ROAD-SAFETY RISK FACTORS AND CRASH PROPENSITY ANALYSIS: RESULTS FROM NIGERIA

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Abstract

A cross-sectional study was crafted to research a gamut of unique, potential traffic risk factors that are linked with crash propensity in a stretch of busy interstate dual-carriage highway spanning 525 km east to west of southern Nigeria. The method adopted entailed: collection of 41-year road traffic accident data from governmental sources, and undertaking of a survey involving questionnaire administration to 532 well-informed respondents drawn from seven of the 36 constituent states of Nigeria. The 41-year accident data were graphed, and the respondents' scores, transposed into 532 x 25 data matrix, was analyzed with Principal Component Analysis (PCA) version of Factor Analysis contained in StatistiXL software. The scree plot and computed eigenvalues justified the adequacy of nine factors extracted by varimax rotation. Our findings suggest that, although road traffic accidents (RTA) rates, which peaked at 11,320 deaths in 1983 from a threshold value of 1000 in 1960, is already on the decline. Nevertheless, serious effort should be made to curtail and whittle down the strong influence of the identified potential risk traffic factors in an attempt to reduce or prevent further accidents. A general substantial pay rise granted to civil servants in 1999, as part of dividends of the then-nascent civil democracy, prompted the injection of a great number of used cars (with the concomitant mechanical unreliability) into Nigerian roads. This unfettered mass action, which was both compounded and exacerbated by the effect of other traffic risk factors, generated a backlash in the form of surge of increased number of vehicle crashes and deaths. The results of this study address the causes and panacea to the perceived resurgence of the epidemiological problem. It is suggested that, as a primary prevention measure, annual revalidation of vehicle road worthiness. as well as strict enforcement of penalties for low level of altruism, extraversion, macho attitude and self reported risky driving behaviours, among others, should be instituted by Federal Road Safety Corps (FRSC) as means of exerting firm control and regulation on the identified factors.

Keywords: *Middling, White Noise, Varimax Rotation, Epidemiological Transition, Misattribution.*

Introduction

Previous studies suggest that road traffic injuries and fatalities are the leading cause of death in both developed and developing countries; see, for example, Yang and Kim (2003); Afukaar, Antwi and Ofosu-Amaah (2003); Hancock and Ridder (2003). In 1999, about 750,000 people were killed all over the world as a result of road traffic accident, and the following year (2000) over 1.2 million people were killed due to the same reason (UN, 2003).

Until a few years ago, road traffic accidents in Nigeria, which had spiked in world records, appeared to be a major cause of death to the citizens more than any other causes. For example, whereas USA is reported in 1985 to record 4 deaths per 10,000 vehicle kilometre traveled, Nigeria recorded 240 deaths that same year (Asalor, Onibere and Ovuworie, 1985). Since independence in 1960 and until 1988 when Federal Road Safety Corps (FRSC) was established, Nigeria accident record had shown exponential growth. In particular, there was a phenomenal

rise in road accidents in 1981 in Nigeria amounting to 55,966 cases. This figure compared fairly with 1980 correlate of 30,862 representing 81% rise over the previous year. The 1981 figure was said to represent 300% increase within 10 years period of 1971 to 1981 as reported in Agunloye (1990) and Hauer (2006). And between 1982 and 1984, average accident severity index was 21%; higher figures (between 30% and 36%) were recorded in eight of the 36 constituent states of Nigeria during that period.

The establishment of FRSC coupled with the institution of several intervention policies have tremendously assisted in stemming the trend of RTA rates. Surprisingly, as the chances of the average Nigerian being involved in road traffic accident are getting smaller, corresponding chances of getting killed or injured whenever a commuter is involved in an accident are on the increase. This irony sharpens the focus of the current research question. The research plan, in part, is set afoot to identify these factors, ascertain their correlation and subsequently devise ways and means to achieve monitoring and curtailment of these putative agents of accident causation.

The literature on road traffic accident and prevention is vast. The study Hauer (2006) reported on the concept of frequency-severity indeterminacy. It stated that generally and everywhere, not all cases of reportable accidents are reported, stressing that severity of accident greatly influences reportability. Arising from this situation, the authors note that this omission or commission leads to misattribution, misrepresentation and inherent misinterpretation by researchers. The authors also gave a stipulative definition of road traffic accident by quoting from American National Standard (ANS, 1996). According to the source, motor vehicle accident is an unstabilized situation that arises when a transport vehicle in transport is out of human control to the extent that it can result to harmful event, by which it is meant an occurrence of injury or damage.

Further, a body of research papers has addressed a catena of factors which encapsulated drivers behaviour, for example Mirza et al. (1998); Hakkert et al. (2000); Petridou and Moustaki (2000); Wouters and Bos (1998); Hakkanen and Summala (2000); groeger and Rothengatter (1998) and Rochlitz (2004). Also, past studies have identified animal-vehicle crashes as another crucial risk factor in road traffic accidents (Dickerson, Peirson and Vickerman, 2000; Philcox, Gregan and Macdonald, 1999; Andreas, 2005). Two persons lost their lives along Benin end of Benin-Sapele Road, Benin City, Edo State, Nigeria, as a result of uncontrolled movement of a cow into the highway on April 28, 2013. The vehicle was severely damaged.

Moreover, Evans and Smith (1999) reported on the method of estimating vehicle speed on highway by measuring the pedestrian throw distance from point of impact. Also, Vasconcellos (1999) discussed the impact of urbanization in road traffic accident. The accident features reported appear to be a ballpark of the Nigerian situation which this study discusses.

A recent study carried out in South Africa showed that defective tyres and brakes are the two most dominant components that contribute to accident causation with overloading as an additional factor to consider. The source claimed that such mechanical failures account for 3% of road accidents and that the same 3% is common to developed countries as well (van Schoor, van Niekerk and Grobbelaar, 2001). In London, the paper Dixey (1999) studied the empirical relationship between accident externality (self-reported behaviours) and traffic volume estimated by traffic count. The econometric model developed suggested that a strong relationship exists between road traffic accident and traffic flow. Also, Dickerson, Peirson and Vickerman, 2000) studied road traffic fatalism in relation to

causes in south west of Nigeria; a highway near Igbo-ora. The researcher discovered that culture, predestination, fatalism, superstitions and generally belief, tend to hamper health promotion initiatives that would have been a panacea for rehabilitating road traffic accident victims.

Furthermore, so many papers have addressed RTA and their management: see Leanne and Macarthur (2006); Mao et al. (1997); King et al. (1994); Svenson, Nypaver and Calhoun (1996a); Lord, Manar and Vizioli (2005); Trinidad and Javier (2005); Kennedy, Isaac and Graham (1996); Wells-Parker and Snow (2001); Baker (2002); Richard (2005); Thomas, Tove and Peter (2005) for sources of excellent, relevant reference materials on road traffic accident and their management. Other studies on accident causative factors had been conducted in Nigeria (see, for example, Ehikhamenor and Obianwulo (2006) which reported on Blood Alcohol Concentration (BAC), of drivers in a southern Nigeria City). Similar BAC studies had been conducted in Mexico and Spain (Hijar et al., 1998; Carmen del Rio and Javier-Alvare, 1999).

The study Igboanugo and Ekhuemelo (2006) on intervention analysis of road traffic accidents in Nigeria from 1993 to 2001, it was reported that the establishment of Federal Road Safety Corps helped to stave off the snowballing rate of accident occurrence in Nigerian roads. The subject matter of the present study has been examined at an international conference on development studies (Igboanugo and Omoregie, 2007). The ideas garnered in the conference helped to enhance the quality of this study.

Researching the contextualization of traffic risk factors to the Nigerian situation had been infrequently undertaken. Previous studies by Ehikhamenor and Obianwuho (2006) and Dixey (2000) had considered few factors such as BAC and health promotion for accident victims for a particular Yoruba community in Southern Nigeria. Recent studies on road traffic accidents are found in Akpoghomeh (2012); Atubi (2010); Aworem, as well as Abdul-Azeez and Olabode (2010).

One of the goals of this study is to identify important traffic risk factors that are associated with road traffic accident causation in Nigeria. Another goal is to discover how these factors do individually and collectively interact to cause accident in Nigerian roads. The study also intends to carry out a comparative analysis of the international impact of these factors and assess the effectiveness of the approaches adopted by other countries in dealing with similar problems.

Method

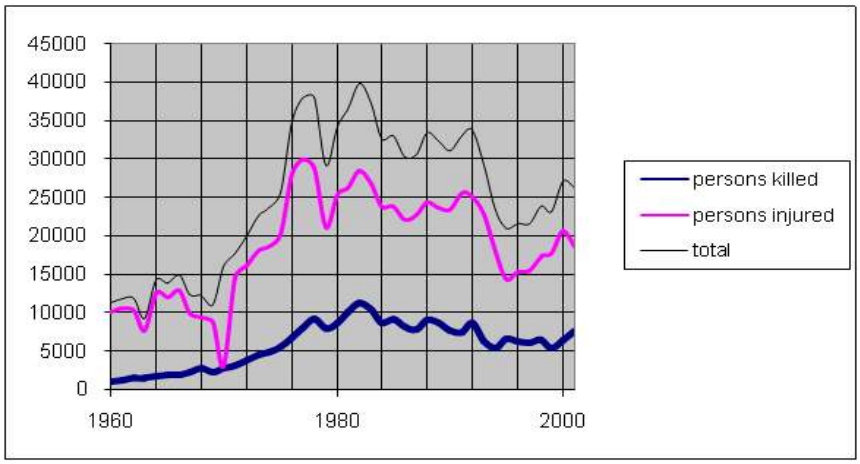

Fig 1: Fatalities and Serious Accidents on All Roads in Nigeria (1960-2001); Source: Nigerian Police Force & FRSC

Oral interviews of some drivers plying the route under investigation and the personnel of Federal Road Safety Corps (FRSC) as well as police were undertaken. In particular, a survey of 532 well-informed respondents, comprising majorly of the group stated therein, was undertaken too. The research instrument used is the questionnaire. The sentences of the questionnaire were couched with identified scale items (25 potential traffic accident risk factors). Rensis Likert's attitudinal 5-point nominal scale was adopted in scaling the response options, namely: completely agree (5), Agree (4), Undecided (3), disagree (2), and completely disagree (1). Pre-questionnaire administration briefing and post-adm inistration debriefing of subjects were undertaken. The respondents' score were collated as data matrix and the Principal Component Analysis (PCA), as furnished by StatistiXL software, was used to extract 9 (nine) factors whose adequacy was confirmed by the use of scree plot and eigenvalue criteria.

Purposive sampling technique was used in selecting the twenty-five (25) specific factors. Thirty six constituent states of Nigeria comprised our sampling frame and the sampling technique used is that of purposive typology.

An assortment of literature on accident analysis and prevention consulted guided in the selection of the twenty-five factors depicted in Table 1.

Table 1: Selected twenty-five (25) accident causative factors

S/N	VARIABLE	SCALE ITEM DESCRIPTION
1	X_1	Traffic Volume/Road Capacity Relativity
2	X_2	Adequacy of Highway Road Sign
3	X_3	Road Curvature and Banking
4	X_4	Lighting System
5	X_5	Road-stream-Dividing Slabs
6	X_6	Drunk-Driving
7	X_7	Fatigue
8	X_8	Drinking and Driving
9	X_9	Nose-to-Tail Driving
10	X_{10}	Drug
11	X_{11}	Over-speeding
12	X_{12}	Drugging and Driving
13	X_{13}	Distraction
14	X_{14}	Traffic Congestion
15	X_{15}	Bad Weather Condition
16	X_{16}	Poor Brake
17	X_{17}	Bald Tyres
18	X_{18}	Faulty Headlight
19	X_{19}	Defective Steering
20	X_{20}	Dangerous Parking
21	X_{21}	Road Traffic Rules
22	X_{22}	Road Traffic Sanctions
23	X_{23}	Overtaking
24	X_{24}	Overloading
25	X_{25}	Reckless and Careless Driving

The extraction of factors was by varimax orthogonal factor rotation. The term rotation means exactly what it implies. Specifically, the reference axes of the factors are turned about the origin until a modal position has been reached. Rotation of factor matrix helps to redistribute the variance from earlier factors to later ones to achieve a simpler, theoretically more meaningful factor pattern. Varimax rotation also causes shift in explanatory power because of the aforesaid redistribution. It is also desirable because it reduces ambiguity, simplifies factor structure and facilitates factor interpretation. It should be noted that percentage of squared factor loading denotes the amount of variance explained by the factor in question. For instance 25 which wields 0.90 factor loading in the last column of Table 6) accounts for (0.90)2 x 100% = 81% of variance of X25 shared among the nine factors extracted. And the total contribution of the nine (9) factors to the explained variance is 0.909 which is termed the communality; it is a squared-row-sum.

Figure 2 which is on varimax rotation is demonstrative.

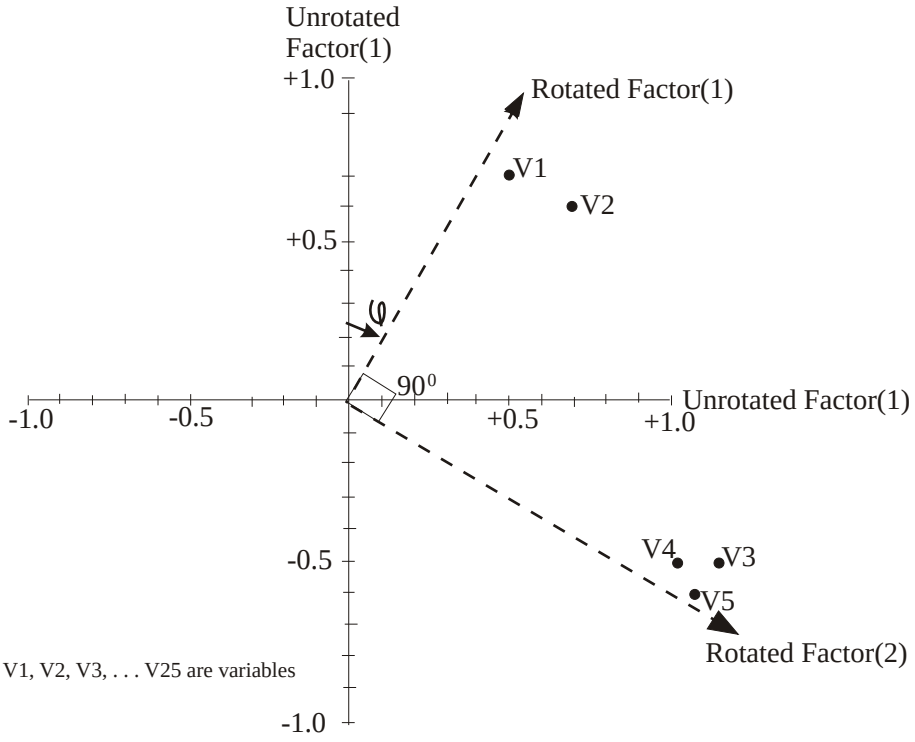

Fig.2 Varimax Orthogonal Factor Rotation.

The threshold value for acceptable factor loading was set at ±0.50; lower values are considered to be below the minimum acceptable level of significance. The eigenvalue (l) is the sum of squared factor loadings on a factor (column). Furthermore, the higher the factor loading, the more influencive is the variable considered.

In sum, this investigation is not only a cross-sectional study of major causes of road traffic crashes in Nigerian roads but also a longitudinal survey. Factor Analysis, a statistical tool for discerning similarity in dissimilarity, was used in analyzing 532 respondents' scores on identified scale items used in structuring the questionnaire. Knowledgeable respondents, mainly from the personnel of the Nigerian police, FRSC and fully licensed active vehicle drivers at Enugu, Asaba, Benin, Ore, Ijebu-Ode, Shagamu and Lagos which are major towns along the highway studied, were the research subjects.

Results and discussion

The outcome of this study will be presented in two aspects namely: presentation and analysis of RTA records obtainedpresentation of results of Principal Component Analysis (PCA) of survey data.
We shall take them seriatim.

Presentation and analysis of RTA data

Crashes, fatalities and injuries, 1960 – 2001

Until independence, deaths resulting from road traffic crashes were comparatively low, less than 1,000 persons for the whole country of about 55 million then.

As it is evident from Figure 1, the phenomenon mushroomed to 11,382 reported deaths per annum in 22 years (1982). Thereafter the tide abated gradually over time following some intervention policies. However, the increase in salary of public servants by Obasanjo administration in 1999 economically empowered them to purchase, albeit, second hand cars that were imported mostly from Belgium. The Nigerian roads then became awash with the unreliable cars with an untoward consequences which reflected in resurgence of the erstwhile abating trend in road traffic crashes.

Table 2 summarizes some accident records from selected states of Nigeria for a particular period.

Table 2: Accidents Results in Some States of Nigeria (1981 – 1984)

	State	Severity Index (%)	Deaths per 100 accidents	Injuries per 100 acciddnts
1	Rivers	15	-	-
2	Bauchi	36	> 30.7	131
3	Niger	54	>30.7	-
4	Sokoto	-	>30.7	-
5	Edo/Delta	-	-	74
6	Anambra/Enugu	-	-	77
7	Benue	-	-	117
8	8 states	> 30	-	-
9	Nigeria	21	31.3	71.7

Source: Nigerian Police Force & FRSC

Table 3 compares road traffic accident figures for Nigeria and Britain.
Table 3: Comparative Fatality and serious Accidents on all roads in Great Britain and Nigeria.

Year Location	1991	1994 – 1998 (average)	2001
Great Britain	47,931	40,481	34,764
England	40,650	34,859	30,276
London	7,279	6,082	5,584
Nigeria	33,150	22,295	26,345

Sources: Department for Transport; the Police service of Northern Ireland and FRSC in Nigeria

Population

The figure for Nigerian population by 1963 census was 55,000,000. By 1991 figure, national population figure was 88.9 million, almost equally divided between both sexes. Since 1991, population growth rate came to 2.9%.

In 2003, the population figure rose to 126 million. However, in 2007, the figure soared to 140,003,542, made up of 71,709,859 males and 68,293,683 females, Vanguard Newspaper (2007).

Deaths stemming from RTA spiked to a value of 11,382 in 1982. Values before and after this date are 10,202 and 10,462 which correspond to those of 1981 and 1983 respectively, all in close neighbourhood. On the basis of population, the average death per 100,000 persons, on national level, is 11 during the period (1981-1983). When this analysis was conducted on state basis, Ogun state had the highest rate of 23 persons per 100,000 population, and was followed by (Edo / Delta), formerly known as Bendel state before the split in (1989), with rate of 22 deaths per 100,000 persons (Agunloye, 1990). Figure 2 depicts the map of Nigeria with the component states delineated.

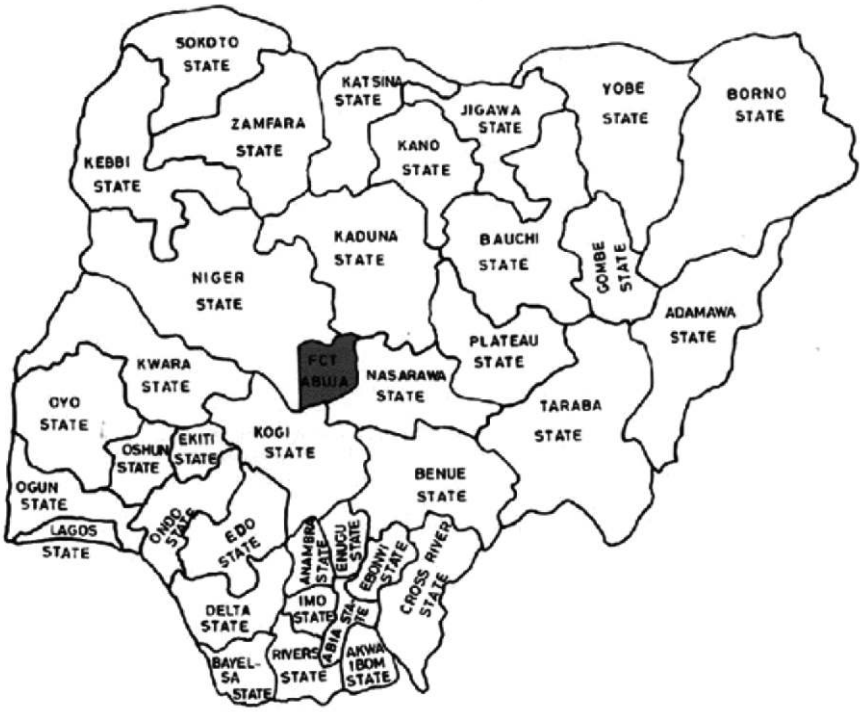

Fig 3: Map of the Federal Republic of Nigeria.

3.2 Presentation of results of PCA of Survey data

In what follows we present, analyze and interpret each of the factor matrix as obtained with the PCA.

3.2.1 Defects-spatiality Concern

Table 4 shows the bipolar (mixed signs) cluster which consists of middlings and mediocre. It deals with safety under condition of hampered visibility and mechanical defects. It is a general factor. The five variables share similar characteristic concern towards emerging hazards which the vehicle is prone to with respect to space and time.

Table 4: Defects-spatiality Cluster Loaded

Creative Label Variable	Defect-Spatiality Concern	Factor Loadings
X_4	Lighting system	-0.753
X_9	Nose-to-tail driving	-0.736
X_{14}	Traffic congestion	-0.603
X_{16}	Poor brake system	0.649
X_{17}	Bald tyres	0.762

The first three variables vary inversely with the other two by virtue of their oppositeness in signs. The cluster suggests worries about the integrity of tyres, visibility and effective braking distance. Variables X4, X9, and X17 which are middlings explain barely 50% of the variance while X14 and X16 (mediocres) account for about 36% (below average).

3.2.2 Infractions and Stimulants Concern

The next cluster depicted in Table 5 is concerned with infractions and stimulants cluster. The survey suggests that, at best, majority of the road users have moderate knowledge of road traffic rules and that record of infringements pertaining to the use of stimulants are not very common on the highway studied. Moreover, all the variables wield negative signs signifying that they covary and conjoin. The first three variables have meritorious factor loadings. The last variable wields middling factor loading that explains less than 25% of the observed variance of X21.

Table 5: Infractions and Stimulants Cluster Loaded

Creative label Variable	Infractions and Stimulants Concern	Factor Loadings
X_6	Drunk-driving	-0.861
X_8	Drinking and driving	-0.822
X_{12}	Drugging and driving	-0.886
X_{21}	Knowledge of road traffic rules	-0.549

Self-reported risky driving behaviour

Table 6 addresses self-reported risky driving behaviour. The three variables wield positive factor loadings implying that they move together and influence each other.

Table 6: Inapposite Driving behaviour Cluster

Creative label Variable	Inapposite Driving Behaviour Concern	Factor Loadings
X_{11}	Over-speeding	0.898
X_{23}	Overtaking	0.720
X_{25}	Reckless and Careless driving	0.900

The three factors share a common characteristic which can be called macho attitude or self-reporting risky driving attitude. Although the variables (X11 and X25) are meritorious because they wield high factor loading, they are however meretricious because they are highly risky factors of road traffic accident causation; X23 is mediocre and meretricious. The higher the factor loading, the more risky the factors.

3.2.4 Veering Tendency Concern

The next cluster depicted in Table 7 deals with factors (drug as well as wet slippery road condition) influencing veering tendencies towards the road median strip. They relate to extraversive attitudes and the concomitant sanctions. The first variable (X5) which is negatively loaded in the group is strongly opposed to the influence of X10 and X15 which are both positively loaded on the factor.

Table 7: Veering Tendencies Cluster

Creative label Variable	Inapposite Driving Behaviour Concern	Factor Loadings
X_5	Road-Stream-dividing Slab	-0.755
X_{10}	Drug	0.587
X_{15}	Bad weather condition	0.848

This cluster accommodates two risky variables that can cause vehicles to veer off road or cross median strip. Drug intake is a personality trait but weather condition is climatically induced. The influence of drugs has been analyzed and interpreted above. Adverse weather condition is acknowledged as RTA risky factor (Hijar et al., 1998; Washington and Mannering, 2000).

Non- Observance Oriented Penalties Concern

Table 8 deals with extraversive attitude and the attendant sanctions.

Table 8: Non- Observance Oriented Penalties Cluster

Creative label Variable	Non-observance Oriented penalties	Factor Loadings
X_{13}	Distraction	-0.894
X_{22}	Sanctions on road traffic abuses	0.868

This bipolar regime wields high factor loadings thus pointing up the high influence the factors exert. The duo exercise opposing effects. The result from Murray et al. (2001) helps to situate this cluster in the broader context of cognitive challenges while driving. In countries where sanctions are not enforced with strictness, distractions and other extraversions are bound to encourage reinforcement. The study by Wouters and Bos (1998) suggest that one way to control this behaviour is for Road Safety personnel to use in-car data recorders to monitor the highway. The study noted that the control is based on the philosophy that people who are aware that they are being observed tend to modify their behaviour.

Thoroughgoing Concern

The next platoon (bipolar) shown in Table 9 is creatively labeled thoroughgoing concern; obviously, under murky situations, obstructions become imperceptible with poor lighting. As in the immediately previous analysis, the effect of X1 is opposed to those of X18 and X20 because of the opposite signs.

Table 9: Thoroughgoing Cluster

Creative label Variable	Thoroughgoing Concern,	Factor Loadings
X_1	Traffic volume/Road Capacity Relativity	-0.747
X_{18}	Faulty headlight	0.649
X_{20}	Dangerous parking	0.883

Failure to heed road signs could result to road accident. The PCA trumps it as the most influencive factor in RTA analysis by virtue of its highest factor loading of the 25 factors considered. Its significance is further emphasized and buttressed in the works Jorgensen and Wentzel-Larsen (1999) and Washington and Mannering (2000).

3.2.9 Control Concern

Finally, our analytical model stresses that either drivers fatigue or mechanical failure in steering or both can lead to loss of vehicle control. Both variables are loaded negatively because they work conjunctively to adversely affect vehicle control on the road.

Table 12: Control Cluster

Creative label Variable	Control Concern	Factor Loadings
X_7	Driver fatigue	-0.695
X_{19}	Defective steering	-0.874

The two risky factors contribute substantially to road traffic crashes as supported by the results of the following studies from Finland and Greece respectively Hakkanen and Summala (2000), and Petridou and Moustaki (2000). The PCA model employed clustered the two factors based on the fact that they can work in sync to adversely affect vehicle control.

Primary prevention measures

In the light of the preceding analysis of results and discussion, the following multiple policy interventions are suggested.

i. Intensification of road safety education programme.
ii. Correction of accident black spots in existing roads.
iii. Enforcement of penalty for self-reported driving attitude.
iv. Use of vehicle data recorders as a means of providing drivers behavioural feedback. This scheme has been experimented in Netherlands with good results (Wouters and Bos, 1998).
v. Mediacy of adequate consideration for citizens who reported traffic infractions.
vi. Introduction of road safety evaluation scheme.
vii. Undertaking of field observations
viii. Introduction of digital breath analyzer for checking suspected drivers who are driving under the influence of alcohol.
ix. Adoption of concentrated general enforcement policy on the highway studied. This approach was successful on 700 km inter-urban roads in Israel (Hakkert et al., 2000)
x. Detailing FRSC personnel to check the following:
a) Turning performance of drivers under covert observation.
b) Signaling while turning.
c) Compliance with stop and yield signs.
d) Stricter enforcement of the use of

seat belt by drivers and front seat passengers.

e) Compliance with keeping to the right on dual carriage roads.

f) Not crossing of the median strip at single carriage way.

xi. Finally, annual revalidation of vehicle road worthiness as well as enforcement of stiff penalties for low level of altruism, macho attitude, and self-reported risky driving behaviours should be instituted by Federal Road Safety Corps (FRSC) as a means of exerting control and regulation on the identified factors

It is envisaged that strict penalties for the above violations should serve as deterrent factor for the perceived accident trend. Taken together, sensitization of drivers on the potential hazardousness of these factors can assist in curtailing and whittling away these strong influences which the aforesaid factors wield on drivers.

Conclusion

Arising from our findings, analysis and interpretation of results, we can shape our viewpoints in the following conclusive statements.

1. Principal Component Analysis techniques applied has reduced the 25-variable structure into 9 specific dimensions. Accident analysis and prevention measures can now revolve around these nine areas instead of having to deal with the individual variables
2. Signing of potential traffic hazards is very crucial to road traffic accident control and prevention.
3. The 25 traffic risk factors identified in the PCA have been positioned and contextualized in the broader perspective of global accident studies.
4. The data used in this study have evidently shown that reported cases for injuries and fatalities rose from low threshold (1000) at independence (1960) to an alarming proportion (11,382 deaths) in 1983 before declining to about 6,000 deaths in recent years.

Demographic changes, urbanization and changing life style appear to have accounted for this development. The various road safety intervention policies introduced by the Federal Government of Nigeria helped to stem the gangrenous trend. The introduction of Federal Road Safety Corps in 1988 appears to be one of the best health promotion interventions aimed at epidemiological transition.

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