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# Spatial Analysis and Time Trend Regression of Multifactorial Violence-related Death and its Connection with Public Health in Nigeria

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## Abstract

Interpersonal violence poses a formidable obstacle to harmonious coexistence, socioeconomic development, and public health globally, given its deleterious consequences and attendant mortality. In a multicultural society like Nigeria, violence is an unfortunate inevitability. This study undertakes a spatial analysis and Poisson time trend analysis of violence-related mortality cases in Nigeria, aiming to elucidate the dynamics, assess the public health burden, estimate relative risk, identify hotspots, and inform policy interventions to mitigate violence in severely affected areas. A total of 195,170 cases were recorded between 2006 and 2023, with Borno (46,425), Lagos (12,086), and Kaduna (10,548) accounting for 24%, 6%, and 5% of cases, respectively. In contrast, Ekiti state had the lowest number of cases (752). Notably, death rates in 2014 and 2015 accounted for 12% and 9% of all deaths rates that were attributed to violence during the period considered. The violent death rate showed clear regional differences, with over half of all deaths occurring in the North Central and North East regions. The South East and South West regions contributed 8% and 10% of the remaining share, respectively, while the North West and South South regions contributed 12% and 14%, respectively. These figures show statistically significant socioeconomic and public health differences between the country's northern and southern regions ($F = 82.709$, $P<0.000$). Analysis of relative risk showed that while Plateau, Cross River, and Anambra had constant incidence rates, 27 states had elevated relative risk and seven states had a minimal drop in violence-related death. According to the study's findings, violence can have a significant impact on the health of mothers and children, making the nation's already fragile public health situation much worse. These findings underscore the complexity of Nigeria's violence landscape, highlighting the need for targeted, region-specific interventions to address the escalating violence and its public health repercussions. Policymakers and governments at all levels must prioritize evidence-based strategies to mitigate violence and promote peaceful coexistence in Nigeria.

**Keywords:** Violence deaths; Poisson; Trend, Spatial analysis; Public health, Violence

## Introduction

Nigeria is a multifaceted, complex nation with no less than 250 million inhabitants from different ethnic backgrounds who speak over 500 different languages. The three main ethnic groups are the Hausa-Fulani in the north, the Yoruba in the southwest, and the Igbo in the east, together comprising around 60% of the population (Akinyemi & Mobolaji, 2022). While Nigeria's ethnic diversity, which is both a reflection of the country's rich cultural past and a source of instability, has made political and social instability worse, these main ethnic groups have regularly switched positions of power, which has increased tensions between them and encouraged political inclusivity (Marshall, 2020). Nigeria has seen an expansion in rebel and pro-government organisations over time, which has led to a concerning spike in violent crimes and mortalities nationwide, making the country one of the most violent and criminally concentrated countries in Africa as positioned by the United Nations (UN), further indicating the country's significant security issues (Ukoji & Ukoji, 2023).

Nigeria ranked 17th in the world with a crime index of 63.27 per 100,000 people in the Crime Index for Country (CIC), 2021 (Cepeda et al., 2021). While the "End SARS" demonstrations in late 2020 exposed the pervasiveness of violence in the country, this figure reflects that reality. These demonstrations were initiated by youths in Nigeria to demand an end to the violence committed against police by the Special Anti-Robbery Squad (SARS) (Adams & Dorcas, 2024). Nevertheless, the nationwide rallies quickly descended into violence, inflicting numerous injuries and fatalities. These incidents are not unique; rather, they are a symptom of a more serious, structural issue with violence in Nigeria. This violence can manifest itself in a variety of ways, including kidnappings, armed robberies, interethnic strife, and communal disputes (Sasu, 2022).

Nigerian violence has a deep historical, social, and economic basis and is characterised by complexity. The World Health Organisation (WHO) defines violence as "the intentional use of physical force or power, threatened or actual, against oneself, another person, or a group or community, which either results in or has a high likelihood of resulting in injury, death, psychological harm, mal-development or deprivation" (WHO, 2002). The three subtypes of violence identified by the WHO are self-directed, interpersonal, and collective. According to Montclos, (2016), who named Nigeria as one of the world's most fragile nations in 2014, violence is very likely to result in death, psychological harm, or other adverse results because of the country's weak state.

The number of violent mortalities in Nigeria is astonishing. Estimated homicide rates in the nation in 2019 were 9.16 per 100000 population, which highlights the grave security situation (WHO, 2021). The type and distribution of violent deaths in Nigeria have been better understood because of earlier research. Obiorah & Amakiri, (2014) conducted a review of autopsy records of violent death victims in Rivers State and found that homicides accounted for the majority of violent deaths (50.5%). The study by Nwankwo & James, (2016), which discovered that 8,516 violent deaths occurred in Nigeria between June 2006 and September 2015, further highlighting the persistent threat of violence throughout the country.

The northern region of Nigeria has been the focus of violence mainly due to the insurgency led by Boko Haram and other extremist groups. Research by Azad, Crawford, and Kaila (2018) indicates that violence against a family member occurred in nearly almost half (49%) of homes in the northeast region of Nigeria between 2010 and 2017, indicating the region's propensity for conflict (Odozi & Oyelere, 2019). Such pervasive violence has serious implications for public health, including mental health, public safety, and the health of mothers and children. The Nigerian government must create and put into action efficient plans to handle the underlying causes of violence and its catastrophic effects because the country's population displacement, disruption of healthcare services, and infrastructure destruction only serve to worsen these problems.

Violence has a significant detrimental effect on public health, beyond the immediate death rate. With the identified regional disparities in violent mortalities, specialised solutions that take into account the distinct sociopolitical and economic dynamics of various locations are considered important (Onifade et al., 2013). While organised crime and economic instability are contributing to an increase in violence in southern Nigerian states, insurgency-related violence mostly affects the northern areas (Onifade et al., 2013). These trends worsen public health problems like overworked healthcare systems, restricted access to essential medicines, and long-term mental health effects on impacted communities (Ogaji & Seiyefa, 2015). To create specialised interventions that range from counterinsurgency operations in the north to economic empowerment schemes in the south, policymakers and public health experts must be aware of these regional variations (Onifade et al., 2013).

To examine violence and its correlates, numerous studies have adopted a variety of techniques. In the case of Australia, Canada, and the United States, Wilkins et al. (2019) found that factors such as residential instability and income inequality were significantly associated with these

rates after using multilevel models to assess associations between selected explanatory variables and suicide and homicide rates. The southern part of Nigeria has a higher frequency of armed robbery, according to Adubisi et al.'s (2019) multivariate research comparing crime rates between the two regions. In their analysis of variables linked to recurrent self-inflicted injuries, Peterson et al., (2019) found that female gender and younger age were significant predictors. These studies highlight how crucial it is to comprehend the complex elements causing violence through the use of reliable statistical tools; this study will take the same approach in examining violent deaths in Nigeria.

Nigeria is still experiencing a great deal of insecurity despite multiple attempts to reduce violence. Public health, government, and the nation's overall growth are all significantly impacted by this ongoing bloodshed. Therefore, examining violent mortalities in Nigeria is important not only to comprehend the trends and causes of violence but also to guide the development of intervention and policy plans meant to lessen violence and the harms that correspond with it. Therefore, to offer useful insights to practitioners and policymakers, this study examines the temporal and spatial distributions of violent deaths in Nigeria. This is achieved by examining monthly records of violent mortality statistics across the 36 states and the FCT, thereby presenting a data-driven approach to dealing with the Nigerian violence's complex situation.

**Data and Methods**

Death rates per 100,000 population and absolute total number of deaths due to violence caused by multifactorial[1] instances were downloaded from Nigeria Watch monitors website (https://www.nigeriawatch.org/index.php?urlaction=evtStat) on monthly basis from June 2006 to December 2023. Each time series span June 2006 to December 2023 covering a total of 211 data points per state. The map of the study area, global homicide rates and descriptive statistics of the dataset is given are shown in figure 1 and Table 1 respectively.

[1] Violent deaths in Nigeria are deaths related to multifactorial cause majority of which are anthropogenic such as cattle grazing, convicts execution, crimes, political issues, economic issues, land issues, market issues, religion issues, sorcery, fire/explosion, road accident, and other accidents as well as natural disaster,.

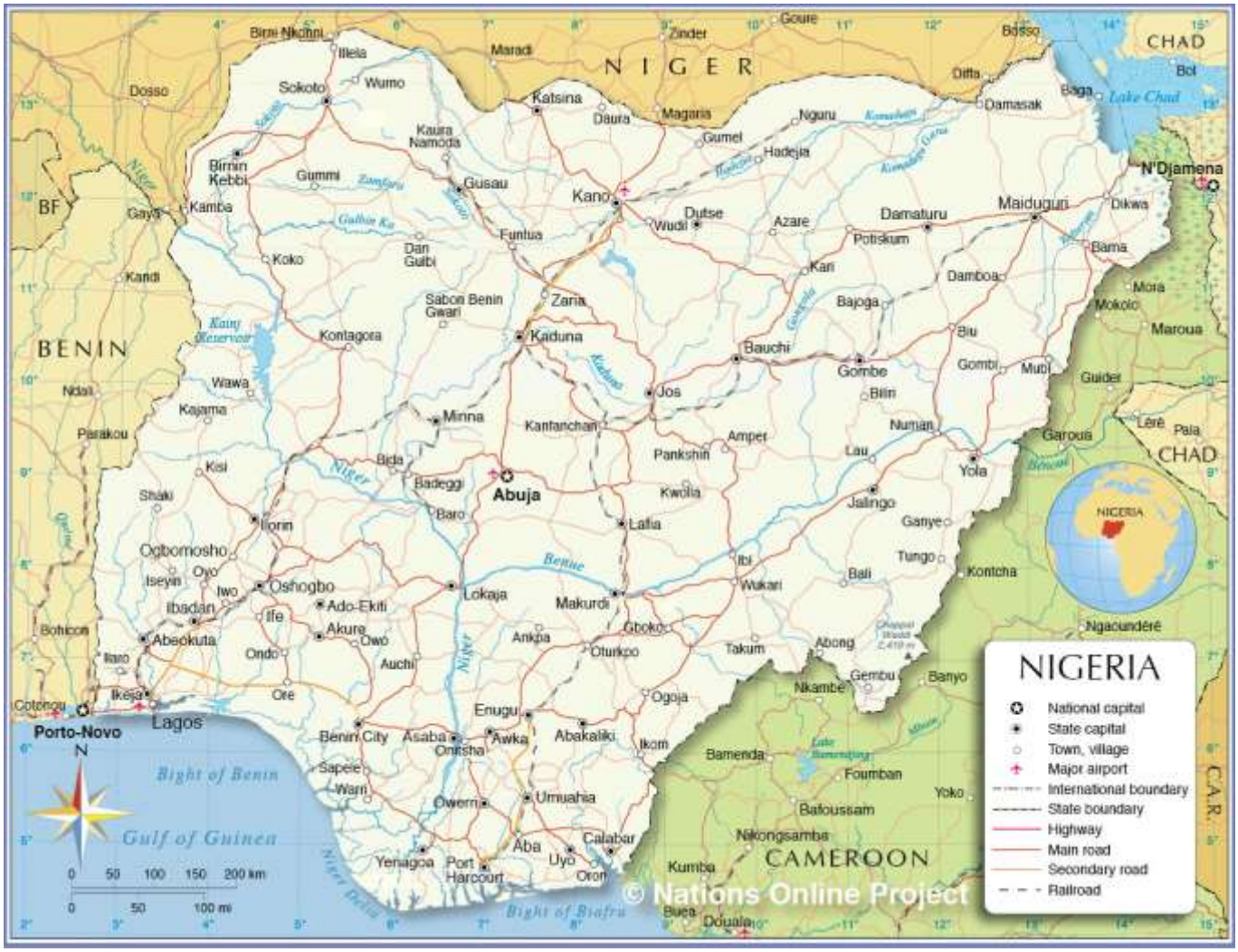


Figure 1: Map of the study area

**Source: https://www.nationsonline.org/oneworld/map/nigeria-political-map.htm#google_vignette**

**Table 1:** Descriptive features of violence-rated mortality by state

| states | Minimum | Maximum | Mean | Std. Deviation | Sum | Skewness | Kurtosis | % of total |
|---|---|---|---|---|---|---|---|---|
| Abia | 0.0224 | 5.3824 | 0.3069 | 0.4796 | 57.7040 | 6.9711 | 67.7862 | 1.4648 |
| Adamawa | 0.0194 | 13.8031 | 0.7878 | 1.6085 | 129.9804 | 5.3572 | 34.7524 | 3.2996 |
| Akwa Ibom | 0.0144 | 1.8259 | 0.1791 | 0.2228 | 34.3924 | 3.7439 | 19.3514 | 0.8731 |
| Anambra | 0.0208 | 14.1266 | 0.4781 | 1.0766 | 99.9146 | 10.4512 | 127.2477 | 2.5364 |
| Bauchi | 0.0130 | 5.1968 | 0.2982 | 0.4673 | 55.4742 | 7.0787 | 67.4854 | 1.4082 |
| Bayelsa | 0.0361 | 3.7227 | 0.5475 | 0.6434 | 108.9623 | 2.8391 | 9.5482 | 2.7661 |
| Benue | 0.0152 | 10.0253 | 0.6828 | 1.0740 | 139.2930 | 5.3792 | 37.6891 | 3.5360 |
| Borno | 0.0218 | 31.5400 | 3.9711 | 5.5098 | 802.1607 | 2.8623 | 9.5815 | 20.3633 |
| Cross River | 0.0213 | 3.1846 | 0.3691 | 0.4570 | 71.2272 | 3.0642 | 12.1135 | 1.8081 |
| Delta | 0.0229 | 13.4900 | 0.6366 | 0.9888 | 134.3189 | 10.8699 | 138.0141 | 3.4098 |
| Ebonyi | 0.0288 | 2.5381 | 0.3408 | 0.3395 | 63.0425 | 2.8533 | 12.5862 | 1.6004 |
| Edo | 0.0238 | 3.6143 | 0.4867 | 0.4719 | 102.2037 | 3.2787 | 16.5193 | 2.5945 |
| Ekiti | 0.0250 | 0.7334 | 0.1373 | 0.1205 | 24.4451 | 2.2400 | 7.0076 | 0.6206 |
| Enugu | 0.0186 | 1.0737 | 0.2349 | 0.1932 | 46.0434 | 1.6438 | 3.5432 | 1.1688 |
| FCT | 0.0205 | 8.1839 | 0.6623 | 0.8219 | 139.0783 | 4.7238 | 35.6319 | 3.5306 |
| Gombe | 0.0249 | 4.7494 | 0.3516 | 0.7135 | 50.6282 | 4.2930 | 19.6211 | 1.2852 |
| Imo | 0.0210 | 2.2015 | 0.2519 | 0.2600 | 50.6412 | 3.4799 | 18.6428 | 1.2856 |
| Jigawa | 0.0141 | 1.5873 | 0.1472 | 0.2085 | 22.3771 | 3.9067 | 20.1412 | 0.5681 |
| Kaduna | 0.0146 | 8.9556 | 0.6189 | 0.9217 | 126.2596 | 4.6129 | 33.7904 | 3.2052 |
| Kano | 0.0061 | 1.8886 | 0.1304 | 0.2012 | 26.2145 | 5.3009 | 36.7654 | 0.6655 |
| Katsina | 0.0128 | 1.7805 | 0.2826 | 0.3596 | 53.9776 | 2.2489 | 4.8093 | 1.3702 |
| Kebbi | 0.0184 | 3.3629 | 0.3175 | 0.5468 | 40.0026 | 3.6990 | 15.9699 | 1.0155 |
| Kogi | 0.0196 | 3.1542 | 0.3960 | 0.4069 | 79.9923 | 2.9366 | 13.4752 | 2.0306 |
| Kwara | 0.0263 | 2.8834 | 0.3700 | 0.4336 | 69.9206 | 2.6347 | 8.8600 | 1.7750 |
| Lagos | 0.1206 | 8.1538 | 0.5189 | 0.6252 | 109.4910 | 9.0331 | 106.6016 | 2.7795 |
| Nasarawa | 0.0325 | 10.6913 | 0.8086 | 1.4661 | 148.7738 | 3.9130 | 18.6838 | 3.7767 |
| Niger | 0.0164 | 5.9925 | 0.5029 | 0.7217 | 99.5725 | 4.1652 | 23.8381 | 2.5277 |
| Ogun | 0.0707 | 4.5861 | 0.5250 | 0.4392 | 109.7254 | 5.1010 | 39.5542 | 2.7854 |
| Ondo | 0.0229 | 1.3075 | 0.3015 | 0.2408 | 59.9944 | 1.4598 | 2.2835 | 1.5230 |
| Osun | 0.0171 | 1.1463 | 0.2046 | 0.1986 | 41.1311 | 1.8616 | 4.0570 | 1.0441 |
| Oyo | 0.0101 | 2.8257 | 0.2123 | 0.2606 | 44.3728 | 5.8966 | 51.4069 | 1.1264 |
| Plateau | 0.0217 | 16.2344 | 0.9722 | 2.1264 | 194.4302 | 5.6009 | 35.4059 | 4.9357 |
| Rivers | 0.0113 | 3.7674 | 0.4611 | 0.5141 | 97.2948 | 3.2792 | 15.1705 | 2.4699 |
| Sokoto | 0.0164 | 2.6228 | 0.2642 | 0.3638 | 42.2689 | 3.5367 | 17.5260 | 1.0730 |
| Taraba | 0.0283 | 12.7265 | 0.8926 | 1.4441 | 145.4906 | 4.8973 | 32.6421 | 3.6934 |
| Yobe | 0.0240 | 8.0125 | 0.9382 | 1.3597 | 138.8595 | 2.5625 | 7.6742 | 3.5250 |
| Zamfara | 0.0217 | 6.0443 | 0.9922 | 1.1555 | 179.5958 | 1.7679 | 3.0044 | 4.5591 |
| Total | 0.0061 | 31.5400 | 0.5618 | 1.3791 | 3939.2553 | 10.7549 | 170.0303 | 100.0000 |

## Methodology

Count and rate data are typically non-Gaussian distributed due to their high skewness. Suitable alternatives for modeling such data include the Poisson and Negative Binomial distributions. Therefore, this study employed Poisson and Negative Binomial time trend regression techniques, categorized under generalized linear models (GLMs), to analyze the variations in violent deaths related to time and monthly seasonal effects. Furthermore, the GLM can effectively handle over-dispersion in the data. In contrast, traditional linear models often struggle to accurately capture this phenomenon, leading to biased estimates of parameters and reduced precision in estimating population parameters.

The violent death denoted as $y$ is a count data and can be assumed to have Poisson and Negative binomial distribution. In the Poisson distribution, the violent death $y$ recorded at time interval $t$ has a probability mass function (pmf) given as;

$$P(Y = y, \gamma) = \frac{\lambda^y e^{-\lambda}}{y!} \quad (1)$$

The pmf has one parameter $\lambda$ which is the mean and the variance (equi-dispersion) and $y$ is nonnegative integer. A regression technique is adopted to model the expected count of violent death, $y, E(Y)$, as a function U of the set of predictor variables $X_1 \cdots X_K$ and $\beta$ coefficient given as; $\lambda = U(X, \beta)$ (2)

The substitution of equation 2 into 1 give the general form of the likelihood function for Poisson regression, expressed as;

$$L(Y; \beta) = \prod [U(X, \beta)]^Y \frac{e^{-U(X,\beta)}}{y!} \quad (3)$$

The estimates of parameter $\beta$ are obtained by maximizing the likelihood function. Also, it is necessary to know the function $U$ and it is generally assumed to be log-linear. This translates to modelling the natural log$(ln)$ of $E(Y)$ as the linear function of the matrix $X$ of the predictors. Thus,

$$U(X, \beta) = \exp(X\beta) = \exp(\beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \cdots + \beta_3 X_K) \quad (4)$$

Two separate Poisson regressions were fitted for each of the 36 states and the Federal Capital Territory (FCT) using maximum likelihood estimation in the STATA version 16 statistical package. The specifications of the model are;

$$\ln(\lambda_t) = E(Y) = \beta_0 + \beta_1 t, t = 0, 1, 2, \cdots, T \quad (5)$$

$$\ln(\lambda_t) = E(Y) = \beta_0 + \beta_1 t + \beta_2 D \quad (6)$$

The variables $t$ and $D$ in the equation (5) and (6) are the time trend and monthly seasonal dummies, respectively. AIC and BIC criteria are used to set optimal model.

The drawback of Poisson regression is the near impossible equi-dispersion assumption. The mean and variance are hardly equal in real life experience. As shown in table 1, the variances of the recorded violent death are greater than the mean for almost all the locations under study. This is commonly called over-dispersion problem.

Negative binomial distribution, however, is another exponential family distribution that is suitable for count or rate data and does not assume equi-dispersion assumption. In the Negative binomial distribution, $Y \sim Negbin(\lambda, \alpha)$ with $\lambda \geq 0$, $\alpha \geq 0$ and the violent death $y$ recorded at time interval $t$ has a probability mass function (pmf) given as;

$$P(Y = y;\ \lambda, \alpha) = \frac{\Gamma(\lambda+y)}{\Gamma(\lambda)\Gamma(y+1)} \left(\frac{1}{1+\alpha}\right)^{\lambda} \left(\frac{\alpha}{1+\alpha}\right)^{y} \quad (7)$$

The pmf has two parameters $\lambda$ and $\alpha$ with mean $\lambda$ and variance $\lambda + \alpha\lambda^2$. In this study, $\alpha$ represent the over-dispersion parameter that serves as the measure of dispersion and $y$ is nonnegative integer. For all the 36 states and Federal Capital Tertiary, two Negative binomial regressions were fitted. Hence, the model specification for a negative binomial is given as:

$$\ln(\lambda_t) = E(Y) = \beta_0 + \beta_1 t + e, t = 0, 1, 2, \cdots, T \quad (8)$$

$$\ln(\lambda_t) = E(Y) = \beta_0 + \beta_1 t + \beta_2 D + e \quad (9)$$

The exponential of the coefficient of Poisson and Negative binomial models were obtained using Poisson and Negative binomial regression. This is often referred to as rate ratio or

incidence rate ratio (IRR) and it allows interpretation of the result as a rate ratio or relative risk. In other words, it reveals how much the rate (or risk) of the event changes for a one-unit increase in the predictor variable, assuming all other variables in the model are held constant. A relative risk (RR) value is used to compare the likelihood of an event occurring in an exposed group versus a control group. In this study, an RR value of 1.00 would indicate that the risk of violence-related death is the same over the period, while RR values less than or greater than 1 portray a signal of a reduction (increase) in the risk of violent fatality instances. Consequently, RR was computed for each state and mapped to depict its spatial distribution.

**Results**

Violence-related deaths in Nigeria for the period under consideration range between 24 (Enugu) and 1765 (Borno), with a mean value of 276. Annually, the lowest and highest values of death due to violence were recorded in 2006 and 2014, respectively. Between 2008 and 2014, there was a continuous increase in the trend. The incidence rose again between 2018 and 2020, after declining between 2015 and 2017. Figure 3 presents the spatio-temporal distribution of violent deaths rate per 100,000 population between 2006 and 2023. It showed deaths due to violence are not evenly distributed across the states in the country, as well as dissimilar dynamics of violent death per state for the period under consideration. Around 2006 and 2008, states in the northern part of the country have experienced less violence compared to states in the southern part of the country, though some states in the north east and north central recorded elevated rates like their counterparts in the south east, south south, and south west. From 2011 upward, the pattern changed and states in the northern part of the country became less peaceful than the states in the southern region. It is worthy of note that the northeastern region had a consistent higher rate of violent death compared with other regions. In 2018 to date, the elevated violence incidence in the north-east zone had spread to other regions, with neighboring northern zones such as the north-west and north-central having a larger share of the spillover effects. Lagos State in the south west and Anambra State in the south east were also part of the states in the nation that had experienced a higher violent death rate than others. The changing dynamics of the violent death rate in the country could not be unconnected with several social unrest and extremist groups, such as the Boko-haram in the northern region, as well as the secession agitation for the Biafra nation and the End-SARS protest, which started in the south-

western part of the country, notably Lagos, and spread to other regions of the country. Herdsmen criminal activities in the south west, coupled with kidnapping and related happenings, had been threatening the peaceful coexistence of Nigeria. Figure 4 displays the total rate of violent death per state from 2006–2023. It portrayed Borno state as having the highest rate and was immediately followed by states like Zamfara and Plateau states, while Kano and Jigawa states could be regarded as relatively peaceful as their counterparts in other geopolitical political zones in the country.

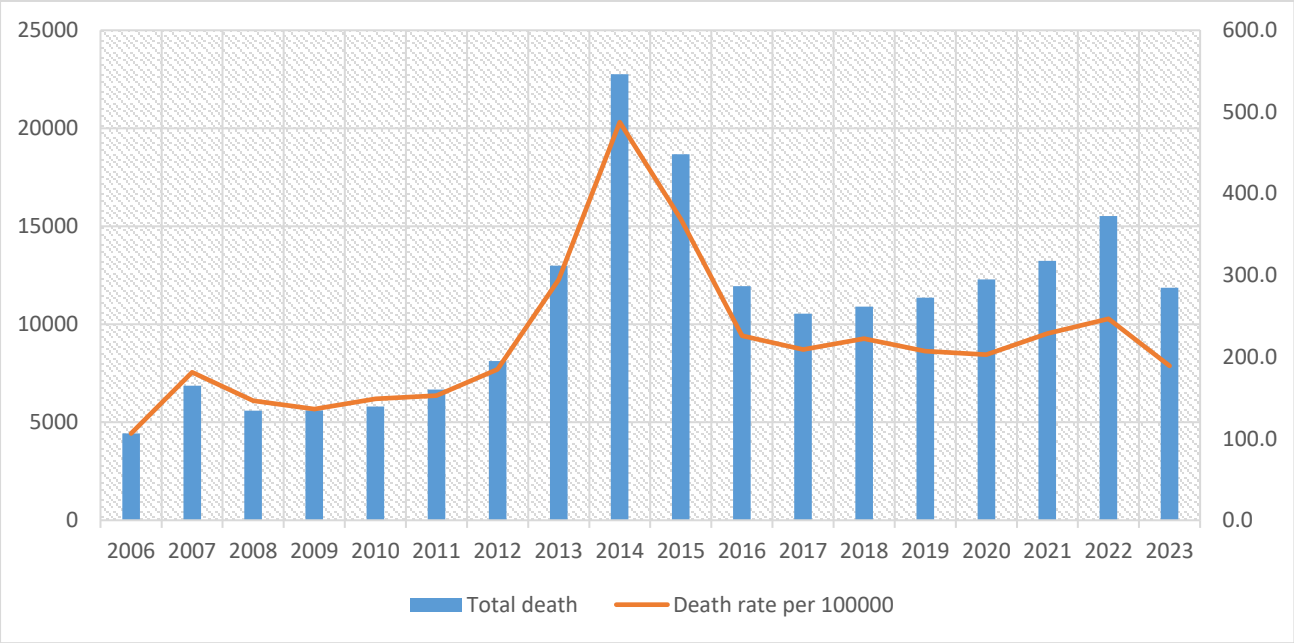


Figure 2: Distribution of violence-related total death (blue) and death rate per 10000 population (orange) in Nigeria from 2006-2023


Figure 3: Spatio-temporal distribution of annual violence-rated death rate per 100000

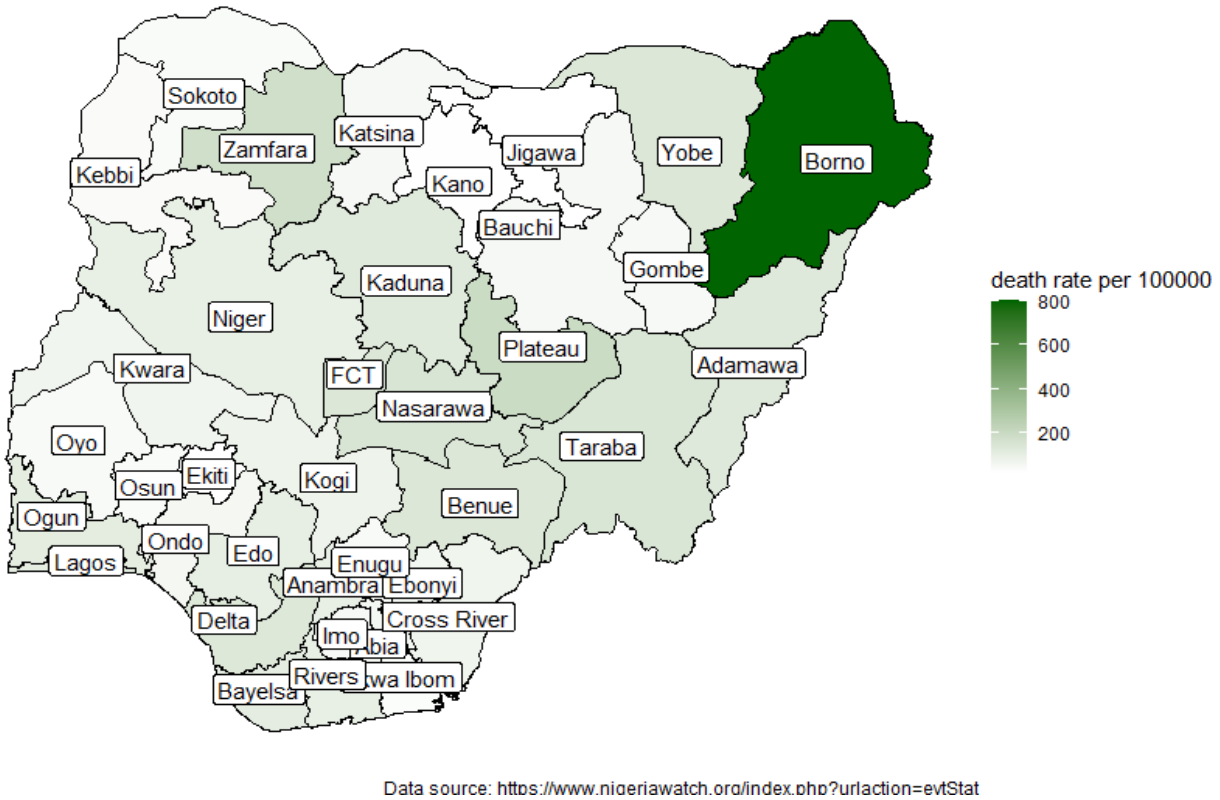


Figure 4: Spatial distribution of total violence-related death rates per 100000 population (2006-2023)

Table 2 is a significance test accessing the difference in the violent death rate per 100,000 across the six geopolitical zones in Nigeria. It depicted a statistically significant difference in

the rate ($F = 82.709$, $p < 0.05$), with the highest recorded in the north-east and followed by the north central, south-south, and north-west. While the south-east and south-west had recorded the lowest rate under the period considered.

Table 2: Differences in the mean monthly death rates per 100000 by geopolitical zone in Nigeria

| | Mean ± SD | 95% Confidence Interval for Mean | | Minimum | Maximum | F-statistics (P-value) |
|---|---|---|---|---|---|---|
| | | Lower Bound | Upper Bound | | | |
| North Central | $0.6280 \pm 1.1698^{b}$ | 0.5664 | 0.6896 | 0.0152 | 16.2344 | 82.709 (0.00000) |
| North East | $1.3121 \pm 3.0054^{a}$ | 1.1263 | 1.4979 | 0.013 | 31.54 | |
| North West | $0.4039 \pm 0.7114^{cd}$ | 0.3638 | 0.4439 | 0.0061 | 8.9556 | |
| South East | $0.3242 \pm 0.5842^{d}$ | 0.2875 | 0.3608 | 0.0186 | 14.1266 | |
| South South | $0.4510 \pm 0.6178^{c}$ | 0.4162 | 0.4857 | 0.0113 | 13.49 | |
| South West | $0.3224 \pm 0.3933^{d}$ | 0.3002 | 0.3446 | 0.0101 | 8.1539 | |

Note: Mean ± Standard deviation (SD) with different superscript is statistically significant at 5% level with a>b>c>cd>d

The study seeks to unearth the dynamics of violent death per state by using different models namely: Poisson time trend (M1), Poisson time trend with a monthly dummy (M2), negative binomial time trend (M3), and negative binomial time trend with a monthly dummy (M4). Results of the models were compared using two information criteria (Akaike and Bayesian). There a possibility of agreement and disagreement of the two criteria in selecting the adequate model for each state as shown in table 3. The two model selection criteria unanimously selected model specification 8 as the adequate model 26 times while they differ11 times. This gives a concordance and disconcordance rate 70.3% $((26/37) * 100)$ and 29.7% $((11/37) * 100)$, respectively. However, due to its higher penalty value compared to the AIC, the BIC-selected model is maintained in cases when they diverge (Vrieze, 2012). Thus, for violent fatality instances in each state, a negative binomial time trend is found appropriate. This result also justify the fact the data analysed was over-dispersed.

The relative risk (RR) for each state based on the best fit model is presented in the last column of Table 3. Based on the p-value of less than 0.05, 24 of out 37 states had statistically significant

trend change, while the remaining were insignificant. As seen in Figure 5, three states (8.1%) had a consistent trend of violence-related deaths over the study period, whereas seven (18.9%%) of Nigeria's states saw a minimal drop in the rate of violence-related mortality. 27 states (73.0%) have experienced a higher than average number of violent deaths. The 27 states with an increasing level of violence-related death were spread across the six geopolitical zones, with 6 states (Borno, Benue, Kogi, Kwara, Nasarawa, and Niger) in the north central, 5 states (Adamawa, Bauchi, Gombe, Taraba, and Yobe) in the north east, 7 states (Jigawa, Kaduna, Kano, Katsina, Kebbi, Sokoto, and Zamfara) in the north west, 4 states (Abia, Ebonyi, Enugu, and Imo) in the south east, only Akwa Ibom in the south, and 4 states (Ekiti, Ogun, Osun, and Ondo) in the south west. According to the ranking of relative risk presented in figure 6, Zamfara, Niger, Borno, Katsina, Sokoto, and Kaduna had increased by 1.6%, 1.4%, 1.3%, 1.2%, and 1.1%, respectively. The rate of increase in the trend in the remaining states ranges from 0.1% in Ekiti and Kano states, to 0.8% in Jigawa and Enugu states. Whereas, the number of deaths inflicted by violence decreased by 0.4% (1-0.996) in Bayelsa, Rivers, and Edo states; 0.2% in FCT-Abuja and Oyo State; and 0.1% in Bayelsa. This result indicates that violent death increases are not limited to a particular geopolitical zone but cut across zones at different magnitudes.

**Table 3:** Comparison accuracy measures of four models and estimate of best model per state

| | | AIC OF THE FITTED MODELS | | | | BIC OF THE FITTED MODELS | | | | MODEL | | MODEL ESTIMATES | | IRR |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Reg** | State | M1 | M2 | M3 | M4 | M1 | M2 | M3 | M4 | AIC | BIC | beta | P-value | Exp(beta) |
| **NORTH CENTAL** | Benue | 10831 | 8855 | 1936 | 1907 | 10838 | 8899 | 1946 | 1954 | M4 | M3 | 0.0053 | 0.014 | 1.005 |
| | Borno | 62088 | 60484 | 2592 | 2606 | 62095 | 60527 | 2602 | 2653 | M3 | M3 | 0.0131 | 0.001 | 1.013 |
| | FCT_Abuja | 3434 | 3364 | 1617 | 1631 | 3440 | 3408 | 1627 | 1678 | M3 | M3 | -0.0023 | 0.045 | 0.998 |
| | Kogi | 3761 | 3509 | 1610 | 1610 | 3767 | 3552 | 1620 | 1657 | M3 | M3 | 0.0025 | 0.050 | 1.003 |
| | Kwara | 3287 | 3093 | 1419 | 1424 | 3294 | 3136 | 1429 | 1471 | M3 | M3 | 0.0041 | 0.005 | 1.004 |
| | Nasarawa | 7953 | 7598 | 1558 | 1569 | 7960 | 7641 | 1568 | 1616 | M3 | M3 | 0.0017 | 0.443 | 1.002 |
| | Niger | 5865 | 5342 | 1685 | 1690 | 5872 | 5385 | 1695 | 1736 | M3 | M3 | 0.0144 | 0.000 | 1.014 |
| | Plateau | 15740 | 14772 | 1902 | 1906 | 15747 | 14816 | 1912 | 1952 | M3 | M3 | 0.0003 | 0.920 | 1.000 |
| **NORTH EAST** | Adamawa | 13055 | 12152 | 1634 | 1643 | 13062 | 12196 | 1644 | 1690 | M3 | M3 | 0.0057 | 0.040 | 1.006 |
| | Bauchi | 5332 | 5066 | 1607 | 1614 | 5338 | 5110 | 1617 | 1661 | M3 | M3 | 0.0031 | 0.135 | 1.003 |
| | Gombe | 4851 | 4474 | 1169 | 1174 | 4857 | 4518 | 1179 | 1220 | M3 | M3 | 0.0070 | 0.006 | 1.007 |
| | Taraba | 8882 | 7517 | 1581 | 1574 | 8889 | 7561 | 1591 | 1621 | M4 | M3 | 0.0067 | 0.018 | 1.007 |
| | Yobe | 10029 | 9381 | 1505 | 1517 | 10035 | 9425 | 1515 | 1564 | M3 | M3 | 0.0026 | 0.296 | 1.003 |
| **NORTH WEST** | Jigawa | 2865 | 2643 | 1154 | 1167 | 2872 | 2686 | 1164 | 1214 | M3 | M3 | 0.0078 | 0.000 | 1.008 |
| | Kaduna | 12957 | 11633 | 2008 | 1984 | 12963 | 11676 | 2018 | 2031 | M4 | M3 | 0.0104 | 0.000 | 1.010 |
| | Kano | 4853 | 4388 | 1588 | 1582 | 4860 | 4432 | 1598 | 1629 | M4 | M3 | 0.0008 | 0.599 | 1.001 |
| | Katsina | 5320 | 4981 | 1615 | 1622 | 5327 | 5024 | 1625 | 1669 | M3 | M3 | 0.0121 | 0.000 | 1.012 |
| | Kebbi | 4869 | 4416 | 1116 | 1118 | 4876 | 4460 | 1126 | 1165 | M3 | M3 | 0.0067 | 0.028 | 1.007 |
| | Sokoto | 3643 | 3433 | 1299 | 1312 | 3650 | 3477 | 1309 | 1359 | M3 | M3 | 0.0117 | 0.000 | 1.012 |
| | Zamfara | 9077 | 8582 | 1816 | 1830 | 9084 | 8626 | 1826 | 1877 | M3 | M3 | 0.0157 | 0.000 | 1.016 |
| **SOUTH EAST** | Abia | 3544 | 3226 | 1400 | 1400 | 3551 | 3270 | 1410 | 1447 | M3 | M3 | 0.0053 | 0.001 | 1.005 |
| | Anambra | 7975 | 7281 | 1792 | 1783 | 7982 | 7325 | 1802 | 1830 | M4 | M3 | 0.0005 | 0.868 | 1.000 |
| | Ebonyi | 2289 | 2254 | 1330 | 1343 | 2296 | 2298 | 1340 | 1390 | M3 | M3 | 0.0063 | 0.000 | 1.006 |
| | Enugu | 1640 | 1633 | 1130 | 1147 | 1647 | 1677 | 1140 | 1194 | M3 | M3 | 0.0084 | 0.000 | 1.008 |
| | Imo | 2982 | 2746 | 1492 | 1490 | 2989 | 2790 | 1502 | 1536 | M4 | M3 | 0.0057 | 0.000 | 1.006 |
| **SOUTH SOUTH** | Akwa Ibom | 2803 | 2512 | 1349 | 1337 | 2809 | 2556 | 1359 | 1384 | M4 | M3 | 0.0036 | 0.004 | 1.004 |
| | Bayelsa | 2955 | 2826 | 1434 | 1442 | 2962 | 2869 | 1444 | 1489 | M3 | M3 | -0.0031 | 0.051 | 0.997 |
| | Cross River | 3865 | 3594 | 1504 | 1507 | 3871 | 3638 | 1514 | 1554 | M3 | M3 | 0.0003 | 0.849 | 1.000 |
| | Delta | 5938 | 5239 | 1861 | 1845 | 5945 | 5283 | 1871 | 1892 | M4 | M3 | -0.0014 | 0.387 | 0.999 |
| | Edo | 3386 | 3286 | 1636 | 1649 | 3393 | 3329 | 1646 | 1696 | M3 | M3 | -0.0029 | 0.003 | 0.997 |
| | Rivers | 5592 | 5411 | 1851 | 1863 | 5599 | 5455 | 1861 | 1910 | M3 | M3 | -0.0030 | 0.001 | 0.997 |
| **SOUTH WEST** | Ekiti | 1249 | 1255 | 1011 | 1029 | 1255 | 1299 | 1021 | 1076 | M3 | M3 | 0.0014 | 0.277 | 1.001 |
| | Lagos | 6177 | 5633 | 2000 | 1998 | 6184 | 5677 | 2010 | 2045 | M4 | M3 | -0.0042 | 0.000 | 0.996 |
| | Ogun | 3459 | 3239 | 1725 | 1723 | 3466 | 3283 | 1735 | 1770 | M4 | M3 | 0.0037 | 0.000 | 1.004 |
| | Ondo | 2585 | 2487 | 1503 | 1513 | 2592 | 2531 | 1513 | 1560 | M3 | M3 | 0.0026 | 0.008 | 1.003 |
| | Osun | 2296 | 2211 | 1357 | 1363 | 2302 | 2255 | 1367 | 1410 | M3 | M3 | 0.0021 | 0.058 | 1.002 |
| | Oyo | 3198 | 2965 | 1560 | 1556 | 3205 | 3009 | 1570 | 1603 | M4 | M3 | -0.0022 | 0.091 | 0.998 |

Note

M1: Poisson time trend regression (Model 5, page 6)

M2: Poisson time trend regression with monthly dummy (Model 6, page 6)

M3: Negative binomial time trend regression (Model 8, page 6)

M4: Negative binomial time trend regression with monthly dummy (Model 9, page 6)

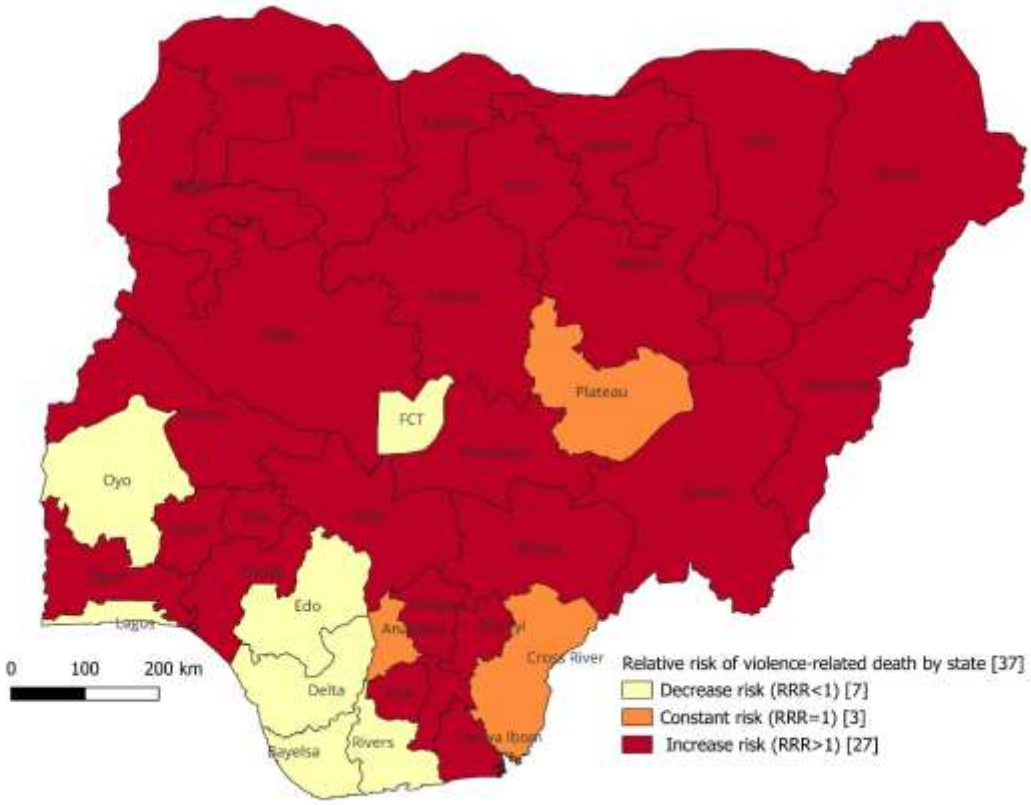


Figure 5: Spatial distribution of relative risk of violence-related death by state

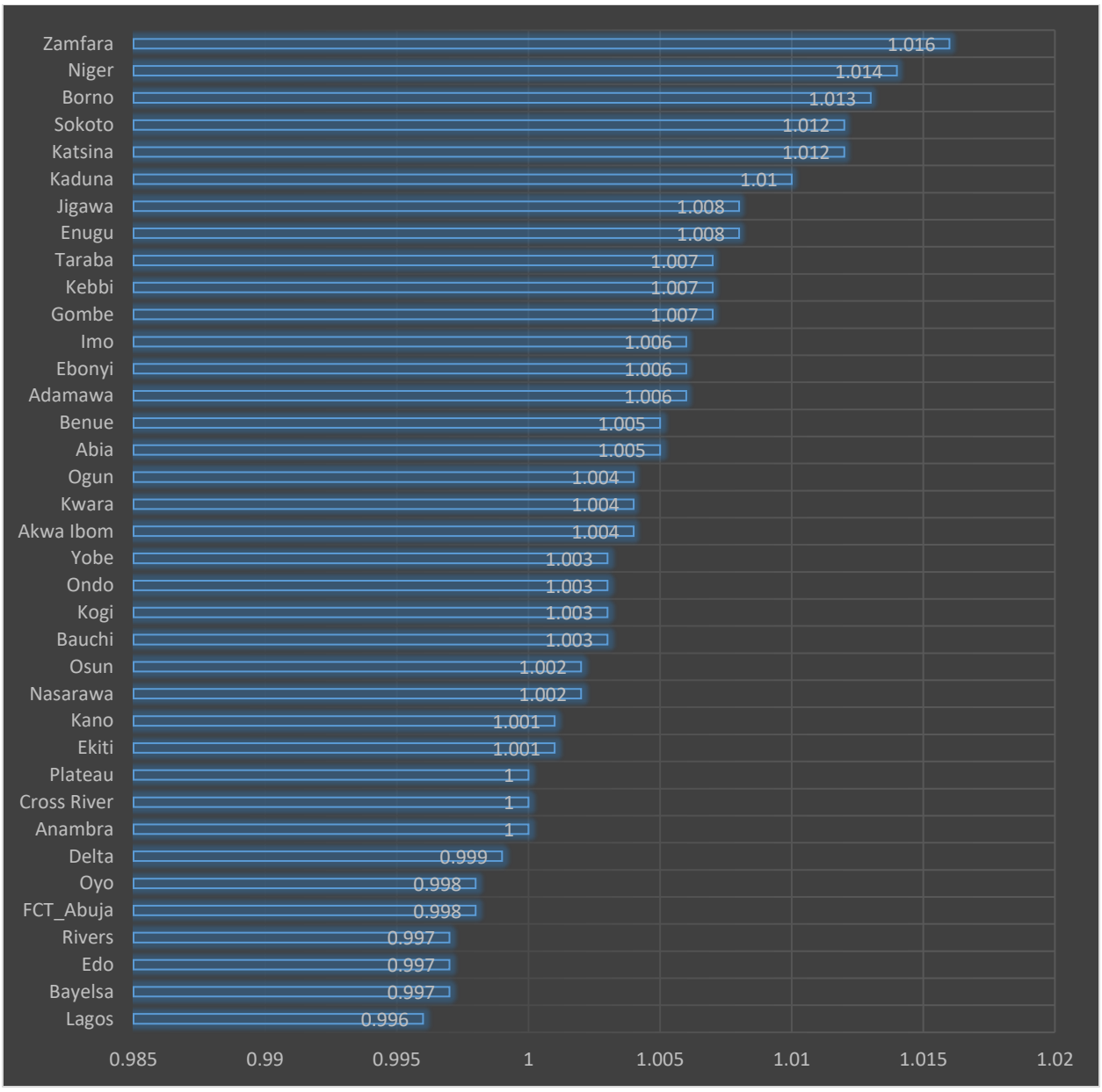


Figure 6: Rank of state according to the magnitude of relative risk of violence-related death

The relationship and effect of the violence-related death rate on some selected indicators of maternal and child health computed from nationally representative demographic and health surveys was examined. The attempt here was to assess how the incidence of violence could hamper public health. Table 4 presents correlation and regression analyses, and it showed that violence incidence has a negative impact on each of the selected maternal and child variables. Specifically, violence-related activities had a negative and insignificant effect on ultilisation of insecticide-

treated bednet, institutional delivery, BCG vaccination coverage, and antenatal care attendance, while a positive and insignificant association was established between the incidence of violence and measles cases. In the case of the regression result, it was noted that a unit increase in violent activities would reduce the chance of insecticide bednet ultilisation, institutional delivery, and BCG immunisation coverage by 0.186, 1.228, and 0.488, respectively. Whereas the possibility of having an increase in measles cases would result from recurrent violence-rated activities. The p-value associated with each of the regression coefficients was greater than 0.05, indicating that the impact was not statistically significant. This result indicated that a peaceful community seems to enjoy favourable public health. However, public health cannot be solely explained by violent activities, bearing in mind that there are several other factors that affect the effectiveness and efficiency of the health sector.

Table 4: Assessment of effect of violence incidence of public health

| **Violence-death rate** | LLIN net utilization | Institutional delivery | BCG | ANC | Measles |
|---|---|---|---|---|---|
| **Correlation coefficient** | -0.154 | -0.032 | -0.152 | -0.184 | 0.001 |
| **P-value** | 0.362 | 0.851 | 0.369 | 0.274 | 0.999 |
| **Regression coefficient** | | | | | |
| Intercept | 34.916(0.001) | 64.392(0.001) | 73.276(0.001) | 83.2390.001) | 12.154(0.001) |
| Beta | -0.186(0.706) | -1.228(0.133) | -0.488(0.369) | -0.822(0.051) | 0.001(0.996) |

**Discussion**

The findings of this study highlight significant regional and temporal patterns in Nigeria's violence-related fatality rate from 2006 to 2023. The violent death rates per 100000 ranged from 0.0061 in Kano to 31.5400 in Borno, with an average of 218.8475 per 100000 deaths annually. Therefore, interpreting these values in conjunction with presented figures and analyses yield a more complete picture. Violent mortality rates are continuously higher in northern states, particularly in the northeast than in southern regions, as revealed by the spatio-temporal distribution of annual violence-related death rates per 100000 population. Notably, following a temporary decline from 2015 to 2017, violence rose again from 2008 to 2014 and again from 2018

to 2020. These findings suggest cyclical patterns influenced by underlying socio-political instability, as revealed by previous studies (Fagbemi & Fajingbesi, 2022).

The northeast's persistently high rates underscore the devastation occasioned by the Boko Haram insurgency, supporting the report of the Armed Conflict Location and Event Data, (2023). While low rates of violence are recorded in the South, exceptions like Lagos (Southwest) and Anambra (Southeast) highlight how unequal violence is across different geographic locations (Montclos, 2016). Events like the End-SARS marches and separatist agitations have exacerbated these anomalies, pointing to a broader national issue with government and social cohesion (Global Conflict Tracker, 2023). The significant disparity in violence rates between the northeast and the north-central and south-south geopolitical zones indicates that the northeast is the most affected ($F = 82.709$, $p < 50$). These differences are in line with earlier studies that attribute violence in northern Nigeria to terrorism, banditry, and inter-communal conflicts (Saminu et al., 2022; Nwachukwu et al., 2023), While violence in the South is associated with protests, criminal activity, and political unrest (Ukoji & Ukoji, 2023). The evolution of violence, especially the way instability in the northeast is spreading to other regions, indicates a worrying diffusion effect that requires targeted interventions (Lenshie & Jacob, 2020).

The study presents significant public health implications as healthcare services in high-violence areas have increased challenges, including managing physical injuries, psychological distress, and displacement (Arage et al., 2023). Northeastern Nigeria is particularly affected by these problems, given the region already has a poor healthcare system (Arage et al., 2023). According to UNODC, (2023), the high prevalence of chronic illnesses and post-traumatic stress disorder (PTSD) among affected individuals underscores the need for integrated mental health care in conflict zones (Kar, 2024). Further exacerbating pre-existing disparities, the disruption of health services in these communities jeopardises routine care (Rivara et al., 2019).

From a policy viewpoint, these findings demonstrate the necessity of a multi-sectoral approach to violence reduction (Onifade et al., 2013b). While political uncertainty remains a substantial factor, it is important to address systemic issues such as poverty, unemployment and marginalisation (Fagbemi & Fajingbesi, 2022). Furthermore, targeted economic development programs and equitable resource distribution could reduce the root causes of violence, especially in northern Nigeria (Olumba, 2024). Additionally, the finding’s observation of violence's cyclical nature

suggests that short-term declines should not be confused with long-term stability (Onifade et al., 2013b). Instead, governments and other stakeholders must anticipate and stop potential resurgences through continuous peace-building efforts and community resilience projects (Hillis et al., 2017). Non-governmental organisations (NGOs) and international players have significant roles in supporting long-term conflict resolution; interventions should prioritise capacity building and local engagement (Marshall, 2020). For instance, resolving land-use conflicts and promoting intercommunal dialogue could lessen the frequency of violence in north-central states (Alimba, 2014). Similarly, promoting youth employment initiatives in violent regions can help reduce the number of individuals joining militant groups (Oluwaleye, 2021).

While this study highlights significant trends, it also highlights areas that require further research. Understanding the social and economic factors that contribute to regional variations in violence, for example, may increase the efficacy of targeted interventions (Onifade et al., 2013b). Further research is necessary to identify mediation factors, such as the quality of governance and the effectiveness of law enforcement, even if the association between political instability and violence is consistent with earlier findings (Kar, 2024). The report also suggests better data collection and monitoring techniques. The geographical differences in violent fatality rates that have been identified underscore the need for accurate and current statistics to inform policy and programmatic responses. According to Global Conflict Tracker (2023), strengthening the Nigeria Security Tracker and other monitoring systems will facilitate accountability and timely interventions.

The study offers a strong framework for comprehending violence dynamics by applying four different statistical models to analyse violent deaths across Nigerian states: Poisson time trend, Poisson time trend with a monthly dummy, negative binomial time trend, and negative binomial time trend with a monthly dummy. Accurate inference depends on the selection of proper models, as demonstrated by the comparison of model outcomes using the Akaike Information Criterion (AIC) and the Bayesian Information Criterion (BIC). The results show a 70.3% concordance rate between AIC and BIC, with the negative binomial time trend—the model chosen by BIC—maintaining its greater penalty value in the event of disagreement.

The negative binomial temporal trend model used in this study fits the data well since violent death records sometimes contain over-dispersed count data (Yirga et al., 2020). The model's capacity to

generate accurate estimates enhances a better understanding of trends in violent deaths across Nigeria (Lindén & Mäntyniemi, 2011). While the model addresses statistical over-dispersion, it model does not sufficiently account for the political and socioeconomic factors that significantly impact violence (Lindén & Mäntyniemi, 2011). The findings show that most Nigerian states have seen an increase in violent fatalities, with the north-central, north-west, and north-east regions having the highest rates (Elachi et al., 2015; Olarewaju, 2021). While deaths from violence have significantly increased in states like Borno, Katsina, and Zamfara, a lesser percentage of states, such as Bayelsa, Rivers, and FCT-Abuja, had a tiny decline in the rate of violent deaths. However, these declines were not statistically significant. This suggests that while there have been some localised improvements in the degree of violence, the overall trend in Nigeria remains alarming, with an increase in violence observed in a sizable number of states (Ukoji & Ukoji, 2023). Even though political instability is commonly cited as a primary driver of violence, this study highlights the need to look into other factors, such as socioeconomic conditions and the quality of governance, to understand better the complex dynamics of violence in the country (Fagbemi & Fajingbesi, 2022).

There are important public health implications from the apparent declines in violent deaths in certain states. These findings could guide the distribution of resources and focused initiatives, implying that effective strategies in places with higher levels of security could be modified for application in more violent locations (Armstead et al., 2021). By giving security services a data-driven foundation for more strategic resource and manpower allocation, the approach may increase the efficacy of efforts to avoid violence (Willis et al., 2019). Within a more comprehensive framework, this research offers significant insights into the dynamics of violence at the state level in Nigeria, highlighting the necessity of specialised approaches to violence prevention and control (Braaf & Meyering, 2013). To provide a more comprehensive knowledge of the root causes of violence and the efficacy of different intervention measures, future research should incorporate qualitative insights in addition to quantitative findings (Aspers & Corte, 2019).

The findings demonstrate substantial regional differences and temporal fluctuations and offer important new insights into the distribution and patterns of violent deaths in Nigeria. While 2 states consistently reported decreases in violence-related mortality and 9 states showed slight decreases, the data indicates that violent death rates have decreased by 0.2% and 0.1% in Delta and Edo states,

respectively. The outcomes are consistent with reports in the ACLED, (2023), which details comparable regional differences and continuous security issues throughout Nigeria.

The prevalence of violence in Nigeria is demonstrated by the fact that 70.3% of the states have higher-than-average rates of violent deaths. This is consistent with the Global Terrorism Index (GTI) which identifies Nigeria as one of the countries most affected by terrorism and violent conflicts, particularly in the northern part of the country (Institute for Economics and Peace, 2023). The fact that the majority of states with increased rates of violent deaths are in the northern region—42% each in the North West and the North East, and 16% in the North Central—confirms the dire consequences of insurgencies like Boko Haram and banditry (Tafida et al., 2023). This is consistent with research that shows how these regions' persistent war and instability provide serious security issues (Arage et al., 2023).

The findings show that violence in Nigeria is spreading throughout the country's southern regions, including the South East, South-South, and South West. This shift shows that violence has spread more extensively across regional boundaries, challenging the notion that it is primarily a northern issue (Mamman, 2020). The rise in violent deaths in these southern states highlights the need for a more comprehensive understanding of Nigerian violence since it points to a more pervasive, systemic problem of insecurity that needs to be addressed in all regions (Onifade et al., 2013). The increased violence is not only a security concern but also a public health one that is impacting communities across the country. The rise in violent deaths, which is linked to higher mortality rates and higher healthcare burden, exacerbates health inequities (Alumona et al., 2019). Given the geographic dispersion of violence, region-specific approaches are essential to addressing the problem. The southern regions may experience distinct causes of violence, such as economic reasons, necessitating focused development and intervention measures, whilst the northern regions might need counterinsurgency efforts to address political and militant violence (Olumba, 2024). The intricacy of the violence and its effects on public health throughout Nigeria are highlighted by this regional diversity.

## Conclusion

This study offers a thorough investigation of Nigeria's violence-related mortality rate, illuminating the intricate dynamics and geographical differences that underpin this pressing public health concern. The current research's findings highlight how crucial it is that governments and

policymakers prioritize evidence-based tactics to reduce violence and encourage peaceful coexistence in Nigeria, as the study's geographical analysis and Poisson temporal trend analysis demonstrated. According to the study's spatial analysis and Poisson temporal trend analysis, violence is dispersed throughout the nation in a variety of patterns and amounts, rather than being concentrated in one area. The regional differences in violent deaths are a reflection of this complexity.

The identified disparity in trends implies that violent crime rates and the deaths that ensue are influenced by underlying factors in different regions. States that have growing spatial disparities in the number of violent crime-related deaths may be grappling with problems such as socioeconomic disparities, social unrest, insufficient resources for law enforcement, and limited access to opportunities for education and employment. A violent environment that increases the likelihood of violent crimes and the deaths that ensue could be fostered by these elements.

On the other hand, the decrease in the spatial distribution of fatalities connected to violent crime may have been a result of state-specific laws and initiatives targeted at curbing violence. It is likely that these jurisdictions focused on tackling the underlying causes of violence, such as poverty and inequality, and boosted financing for mental health services and gun control laws. Political violence is a factor that inflated mortality rate connected to violence, placing a serious burden on public health, as evidenced by substantial rate of violent death in 2014 and 2015, respectively. These results imply that the present approaches to addressing violence in Nigeria are insufficient, and that more potent strategies are required to lower the prevalence of violence and the ensuing negative effects on public health.

The implications of this study are clear: to reduce violence and encourage peaceful coexistence in Nigeria, governments at all levels must prioritise evidence-based policies. This necessitates a multidimensional strategy that tackles the underlying causes of violence, such as social injustice, poverty, and inequality. It also necessitates the creation of efficient laws and initiatives that support social harmony, community involvement, and dispute resolution. In summary, this study makes a significant contribution to our knowledge of the death rate associated with violence in Nigeria. The results of this study highlight the pressing need for governments and policymakers to give evidence-based approaches a high priority to reduce violence and encourage peaceful coexistence in Nigeria. Nigeria can lessen the prevalence of violence and the associated health consequences

for its citizens by implementing a comprehensive and context-specific strategy that targets the underlying causes of violence, fosters community involvement, and fosters social cohesion.

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