MODELING OF ROAD TRAFFIC CRASH COUNTERMEASURES IN OGUN STATE

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ABSTRACT
Road traffic crash is a global concern and Nigeria is not left behind. In 2016, 387 Road Traffic Crashes were recorded in Ogun State out of which 279 persons were killed and 1366 were injured. The aim of the study is to develop a model for describing road traffic crash countermeasures in Ogun State. Questionnaire on existing safety measures which involved 8 questions were administered to 240 respondents drawn from six of the twenty LGAs of Ogun State. A multivariate regression model was developed for describing road traffic crash countermeasures. The model revealed that all the countermeasures contributed positively to the overall level of road traffic crash control. Maintenance of road network with positive regression parameter of 1.0610 contributed most to the overall reduction in road traffic crash in the study area. It is therefore concluded that more attention should be channeled towards road maintenance and rehabilitation in Ogun State.

Keywords: Countermeasures, crashes, road network, road maintenance.

1. INTRODUCTION
Road traffic crash (RTC) is one of the causes of preventable injuries and death globally. World Bank revealed that road traffic accident cost 1-2% of the gross national product (GNP) of developing countries, or double the aggregate sum of advancement received worldwide by developed nations [1]. This research is specially targeted to draw the attention of road traffic/safety regulatory agencies in Ogun State on the need to develop sustainable and reliable mitigating strategies to meander recurrent road crash cases across road networks in the state. Around 1.2 million people died annually worldwide as a result of road fatalities and Injuries. These unfortunate casualties possess 30-70% of orthopedic beds in developing country’s hospital [2].

With continuation of present patterns, road traffic accident is anticipated to be the third driving supporter of the worldwide level of disease, simply behind clinical depression and coronary illness by 2020 [3]. In developing nations 90 percent of the Disability Adjusted Life Years' (DALYs) lost happen as a result of road traffic accident [4]. One DALY is generally proportional to one solid year of life lost. In developing nations 75% of every single poor family who lost a part to road traffic death announced a decline in their way of life and 61 percent revealed that they needed to obtain cash to cover costs following their misfortune.

To this end, strong and innovative policies need to be brought to bear, globally, as part of the objective the decade of action to reach the target of 50% reduction in road death/fatalities by year 2020. This was also emphasized in the United Nations sustainable development goals [5].

1.1 Safety Measures to Curb Road Crashes
Road safety measure or system has no particular or standard package appropriate for all countries or states. Interventions proven in one state such as Ondo state may not easily be transferable to Ogun State, and will require careful adaptation and evaluation before any intervention measures can be deployed. Where interventions are inadequate, there is need to develop new measures through scientific research. Whether in high-income, or low-income and middle-
income states in Nigeria, there are several good practices that can be followed [6]:

I. Dealing with vulnerability to risk through effective transport system;
II. Improving the road network as safety measure in curbing road traffic crashes;
III. Improving road users visibility;
IV. Encouraging the design of protective device in vehicle;
V. Ensure compliance with road safety regulations;
VI. Promoting post-crash care.

1.1.1 Dealing with vulnerability to risk through effective transport system
Safety-conscious planning and design of the land use and road network is necessary to reduce the risk of road traffic death and injuries. Exposure to risk of road traffic injury can be decreased in Ogun State by strategies that include:

I. Reducing volume of traffic for effective and efficient road safety management;
II. Creating alternative routes to ensure free flow of traffic;
III. Switching from higher-risk to lower-risk modes of transport should be encouraged;
IV. Promoting safety-centered planning, design and operation of the road network.

1.1.2 Improving the road network as safety measure in curbing road traffic crashes
Examples of road design considerations for road traffic injury and death prevention is by classifying roads and setting speed limits by their function. Some of the roads are for certain purpose. They are used by various types of vehicles with differences in speed, degree of protection and mass of vehicle. In built-up and on urban roads this often results to conflicts between the activities of motor vehicle users and pedestrians/ cyclists safety. Classifying roads functionality in the form of a “road hierarchy”, as it is known in highway engineering is important for providing safer routes and safer designs. Such a classification takes account of land use, location of crash sites, vehicle and pedestrian flows, and objectives such as speed control.

1.1.3 Improving visibility of road users
The fundamental prerequisites for the safety of all road users is to be seeing and being seen. Visibility of particular groups of road users can be improved in various ways. Adoption and enforcement of laws requiring daytime running lights and use of mounted brake lights, positioned on the rear windshield of cars, giving a high visibility from the rear.

1.1.4 Encouraging the design of protective device in vehicles
Crash-protective vehicles design is essential to passenger survival during any crash. With laminated windscreens fastened to the car to prevent ejection, collapsible steering column, reinforced front and passenger compartment, door locks that prevent doors from opening during a crash and crash-resistant roofs, it can be guaranteed that fatality rate will drop sharply.

1.1.5 Ensuring compliance with road safety regulations
Enforcing road safety rules is one of the important aspects of road traffic injury prevention in Nigerian and the rest of the world. It is necessary to ensure compliance through enforcement, information and education. Attempts at enforcing road traffic legislation will not have any lasting effect, either on road user behavior or on road traffic crashes unless the enforcement is continued for a long time, and is perceived to be so by road users [7]. Enforcement levels need to be high and total so as to ensure that the perceived risk of being caught remains high. Imposing very strict penalties (in the form of higher fines or longer prison sentences) as being practiced in Nigeria today, does not affect road-user behavior. Because once they pay for their fine their vehicle will be released without corrective measures. But once offenders are caught, their penalties should be dealt with swiftly using selective enforcement strategies. Automated means such as high-speed cameras are cost effective and should also be deployed on Nigerian roads. This should be encouraged to assist in monitoring and tracking purposes.

Enforcement of the following road traffic laws; speed limits, use of seat-belts, alcohol impairment, use of crash-helmet and child restraints are all geared towards ensuring safer motoring environment.

The human factors constitute about 80% of the cause of road traffic accidents recorded in Nigeria today [8]. Human factors involve the drivers, law enforcement agents, pedestrians and the engineers as used in road
crashes investigations globally. Most drivers on Nigeria roads are very rude, recklessly, discourteous and have scant regard for human life. This has led to daily avoidable carnage on Nigeria roads especially within the study area. Virtually all of the significant factors contributing to the high proportion of crashes in Ogun State, the human factors top the list. [9].

Road traffic death and injuries have significant effect on socio-economic aspirations and development in Nigeria, due to the premature loss of qualified professionals and able youths who are the future leader of this nation [10].

Ogun State, a heavily motorized state in Nigeria has been labeled with poor road condition and high rate of road traffic crashes. On a daily basis crash is being recorded in the state most of which are fatal. Lagos-Ibadan corridor ranked third in RTC in 2016 with 397 crashes involving 3526 persons resulting in 228 deaths and 1244 others injured [11,12]. In 2018 December, Ogun state was one of the three states which recorded the highest number of road crashes and fatalities in Nigeria.[13].

Hence, need to evaluate the existing road crash countermeasures deployed to curb road traffic crash in Ogun state, Nigeria.

2. METHODOLOGY

The population of this study consists of all traffic officials and commercial drivers in six local government areas in Ogun State with major carriages. These are Ado- Odo Ota, Abeokuta north and south, Ijebu-Ode, Sagamu, and Obafemi Owode numbering about 360 registered commercial Drivers and 240 traffic officials.

The total number of registered commercial drivers and traffic officials investigated were two hundred and forty (240). The sample size was determined based on the following calculations carried out using the formula developed by Toro Yamane

\[
n = \frac{N}{1 + N(e)^2}
\]

Where \(N=600\) 95% confidence level and \(p =0.05\)
Sample size derived was 240

A purposive sampling technique was adopted for the selection of the two corridors namely Lagos- Ibadan and Lagos – Abeokuta.

Multivariate regression analysis was carried out on the obtained data to establish the effect of each road safety measure variables on the overall crash countermeasures carried out in the study area. MATLAB software was used for the computation.

\[
y = \beta_0 + \beta_1X_1 + \beta_2X_2 + \beta_3X_3 + \beta_4X_4 + \beta_5X_5 + \beta_6X_6 + \beta_7X_7 + \beta_8X_8 + \varepsilon
\]

(1)

Figure 1: A map of Ogun State showing major road networks in Ogun State.
(www.google.com/ogunroadnetwork)
Using the method of least squares, we can develop a set of normal equations
\[
\Sigma y = n \beta_0 + \beta_1 \Sigma X_1 + \beta_2 \Sigma X_2 + \beta_3 \Sigma X_3 + \beta_4 \Sigma X_4 + \beta_5 \Sigma X_5 + \beta_6 \Sigma X_6 + \beta_7 \Sigma X_7 + \beta_8 \Sigma X_8 + \epsilon
\]
\[
\Sigma X_1y = \beta_0 \Sigma X_1 + \beta_1 \Sigma X_1^2 + \beta_2 \Sigma X_1X_2 + \beta_3 \Sigma X_1X_3 + \beta_4 \Sigma X_1X_4 + \beta_5 \Sigma X_1X_5 + \beta_6 \Sigma X_1X_6 + \beta_7 \Sigma X_1X_7 + \beta_8 \Sigma X_1X_8 + \epsilon
\]
\[
\Sigma X_2y = \beta_0 \Sigma X_2 + \beta_1 \Sigma X_2^2 + \beta_2 \Sigma X_2X_3 + \beta_3 \Sigma X_2X_4 + \beta_4 \Sigma X_2X_5 + \beta_5 \Sigma X_2X_6 + \beta_6 \Sigma X_2X_7 + \beta_7 \Sigma X_2X_8 + \epsilon
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\Sigma X_3y = \beta_0 \Sigma X_3 + \beta_1 \Sigma X_3^2 + \beta_2 \Sigma X_3X_4 + \beta_3 \Sigma X_3X_5 + \beta_4 \Sigma X_3X_6 + \beta_5 \Sigma X_3X_7 + \beta_6 \Sigma X_3X_8 + \epsilon
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\Sigma X_4y = \beta_0 \Sigma X_4 + \beta_1 \Sigma X_4^2 + \beta_2 \Sigma X_4X_5 + \beta_3 \Sigma X_4X_6 + \beta_4 \Sigma X_4X_7 + \beta_5 \Sigma X_4X_8 + \epsilon
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\Sigma X_5y = \beta_0 \Sigma X_5 + \beta_1 \Sigma X_5^2 + \beta_2 \Sigma X_5X_6 + \beta_3 \Sigma X_5X_7 + \beta_4 \Sigma X_5X_8 + \epsilon
\]
\[
\Sigma X_6y = \beta_0 \Sigma X_6 + \beta_1 \Sigma X_6^2 + \beta_2 \Sigma X_6X_7 + \beta_3 \Sigma X_6X_8 + \epsilon
\]
\[
\Sigma X_7y = \beta_0 \Sigma X_7 + \beta_1 \Sigma X_7^2 + \beta_2 \Sigma X_7X_8 + \epsilon
\]
\[
\Sigma X_8y = \beta_0 \Sigma X_8 + \beta_1 \Sigma X_8^2 + \epsilon
\]

The validity test was carried out to guide the utilization of the model developed. The existing road safety measures examined were eight and these form the independent variables for the multivariate analysis carried out. Table 1 shows a description of these variables.

Table 1: Exiting road safety measures

<table>
<thead>
<tr>
<th>Variable code</th>
<th>Existing road safety measures</th>
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<tbody>
<tr>
<td>X1</td>
<td>The use of seatbelt</td>
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<td>X2</td>
<td>Installation of traffic light in selected intersection</td>
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<td>X3</td>
<td>Enforcement of traffic rules and regulation</td>
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<td>X4</td>
<td>Maintenance of road network</td>
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<td>X5</td>
<td>Public enlightenment on road safety rules</td>
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<td>X6</td>
<td>Vehicle road worthness testing and certification</td>
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<td>X7</td>
<td>The regulation and issuance of driving licence</td>
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<td>X8</td>
<td>Installation of speed limiter on commercial vehicles</td>
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</tbody>
</table>

X7 = The regulation and issuance of driving licence
X8 = Installation of speed limiter into commercial vehicles.

The variables X1 to X8 are the various existing road safety measures while the crash countermeasures (y) are the output from the model. Table 2 gives a description of the values of the various regression parameters that constituted the model based on their partial derivative with respect to overall countermeasures.

Table 2: Model description.

<table>
<thead>
<tr>
<th>Description</th>
<th>( \frac{\partial y}{\partial X_i} )</th>
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<tbody>
<tr>
<td>Road crash countermeasure with respect to seatbelt</td>
<td>0.9974</td>
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<tr>
<td>Road crash countermeasure with respect to light in selected intersection</td>
<td>0.9801</td>
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<tr>
<td>Road crash countermeasure with respect to traffic rules and regulation</td>
<td>0.9939</td>
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<tr>
<td>Road crash countermeasure with respect to maintenance of road network</td>
<td>1.0610</td>
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<td>Road crash countermeasure with respect to safety rules</td>
<td>1.0056</td>
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<td>Road crash countermeasure with respect to testing and certification</td>
<td>0.9899</td>
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<td>Road crash countermeasure with respect to regulation and issuance of driving licence</td>
<td>0.9996</td>
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<td>Road crash countermeasure with respect to speed limiter</td>
<td>0.9991</td>
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3. RESULTS AND DISCUSSION

The developed multivariate linear regression model is shown in equation (10)

\[ y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \beta_5 X_5 + \beta_6 X_6 + \beta_7 X_7 + \beta_8 X_8 + \epsilon \]

The details of the computation using the summing variables are shown in appendix 1

\( y + 0.0091x_8 + \delta \)

(10)

\( A = -0.0671 + 0.9974x_1 + 0.9801x_2 + 0.9939x_3 + 1.0610x_4 + 1.0056x_5 + 0.9899x_6 + 0.9996x_7 + 0.9911x_8 + \delta \)
The standard error of the model is 0.2122. However, the combination of the independent variables yielded a coefficient of determination ($R^2$) of 1 which indicates that the model explained all the variability of the response data around its means. In addition, the coefficient of determination obtained indicates that the regression predictions perfectly fit the data [14].

4. CONCLUSION

The interactions of the itemized road traffic crash countermeasures were established using multivariate technique and the model revealed that all the countermeasures contributed positively to the overall level of road traffic crash control. Maintenance of road network with positive regression parameter of 1.0610 contributed most to the overall reduction in road traffic crash in the study area. Installation of traffic light in selected intersection contributed least (0.9801) to the overall reduction in the road traffic crash and fatality. This could be due to the fact that corridors investigated are trunk. A roads which barely require the intervention of traffic lights.

5. REFERENCES


APPENDIX 1: COMPUTATION OF THE NORMAL EQUATION PARAMETERS

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<th>X1y</th>
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Nigerian Journal of Technology, Vol. 38, No. 4, October 2019 818
MODELING OF ROAD TRAFFIC CRASH COUNTER MEASURES IN Ogun State,

A.J. Babalola & M.K. Onifade

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### APPENDIX 2: A SET OF NORMAL EQUATIONS

The obtained values of the summing variables (Appendix 1) were substituted into equation (1) which was represented as a set of linear equations as shown in 2.1 to 2.9

\[
4057 = 240\beta_0 + 473\beta_1 + 514\beta_2 + 522\beta_3 + 549\beta_4 + 532\beta_5 + 512\beta_6 + 567\beta_7 + 588\beta_8 \tag{2.1}
\]

\[
8313 = 473\beta_0 + 1109\beta_1 + 1027\beta_2 + 1036\beta_3 + 1098\beta_4 + 1082\beta_5 + 1045\beta_6 + 1137\beta_7 + 779\beta_8 \tag{2.2}
\]

\[
9054 = 514\beta_0 + 1027\beta_1 + 1272\beta_2 + 1131\beta_3 + 1224\beta_4 + 1157\beta_5 + 1144\beta_6 + 1233\beta_7 + 867\beta_8 \tag{2.3}
\]

\[
9120 = 522\beta_0 + 1036\beta_1 + 1131\beta_2 + 1300\beta_3 + 1220\beta_4 + 1163\beta_5 + 1142\beta_6 + 1241\beta_7 + 887\beta_8 \tag{2.4}
\]

\[
9607 = 549\beta_0 + 1094\beta_1 + 1224\beta_2 + 1220\beta_3 + 1415\beta_4 + 1213\beta_5 + 1222\beta_6 + 1306\beta_7 + 901\beta_8 \tag{2.5}
\]

\[
9721 = 532\beta_0 + 1082\beta_1 + 1157\beta_2 + 1163\beta_3 + 1213\beta_4 + 1336\beta_5 + 1148\beta_6 + 1286\beta_7 + 886\beta_8 \tag{2.6}
\]

\[
9073 = 512\beta_0 + 1045\beta_1 + 1144\beta_2 + 1142\beta_3 + 1222\beta_4 + 1148\beta_5 + 1282\beta_6 + 1229\beta_7 + 861\beta_8 \tag{2.7}
\]

\[
9818 = 567\beta_0 + 1137\beta_1 + 1233\beta_2 + 1241\beta_3 + 1306\beta_4 + 1286\beta_5 + 1229\beta_6 + 1469\beta_7 + 917\beta_8 \tag{2.8}
\]

\[
6907 = 388\beta_0 + 779\beta_1 + 867\beta_2 + 887\beta_3 + 910\beta_4 + 886\beta_5 + 861\beta_6 + 917\beta_7 + 800\beta_8 \tag{2.8}
\]

The values of the variables of equations 2.1 to 2.8 were obtained by converting the equations into their matrix forms.
**APPENDIX 3: MATLAB COMPUTATION OF THE REGRESSION PARAMETERS**

A = 
\[
\begin{bmatrix}
240 & 473 & 514 & 522 & 549 & 532 & 512 & 567 \\
473 & 1027 & 1036 & 1098 & 1082 & 1045 & 1137 & 779 \\
514 & 1027 & 1272 & 1131 & 1224 & 1157 & 1144 & 1233 \\
522 & 1036 & 1131 & 1300 & 1220 & 1163 & 1142 & 1241 \\
549 & 1098 & 1224 & 1220 & 1415 & 1213 & 1222 & 1306 \\
532 & 1082 & 1157 & 1163 & 1213 & 1336 & 1148 & 1286 \\
512 & 1045 & 1144 & 1142 & 1222 & 1148 & 1282 & 1229 \\
567 & 1137 & 1233 & 1241 & 1306 & 1286 & 1229 & 1469 \\
388 & 779 & 867 & 887 & 910 & 886 & 861 & 917 \\
\end{bmatrix}
\]

A = Columns 1 through 8
\[
\begin{bmatrix}
240 & 473 & 514 & 522 & 549 & 532 & 512 & 567 \\
473 & 1109 & 1027 & 1036 & 1098 & 1082 & 1045 & 1137 \\
514 & 1027 & 1131 & 1224 & 1157 & 1144 & 1233 & 867 \\
522 & 1036 & 1131 & 1300 & 1220 & 1163 & 1142 & 1241 \\
549 & 1098 & 1224 & 1220 & 1415 & 1213 & 1222 & 1306 \\
532 & 1082 & 1157 & 1163 & 1213 & 1336 & 1148 & 1286 \\
512 & 1045 & 1144 & 1142 & 1222 & 1148 & 1282 & 1229 \\
567 & 1137 & 1233 & 1241 & 1306 & 1286 & 1229 & 1469 \\
388 & 779 & 867 & 887 & 910 & 886 & 861 & 917 \\
\end{bmatrix}
\]

B = inv (A)
\[
B =
\begin{bmatrix}
0.1278 & -0.0056 & -0.0051 & -0.0090 & -0.0090 & -0.0091 & -0.0027 & -0.0130 & -0.0030 \\
-0.0056 & 0.0062 & 0.0000 & 0.0000 & -0.0003 & -0.0011 & -0.0009 & -0.0005 & -0.0002 \\
-0.0051 & 0.0000 & 0.0069 & 0.0002 & -0.0016 & -0.0004 & -0.0010 & -0.0006 & -0.0011 \\
-0.0091 & 0.0000 & 0.0002 & 0.0067 & -0.0007 & 0.0001 & -0.0006 & -0.0003 & -0.0016 \\
-0.0092 & -0.0003 & -0.0017 & -0.0008 & 0.0074 & 0.0006 & -0.0014 & -0.0001 & 0.0002 \\
-0.0092 & -0.0011 & -0.0005 & 0.0000 & 0.0006 & 0.0071 & -0.0000 & -0.0014 & -0.0009 \\
-0.0027 & -0.0009 & -0.0010 & -0.0005 & -0.0014 & -0.0000 & 0.0063 & -0.0005 & -0.0007 \\
-0.0013 & -0.0005 & -0.0006 & -0.0003 & -0.0001 & -0.0014 & -0.0005 & 0.0083 & 0.0006 \\
-0.0024 & -0.0001 & -0.0010 & -0.0015 & -0.0002 & -0.0010 & -0.0006 & 0.0006 & 0.0067 \\
\end{bmatrix}
\]

C = [4057;8313;9054;9120;9607;9271;9073;9818;6907]

D =
\[
\begin{bmatrix}
4057 & -0.0671 \\
8313 & 0.9974 \\
9054 & 0.9801 \\
9120 & 0.9939 \\
9607 & 1.0610 \\
9271 & 1.0056 \\
9073 & 0.9899 \\
9818 & 0.9996 \\
6907 & 0.9991 \\
\end{bmatrix}
\]

D = B*C