $d_n = e_n \big/ \sqrt{\hat{\sigma}^2}$, $n = 6, 7, \ldots, 90$.

Table 4: Estimated trend, residual and standardized residual values

$\hat{t}_n$	e_n	d_n	$\hat{t}_n$	e_n	d_n	$\hat{t}_n$	e_n	d_n	$\hat{t}_n$	e_n	d_n
157.4	-5.4	0.0	177.0	122.0	1.0	196.6	-27.6	-0.2	216.2	212.8	1.7
158.2	-92.2	-0.7	177.8	399.2	3.2	197.4	-85.4	-0.7	217.0	252.0	2.0
158.9	-124.9	-1.0	178.6	-20.6	-0.2	198.2	-154.2	-1.2	217.8	-73.8	-0.6
159.7	-142.7	-1.1	179.3	145.7	1.2	199.0	-178.0	-1.4	218.6	124.4	1.0
160.5	-8.5	-0.1	180.1	53.9	0.4	199.7	44.3	0.4	219.4	26.6	0.2
161.3	7.7	0.1	180.9	-13.9	-0.1	200.5	206.5	1.7	220.1	-80.1	-0.6
162.1	196.9	1.6	181.7	-50.7	-0.4	201.3	261.7	2.1	220.9	-107.9	-0.9
162.9	-41.9	-0.3	182.5	-114.5	-0.9	202.1	-52.1	-0.4	221.7	-167.7	-1.3
163.7	182.3	1.5	183.3	-159.3	-1.3	202.9	77.1	0.6	222.5	-182.5	-1.5
164.4	50.6	0.4	184.1	17.9	0.1	203.7	-13.7	-0.1	223.3	35.7	0.3
165.2	-35.2	-0.3	184.8	128.2	1.0	204.4	-59.4	-0.5	224.1	199.9	1.6
166.0	-95.0	-0.8	185.6	129.4	1.0	205.2	-100.2	-0.8	224.8	229.2	1.8
166.8	-122.8	-1.0	186.4	-32.4	-0.3	206.0	-137.0	-1.1	225.6	-68.6	-0.5
167.6	-147.6	-1.2	187.2	111.8	0.9	206.8	-179.8	-1.4	226.4	32.6	0.3
168.4	21.6	0.2	188.0	-5.0	0.0	207.6	-0.6	0.0	227.2	-60.2	-0.5

169.1	62.9	0.5	188.8	-66.8	-0.5	208.4	176.6	1.4
169.9	207.1	1.7	189.5	-92.5	-0.7	209.2	206.8	1.7
170.7	-32.7	-0.3	190.3	-111.3	-0.9	209.9	-40.9	-0.3
171.5	91.5	0.7	191.1	-161.1	-1.3	210.7	83.3	0.7
172.3	15.7	0.1	191.9	0.1	0.0	211.5	-61.5	-0.5
173.1	-21.1	-0.2	192.7	142.3	1.1	212.3	-33.3	-0.3
173.9	-35.9	-0.3	193.5	194.5	1.6	213.1	-118.1	-0.9
174.6	-121.6	-1.0	194.3	-51.3	-0.4	213.9	-154.9	-1.2
175.4	-140.4	-1.1	195.0	21.0	0.2	214.6	-178.6	-1.4
176.2	-36.2	-0.3	195.8	-11.8	-0.1	215.4	-60.4	-0.5

It can be seen that only 3 out of the 90 computed standardized residuals fall outside the interval $(-1.96, 1.96)$. Thus, based on the given data, more than 95% of the standardized residuals fall in this interval. There is therefore enough evidence that the errors are normally distributed.

The trend values corresponding to the first five and the last five of the observed values of *y* are omitted. Such omissions will always occur with a moving average trend. Equation (9) can be used to estimate these values. The last trend value (Year 10 at series point 4) is $t_{95} = 203.1.$ From Equation (9), the estimated trend value for Year 10 at series point 5, is approximately

$$\hat{t}_{96} = 165.805 + 0.52895 \times 96 = 216.6.$$

Similarly, $\hat{t}_{97} = 217.1,$ $\hat{t}_{98} = 217.6,$ $\hat{t}_{99} = 218.2$ and $\hat{t}_{100} = 218.7.$

2.2 Regional variation

The purpose of analysing these data is not the determination of the trend. Interest is centred on forecasting, or the ability to estimate future road traffic fatality values using regional variation.

In the additive component model, the regional factors are individually expressed as deviation from the trend. Given the original road traffic fatality values (*y*) and the corresponding estimated trend values $(\hat{t})$ based on Equation (9), the procedure for calculating the regional variation is as follows.

1. For each point *n*, calculate the difference between the original value (y_n) and the estimated trend $(\hat{t}_n)$. That is, the value of $r_n = y_n - \hat{t}_n.$ The calculations to find the regional variations (r_n) are shown in Table 5. The additive model is given by

$$y_n = t_n + r_n.$$

Table 5: Regional variations r_n together with the trend values t_n

		y_n	t_n	r_n			y_n	t_n	r_n			y_n	t_n	r_n
2010	1	424	213.9	210.1	2004	1	299	182.2	116.8	2007	1	407	198.1	208.9
	2	454	214.5	239.5		2	577	182.7	394.3		2	463	198.6	264.4
	3	157	215.0	-58.0		3	158	183.3	-25.3		3	150	199.1	-49.1
	4	259	215.5	43.5		4	325	183.8	141.2		4	280	199.7	80.3
	5	167	216.1	-49.1		5	234	184.3	49.7		5	190	200.2	-10.2
2001	6	152	169.0	-17.0		6	167	184.8	-17.8		6	145	200.7	-55.7
	7	66	169.5	-103.5		7	131	185.4	-54.4		7	105	201.2	-96.2
	8	34	170.0	-136.0		8	68	185.9	-117.9		8	69	201.8	-132.8
	9	17	170.6	-153.6		9	24	186.4	-162.4		9	27	202.3	-175.3
	10	152	171.1	-19.1		10	202	187.0	15.0		10	207	202.8	4.2
2002	1	169	171.6	-2.6	2005	1	313	187.5	125.5	2008	1	385	203.4	181.6
	2	359	172.2	186.8		2	315	188.0	127.0		2	416	203.9	212.1
	3	121	172.7	-51.7		3	154	188.5	-34.5		3	169	204.4	-35.4
	4	346	173.2	172.8		4	299	189.1	109.9		4	294	204.9	89.1
	5	215	173.7	41.3		5	183	189.6	-6.6		5	150	205.5	-55.5
	6	130	174.3	-44.3		6	122	190.1	-68.1		6	179	206.0	-27.0
	7	71	174.8	-103.8		7	97	190.7	-93.7		7	95	206.5	-111.5
	8	44	175.3	-131.3		8	79	191.2	-112.2		8	59	207.1	-148.1
	9	20	175.9	-155.9		9	30	191.7	-161.7		9	36	207.6	-171.6
	10	190	176.4	13.6		10	192	192.3	-0.3		10	155	208.1	-53.1
2003	1	232	176.9	55.1	2006	1	335	192.8	142.2	2009	1	429	208.6	220.4
	2	377	177.4	199.6		2	388	193.3	194.7		2	469	209.2	259.8
	3	138	178.0	-40.0		3	143	193.8	-50.8		3	144	209.7	-65.7
	4	263	178.5	84.5		4	216	194.4	21.6		4	343	210.2	132.8
	5	188	179.0	9.0		5	184	194.9	-10.9		5	246	210.8	35.2
	6	152	179.6	-27.6		6	169	195.4	-26.4		6	140	211.3	-71.3
	7	138	180.1	-42.1		7	112	196.0	-84.0		7	113	211.8	-98.8
	8	53	180.6	-127.6		8	44	196.5	-152.5		8	54	212.4	-158.4
	9	35	181.1	-146.1		9	21	197.0	-176.0		9	40	212.9	-172.9
	10	140	181.7	-41.7		10	244	197.5	46.5		10	259	213.4	45.6

2. For each region, we find the arithmetic mean of all the regional values, that is, the average estimated regional variation (see Table 6).
3. The total of the average estimated seasonal regional variation is expected to be zero. Since the total is -2.3, one or more of the values are adjusted to obtain a total of zero.

Table 6: Arithmetic mean of the values of r_n in Table 5, for each of the 10 regions

Seasons Code	Greater Accra 1	Ashanti 2	Wester n 3	Eastern 4	Central 5	Volta 6	Northern 7	Upper East 8	Upper West 9	Brong -Ahafo 10	
Average regional variations	139.8	230.9	-45.6	97.3	0.3	-39.5	-87.6	-135.2	-163.9	1.2	-2.3
Adjusted regional variations	140	231.1	-45.4	97.5	0.6	-39.2	-87.3	-135	-163.7	1.4	**0**

The interpretation of the figures is that for the Ashanti region (2), for instance, the value of the data is about 231.1 above the trend and that for the Upper West region (9), it is 135 below the trend line.

3. Forecasting

So far, we have made use of the road traffic fatality (RTF) data in Table 1, which is the historical data to study what had happened in the past in order to better understand the underlying structure of the data. This understanding provides the means necessary for predicting future occurrences of RTF. Forecasting involves projecting the values of a variable based entirely on the past and present observations of the variable. Forecasting values for future RTF is demonstrated below. The estimated trend values $(\hat{t})$, calculated based on Equation (9) and the average adjusted regional variation components (*s*), calculated in Table 6 for two selected years, are given in Table 7.

Table 7:The trend values and the average seasonal variation for 2009 and 2010

	2009 (Year 9)									
	Greater Accra 1	**Ashanti 2**	**Western 3**	**Eastern 4**	**Central 5**	**Volta 6**	**Northern 7**	**Upper East 8**	**Upper West 9**	**Brong -Ahafo 10**
y	429	469	144	343	246	140	113	54	40	259
t	208.6	209.2	209.7	210.2	210.8	211.3	211.8	212.4	212.9	213.4
s	140	231.1	-45.4	97.5	0.6	-39.2	-87.3	-135	-163.7	1.4
	2010 (Year 10)									
	Greater Accra	**Ashanti**	**Western**	**Eastern**	**Central**	**Volta**	**Northern**	**Upper East**	**Upper West**	**Brong -Ahafo**
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
y	424	454	157	259	167	143	114	45	54	169
t	213.9	214.5	215.0	215.5	216.1					
s	140	231.1	-45.4	97.5	0.6	-39.2	-87.3	-135	-163.7	1.4

Assuming that the trend in the year 2011 (i.e. year 11) follows the same pattern as in years 1 to 10, and an additive model is appropriate, the forecast for RTF of the ten regions for the year 2011 are determined using the following procedure.

1. Estimate the trend values for the series points of Year 11. From Equation (9), the least squares regression estimate of the trend values for Year 11 at series point 1 is approximately

$$\hat{t}_{101} = 165.805 + 0.52895 \times 101 = 219.2.$$

Similarly

$$\hat{t}_{102} = 219.8,\ \hat{t}_{103} = 220.3,\ \hat{t}_{104} = 220.8,\ \hat{t}_{105} = 221.3,\ \hat{t}_{106} = 221.9,$$
$$\hat{t}_{107} = 222.4,\quad \hat{t}_{108} = 222.9,\ \hat{t}_{109} = 223.5 \text{ and } \hat{t}_{110} = 224.0.$$

2. Corresponding to each of the estimated trend values for Year 11, is the regional factor. These values are given as $s_1 = 140$, $s_2 = 231.1$, $s_3 = -45.4$, $s_4 = 97.5$, $s_5 = 0.6$, $s_6 = -39.2$, $s_7 = -87.3$, $s_8 = -135$, $s_9 = -163.7$ and $s_{10} = 1.4$.
3. Add the estimated trend values to the corresponding regional factors to obtain the forecast values. Let $y_{p,n}$ denote the forecast for Year *p* at series point *n*, where *n* = 1, 2, …, 10. It follows that the forecast for Year 21 at series point 1 is

$$y_{11,1} = t_{101} + s_1 = 219.2 + 140 = 359.$$

This means that in the year 2011, about 359 of the road traffic casualties in Greater Accra are expected to die. The other forecast values for the remaining 9 regions for the year 2011 (year 11) are $y_{11,2} = 451$, $y_{11,3} = 175$, $y_{11,4} = 318$, $y_{11,5} = 222$, $y_{11,6} = 183$, $y_{11,7} = 135$, $y_{11,8} = 88$, $y_{11,9} = 60$, and $y_{11,10} = 223$.

Table 8 shows the regional distribution of the expected road traffic fatalities together with the estimated totals as computed by the analysis from the year 2010 to the year 2030.

Table 8:Expected distribution of road traffic fatalities in Ghana from 2010 to 2030

Year	Greater Accra	Ashanti	Western	Eastern	Central	Volta	Northern	Upper East	Upper West	Brong-Ahafo	Total
2010	354	446	170	313	217	177	130	83	54	220	**2163**
2011	359	451	175	318	222	183	135	88	60	273	**2264**
2012	365	456	180	324	227	188	140	93	65	278	**2317**
2013	370	461	185	329	233	193	146	99	70	298	**2384**
2014	375	467	191	334	238	199	151	104	76	317	**2451**
2015	380	472	196	339	243	204	156	109	81	337	**2518**
2016	386	477	201	345	248	209	162	114	86	357	**2585**
2017	391	483	207	350	254	214	167	120	91	376	**2652**
2018	396	488	212	355	259	220	172	125	97	396	**2720**
2019	402	493	217	361	264	225	177	130	102	415	**2787**
2020	407	498	222	366	270	230	183	136	107	435	**2854**
2021	412	504	228	371	275	236	188	141	113	454	**2921**
2022	417	509	233	376	280	241	193	146	118	474	**2988**
2023	423	514	238	382	285	246	199	151	123	494	**3056**
2024	428	520	244	387	291	251	204	157	129	513	**3123**
2025	433	525	249	392	296	257	209	162	134	533	**3190**
2026	439	530	254	398	301	262	214	167	139	552	**3257**
2027	444	535	260	403	307	267	220	173	144	572	**3324**
2028	449	541	265	408	312	273	225	178	150	591	**3391**
2029	454	546	270	414	317	278	230	183	155	611	**3459**
2030	460	551	275	419	322	283	236	188	160	631	**3526**
Total	8544	10468	4672	7684	5661	4836	3837	2846	2255	9127	**59929**
Mean	407	498	222	366	270	230	183	136	107	435	285

The number of fatal road traffic accidents and their resulting fatalities in 2009 were the highest ever recorded in Ghana as at the year 2010 (see

Table 1). From the analysis, a total of 2 163 deaths are estimated to occur in 2010 as a result of road traffic accidents. This represents a decrease of 3.4% over the 2009 observed figures. However, the actual number of fatalities as observed from the 2010 data, decreased by 11% over the 2009 observed figures. The result shows that the expected road traffic fatalities, as estimated by the analysis for the year 2010, exceeded the total observed fatalities for that same year by 8%.

Table 9, on the next page, presents the breakdown of the actual regional distribution of road traffic fatalities together with the corresponding estimated fatalities from the analysis for the year 2011. It can be seen that the total national estimated number of road traffic fatalities, from the analysis, is within 3% of the actual observed national figure for 2011. Of the 10 regional figures for 2011, six (6) (i.e. Greater Accra, Ashanti, Western, Central, Northern and Brong-Ahafo regions) are within 15% of the actual figure.

Table 9: The estimated and the actual road traffic fatalities for 2011, by regions

	Greater Accra	**Ashanti**	**Western**	**Eastern**	**Central**	**Volta**	**Northern**	**Upper East**	**Upper West**	**Brong-Ahafo**	**National**
Actual Fatalities	408	474	203	248	203	139	123	54	50	297	**2199**
Estimated Fatalities	359	451	175	318	222	183	135	88	60	273	**2264**
% change	12.0	4.9	13.8	28.2	9.4	31.7	9.8	63.0	20.0	8.1	3.0

The actual national number of road traffic fatalities, together with the number of fatalities estimated from the analysis (from 2001 to 2011), are given in Table 10. The absolute percentage differences between the estimated and actual values are also given in Table 10.

Table 10: Comparison of actual national fatalities and fatalities estimated from the analysis

Year	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Observed fatalities	1660	1665	1716	2185	1784	1856	2043	1938	2237	1986	2199
Estimated fatalities	1687	1740	1793	1846	1899	1952	2005	2057	2110	2163	2264
Error	–27	–75	–77	339	–115	–96	38	–119	127	–177	–65
Error percentage	1.6	4.5	4.5	15.5	6.4	5.2	1.9	6.2	5.7	8.9	2.9

It can be seen that, of the 11 estimated national figures, 10 are within 10% of the actual figures and one is in error by 15.5% of its actual value.

4. Discussion

The expected percentage increase, from 2010 to 2030, of road traffic fatalities for each of the 10 regions in Ghana, is given in Table 11. It can be seen that, the number of road traffic fatalities has continued to rise in Ghana, typical in many of the low-income and middle-income countries. The number of road traffic fatalities in Ghana are predicted to rise from 1 986 in the year 2010 to 3 526 in the year 2030, an increase of about 77.5%. This finding is consistent with one of the key findings on global trends and projections presented in the *World report on road traffic injury prevention*, which revealed that road traffic deaths are predicted to increase by 83% in low-income and middle-income countries (if no major action is taken). The overall global increase is predicted to be 67%, by 2020 if appropriate action is not taken.

Table 11: Expected percentage increase in road traffic fatalities from 2010 to 2030

Year	Greater Accra	Ashanti	Western	Eastern	Central	Volta	Northern	Upper East	Upper West	Brong-Ahafo	Total
2010	424	454	157	259	167	143	114	45	54	169	**1986**
2030	460	551	275	419	322	283	236	188	160	631	**3526**
%	**8.5**	**21.4**	**75.2**	**61.8**	**92.8**	**97.9**	**107.0**	**317.8**	**196.3**	**273.4**	**77.5**

The expected percentage increase in road traffic fatalities, from the year 2010 to the year 2030, is highest for the Upper East region, with increase of over 317.8%, followed by the Brong-Ahafo region (273.4%), the Upper West region (196.3%), in that order. Greater Accra region, with the highest population density in Ghana, recorded the least percentage increase in road traffic fatalities (8.5%) over the same interval of time, followed by the Ashanti Region (21.4%).

5. Conclusion and recommendations

Analysis of road traffic fatalities in Ghana by geographical/administrative regions has been performed using road traffic accident statistics data from the National Road Safety Commission, Ghana Statistical Service and Driver and Vehicle Licensing Authority. The data span 2001 to 2010.

(a) Road traffic fatality statistics buttress the point that crash outcomes between 2001 and 2010 have aggravated considerably. This is due to the fact that a large proportion of road traffic accident trauma patients in Ghana do not have access to formal Emergency Medical Services.

(b) In Ghana, many of the injured persons in road traffic accidents (RTAs) are transported to the hospital by some type of commercial vehicle, such as a taxi or a bus. It has also been reported that taxi and bus drivers regularly arrive at RTA sites while either injured vehicle occupants or pedestrians are still present, and usually participate in the care and/or transport of such casualties. As commercial drivers play such a prominent part in the transport and care of road traffic accident casualties, it follows that if properly trained, these drivers could significantly improve pre-hospital trauma care. This suggests that improvements in pre-hospital care in Ghana, especially among commercial vehicle drivers, could potentially have an important impact on decreasing the mortality of critically injured road traffic casualties.

(c) In Ghana, there are very inadequate emergency medical services (EMS) to render pre-hospital care to roadway casualties. The inadequacy of formal EMS necessitates that innovative and low cost solutions be devised to meet the growing need for pre-hospital trauma care in such countries (Tiska, et al., 2002). To convert these recommendations to solid, sustainable action in improving care for the injured, we need to continue to engage in advocacy and to work with Parliament, the Ministry of Health, National Road Safety Commission and, other stakeholders.

(d) Most vehicles plying the roads of Ghana lack the necessary modern safety mechanisms and equipments to minimize the occurrences and consequences of automobile accidents. Most modern vehicles have some kind of mechanism with which you can put a lock on windows and doors which are designed to keep children safe. Many vehicles have sensor systems that allow you to determine if a child or an object is behind or near to the car and wheels. Modern cars have air bags to protect the driver and the passenger riding in the front seat. Air bags are usually inside the steering wheel and dashboard in front of the passenger seat. It is speculated that an increase in automobile safety in Ghana will go a long way in reducing road traffic fatalities.

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