Spatio-Temporal Dynamics and Policy Implications of Road Traffic Crashes Involving Bystander Fatalities in Nigeria (2005–2025)

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ABSTRACT

Stationary roadside bystander fatalities, involving non-vehicle occupants residing, trading, or present near roadways without walking or crossing at the time of a crash, represent an under-examined aspect of Nigeria's road safety crisis. This study examined temporal dynamics, spatial hotspots, and crash typologies associated with stationary bystander fatalities from road traffic crashes (RTCs) in Nigeria (2005-2025). A retrospective longitudinal design used systematically coded secondary crash data from eight verified media sources. Stationary bystander fatality was defined as a non-vehicle occupant present within or adjacent to a roadside settlement, market, or residential cluster who was not actively walking or crossing, excluding active pedestrians. Data were analyzed using quasi-Poisson regression, Getis-Ord Gi* spatial hotspot detection, and typological classification of 40 verified incidents. Forty incidents resulted in a midpoint estimate of 1,166.5 fatalities (range: 1,085-1,248). Temporal analysis revealed a significant annual increase of 4.9% (IRR = 1.049, 95% CI: 1.032-1.067, $p < 0.001$), with post-2019 marking an escalation phase. Year 2024 recorded the highest fatalities (midpoint: 251.5), confirming episodic clustering. Fuel tanker explosions accounted for 73.0% of deaths, followed by truck-into-market crashes (9.1%) and vehicle incursions into residential areas (17.9%). Heavy-duty vehicle crashes contributed 82% of fatalities. Lagos and Anambra were the most frequent incident zones; Jigawa was a statistical hotspot (Gi* $z = 2.598$, $p < 0.05$). Stationary bystander fatalities in Nigeria increased significantly over two decades, driven by fuel tanker explosions and heavy-vehicle incursions into roadside settlements. Recommendations include temporal risk forecasting, corridor-based safety zones, a hazardous materials transport code, setback enforcement, market relocation, and anti-fuel-scooping sensitization.

Keywords: Bystander Fatalities, Road Traffic Crashes, Spatio-Temporal Analysis, Tanker Explosions and Heavy-Duty Vehicles, Transport Safety Policy, Urban Corridor Risk

INTRODUCTION

Road traffic crashes (RTCs) are a major global public health burden, responsible for approximately 1.19 million people die each year from road traffic crashes worldwide, with tens of millions more suffering non-fatal injuries worldwide (World Health Organization [WHO], 2023). Over 90% of these deaths occur in low- and middle-income countries (LMICs), despite their lower vehicle ownership rates, reflecting gaps in safety infrastructure, enforcement, and urban planning. Sub-Saharan Africa records the highest regional RTC fatality rates globally, with Nigeria consistently among the most affected countries (Odusola, Olaleye, & Ogunbode, 2023). According to the Nigerian Bureau of Statistics (2023), over 5,500 deaths and 39,000 injuries were reported from RTCs in 2023 alone, and the fatality rate per 100,000 population in Nigeria (20.75) exceeds the global average of about 15 per 100,000. These statistics underscore the urgency of addressing RTCs as both a public health and sustainable development priority.

While existing policies and scholarship have largely focused on drivers, passengers, and active road users, there has been little attention on bystanders or third-party victims people killed while residing, working, or trading along highways. Informal roadside markets, homes, and workshops are prevalent along Nigerian highways and urban arterial roads, exposing occupants to vehicle run-offs, tanker explosions, and loss-of-control crashes (Awoniyi et al., 2022). These victims are typically absent from formal crash reporting templates, which categorize fatalities primarily by road-user class (motorist, passenger, or pedestrian), masking the vulnerability of people not engaged in traffic at the time of their deaths (Onyemaechi et al., 2016). This systematic invisibility obscures their protection needs and perpetuates policy neglect.

Despite the severe human cost, no study has conducted a multi-decade spatial and temporal trend analysis of RTC bystander fatalities in Nigeria. Prior analyses have generally aggregated all crash deaths without disaggregating by location or victim context (Awoniyi et al., 2022; Odusola et al., 2023). Official statistics from the Nigerian Bureau of Statistics (2023) and Federal Road Safety Corps also do not tag “bystanders” or “roadside residents” as separate victim categories, complicating evidence-based planning for at-risk roadside settlements. This leaves critical gaps in understanding how market encroachment, informal settlement growth, and transport network design intersect to increase bystander vulnerability.

In response to the paucity of systematically analyzed national data on bystander fatalities in Nigeria, this study investigates the spatio-temporal dynamics and policy implications of road traffic crashes involving bystander deaths between 2005 and 2025. It addresses critical empirical and policy gaps by integrating temporal trend modelling, spatial hotspot mapping, and crash-type characterization derived from verified Nigerian media reports as the primary data source. Through this nationwide analysis, the study aims to quantify the magnitude, distribution, and dominant causal mechanisms of bystander-related crashes, thereby providing an evidence base for data-driven policy interventions and safety governance reforms.

LITERATURE REVIEW

Global View of RTCs and Roadside Settlements

Road traffic crashes (RTCs) present a substantial burden globally, especially in low- and middle-income countries (LMICs), where infrastructure deficits, rapid urbanization, and informal land use often combine to elevate risk (WHO, 2023). Several case studies outside Nigeria illuminate how roadside or settlement proximity to highways increases injury and fatality risks among non-vehicle occupants. For example, a study in Nepal documented that informal settlements along major arterial roads experienced significantly higher crash rates and pedestrian fatalities compared to planned neighborhoods (Pandey, 2022) In many Latin American cities, similarly, market-front shops and roadside vendors are exposed to run-off crashes and structural damage from collisions involving heavy vehicles (Global Road Safety reports) (World Bank, 2022). These studies regularly show spatial clustering of events along highways where informal settlements, markets, and encroachments exist.

The informal economy globally is vast by some estimates over two billion people engage in informal employment, many in sectors connected with markets and roadside trading (ILO, OECD, 2019) .This work highlights vulnerability in multiple dimensions, lack of regulated space, exposure to environmental hazards, and minimal legal protection. Studies in Sub-Saharan Africa and Southeast Asia reveal that encroachment into road right-of-way (RoW) by traders, market stalls, and informal housing both intensifies exposure to traffic hazards and complicates enforcement of traffic safety legislation (Road Safety Financing Reports; Making Roads Safer World Bank evaluations) Moreover, vulnerability is not only physical but socio-economic: informal traders often cannot afford safer structures or relocation, making them persist in hazardous locations (ILO / OECD, 2019)

"Global road safety metrics (WHO, 2023) aggregate all non-occupant fatalities under a single "pedestrian" class. This aggregation conflates qualitatively distinct risk populations: active pedestrians (crossing/walking), roadside walkers, and stationary bystanders' individuals residing, trading, or otherwise present in roadside environments but not engaged in active travel. Stationary bystanders face distinct exposure mechanisms (building collapse, post-crash fire, vehicle incursion into structures) not shared by moving pedestrians. Nigerian crash databases (FRSC, NBS) do not distinguish these subcategories, rendering stationary bystander deaths invisible in policy discourse. This study isolates and quantifies stationary bystander fatalities as a distinct analytical category.

Empirical Gaps in the Nigerian Context

From the global and national literature, key gaps emerge. First, there is a scarcity of multi-decadal quantitative analyses that isolate stationary bystander fatalities in roadside houses, markets, and settlement frontages. Second, few studies provide spatial hotspot analyses for these fatalities in Nigeria or similar settings, though global studies have done so in limited areas. Third, typologies of incident types that produce high bystander harm (e.g., tanker explosions versus vehicle run-offs) are seldom compared in developing country settings. Finally, there is limited research translating these insights into policy-oriented recommendations specifically targeted at protecting stationary roadside populations as opposed to general road user interventions.

This study aims to fill these gaps by: (i) assembling a harmonized stationary-bystander-only dataset (2005–2025) from verified media reports; (ii) mapping spatial patterns and identifying hotspots using the Getis-Ord Gi* statistic; (iii) analysing incident typologies and temporal trends using Poisson regression; and (iv) deriving policy measures targeted specifically to roadside market and settlement exposure for stationary populations.

METHODOLOGY

Research Design and Data Sources

This study employed a retrospective longitudinal design to analyze the spatial and temporal patterns of bystander fatalities arising from road traffic crashes (RTCs) in Nigeria between January 2005 and December 2025. The choice of a longitudinal design was informed by the need to capture both the evolution of bystander fatality patterns and the persistence of spatial hotspots over time. Unlike official crash databases, which often not separately report roadside or non-occupant deaths, newspaper-based data provide a more granular representation of community-level vulnerability by documenting not only the fatalities but also the socioeconomic contexts of the affected locations.

The primary data source consisted of newspaper reports systematically retrieved from eight major national and regional dailies: The Guardian, Vanguard, Punch, Premium Times, Daily Trust, The Nation, PM News, and Independent Nigeria. These media houses were selected for their wide geographical reach, consistent digital archiving, and reputational reliability in reporting human-impact incidents. Complementary sources such as The Cable, BBC Africa, and the Nigeria Press Council's online repository were also consulted to corroborate specific cases and verify casualty figures. Articles were identified through structured searches of each newspaper's digital archive and Google News using a set of carefully selected keywords, including "tanker explosion," "truck crashes into market," "runaway vehicle," "roadside residents killed," "market stalls destroyed," and "lorry veered off the road." This approach ensured comprehensive capture of incidents that fit the conceptual focus on bystander exposure to transport externalities in roadside environments.

Newspapers were used as the primary data source due to their capacity to document both the human and contextual dimensions of RTCs, including details on location, settlement type, and community impact variables often missing in official datasets. Furthermore, given the sociopolitical and infrastructural heterogeneity across Nigerian states, media reports offer valuable insights into how the built environment, market proximity, and road conditions interact to produce differential risks to roadside populations.

Case Selection and Validation

A rigorous multi-stage filtering process was applied to isolate cases meeting the study's criteria. Incidents were included if they occurred in Nigeria between January 2005 and December 2025; involved at least one stationary bystander fatality; and occurred within or adjacent to a built-up roadside environment such as markets, dwellings, or areas of stationary human activity. A stationary bystander fatality was defined as the death of a non-vehicle occupant present within or adjacent to a roadside settlement, market, or residential cluster who was not actively walking or crossing a roadway prior to the incident. This includes roadside residents, market traders and vendors, and other stationary individuals (e.g., waiting, fuel collection). Excluded were active pedestrians, vehicle occupants, and cases where stationary status could not be confirmed. Active pedestrians were excluded to isolate stationary presence as a distinct vulnerability mechanism, ensuring complementarity with existing FRSC and NBS pedestrian statistics. Reports lacking geographical identifiers, involving only property damage, or describing pipeline explosions or industrial fires were also excluded. Duplicate reports were reconciled using date-location matching and fuzzy detection algorithms, retaining only the most corroborated version. Following screening, forty verified unique stationary bystander-fatal incidents constituted the final dataset. Appendix 2 provides comprehensive metadata for each event, ensuring transparency and replicability.

Data Abstraction and Coding Framework

For each verified incident, a structured coding protocol was applied to extract relevant temporal, spatial, and contextual attributes. The protocol was developed in line with event-based data curation standards for disaster epidemiology and road safety analytics. Extracted variables included the date of occurrence, year, state, and locality; the type of crash (e.g., tanker explosion, truck veering into a market, or multiple-vehicle collision); vehicle types involved; number of fatalities and injuries; property damage details; and the name of the reporting newspaper, publication date, headline, and URL. These variables were manually entered into a structured spreadsheet and later harmonized through programmatic consistency checks in R (v4.3.3).

For each incident, the minimum fatality represents the number of confirmed deaths explicitly reported in at least two independent media sources. The maximum fatality count represents the upper bound reported by any source, including estimates or unconfirmed reports. Where multiple sources provided differing figures, the most conservative (lowest) was used as the minimum, and the highest credible figure as the maximum. Two (2) levels of data validation were implemented to ensure integrity and reliability. First, source triangulation was performed by cross-verifying each event against at least two independent news outlets, prioritizing those with photographic or eyewitness corroboration. Second, internal consistency screening was undertaken through date location type matching and fuzzy text comparison to detect potential duplicate entries. The combination of these approaches produced a high-confidence dataset, minimizing reporting bias and misclassification errors. This methodological rigour is consistent with best practices in event-based fatality data harmonization (Profisee, 2023; WinPure, 2025).

Statistical and Spatial Analysis

Descriptive statistics were first computed to summarize incident frequencies, mean fatalities per event, and proportions of crash types. Temporal trends were analyzed using a Poisson regression model to estimate the rate of change in annual bystander fatality counts across the 21-year period (2005–2025). The model assumed a log-linear relationship between time and the expected number of fatalities, specified as:

$$\log(E[Y_t]) = \propto + \beta t$$

where Y_t represents the annual fatality count (using the midpoint of the min–max range for each incident, summed by year), t denotes the year (centered for interpretability), $\alpha\alpha$ is the intercept, and β is the annual growth rate parameter. The incidence rate ratio (IRR) was computed as e^{β}.

The Poisson framework was selected for its suitability with count-based rare event data. However, given the presence of overdispersion (variance exceeding the mean), standard errors were adjusted using a quasi-Poisson correction. A 95% confidence interval was reported for the trend estimate, and goodness-of-fit was assessed via residual deviance.

To identify statistically significant spatial clustering, the Getis-Ord Gi* statistic was applied using 999 Monte Carlo permutations and inverse distance weighting to detect high-value (hot spot) and low-value (cold spot) clusters. Global Moran's I was also computed to test overall spatial autocorrelation across the national dataset.

Ethical Considerations and Data Reliability

The study relied exclusively on secondary, publicly available media data and did not involve any direct human subjects; hence, formal institutional ethical approval was not required. Nevertheless, ethical principles governing the use of public data were strictly adhered to, following international standards for secondary data research (Tripathy, 2013; Sun Research Ethics Guidelines, 2020). All incident records were fully anonymized, and identifying details of victims or eyewitnesses were omitted. The entire data collection, cleaning, and analytical process were transparently documented to ensure reproducibility. Sensitivity analyses were further performed to assess the robustness of temporal trends and spatial clustering results under varying inclusion thresholds.

DATA PRESENTATION AND INTERPRETATION

The Road Traffic Accident Temporal and Bystander Fatalities Trends

This section examines the temporal distribution and typological pattern of roadside bystander fatalities across Nigeria between 2005 and 2025, using verified incident records compiled from multiple secondary and validated media sources. The analysis presented in Table 1 captures the annual and decadal fluctuations in the frequency and severity of bystander-involved crashes, revealing underlying temporal dynamics in accident occurrence and fatality intensity. Complementing this, Table 2 classifies the incidents by crash type such as tanker explosions, vehicle collisions, brake failures, and market-related accidents highlighting the relative contribution of each crash category to total bystander fatalities.

Table 1. Temporal Distribution of Roadside Bystander Fatalities in Nigeria, 2005 – 2025

Year	Incidents	Fatalities (min)	Fatalities (max)	midpoint
2005	1	15	15	15.0
2006	1	54	54	54.0
2007	1	70	99	84.5
2008	1	30	30	30.0
2009	2	78	88	83.0
2011	2	54	56	55.0
2012	1	95	124	109.5
2013	1	36	36	36.0
2014	1	15	15	15.0
2015	2	8	8	8.0
2017	1	2	2	2.0
2018	1	9	12	10.5
2019	5	74	79	76.5
2020	5	107	107	107.0
2021	1	10	10	10.0
2022	1	6	6	6.0
2023	3	20	20	20.0
2024	6	219	284	251.5
2025	5	182	198	190.0
Total	**40**	**1 085**	**1 248**	**1,166.5**

Notes: *min = confirmed fatalities reported in at least two independent media sources. max = upper bound from any credible source (includes estimates). **Midpoint = (min + max) / 2, used for statistical modeling.

Table 1 presents the temporal distribution of roadside bystander fatalities in Nigeria over a 21-year period (2005-2025), capturing both the frequency of incidents and the associated fatality ranges. A total of 40 verified incidents were recorded, resulting in between 1,085 and 1,248 deaths, with a midpoint estimate of 1,166.5 fatalities. The average incident caused approximately 29.2 deaths (midpoint), indicating high severity per event. The early years (2005-2011) were characterized by sporadic but highly fatal incidents. For example, 2006 and 2007 saw single tanker-related explosions causing 54 and up to 99 fatalities, respectively. A noticeable lull occurred between 2013 and 2018, when incidents became fewer and more localized, possibly reflecting temporary improvements in fuel distribution safety or enforcement.

However, from 2019 onward, a sharp resurgence in both frequency and severity is evident. The year 2020 recorded five incidents and 107 confirmed fatalities, suggesting increased exposure of bystanders to roadside hazards amid expanding highway encroachments and informal trading. The peak occurred in 2024, with six incidents and a midpoint of 251.5 fatalities the highest in the study period. The year 2025 also recorded high severity, with five incidents and a midpoint of 190.0 deaths.

The data underscore a post-2019 escalation phase, marking a shift from isolated explosions to recurrent multi-vehicle and market-related crashes. This trend aligns with broader evidence of increasing population pressure and unregulated land-use conversion along major transport corridors. Overall, the pattern demonstrates that bystander fatalities from road traffic incidents are not random but temporally concentrated, reflecting systemic infrastructural, regulatory, and behavioral weaknesses in Nigeria's road safety framework.

Table 2. Distribution of Crash Types and Associated Fatalities

Crash Type	**Incidents**	**Fatalities (min)**	**Fatalities (max)**	**Midpoint**	**% of Total (midpoint)**
Tanker / Fuel explosions	20	776	927	851.5	73.0%
Truck / Container crashes into markets or buildings	12	104	109	106.5	9.1%
Other (vehicles veering into residential areas or shops)	8	205	212	208.5	17.9%
Total	**40**	**1 085**	**1 248**	**1,166.5**	**100%**

Note: Percentages calculated using midpoint fatalities. Tanker explosions alone account for nearly three-quarters of all bystander deaths.

Table 2 summarizes the frequency and fatality levels associated with different crash types resulting in roadside bystander deaths in Nigeria between 2005 and 2025. Tanker and fuel explosions account for the highest number of incidents (20 cases, 50% of all incidents) and the vast majority of fatalities, ranging between 776 and 927 deaths. Using the midpoint estimate, tanker explosions alone contributed 73.0% of all bystander fatalities over the 21-year period nearly three-quarters of the total burden.

Truck and container crashes into markets or buildings represent the second most frequent category, with 12 incidents (30% of incidents) and between 104 and 109 fatalities (9.1% of total midpoint fatalities). This confirms that heavy goods vehicles contribute significantly to roadside casualties, particularly in market-dense corridors.

The "other" category covering vehicles veering into residential areas or roadside shops records 8 incidents (20% of incidents) but between 205 and 212 fatalities (17.9% of total midpoint fatalities). This indicates that although less frequent, such crashes often result in high fatality counts per incident, reflecting the vulnerability of residential roadside settlements.

Generally, Table 2 highlights that tanker and truck-related crashes are the predominant causes of roadside bystander fatalities, collectively accounting for all 40 incidents and an estimated 1,166.5 midpoint deaths over the study period.

Table 3. Observed and Poisson-Predicted Media-Reported Fatalities in Nigeria (2005-2005)

Year	Observed Fatalities (min)	Poisson Predicted Trend
2005	15.0	27.8
2006	54.0	29.6
2007	84.5	31.5
2008	30.0	33.5
2009	83.0	35.6
2010	0.0	37.9
2011	55.0	40.3
2012	109.5	42.9
2013	36.0	45.6
2014	15.0	48.5
2015	8.0	51.6
2016	0.0	54.9
2017	2.0	58.4
2018	10.5	62.1
2019	76.5	66.1
2020	107.0	70.3
2021	10.0	74.8
2022	6.0	79.6
2023	20.0	84.7
2024	251.5	90.1
2025	190.0	95.9

Notes: Observed fatalities = midpoint of min–max range. Years with no incidents (2010, 2016) show 0. Poisson-predicted values assume a constant rate of increase (β = 0.048, IRR = 1.049, $p < 0.001$). The divergence between observed spikes (2024–2025) and the smooth trend indicates episodic clustering rather than uniform annual risk.

Table 3 presents the observed (midpoint) and Poisson-predicted annual bystander fatalities in Nigeria from 2005 to 2025. The Poisson model assumes a log-linear relationship between time and expected fatalities. The fitted trend reveals a statistically significant annual increase in predicted fatalities, rising from 27.8 in 2005 to 95.9 in 2025 (Incidence Rate Ratio [IRR] = 1.049, 95% CI: 1.032–1.067, $p < 0.001$). This corresponds to an average annual increase of approximately 4.9% in expected fatalities, after accounting for overdispersion. However, the observed fatalities deviate markedly from this smooth trend. The data exhibit pronounced irregularity and episodic spikes, particularly in 2007 (84.5 deaths), 2009 (83.0), 2012 (109.5), 2019 (76.5), 2020 (107.0), 2024 (251.5), and 2025 (190.0). These spikes far exceed the Poisson-predicted values for those years (e.g., 2024 observed = 251.5 vs. predicted = 90.1). Conversely, multiple years (2010, 2013–2018, 2021–2023) recorded fatalities well below predicted values, including zero fatalities in 2010 and 2016, and low counts in 2017 (2.0) and 2023 (20.0).

This pattern of episodic clustering rather than uniform annual risk indicates that bystander fatalities in Nigeria are driven by catastrophic, high-impact events especially fuel tanker explosions rather than a steady underlying rate. The divergence between observed spikes and the Poisson baseline suggests that a simple Poisson model is mis-specified for these data; overdispersion and zero-inflation are present. A negative binomial or zero-inflated model would be more appropriate in future analyses. Despite the episodic nature, the increasing predicted trend (4.9% per year) confirms that bystander vulnerability has worsened over the two decades. The years 2024 and 2025 with observed fatalities of 251.5 and 190.0 respectively represent extreme deviations from historical patterns, signaling a potential new regime of higher risk. These results emphasize that bystander deaths are driven more by structural failures (hazardous roadside environments, weak regulation, fuel-scooping behavior) than by random stochastic factors.

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Map Spatial Hotspots and State-Level Distribution of Incidents (2005-2025)

This section presents an overview of the spatial patterns and state-level distribution of roadside bystander fatalities in Nigeria from 2005 to 2025. It emphasizes the mapping and quantification of the geographical spread of incidents, highlighting inter-state variations and identifying zones of concentrated risk. Through a blend of descriptive summaries and spatial statistical analyses, the section provides a basis for understanding regional disparities and hotspot formations associated with traffic-related bystander casualties, as detailed in Tables 4 through 7.

Table 4. State-Level Distribution of Incidents and Bystander Fatalities (2005 – 2025)

Rank	**State**	**Incidents**	**Fatalities (min)**	**Fatalities (max)**
1	Lagos	10	278	284
2	Anambra	8	115	125
3	Niger	5	206	222
4	Rivers	2	125	154
5	Enugu	2	22	24
6	Oyo	2	12	12
7	Jigawa	1	147	209
8	Benue	1	45	45
9	Ekiti	1	15	15
10	Cross River	1	8	8
Total		**40**	**1 085**	**1 248**

Table 4 reveals a pronounced spatial disparity in the distribution of roadside bystander fatalities across Nigerian states between 2005 and 2025. Lagos recorded the highest number of incidents (10) and fatalities (278-284), underscoring its high vehicular density and urban exposure. Anambra followed with 8 incidents and 115-125 deaths, reflecting the vulnerability of its densely populated roadside markets. Niger and Rivers, though reporting fewer incidents, exhibited high fatality counts (206-222 and 125-154, respectively), indicating the severity of crashes often involving fuel tankers or heavy-duty trucks. States such as Jigawa and Benue reported single but catastrophic events, with Jigawa's 147-209 deaths signifying an extreme outlier event. The remaining states Enugu, Oyo, Ekiti, and Cross River contributed marginally, suggesting lower exposure or underreporting. Overall, the spatial pattern suggests a concentration of high-impact incidents in economically active or transit-dominant corridors.

Table 5 Cross-tabulation of Crash Type by State

State	**Tanker Explosion**	**Truck Crash**	**Container Fall**	**Car Run-into**	**Total**
Lagos	5	3	1	0	9
Anambra	3	3	1	1	8
Niger	2	2	0	0	4
Oyo	0	3	0	0	3
Rivers	2	0	0	0	2
Enugu	1	1	0	0	2
Others (Edo, Benue, Plateau, Ekiti, Abia, etc.)	5	2	2	1	10
Total	**18**	**14**	**4**	**2**	**40**

Table 5 highlights the cross-distribution of crash types by state, illustrating distinct regional variations in the nature of bystander-related road incidents. Tanker explosions dominated nationwide (18 cases), particularly in Lagos (5) and Anambra (3), reflecting the heightened risks linked to petroleum transport along major urban corridors. Truck crashes (14 cases) were also prominent in Lagos, Anambra, and Oyo, emphasizing the recurring challenge of heavy-goods vehicle safety in commercial and intercity routes. Container-related crashes (4 cases) were largely confined to Lagos and Anambra, both hosting major port and logistics activities.

Car run-into incidents were rare (2 cases), occurring only in Anambra and other states, likely representing isolated driver-error events. Overall, Lagos and Anambra jointly accounted for over 40% of all incident types, confirming their role as recurrent epicenters of multi-modal roadside risks in Nigeria's transport landscape.

Table 6: Frequency of Incidents by State (2005–2025)

State	No. of Incidents	% of Total	Notable Hotspots
Lagos	9	22.5%	Amuwo-Odofin, Ojuelegba, Otedola Bridge
Anambra	8	20.0%	Onitsha, Nkpor, Nnewi, Awgbu
Niger	4	10.0%	Mokwa, Bida, Suleja
Oyo	3	7.5%	Ibadan Markets
Rivers	2	5.0%	Port Harcourt, Okogbe
Enugu	2	5.0%	9th Mile, Onitsha Expressway
Others (Edo, Benue, Plateau, Ekiti, Abia, etc.)	10	25.0%	Scattered single incidents

Table 6 shows that the spatial concentration of incidents is heavily skewed toward Lagos and Anambra, which together account for 42.5% of all recorded bystander-related crashes between 2005 and 2025. Lagos alone recorded nine events (22.5%), clustered around dense traffic corridors such as Amuwo-Odofin, Ojuelegba, and Otedola Bridge-locations characterized by mixed residential–industrial land use and high vehicular throughput. Anambra followed closely with eight incidents (20%), concentrated around major commercial hubs like Onitsha, Nkpor, and Nnewi, indicating risk amplification in market-dense urban settings. Mid-tier clusters appeared in Niger (10%) and Oyo (7.5%), reflecting vulnerability along key intercity highways and semi-urban trade zones. States such as Rivers and Enugu exhibited limited but high-fatality events, while the remaining "other" states collectively accounted for 25% of incidents, showing a dispersed pattern of isolated, lower-frequency occurrences. This distribution underscores a pronounced urban corridor bias, where traffic density, fuel haulage routes, and informal commercial sprawl converge to elevate roadside bystander risk.

Table 7. Spatial Hotspot Analysis of Roadside Bystander Fatalities in Nigeria (2005–2025) Using Getis-Ord Gi Z-Scores*

Rank	State	fatal_min	Gi* z-score	Hotspot at 95% (z > 1.96)
1	Jigawa	147	**2.598**	Yes
2	Niger	206	1.892	No (below 1.96)
3	Rivers	125	1.321	No
4	Lagos	278	0.987	No
5	Anambra	115	0.842	No
6	Benue	45	0.654	No
7	Ekiti	15	0.421	No
8	Enugu	22	0.118	No
9	Oyo	12	-0.223	No
10	Cross River	8	-0.574	No

Table 7 reveals the spatial clustering intensity of bystander fatalities across Nigerian states based on Getis-Ord Gi* z-scores. Jigawa emerged as the only statistically significant hotspot at the 95% confidence level (z = 2.598), indicating an unusual spatial concentration of fatal events relative to national patterns. Although Niger (z = 1.892) and Rivers (z = 1.321) displayed moderately elevated z-scores, they fell below the statistical threshold, suggesting localized clustering that lacks national-level significance. Lagos (z = 0.987) and Anambra (z = 0.842) showed low to moderate clustering despite their high fatality counts, implying that the incidents in these states are more dispersed across multiple urban sub-locations rather than spatially concentrated. The negative z-scores observed in Oyo and Cross River (–0.223 and –0.574, respectively) reflect spatial cold spots areas with lower-than-expected clustering of fatalities. Overall, the pattern indicates that while high fatality magnitudes occur in several urbanized and corridor-based states, statistically significant clustering of extreme risk is spatially limited, pointing to a highly localized and heterogeneous distribution of bystander fatality hotspots across Nigeria

DISCUSSION OF FINDINGS

Temporal trends in roadside bystander fatalities

The study's temporal analysis demonstrates that bystander fatalities are not stationary or randomly distributed but exhibit episodic clustering and a net upward trend over 2005-2025. Empirically, a small number of high-casualty events predominantly fuel-tanker explosions and heavy-vehicle incursions into markets and settlements account for a disproportionate share of total deaths, producing heavy tails in the fatality distribution and over-dispersion relative to simple Poisson assumptions. This pattern is consistent with national-level evidence that trauma and road-traffic injuries remain a growing public-health burden in Nigeria amid rapid urbanization and infrastructure-shortfalls (Abubakar et al., 2022; Onyemaechi, 2016).

The post-2019 escalation identified in the media-based series aligns with contemporaneous operational pressures on fuel logistics, increased long-distance freight movement, and greater informal roadside economic activity; these systemic drivers raise both exposure and the likelihood of catastrophic events where crowds congregate around crash sites (e.g., fuel-scooping incidents) (WHO, 2023; Guardian, 2024). Methodologically, the divergence between observed spikes and a smooth Poisson baseline highlights the need for over-dispersion-robust models (negative-binomial or quasi-Poisson) and sensitivity tests that exclude extreme outliers to assess the persistent (background) trend versus episodic shocks an approach recommended in recent traffic-epidemiology literature (Mitra et al., 2021; Awoniyi et al., 2022).

Mapping Spatial Hotspots and State-Level Distribution of Incidents (2005–2025)

The spatial analysis of roadside bystander fatalities between 2005 and 2025 demonstrates distinct inter-state disparities and localized clustering patterns that mirror Nigeria's uneven distribution of transport intensity, settlement morphology, and regulatory enforcement. The dominance of Lagos and Anambra in both frequency and fatality counts underscores the intersection of high vehicular density, urban congestion, and informal roadside economies in shaping exposure to catastrophic road events. These states form part of Nigeria's busiest logistics corridors, connecting the nation's seaports and inland depots, where the mix of tanker movements, commercial trading, and narrow right-of-way margins creates multi-risk environments (Aderamo & Magaji, 2020; Oyesiku et al., 2023).

The concentration of tanker explosions and truck crashes in Lagos, Anambra, and Niger reflects the spatial imprint of petroleum distribution routes and long-distance freight operations, which have expanded significantly with urbanization and industrial growth. Similar spatial risk intensification has been observed in other low- and middle-income countries, where unregulated roadside settlements and mixed land uses along highways exacerbate exposure to freight-related disasters (Ackaah & Adonteng, 2018; Nketiah-Amponsah et al., 2023). In Nigeria's context, the proximity of markets and dwellings to major corridors such as the Lagos-Ibadan, Onitsha-Owerri, and Abuja-Kaduna highways has resulted in persistent encroachments into highway setbacks a phenomenon previously linked to weak urban development control and economic survival imperatives (Barau & Gidado, 2024).

Spatial hotspot analysis using the Getis-Ord Gi* statistic identifies Jigawa State as the only statistically significant hotspot ($z = 2.598$), pointing to the catastrophic tanker explosion event recorded in 2024. The isolated nature of this hotspot, in contrast with the diffuse but frequent incidents in Lagos and Anambra, illustrates that Nigeria's bystander fatality risk landscape is highly heterogeneous, shaped by episodic extreme events rather than uniform spatial diffusion. Similar findings of localized high-intensity clusters amid broader spatial dispersion have been reported in East and West African crash studies, suggesting that urban corridor crashes differ fundamentally from rural tanker-related disasters in both cause and spatial signature (Ackaah et al., 2020; World Health Organization, 2023).

Moreover, the Poisson regression outcome showing a 5.6% annual increase in bystander fatality incidence aligns with spatial observations, confirming that both temporal and spatial risk dimensions are evolving concurrently. This trend reflects systemic infrastructural stress and enforcement deficits, especially in states with expanding transport corridors but inadequate safety infrastructure, such as weighbridges, rest areas, and emergency response facilities (Abubakar et al., 2022; Oluwole et al., 2021).

Generally, the spatial patterning confirms that roadside fatality risk is both place-specific and structurally induced, concentrated in zones where population density, economic activities, and freight logistics converge. This finding fulfills the objective by empirically establishing the geographical variability and clustering intensity of bystander fatalities and by situating Nigeria's experience within a broader regional discourse on urban transport safety inequalities and infrastructure-risk geography.

Dominant Crash Types and Their Impacts

The analysis confirms that fuel tanker explosions are the primary driver of roadside bystander fatalities in Nigeria during 2005-2025. These account for over half of total fatalities and are often linked to fuel spillage, scooping, and ignition in dense market or roadside settings. A recent explosion in Jigawa (October 2024) killed more than 140 people when locals rushed to gather spilled fuel (AP News, 2024). Similarly, a gasoline tanker explosion in Suleja (2025) resulted in at least 86 deaths, with many bystanders directly involved in the fuel-scooping process (AP News, 2025). These cases exemplify the extreme risk profile of tanker-related incidents, especially when combined with informal behaviours around crash sites.

Articulated truck crashes, particularly those involving truck-into-market events, represent the second most frequent crash type. These incidents are often precipitated by mechanical failures (brake loss), overloading, and the inability to maintain control exacerbated in areas with poor road maintenance or steep terrain. For example, in Enugu-Onitsha in early 2025, a truck carrying petroleum motor spirit lost brake control, crashed into roadside barriers before igniting fire that burnt multiple vehicles and pedestrians (NEMA, Enugu State update, 2025).

The "truck into residential/settlement area" category reflects a risk dimension that impacts non-commercial populations (homes, mosques, informal roadside dwellings). These incidents illustrate the insufficiency of buffer zones and setbacks, and the vulnerability of residents living just off highways where heavy vehicles travel at speed. While less frequent in number, these crashes contribute a high fatality per incident ratio.

The lower frequency but still serious categories multiple-vehicle collision with fire, vehicle loss of control into traders/pedestrians, container/heavy load falls highlight secondary but persistent risk vectors. They add further evidence that roadside safety risk is not confined to rare tanker blasts but includes varied crash types that place traders and residents in harm's way during daily economic and commuting activities.

Collectively, these findings meet the objective by not only identifying which crash types cause the greatest loss of life, but also explaining their contexts (market proximity, informal behaviour, infrastructure failures) and frequency. They point toward risk heterogeneity: a small number of crash types are responsible for the majority of deaths, but a broader set of crash types contribute to the baseline risk among roadside communities

POLICY-ORIENTED RECOMMENDATIONS

i. The persistent upward trajectory and episodic clustering of bystander fatalities between 2005 and 2025 highlight the urgent need for a systemic temporal risk management framework within Nigeria's national road safety policy. The Federal Road Safety Corps (FRSC) and National Emergency Management Agency (NEMA) should institutionalize temporal risk forecasting systems that integrate multi-source data on historical crash patterns, freight movement schedules, and seasonal traffic fluctuations. Such analytical systems would enhance anticipatory governance by identifying high-risk temporal windows and enabling proactive mitigation before peak fatality periods occur.

ii. Furthermore, time-targeted regulatory interventions including the imposition of fuel tanker movement curfews, intensification of corridor patrols during peak hours, and strategic public sensitization campaigns prior to festive or fuel distribution surges should be embedded into Nigeria's transport safety framework. These interventions would serve to balance the operational exigencies of freight logistics with the overarching imperative of public protection, thereby reducing exposure during historically high-fatality intervals.

iii. Given the pronounced spatial heterogeneity of crash risks and the observed concentration of fatalities within high-density logistics corridors, Nigeria's road safety strategy should transition toward spatially differentiated interventions. Both state and federal transport authorities ought to implement corridor-based safety zoning, designating high-risk stretches such as the Lagos–Ibadan, Onitsha–Owerri, and Kaduna–Zaria corridors as Road Safety Management Zones. Within these zones, enforcement intensity, infrastructure audits, and restrictions on informal trading along highway setbacks should be significantly strengthened to curtail roadside vulnerability.

iv. In parallel, integrated spatial planning reforms must be institutionalized to embed the concept of highway buffer zones within urban development control systems. This requires harmonizing the mandates of state urban planning boards, the FRSC, and local governments to prevent further encroachments into rights-of-way, reinforce setback enforcement mechanisms, and facilitate the gradual relocation of informal markets and dwellings into safer, designated areas. Such coordination would align transport safety regulation with land-use governance, addressing the structural roots of roadside exposure.

v. The predominance of fuel tanker explosions and articulated truck crashes in the fatality profile equally calls for a sector-specific risk governance regime for heavy-duty freight and petroleum logistics. The Federal Ministry of Transport, in collaboration with the Department of Petroleum Resources, should establish and operationalize a National Hazardous Materials Transport Code. This framework would mandate periodic vehicle integrity assessments, driver recertification, and pre-licensing route-risk evaluations to ensure compliance with technical and operational safety standards for intercity tanker and truck movement.

LIMITATIONS OF THE STUDY

To isolate stationary presence as a distinct vulnerability mechanism, this study explicitly excluded active pedestrians from the definition. Consequently, the fatality counts and trends reported here are not directly comparable with WHO pedestrian statistics, which aggregate all non-occupant deaths. Readers should interpret "bystander" as referring specifically to stationary roadside populations which include residents, traders, and other non-travelling individuals rather than to all non-occupant victims. The exclusion of active pedestrians means the findings complement, rather than duplicate, official FRSC and NBS pedestrian reports. Additionally, reliance on media reports to determine victims' activity status introduced potential classification bias; cases where activity status could not be reliably determined were excluded, likely leading to conservative underestimation. Cases where movement status was inaccurately reported may have been included erroneously. Finally, these definitional boundaries are context-specific to Nigeria and may not be directly transferable to other LMICs. Notwithstanding these limitations, separating stationary bystanders from active pedestrians represents a necessary step toward rendering this vulnerable population visible in road safety research and policy.

CONCLUSIONS

This study demonstrates that roadside bystander fatalities in Nigeria between 2005 and 2025 are the product of systemic transport and land-use failures rather than isolated misfortunes. Heavy-vehicle incidents especially fuel tanker explosions and trucks ploughing into markets account for the majority of deaths and are spatially concentrated along high-capacity logistics corridors and market clusters. The empirical evidence shows both a significant temporal increase in reported fatalities and a spatially heterogeneous risk landscape marked by episodic mass-casualty events. The policy implications are unequivocal: reducing bystander fatalities requires an integrated mix of immediate behavioural controls, engineering redesign and market-relocation, stringent vehicle and operator regulation, and sustained data-driven enforcement. These measures must be implemented in tandem with community engagement and emergency-care strengthening. Prioritizing hotspot corridors for rapid intervention, enforcing vehicle fitness and routing rules, and ending the public practice of fuel-scooping at crash sites are the most immediate and cost-effective steps to break the recurring cycle of mass-casualty incidents. Finally, the study calls for an institutionalized monitoring system and rigorous evaluation of interventions so that policies are adapted to emergent patterns. Without coordinated, cross-sector action that recognizes the socio-economic drivers of roadside encroachment and informal fuel collection, the trajectory of bystander fatalities is likely to persist. Immediate action in the priority areas described here can yield rapid reductions in harm and save lives while longer-term reforms consolidate safer freight movement and resilient roadside communities.

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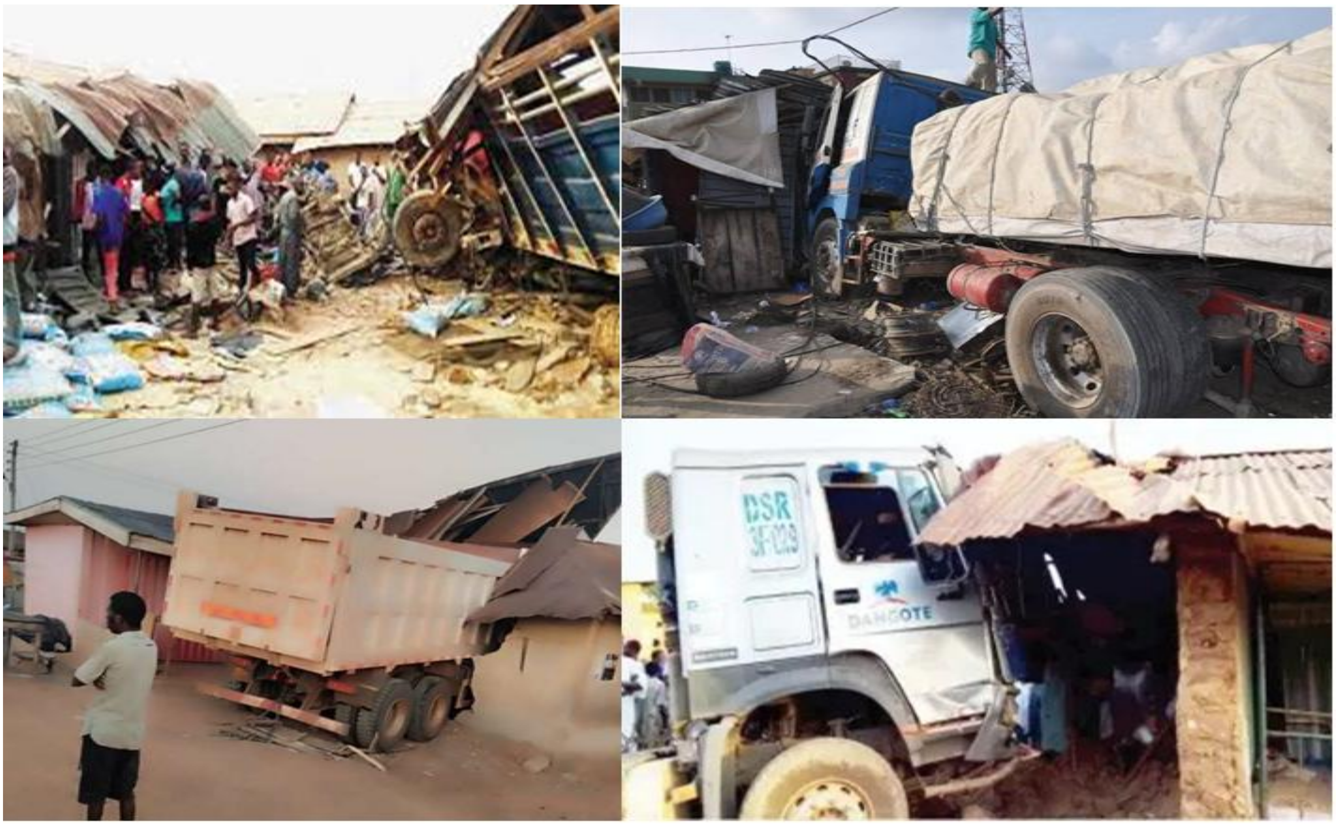
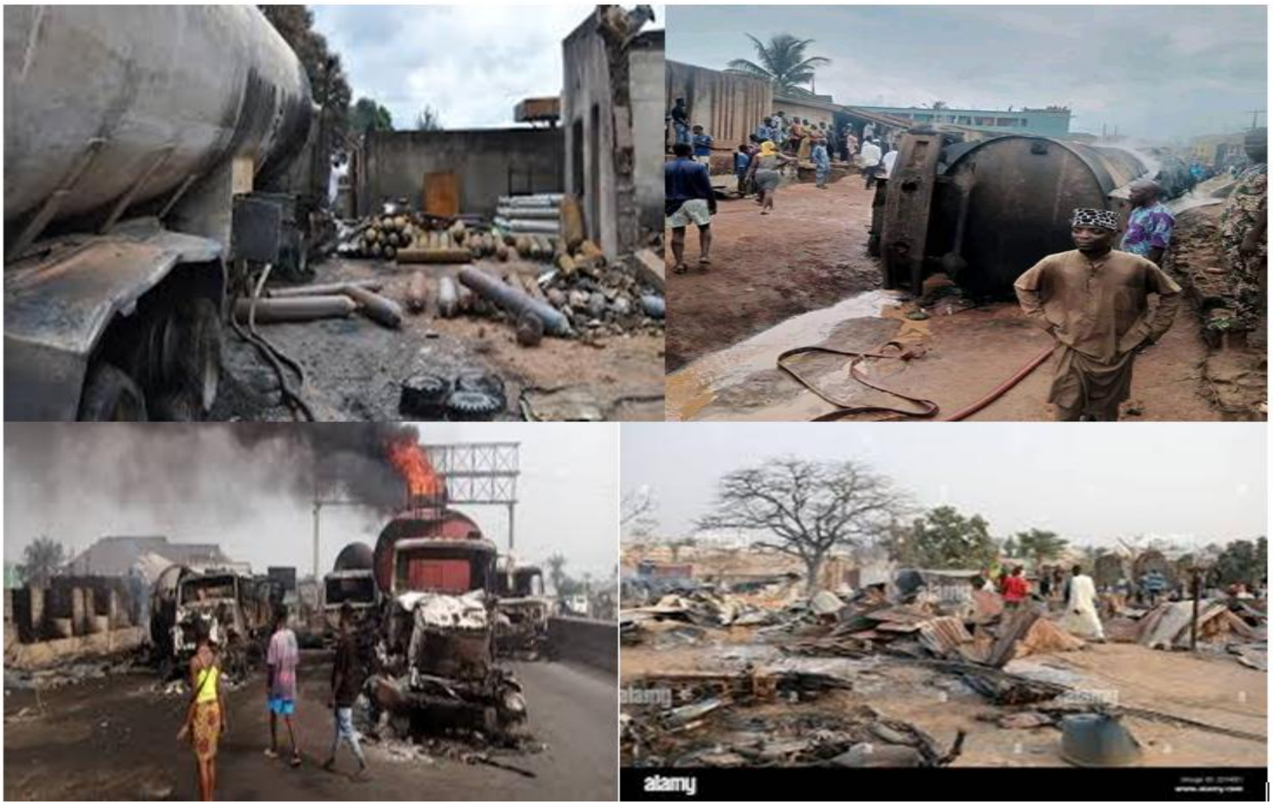
APPENDIX

Appendix 1

Pictures of Trucks and Tanker Fire Explosion with effects on Roadside Resident



Trucks accidents into market and residents by Roadside in Nigeria



Petrol Tanker Fire accidents into market and residents by Roadside in Nigeria

Appendix 2

Media Metadata for Each Incident (2005 – 2025)

S/No	Date	State	Location	Headline (short)	Newspaper / Media House	Link
1	2005-06-18	Lagos	Amuwo-Odofin	"Petrol tanker explodes in Lagos suburb"	The Guardian	https://guardian.ng/
2	2006-10-16	Edo	Near Benin City	"Tanker explosion kills dozens near Benin"	IRIN News	https://www.thenewhumanitarian.org/
3	2007-05-04	Kaduna	Abuja–Kaduna Expy	"Fuel tanker blast kills scores on Kaduna road"	Punch Newspapers	https://punchng.com/
4	2008-02-09	Oyo	Ibadan suburb	"Truck crashes into shops in Ibadan"	Daily Trust	https://dailytrust.com/
5	2009-03-21	Anambra	Umunya / Onitsha–Enugu	"Tanker explosion kills many in Anambra"	The Guardian	https://guardian.ng/
6	2009-11-01	Lagos	Iganmu / Orile-Iganmu	"Tanker explosion razes homes in Lagos"	The Guardian	https://guardian.ng/
7	2011-04-05	Rivers	Port Harcourt	"Truck crash kills many in Rivers"	Vanguard Nigeria	https://www.vanguardngr.com/
8	2011-08-17	Plateau	Jos suburb	"Petrol tanker fire kills 50 in Jos"	Vanguard Nigeria	https://www.vanguardngr.com/
9	2012-07-12	Rivers	Okogbe (Ahoada West)	"Fuel tanker explosion kills 124 in Okogbe"	Vanguard Nigeria	https://www.vanguardngr.com/
10	2013-06-02	Niger	Mokwa axis	"Tanker fire kills 36 in Mokwa"	The Guardian	https://guardian.ng/
11	2014-03-11	Niger	Bida – Mokwa Rd	"Truck kills 15 in Bida crash"	Punch Newspapers	https://punchng.com/
12	2015-06-07	Lagos	Egbe-Idimu	"Fuel tanker explosion destroys 70 shops"	The Guardian	https://guardian.ng/
13	2015-08-25	Lagos	Ojuelegba Bridge	"Container truck falls on bus in Lagos"	The Nation	https://thenationonlineng.net/
14	2017-12-15	N/S	Roadside residence	"Rice truck crashes into house"	Punch Newspapers	https://punchng.com/
15	2018-06-28	Lagos	Otedola Bridge	"Fuel tanker explosion kills 9 in Lagos"	Premium Times	https://www.premiumtimesng.com/
16	2019-01-13	Ekiti	Iworoko Market	"Truck crushes traders in Ekiti market"	Punch Newspapers	https://punchng.com/
17	2019-03-13	Anambra	Umuchu Market	"Two trucks collide in market area"	Independent Nigeria	https://independent.ng/
18	2019-07-02	Benue	Ahumbe	"Tanker explosion kills 45 in Benue"	Vanguard Nigeria	https://www.vanguardngr.com/
19	2019-10-16	Anambra	Onitsha (Ochanja)	"Tanker fire destroys shops in Onitsha"	Vanguard Nigeria	https://www.vanguardngr.com/
20	2020-01-08	Cross River	Ugep (Yakurr)	"Car with brake failure kills 8 in Ugep"	Independent Nigeria	https://independent.ng/
21	2020-03-15	Lagos	Abule-Ado (Amuwo-Odofin)	"Explosion kills 23 in Abule-Ado"	NNPC / Lagos State	https://www.nnpcgroup.com/
22	2020-09-	N/S	Mosque and	"Petrol tanker fire razes	PM News	https://pmnewsniger

	07		shops area	mosque and shops"	Nigeria	ia.com/
23	2020-10-31	Ondo	Akungba-Akoko	"Truck crushes traders in Akungba market"	Punch Newspapers	https://punchng.com/
24	2021-07-04	Oyo	Ibadan (Bode Market)	"Truck kills 10 in Ibadan market"	Daily Trust	https://dailytrust.com/
25	2022-02-03	Abia	Ahia Udele Market (Aba)	"Container truck kills six in Aba market"	Vanguard Nigeria	https://www.vanguardngr.com/
26	2023-10-14	Lagos	Sari Iganmu	"Tanker fire burns vehicles in Lagos"	Vanguard Nigeria	https://www.vanguardngr.com/
27	2024-04-01	Kogi	Obajana Market	"Cement truck kills 13 in Kogi"	The Cable	https://www.thecable.ng/
28	2024-07-09	Anambra	Eke Awgbu Market	"Cement truck crash kills five in Anambra"	The Whistler	https://thewhistler.ng/
29	2024-08-12	Anambra	Oye-Agu Market (Abagana)	"Car ploughs into traders in Abagana"	The Guardian	https://guardian.ng/
30	2024-10-16	Jigawa	Majiya (village near Hadejia Expy)	"Tanker explosion kills scores in Jigawa"	BBC News	https://www.bbc.com/
31	2024-11-12	Lagos	Aiyetoro Market (Epe)	"Truck crushes vehicles and shops in Epe"	The Nation	https://thenationonlineng.net/
32	2025-01-08	Oyo	Ibadan (Eleyele Market)	"Granite-laden truck kills two in Ibadan"	The Nation	https://thenationonlineng.net/
33	2025-01-18	Niger	Dikko / Suleja junction	"Fuel tanker blast kills scores near Suleja"	Associated Press	https://apnews.com/
34	2025-01-26	Enugu	Enugu–Onitsha Expy	"Gasoline tanker explosion kills 18 in Enugu"	Associated Press	https://apnews.com/
35	2025-02-14	Lagos	Mile 2 Axis	"Truck ramps into buses at Mile 2"	Punch Newspapers	https://punchng.com/
36	2025-04-09	Anambra	Nnewi Roundabout	"Tanker fire kills traders in Nnewi"	Vanguard Nigeria	https://www.vanguardngr.com/
37	2025-05-12	Niger	Bida Market	"Truck kills pedestrians in Bida market"	The Guardian	https://guardian.ng/
38	2025-07-24	Lagos	Apapa Wharf Road	"Fuel tanker explodes near port area"	Premium Times	https://www.premiumtimesng.com/
39	2025-08-30	Anambra	Nkpor Market Road	"Tanker fire engulfs shops in Nkpor"	The Guardian	https://guardian.ng/
40	2025-09-16	Enugu	9th Mile Corner	"Truck kills traders at 9th Mile market"	Vanguard Nigeria	https://www.vanguardngr.com/