CONTRIBUTIONS OF WET PERIODS ON ROAD CRASHES IN AWKA, ANAMBRA STATE, NIGERIA.

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ABSTRACT: The purpose of this paper is to identify potential interactions between rainfall characteristics and road crashes in Awka, Anambra state. Data on monthly road traffic accidents and rainfall were collected for the study from the Federal Road Safety Commission (FRSC) and Nigeria Meteorological Agency (NIMET). A total of 811 crashes occurred in Anambra state and 419 deaths were recorded between 2013 and 2015, out of which 34% of the total crash and 15% of the total deaths recorded occurred in Awka. It was shown that the total road traffic accidents in Awka is a function of wet period, dry spell effect and some other factors are responsible for this trend. Correlation between road traffic crash and wet period was negatively correlated and not statistically significant. Rain crash effect, an index of crash per unit wet day, was found to be relatively high for the month of June throughout the 3 year period. The reasons for this development were outlined.

KEYWORDS: Accident, Dry Crash Rate, Wet Crash Rate, Rain Crash Effect, Traffic,

1 INTRODUCTION

Road Traffic Accidents (RTAs) has become an important public health concern over the past decade as it is believed that almost 3400 lives are lost every day and millions of people suffer various degrees of injuries and disabilities as a result of RTA (Thompson and Meirmanov, 2004). This has claimed the largest toll of human life among all accident types and appears to be a serious problem globally (Kuo, 2011). The World Health Organisation (WHO) in 2013 reported that road traffic injuries are the eight leading cause of death globally. About 1.24 million people die in road traffic accidents while between 20 and 50 million people are injured (WHO, 2013). Having ranked eighth in the order of causes of death, it is projected to rank third by the year 2020 (WHO, 2004) with an estimated deaths of up to 2.34 million in 2020, representing 3.4% of all deaths (Mandale *et al*, 2011). However, the African region continues to record the highest road traffic death amongst the WHO regions with an average population at risk of 24.1 deaths per 100,000 persons (WHO, 2013). In Nigeria, an average of 12 persons is killed daily by RTA

(Enete and Igu, 2011). The disturbing aspect of this scenario is that victims of RTA are mainly within the productive age group (20 – 50 years) as was observed in Enete and Igu (2011) for Nigeria and Thompson and Meirmanov (2011) in Ghana.

The issue of road traffic accidents is one that requires great care in handling as it is multifaceted. RTA occurs due to a number of factors. These factors were outlined in Shalud and Minhans (2006) and some of which have been studied by numerous workers include but not limited to these: factors related to humans including age, judgment errors (Lemming, 1969), driver's skill (Jorgensen and Abane, 1999; Odero, 1995), attention, fatigue, experience; one related to vehicle such as design (O'Neill, 2009; Lardelli-Claret, 2002), manufacture and maintenance; and road environment (Anyata, 2009; Asalor, 2010) such as geometric alignment, cross section, traffic control devices, surface friction, grade, signage, weather, visibility are considered to be responsible for road accidents.

Studies (Hambly et al; 2013; Qui and Nixan, 2008) have equally shown, as it has become evident, that weather and road accident are quite related and consequently, weather variables are now being considered as major contributors to RTAs across regions. Rainfall has been consistently cited as one of the major causes of weather-related accidents (Qui and Nixan, 2008). Increase in rainfall has been linked to high accident frequencies (Fridstrom et al, 1995; Chang and Chen, 2005) while some other study (Karlaftis and Yannis, 2010) found that it can reduce the number of accidents. In a similar vein, researchers have equally reported that different weather related phenomena and adverse weather conditions such as rainfall (Andrey *et al*, 2002; Ivey et al, 1975; Pisano et al, 2002), fog (Edwards, 1999; Pisano et al, 2002), wet or flooded pavements (Anderson and Chapman, 2011), wind (Nokhandan et al, 2008; Edward, 1999), temperature (Houghton et al, 2001; Mills and Andrey, 2003) etc. affects road conditions like changes in visibility, pavement friction, lane obstruction, lane submersion etc. and the general road infrastructure, eventually increasing the risk of crash. In a more recent study, greater rainfall intensities lead to higher road accidents and injury rates (Hambly et al., 2013). When a vehicle is running on the wet road at high speed, the rainwater flow through the tire tread grooves gives rise to the hydrodynamic pressure; the occurrence of this hydrodynamic force deteriorates the tire traction efficiency because it decreases the tyre contact force (Mondal *et al*; 2008, Cho *et al*; 2006), so that the driving controllability and the braking performance become worse than those on the dry road. Researchers have provided several explanations to this such as the classical

model of the thin film wet traction problem (Rohde, 1977), differential friction in any pavement friction analysis (Burns, 1976) and the theory of "sealing effect" by Perrson *et al* (2004).

Equally, it have been shown that prior to rainy season, most dry roads contain a layer of tar, rubber and oil such that when it starts to rain, these substances mix with the rain water, creating a greasy layer that can be very slippery; this outcome has equally been considered as the dry spell effect (Mondal et al 2011; Enete and Igu, 2011). Most drivers and road users, for example in the south-east of Nigeria, a region with the highest record of road accidents in Nigeria are not quite aware of this. Similarly, most accidents that occur in Awka capital territory, especially along Enugu-Onitsha expressway, can be attributed to a number of factors such as slipperiness which is most common during wet periods because it could lead to skidding.

The study is, therefore motivated by the paucity of knowledge on the relationship between road traffic accidents and elements of weather in Nigeria with non of such study in existence for Awka and environs. The paper therefore, seeks to analyze the effects of rainfall in the form of wet roads on road crashes in Awka Capital Territory, Anambra State.

2 MATERIALS AND METHODS

2.1 Study Area

Awka is located between latitudes 6.20^0N and 6.28^0N, and longitudes 7.00^0E and 7.06^0E on the south eastern part of Nigeria. The city covers 60.2km^2 with a population of 301,659 persons recorded in 2006 (NPC 2006). The climate of Awka is tropical wet and dry based on Koppen's classification. The annual rainfall of the study area ranges from 1383mm to 2090mm while the mean annual rainfall is about 1851.9mm with relative humidity close to 80%; the mean maximum and minimum temperatures are 32.1°C and 23.5°C with mean daily temperature of 27.8^{o}C (Nzoiwu, 2015). Nearly seven out of twelve months of the year enjoy ample rainfall while the remaining four months fall within the dry season. The two seasons are brought about by the two predominant winds that rule the area: the south western monsoon winds from across the Sahara desert (UN-HABITAT, 2009). Rivers that drain the area are Obizi and Obibia rivers in the south, Obizi, Okpuno river in the north, Idemili river in the south and Mamu River in the east (Ezenwaji E.E et al., 2013).

Fig 1: Awka Urban Area

Awka lies below 300metres above sea in a valley on the plains of the Mamu River. A thick sequence of shale and sand stones formed in the Paleocene age underlies most of the area. Geologically, over 80% of the area consists of Imo shale group of lower Eocene era while a small band of Nanka sand is seen in the western parts of the area (Ogbukagu, 1986). The soil

found in Awka is a dark brownish red soil with a plastic and gritty feel, poorly cemented with moderate permeability, it is easily eroded (UN-HABITAT, 2009).

2.2 Data Collection

Daily rainfall dataset for Awka were obtained from the Nigerian Meteorological Agency, Oshodi (NIMET) for a period of 3 years (2013 – 2015). The data was carefully checked and found to be quite homogeneous as there are no gaps to necessitate interpolations. The Road Traffic Crash data (RTC) for 3 year period (2013-2015) were equally collected from the archives of the Federal Road Safety Commission (FRSC), Awka Command for the study area. The rainfall data were used to determine the number of wet and dry days in Awka for the period. A wet day, for this study is defined as any day which receives any amount of rainfall (Enete and Igu, 2011). As a result, wet crashes are crashes or road traffic accidents that occur on any wet day and the same holds for dry crashes

2.3 Data Analysis

A range of statistical procedures employed by Mondal *et al* (2011) in India and Enete and Igu (2011) in Enugu were employed. The statistical methods consist of a number of terms which are subsequently defined below:

Wet – Crash – Rate (WCRi) for the ith month of a year defined as:

$$\mathrm{WCRi} = \frac{\mathrm{WC}}{\mathrm{WD}}$$

where, WC is the total number of crash that took place in wet days of a month and WD is the total number of wet days in the month.

Dry – Crash – Rate (DCRi) for the month of a year is defined as:

$$\mathrm{DCRi} = \frac{\mathrm{DC}}{\mathrm{DD}}$$

where, DC is the total number of crashes that took place in dry days of a month and DD is the total number of dry days in a month. A day which receives no rainfall is termed as a dry day for this study.

Rain – Crash – Effect (RCEi) for the ith month of the year is defined as:

$$\text{RCEi} = \frac{(\text{WCRi} - \text{DCRi})}{\text{DCRi}} \times 100$$

where WCRi and DCRi are as defined above.

3 RESULTS AND DISCUSSION

The wet crash, wet days, dry crash and dry day's records for the years under study derived from the available data are shown in Table 1 below.

Table 1: Wet Crash, Wet Days, Dry Crash and Dry Days for 2013 - 2015

	2013					2014					2015		
Months	WC	WD	DC	DD	WC	WD	DC	DD	WC	WD	DC	DD
Jan	2	2	6	30	0	2	9	29	0	0	13	31
Feb	0	1	3	27	0	1	7	27	0	4	4	24
Mar	3	7	8	24	1	6	6	26	0	4	9	27
Apr	4	9	6	21	3	10	5	20	1	4	11	26
May	4	16	1	15	4	16	5	15	3	12	2	19
Jun	6	18	1	12	10	18	6	12	4	16	2	14
Jul	3	15	5	16	1	18	5	13	2	14	1	17
Aug	6	19	4	12	3	19	3	12	2	16	2	15
Sept	5	21	1	9	4	25	1	5	4	18	0	12
Oct	0	2	7	29	1	12	9	19	4	17	4	14
Nov	0	0	8	30	1	7	7	23	0	2	5	28
Dec	0	0	11	31	0	1	8	30	0	1	8	30
Total	**33**	**110**	**61**	**256**	**28**	**135**	**71**	**231**	**20**	**108**	**61**	**257**

A total of 33, 28 and 20 crashes were witnessed under wet conditions in 2013, 2014 and 2015 respectively; while 61, 71 and 61 crashes were under dry conditions in 2013, 2014 and 2015 respectively. The year 2013 and 2015 have only 110 and 108 wet days respectively while 2014 had the highest number of wet days of 135days. The number of dry days for the years 2013, 2014 and 2015 were 256, 231 and 257 respectively while the annual rainfall in Awka progressed from a total of 1447.3mm in 2013 to 1700mm in 2014 and the highest rainfall amount for the 3years

of 2518.44mm in 2015. Of the total crashes that took place in Awka, the percentage of crashes that took place on wet days are 35.1%, 28.3% and 24.7% for 2013, 2014 and 2015 respectively. In a similar study, Enete and Igu (2011) utilizing similar indices established that 29.8% of road crashes in Enugu occur during the wet month for 2009 with the highest wet crash occurred in the month of June (28crashes). For 2013, the largest wet crash amount occurred in June and August (Figure 2).

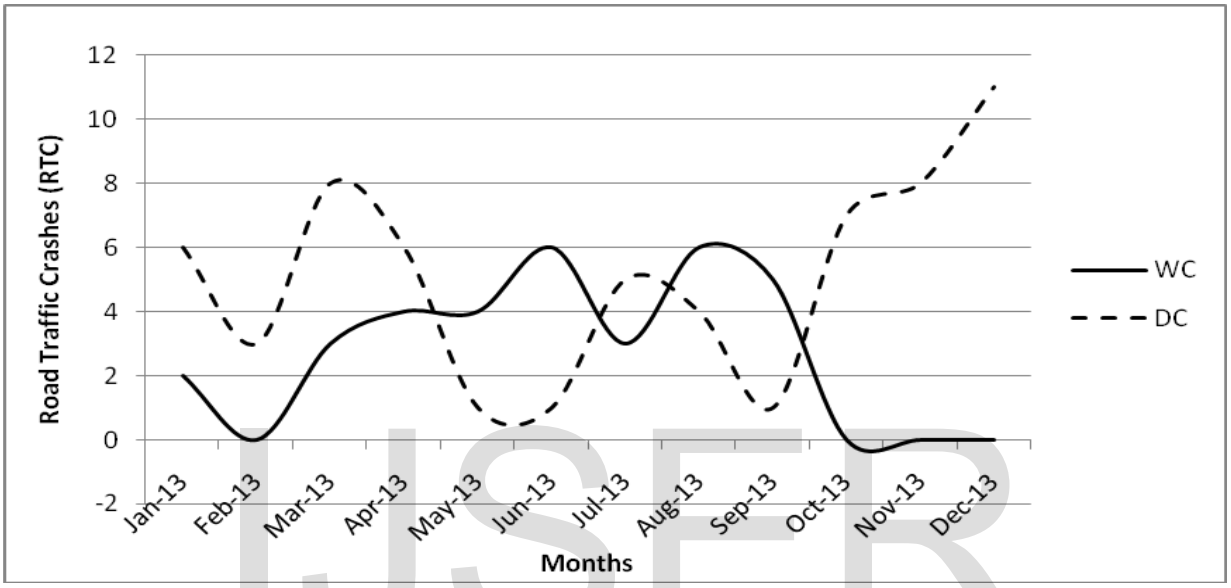

Fig 2: Wet and Dry Crashes in Awka for 2013

It could be seen that wet crash as well as dry crash increased from February but while dry crash (DC) peaked in March, wet crash increased to March and flattened out. This sort of outcome had been attributed by studies (Enete and Igu, 2011) as the "Large dry spell wet day" effect, where after a long dry spell, we tend to witness increase in crashes. In 2014, the highest wet crash (WC) of 10 crashes equally occurred in June (Figure 3). It could also be seen that wet crashes started increasing from February, just as was observed in the previous year (2013).

Based on observation, the repeated occurrence of highest number of road traffic crashes (RTC) in Awka in the month of June agrees strongly with Enete and Igu (2011) where it was equally reported that highest wet crash occurred in the month of June (28 crashes) in Enugu.

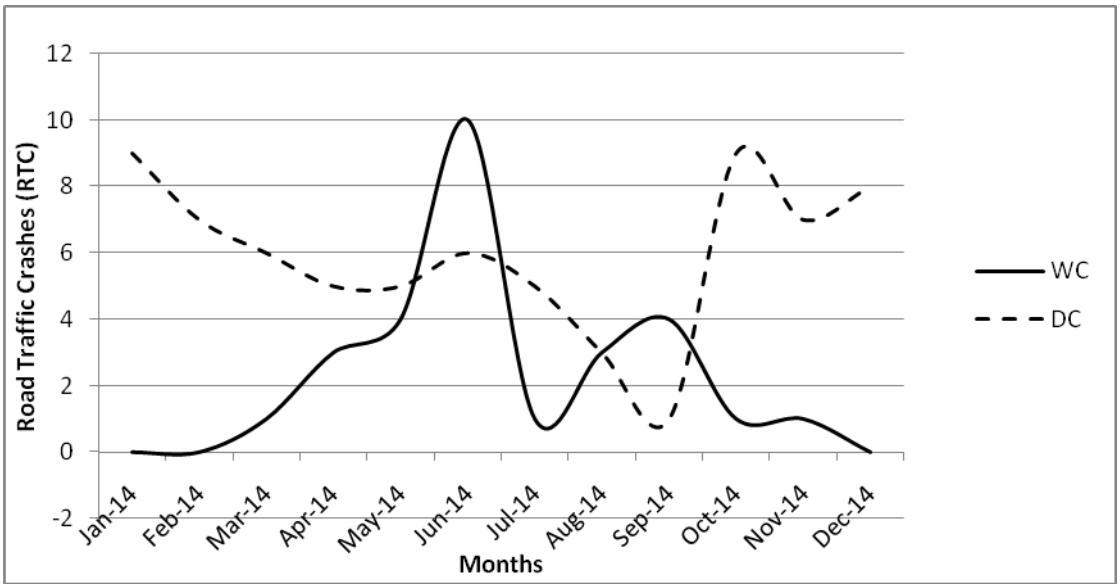

Fig 3: Wet and Dry Crashes in Awka for 2014

For 2015, the highest wet crash was recorded for the months of June, September and October with the highest number of wet days of 16, 18 and 17 respectively (Figure 4).

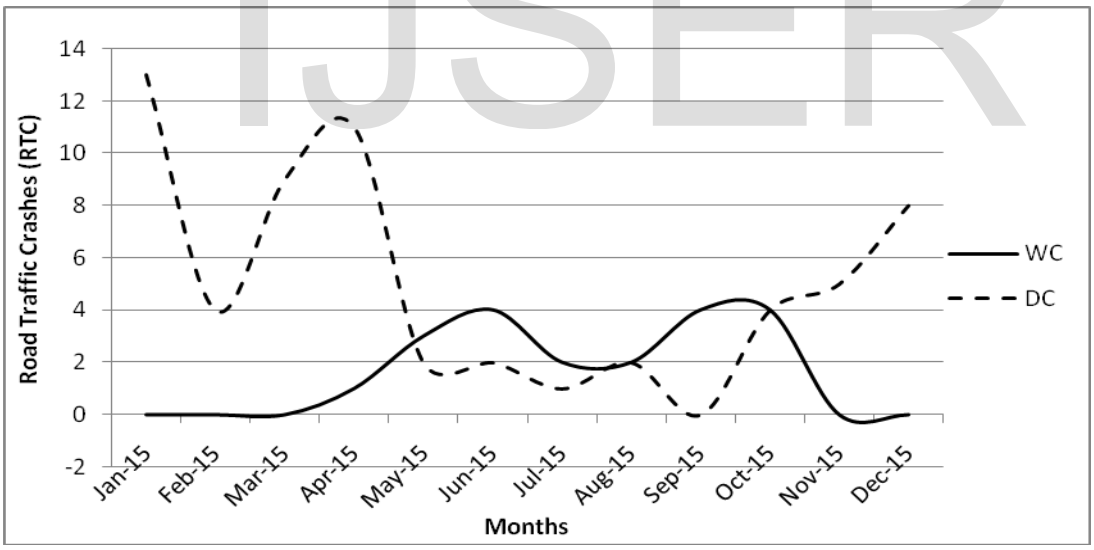

Fig 4: Wet and Dry Crashes for Awka in 2015

Using the relevant equations, the indices of DCRi, WCRi and RCEi were used to analyse the risk of crash during rainfall for all the months of 2013, 2014 and 2015 as shown in Table 2.

Table 2: RCEi, WCRi and DCRi for 2013 - 2015

2013				2014			2015		
Months	**RCEi**	**WCRi**	**DCRi**	**RCEi**	**WCRi**	**DCRi**	**RCEi**	**WCRi**	**DCRi**
Jan	400	1	0.2	-100	0	0.31	-100	0	0.42
Feb	-100	0	0.11	-100	0	0.26	-100	0	0.17
Mar	28.6	0.43	0.33	-27.8	0.17	0.23	-100	0	0.33
Apr	55.6	0.44	0.29	20	0.3	0.25	-40.9	0.25	0.42
May	275	0.25	0.07	-25	0.25	0.33	137.5	0.25	0.11
Jun	300	0.33	0.08	11.1	0.56	0.5	75	0.25	0.14
Jul	-36	0.2	0.31	-85.6	0.06	0.38	142.9	0.14	0.06
Aug	-5.3	0.32	0.33	-36.8	0.16	0.25	-6.25	0.13	0.13
Sept	114.3	0.24	0.11	-20	0.16	0.2	0	0.22	0
Oct	-100	0	0.24	-82.4	0.08	0.47	-17.6	0.24	0.29
Nov	-100	0	0.27	-53.1	0.14	0.3	-100	0	0.18
Dec	-100	0	0.35	-100	0	0.27	-100	0	0.27

RCEi was found to be positive for six months in 2013; positive for only two months in 2014 and increased to 3 months in 2015 (Table 2). A positive RCEi means more crash per unit wet day than unit dry day in a month (Mondal *et al*., 2011). This implies that crash per unit wet day was more in 2013, decreased in 2014 with a slight increase in 2015. For the wet months, the months of June have consistently recorded a positive RCEi. This means that for the 3 years June has consistently recorded more crash per unit wet day than unit dry day in a month. On the other hand, a negative RCEi means less crash per unit wet day than unit dry day in a month. Negative RCEi was observed to occur in 6 out of 12 months for 2013. In 2014, negative RCEi was observed to occur in 10 out of 12 months whereas for 2015, RCEi was recorded to be negative in 8 months. Further, it is obvious that some rainy months have negative RCEi as well as some dry season months. A negative RCEi during rainfall month (Enete and Igu,2011) or monsoon months (Mondal et al., 2011) may be the result of extra care taken by drivers and road users during the rainy season, runoff effect, traffic jam and ember month campaign of the FRSC. Thus, a negative RCEi implies less crash per unit wet day than unit dry day in a month. For the dry months with

high positive RCEi values, for example, in 2013 for January, may be explained dry spell effect. In an attempt to evaluate the relationship between wet period and road crash, a negative though not statistically significant correlation (r = -0.196) was obtained. This is quite insignificant though one cannot write off the potential contribution of weather. The implication of this is that, for the 3 years (36months) understudy, an increase in wet period lead to a slight reduction in road traffic crashes (Figure 4). The effect of rainfall on accidents seems to be related non-linearly with

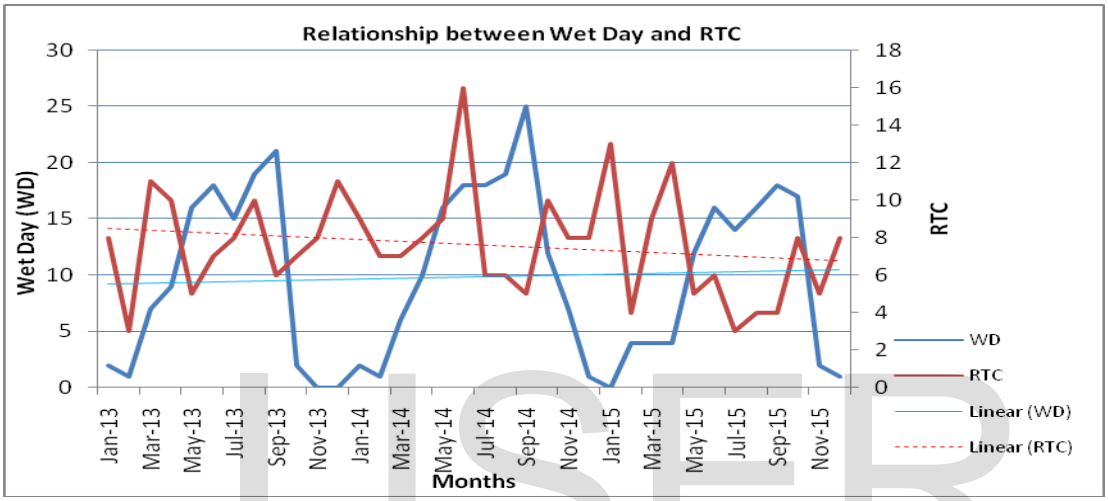

Fig 4: Relationship between RTC and Rainfall

accident rates, while some studies imply linear correlation with the number of accidents (Olaniran, 2016), the findings of this study are quite consistent with most similar studies. Studies have found negative or non-significant correlations between rain and accidents. Karlaftis and Yannis (2010) used 21years of daily amount data for Athens and found that high amount of rainfall may reduce the number of accidents. The effect according to Jaroszweski and Mcnamara (2014) may be due to driver risk compensation behavior or a simultaneous decrease of exposure. This, however, agreed with the assumption made by Enete and Igu (2011) and Mondal *et al* (2011) that a negative RCEi during rainy months could be attributed to extra care by drivers and the fact that negative RCEi accounts for less crash per unit wet day than unit dry day in a month. For some other places, positive effects of rainfall on accidents have been noted (Chang and Chen, 2005; Fristrøm et al., 1998). Enete and Igu (2011) in their study of the interactions between rainfall and road traffic accidents in Enugu found that 29.8% of road crashes in Enugu occurred during wet months of 2009, with the highest wet crash occurred in the month of June.

Figure 4.4 below shows the relationship between wet period and RTC in Awka for 3 years (36months) understudy.

Epidemiology of Road Traffic Accidents (RTAs) in Awka

For the three years understudy, the yearly RTA total, the total number of injuries within these period and persons who lost their life is presented Tables 3 and 4. Of these figures in 2013, Awka recorded 31.6%, 12% and 21.4% of these total crashes, death and injured persons respectively. In 2014, the percentage of the total crashes, deaths and injury were 34.4%, 12.7% and 33.3% respectively. The number of total crash was up by 2.8% in Awka. In 2015, Awka recorded 35.4% of the crashes with the attendant percentage of deaths cases and injured people being 18.9% and 34.5% respectively. Also, based on the findings (Table 4), evidence shows that males have higher risk of RTA than females in Awka except for 2015. Of the total deaths recorded in Awka from 2013 to 2015, males constitute a large part with 81.2% in 2013, 78.6% in 2014 and 36.4% in 2015.

Table 3: Epidemiology of Road Traffic Accidents in Anambra state for the Period of Study

Year	Total Crashes	Deaths	No. of Injured
2013	294	134	766
2014	288	110	606
2015	229	175	628
Total	811	419	2000

Source: FRSC, 2015

Table 4: Epidemiology of Road Traffic Accidents in Awka for the Period of Study

Year	Total Crashes	Deaths	No. of Injured	Male Deaths
2013	93	16	164	13
2014	99	14	202	11
2015	81	33	217	12
Total	273	63	583	36

Source: FRSC, 2015

4 CONCLUSION

The observed percentage of clashes that took place on wet days in Awka advocates that weather is an important factor contributing to the recorded RTAs in the study area. The month of June was found to be consistently high with the amount of recorded road crashes throughout the period. Positive RCEi index was also recorded throughout the 3 year period and as such confirms the above assertion that for the three years more crashes were recorded in the month of June. It was equally observed that the percentage of total crashes that took place in Awka on wet days is 35.1%, 28.3% and 24.7% for 2013, 2014 and 2015 respectively. Also crash per unit wet day was shown to decrease from 2013 to 2015. The results of this research work have revealed a close link between road traffic accident and wet periods in the area. This paper has shown a number of possible interactions between aspects of weather and road traffic accidents. Thus, in an attempt to reduce road traffic crashes, a greater part of the efforts should be made towards social education and seminars on the dangers of road traffic accidents in relation to wet and dry periods This will enlighten the road users and assist them to be cautious when driving especially during wet periods and dry spells. On the part of government and relevant traffic agencies such as FRSC, Anambra State Traffic Management Agency (ATMA) etc., law enforcement on road usage should be effectively established to regulate driving especially at the peak of the rainy season (June and September) and obeying of traffic signs while efforts should be made in checking the excesses of these agencies on the road.

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