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The Effect of Age on Road Traffic Fatality Index in Ghana

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Abstract

In this paper, data on road traffic casualties by age groups, from 2009 to 2013, will be used. Using published road traffic casualty statistics from the National Road Safety Commission of Ghana, a 2 × 8 contingency table is used to determine whether road traffic casualty and age group are independent. A one factor analysis of variance tests shall be used to conduct a comparative analysis of the rate of road traffic fatalities per 100 casualties across the various age groups in Ghana. A multiple comparison test, using the Fisher least significance difference (LSD) method, shall be conducted to determine which pairs of age groups are significantly different.

The study will show that road traffic casualty is not independent of age group. The analysis of variance will show that there are significant differences in road traffic fatality indices (fatality per 100 casualties) among various age groups in Ghana. The risks of dying in a road traffic accident among children under 6 years and older population who are over 65 years are both significantly higher than those of other age groups. This points to the fact that, although smaller number of children under 6 years and older population who are over 65 years die in road traffic accidents each year, 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 age groups. Thus, the probability of being killed in a fatal road traffic accident is significantly high in each of these two age groups.

Keywords: Contingency, analysis of variance, Traffic fatalities, casualties, injuries

1. Introduction

The European Economic Commission (EEC) and the World Health Organization (1979) have recommended a definition for a road traffic accident fatality. This includes only deaths which occur within 30 days following a road traffic accident while road traffic casualties refer to road traffic accident victims injured or killed within 30 days of the accidents. A number of countries have not yet adopted this definition. For example, in some countries, a road traffic fatality is recorded only if the victim dies at the site or is dead upon arrival at a hospital. In order to make comparison of accident statistics between countries reasonable, figures obtained from countries which have not adopted the 30-day fatality definition, should be properly adjusted. No adjustment is required for figures from countries such as Ghana, U.S.A and Great Britain, which have adopted the standard fatality definition.

Casualties of road traffic accidents in Ghana by age groups, from 2009 – 2013, are given in Table 1. Unlike many fatal diseases, road traffic accidents kill people from all age groups, including young and middle-aged people in their active years. A cumulative total of 10 555 fatalities is recorded over the 5-year period. The highest fatalities during the period were in the 26 – 35 year old. Table 1 also shows that the active age group, 16 – 45 years, was the most vulnerable in road traffic fatalities, representing 63.2% of the total fatalities in the 5-year period.

According to the National Road Safety Commission (NRSC) of Ghana 2013 annual report, one key national Road Traffic Fatality index (F. I.) required for characterization and comparison of the extent and risk of road traffic fatality is fatalities per 100 casualties (see Hesse and Ofosu, 2015). In Table 1, the distribution of the rate of road traffic fatalities per 100 accidents by age groups from 2009 – 2013 are also computed.

Table 1. Age distributions of fatalities and injuries from road traffic accidents from 2010 to 2013

		Casualties											
		Persons Killed						Persons Injured					
		2013	**2012**	**2011**	**2010**	**2009**	**Total**	**2013**	**2012**	**2011**	**2010**	**2009**	**Total**
Age groups (Years)	0 – 5	97	113	126	136	130	602	214	241	276	389	401	1521
	6 – 15	148	170	212	217	250	997	529	789	846	962	1112	4238
	16 – 25	315	335	365	269	388	1672	2172	2509	2723	3110	3245	13759
	26 – 35	531	661	658	577	609	3036	3871	4458	5070	5297	5861	24557
	36 – 45	359	441	400	379	383	1962	2162	2753	3009	2932	3138	13994
	46 – 55	188	236	209	184	222	1039	1001	1334	1374	1399	1512	6620
	56 – 65	149	159	126	129	141	704	472	621	493	563	618	2767
	Over 65	111	125	103	95	109	543	190	296	229	266	246	1227
	Total	**1898**	**2240**	**2199**	**1986**	**2232**	**10555**	**10611**	**13001**	**14020**	**14918**	**16133**	**3994**

It can be seen, from Table 2, that the F. I. increased from 24.5 to 31.2 among children under 6 years from year 2009 to 2013, whilst that of the 'over 65' age groups increased marginally from 30.7 to 36.9 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 be observed that, over the 5 year period, the 'over 65' continues to be the age group with the highest national fatality rate. For instance, in 2013, about 37% of all road traffic casualties who were over 65 years lost their lives while 31% of casualties who were 5 years old or less died as a result of road traffic accidents.

Table 2. Rate of fatalities per 100 casualties (fatality indices)

		0 – 5	**6 – 15**	**16 – 25**	**26 – 35**	**36 – 45**	**46 – 55**	**56 – 65**	**Over 65**
		1	**2**	**3**	**4**	**5**	**6**	**7**	**8**
2013	**1**	31.2	21.9	12.7	12.1	14.2	15.8	24.0	36.9
2012	**2**	31.9	17.7	11.8	12.9	13.8	15.0	20.4	29.7
2011	**3**	31.3	20.0	11.8	11.5	11.7	13.2	20.4	31.0
2010	**4**	25.9	18.4	8.0	9.8	11.4	11.6	18.6	26.3
2009	**5**	24.5	18.4	10.7	9.4	10.9	12.8	18.6	30.7
mean		**29.0**	**19.3**	**11.0**	**11.1**	**12.4**	**13.7**	**20.4**	**30.9**

The number of road traffic fatality victims in Ghana can be classified according to two criteria, of a set of entities, namely casualty and age group. Casualty has 2 levels (i.e. fatalities and injured) while age group has 8 levels. These form a 2 × 8 contingency table as shown in Table 3.

Table 3. Road traffic accidents victims from 2010 to 2013

		Age Group								
		0 – 5	**6 – 15**	**16 – 25**	**26 – 35**	**36 – 45**	**46 – 55**	**56 – 65**	**Over 65**	**Total**
casualty	**Fatalities**	602	997	1672	3036	1962	1039	704	543	10555
	Injured	1521	4238	5759	24557	13994	38551	2767	1227	92614
	Total	2123	5235	7431	27593	15956	39590	3471	1770	103169

In this study, we wish to know whether road traffic casualty and age group are independent. If they are independent, then we would expect to find the same proportion of fatalities across various age groups. We also propose the use of the completely randomized single factor experiment to determine if there are significant differences in road traffic fatality index rates among the various age groups.

2. Method

Table 4 shows an $r \times c$ contingency table where O_{ij} is the observed frequency for level i of the first method of classification and level j of the second method of classification, where $R_i = \sum_{j=1}^{c} O_{ij}$ is the *marginal total* for row i and $C_j = \sum_{i=1}^{r} O_{ij}$ is the *marginal total* for column j. Note that $\sum_{i=1}^{r} R_i = \sum_{j=1}^{c} C_j = n$, where n is the total sample size.

Table 4. An $r \times c$ contingency table

		Columns				
		1	2	…	c	Total
Rows	1	O_{11}	O_{12}	…	O_{1c}	R_1
	2	O_{21}	O_{22}	…	O_{2c}	R_2
	.	.	.	.	.	.
	.	.	.	.	.	.
	.	.	.	.	.	.
	r	O_{r1}	O_{r2}	…	O_{rc}	R_r
Total		C_1	C_2	…	C_c	n

We are interested in testing the null hypothesis

H_0: the row-and-column methods of classification are independent

against the alternative hypothesis

H_1: the row-and-column methods of classification are not independent.

The test statistic is given by (see Cramér (1946) and Birch (1964)).

$$H = \sum_{i=1}^{r} \sum_{j=1}^{c} \frac{(O_{ij} - E_{ij})^2}{E_{ij}} \tag{1}$$

were E_{ij} is the expected cell frequency for the $(ij)^{th}$ cell. It can be shown that, if H_0 is true, then:

$$E_{ij} = \frac{R_i \times C_j}{n} = \frac{(\text{column total}) \times (\text{row total})}{\text{grand total}}. \tag{2}$$

It can also be shown that, for large n, the statistic H has an approximate chi-square distribution with $(r - 1)(c - 1)$ degrees of freedom if H_0 is true (see Ofosu and Hesse (2011)). Therefore, we would reject the hypothesis of independence if the observed value of the test statistic H is greater than the critical value $\chi^2_{\alpha,(r-1)(c-1)}$, where α is the size of the test. An extensive treatment of the chi-square distribution can be found in the book by Lancaster (1969).

If we reject the null hypothesis, we conclude that there is some interaction between the two criteria of classification.

3. Results

3.1 Test of Independence

The null and the alternative hypotheses are:

H_0: Casualty is independent of age group.

H_1: Casualty is not independent of age group.

We first find the expected cell frequencies. These are calculated by using Equation (2). Table 5 shows the expected cell frequencies of Table 3 using Equation (2). For example, $E_{11} = \frac{10555 \times 2123}{103169} = 217.200.$

Table 5. Expected cell frequencies of Table 3

		Age Group								
		0 – 5	**6 – 15**	**16 – 25**	**26 – 35**	**36 – 45**	**46 – 55**	**56 – 65**	**Over 65**	**Total**
casualty	**Fatalities**	217.200	535.582	760.250	2822.981	1632.424	4050.368	355.111	181.085	10555
	Injured	1905.800	4699.418	6670.750	24770.019	14323.576	35539.632	3115.889	1588.915	92614
	Total	2123	5235	7431	27593	15956	39590	3471	1770	103169

Note that the expected frequencies in any row or column add up to the appropriate marginal total. The test statistic is

$$H = \sum_{i=1}^{2} \sum_{j=1}^{8} \frac{(O_{ij} - E_{ij})^2}{E_{ij}}.$$

When H_0 is true, H has the chi-square distribution with 7 [i.e. (2 – 1)(8 – 1)] degrees of freedom. We reject H_0 at 0.05 level of significance when the computed value of the test statistic is greater than $\chi^2_{0.05,7} = 14.07$. Substituting both the observed values in Table 3 and their corresponding expected values in Table 5 into $\chi_{ij} = \frac{(O_{ij} - E_{ij})^2}{E_{ij}}$, we obtain the cells in Table 6.

Table 6. Calculations of the observed test statistic

	1	2	3	4	5	6	7	8	Total
χ_{1j}	245.97	213.55	497.18	14.95	55.36	8727.95	172.90	241.22	10169.08
χ_{2j}	97.35	50.24	144.35	1.85	7.76	235.23	43.99	106.75	687.52
Total	343.32	263.79	641.53	16.79	63.12	8963.18	216.89	347.97	10856.59

Thus, the observed value of the test statistic is

$$\chi^2 = \sum_{i=1}^{2} \sum_{j=1}^{8} \frac{(O_{ij} - E_{ij})^2}{E_{ij}} = 10856.59.$$

Since $10856.59 > 14.07$, we reject the hypothesis of independence and conclude that casualty is not independent of age group.

3.2 Completely Randomized Single Factor Experiment

Table 2 is a typical data of a single-factor experiment with 8 levels (age groups) of the factor, where the factor is the effect of age on F. I. We wish to determine if there are significant differences between the average F. I. across the 8 age groups. In Table 2, let y_{ij} represent the i^{th} observation taken under the j^{th} age group and

$$y_{.j} = \sum_{i=1}^{5} y_{ij}, \quad \bar{y}_{.j} = y_{.j}/21, \quad (j=1,\ 2,\ ...,\ 8), \quad y_{..} = \sum_{j=1}^{8}\sum_{i=1}^{5} y_{ij}, \quad \bar{y}_{..} = y_{..}/40.$$

Let μ_j represent the true mean of the j^{th} age group and ε_{ij} the experimental error. The model for the completely randomized single factor experiment is

$$y_{ij} = \mu_i + \varepsilon_{ij}, \quad (j=1,\ 2,\ ...,\ 8,\ i=1,\ 2,\ ...,\ 5). \tag{3}$$

The one-way analysis of variance model assumes that the observations are normally and independently distributed with the same variance for each region or factor level (see Ofosu et al. (2014)).

3.2.1 Validation of Normality and Homogeneity of Variances Assumptions

We check the normality assumption, using the Shapiro-Wilk *W* test. The null hypothesis is

H_0: observations under each region are normally distributed

against the alternative hypothesis

H_1: observations under each region are not from a normally distributed population

The value of the Shapiro-Wilk *W* test statistic for each of the eight age groups is given in Table 7 below.

Table 7. Observed values of the *W* test statistic

Test Statistic	**0 – 5**	**6 – 15**	**16 – 25**	**26 – 35**	**36 – 45**	**46 – 55**	**56 – 65**	**Over 65**
W_o	0.802	0.883	0.864	0.930	0.871	0.951	0.836	0.925

H_0 is rejected at the 5% level of significance if the computed value of *W* is less than 0.762, the tabulated 5% point of the distribution of the Shapiro-Wilk test statistic. For each of the 8 age groups, we fail to reject H_0 and therefore conclude that there is not enough evidence of non-normality of these samples.

Levene's test (Levene 1960) is used to test if 8 samples have equal variances. We wish to test

$H_0: \sigma_1^2 = \sigma_2^2 = ... = \sigma_8^2$ against

$H_0: \sigma_i^2 \neq \sigma_j^2$ for at least one pair (*i*, *j*).

In Table 2, let y_{ij} represent the i^{th} observation taken under the j^{th} age group and

$$y_{.j} = \sum_{i=1}^{5} y_{ij}, \quad \bar{y}_{.j} = y_{.j}/5, \quad (j=1,\ 2,\ ...,\ 8), \quad y_{..} = \sum_{j=1}^{5}\sum_{i=1}^{8} y_{ij}, \quad \bar{y}_{..} = y_{..}/40.$$

t = number of treatments = 8

n_i = number of observations from treatment (region) *i*

$N = n_1 + n_2 + ... + n_9$ = overall size of combined samples = 40,

$D_{ij} = \left| y_{ij} - \bar{y}_i \right|$ = absolute deviation of observation *j* from treatment *i* mean

$\bar{D}_i =$ average of the n_i absolute deviations from treatment *i*

$\bar{D} =$ average of all *N* absolute deviations

The Levene’s test statistic is given by

$$F_{Levene} = \frac{\sum_{i=1}^{8} n_i\left(\bar{D}_i - \bar{D}\right)^2}{7} \bigg/ \frac{\sum_{i=1}^{8} n_i\left(D_{ij} - \bar{D}_i\right)^2}{32}. \tag{4}$$

When H_0 is true, F_{Levene} has the *F*-distribution with 4 and 40 degrees of freedom. H_0 is rejected at significance level 0.05 when the observed value of F_{Levene} is greater than $F_{0.05,\,7,\,32} = 2.33$. Since the observed *F*-ratio, 1.332, is less than the critical *F*-value, 2.33, we fail to reject the null hypothesis at the 0.05 level of significance and conclude that there are no significant differences among the ten variances.

3.2.2 One-way Analysis of Variance

Since the normality and homogeneity of variances assumptions are validated, we can use the one-way analysis of variance to determine if the fatality indices across age groups vary significantly. We wish to test the hypothesis

H_0: The mean fatality indices are the same across the 8 categories of age groups,

against the alternative hypothesis

H_1: The mean fatality indices are not the same for at least 2 of age groups.

The total corrected sum of squares is given by

$$SST = \sum_{j=1}^{8}\sum_{i=1}^{5} y_{ij}^2 - \frac{y_{..}^2}{40} = 2374.360. \tag{5}$$

The sum of squares among treatments is

$$SSA = \sum_{j=1}^{8} \frac{y_{.j}^2}{5} - \frac{y_{..}^2}{40} = 2193.712. \tag{6}$$

The within treatment sum of squares, SSW, can be obtained from the equation

$$SSW = SST - SSA = 180.648. \tag{7}$$

The analysis of variance results, based on the data in Table 2, are summarized in Table 8 below.

Table 8. Analysis of variance table

Source of variation	**Sum of squares**	**Degrees of freedom**	**Mean square**	**F-ratio**
Among treatments	2193.712	7	313.387	
Within treatments	180.648	32	5.645	55.513
Total	2374.360	39		

The test statistic is

$$F = \frac{\text{among treatments mean square}}{\text{within treatments mean square}}.$$

When H_0 is true, *F* has the *F*-distribution with 7 and 32 degrees of freedom. We reject H_0 at significance level 0.05 when the observed value of *F* is greater than $F_{0.05,7,32} = 2.33$. From Table 8, the computed value of *F* is 55.513. Since the observed F-ratio, 55.513, is greater than the critical F-value, 2.33, we reject the null hypothesis at the 0.05 level of significance and conclude that there are significant differences among the fatality indices across the 8 age groups.

4. Discussion

4.1 Multiple Comparison Method

Since the analysis of variance indicates that the null hypothesis should be rejected, it means that there are differences among the 8 treatment means. But as to which of the means are significantly different, the analysis does not specify. Obviously, in such a situation, we need a different method for comparing individual treatment means. One such methods is the multiple comparison test.

Over the years, several methods for making multiple comparison tests 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" (see Ofosu et al. (2014)). To use this method, we first calculate the least significant difference, (LSD), for the given data. This is given by

$$LSD = t_{\frac{1}{2}\alpha,\ N-k}\sqrt{\frac{2MSW}{n}}, \tag{8}$$

where the level of significance $\alpha = 0.05,\ N = 40,\ n = 5,\ k = 8$ and $MSW = 5.645$. This gives $LSD = 3.068$.

The observed difference between each pair of means is compared to the *LSD*. If the observed numerical difference is greater than 3.068, then the road traffic fatality indices of the two age groups are significantly different. The values of the observed numerical differences between pairs of means of the 8 age groups are given in Table 9. Pairs of age groups with fatality indices not significantly different are highlighted in Table 9.

Table 10. Observed numerical differences between pair of means of road user classes

		0 – 5	6 – 15	16 – 25	26 – 35	36 – 45	46 – 55	56 – 65	Over 65
		29.0	19.3	11.0	11.1	12.4	13.7	20.4	30.9
0 – 5	29.0		9.7	18.0	17.9	16.6	15.3	8.6	**1.9**
6 – 15	19.3			8.3	8.2	6.9	5.6	**1.1**	11.6
16 – 25	11.0				**0.1**	**1.4**	**2.7**	9.4	19.9
26 – 35	11.1					**1.3**	**2.6**	9.3	19.8
36 – 45	12.4						**1.3**	8.0	18.5
46 – 55	13.7							6.7	17.2
56 – 65	20.4								10.5
Over 65	30.9								

For example, from Table 9, it can be seen that, the observed numerical difference between the mean fatality indices for the age groups '0 – 5' and '26 – 35' is 17.9. Since 17.9 is greater than 3.068, it follows that there is a significant difference between the two age groups with respect to F. I. It is obvious that the road traffic fatality index for '0 – 5' age group is significantly higher than that of other age groups except for 'Over 65'. This means that, the risk of dying in a road traffic accident among '0 – 5' and 'Over 65' are both significantly higher than those of other age groups, recording an average rate of 29.0 and 30.9 deaths per 100 casualties, respectively.

5. Conclusion

We've shown that road traffic casualty level depends on age group of victims involved using a 2 × 8 contingency analysis.

The analysis of variance revealed that there are significant differences in road traffic fatality indices (fatality per 100 casualties) among various age groups in Ghana. The risks of dying in a road traffic accident among children under 6 years and older population who are over 65 years are both significantly higher than those of other age groups. This points to the fact that, although smaller number of children under 6 years and older population who are over 65 years die in road traffic accidents each year, 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 age groups. Thus, the probability of being killed in a fatal road traffic accident is significantly high in each of these two age groups. This may be due to higher fragility of children and older population of road users.

These findings are consistent with a related study by Loughran et al. (2007), in which they reported that older drivers are more than twice as likely as middle-aged drivers to cause an accident. The research revealed that drivers and passengers riding in cars driven by older drivers are nearly seven times likelier to die in an auto accident than are passengers and drivers riding in cars driven by middle-aged drivers. This statistic suggests that older individuals are much likelier than middle-aged individuals to die in a car accident. Given these trends, the research suggests that public policy should focus more on improving the safety of automobile travel for older drivers and less on screening out older drivers whose driving abilities have deteriorated unacceptably.

References

Bancroft, T. A. (1968). Topics in intermediate statistical methods. *Iowa State university Press, Ames, Iowa*.

Birch, M. W. (1964). A new proof of the Fisher-Pearson theorem. *Annals of Mathematical Statistics*, *35*, 817 – 824. http://dx.doi.org/10.1214/aoms/1177703581

Cramér, H. (1946). Mathematical Methods of Statistics. Princeton University Press, Princeton, N. J.

Daniel, W. W., & Coegler, C. E. (1975), Beyond Analysis of variance: A comparison of some multiple comparison procedures. *Physical Therapy*, *55*, 114 – 150.

Daniel, W. W. (1980). Multiple comparison procedures. A selected Bibiography. Vance Bibliographies, Monticello, III, 1980.

Duncan, D. B. (1951). A significance test for difference between ranked treatments in an Analysis of variance. *Verginal Journal of science*, *2*, 171 – 189.

Duncan, D. B. (1952). On the properties of the multiple comparison tests. *Verginal Journal of Science*, *3*, 50 – 67.

Duncan, D. B. (1955). Multiple Range and Multiple F-Tests. *Biometrics*, *11*, 1 – 42. http://dx.doi.org/10.2307/3001478

Hesse, C. A., & Ofosu, J. B. (2015). The Effect of Road Traffic Fatality Rate on Road Users in Ghana. *Research Journal of Mathematics and Statistics*, *7*(4), 53-59. http://dx.doi.org/10.19026/rjms.7.2207

Keuls, M. (1952). The use of the studentized range in connection with an Analysis of variance. *Euphytica*, *1*, 112 – 122. http://dx.doi.org/10.1007/BF01908269

Lancaster, H. O. (1969). The chi-squared distribution. John Wiley and Sons, New York.

Levene, H. (1960). In *Contributions to Probability and Statistics: Essays in Honor of Harold Hotelling*, I. Olkin et al. eds., Stanford University Press, pp. 278-292.

Loughran, D. S., Seabury, S. A., & Zakaras, L (2007). *Regulating Older Drivers: Are New Policies Needed?* Santa Monica, Calif.: RAND Corporation, OP-189-ICJ.

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. http://dx.doi.org/10.1093/biomet/31.1-2.20

Ofosu, J. B., & Hesse, C. A. (2011). Elementary Statistical Methods. *EPP Books Services, Accra*.

Ofosu, J. B., Hesse, C. A., & Otchere, F. (2014). Intermediate Statistical Methods. *EPP Books Services, Accra*.

O'Neill, R., & Wetherill, G. B. (1971). The Present State of Multiple Comparison Methods. *Journal of the Royal Statistical Society*, B, 33, 218 – 241.

Scheffé, H. (1959). Analysis of variance. *John Wiley and Sons*. *New York*.

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

Tukey, J. W. (1949). Comparing Individual Mean in the Analysis of variance. *Biometrics*, *5*, 99 – 114. http://dx.doi.org/10.2307/3001913

Tukey, J. W. (1953). The problem of multiple comparisons. *Ditto*, Princeton University.

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

World Health Organization. (1997). Road Traffic Accidents Statistics. Copenhagen, Regional Office for Europe.