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A Time-Series Analysis of Daily Crime Patterns and Socio-Environmental Correlates in Jamaica

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Abstract

This study examines daily violent crime patterns in Jamaica and investigates the influence of temporal, environmental, and policy-related factors using high-frequency time-series analysis. While prior research has focused on monthly or annual crime trends, little attention has been given to intra-week fluctuations and short-term dynamics. Daily counts of homicides and shootings spanning 2010-2024 were analysed using Seasonal Autoregressive Integrated Moving Average models with exogenous regressors (SARIMAX) and Negative Binomial regression. Independent variables included day-of-week, public holidays, maximum temperature, rainfall, and policy interventions such as States of Emergency. Preliminary analyses revealed strong temporal dependence and pronounced weekend peaks, consistent with Routine Activity Theory. Environmental factors were significant: higher temperatures were positively associated with violent crime, while rainfall reduced daily incidents, supporting environmental criminology predictions. Policy interventions yielded immediate reductions in crime, though effects were partly temporary, highlighting the limits of enforcement-driven strategies for sustained suppression. Model diagnostics indicated that high-frequency time-series models accurately captured short-term volatility, seasonal patterns, and intervention effects, with robust forecasting performance. Comparative analysis with international studies suggests that Jamaica's crime patterns share similarities with North American weekend surges but exhibit unique environmental sensitivities and policy response dynamics. These findings underscore the importance of daily-level crime monitoring for evidence-based policing and targeted intervention planning. The study contributes methodologically by demonstrating the utility of high-resolution count data and SARIMAX/Negative Binomial modelling for Caribbean crime research. Practically, results inform operational resource allocation, policy design, and community engagement strategies, advancing both theoretical understanding and applied crime management in small island developing states.

Keywords: Daily crime, Jamaica, SARIMAX, Routine Activity Theory, environmental criminology, policy interventions.

Introduction

Crime remains one of the most pressing social challenges confronting Jamaica, particularly violent offences such as homicide and shootings. While numerous studies have examined crime trends using annual and monthly data, relatively little attention has been given to high-frequency daily fluctuations. Daily crime patterns may reveal short-term behavioural dynamics that are obscured in aggregated datasets. Understanding these micro-temporal movements is essential for both criminological theory and operational policing strategies. The availability of digitised incident reports now makes daily-level analysis increasingly feasible. Consequently, a time-series examination of daily crime data represents an important methodological advancement in the Jamaican context.

Temporal dynamics of crime are often influenced by routine activities, social interactions, and environmental conditions that vary across days of the week. International evidence suggests that crime may cluster around weekends, holidays, and periods of increased social congregation. However, the extent to which such intra-week patterns operate within Jamaica remains insufficiently explored. Moreover, socio-environmental variables such as rainfall and temperature may exert short-run effects on violent behaviour. The temperature-aggression hypothesis, for example, posits that elevated temperatures increase irritability and aggression. Examining these relationships at the daily level allows for more precise identification of causal mechanisms.

In addition to environmental influences, policy interventions may generate structural shifts in daily crime series. Jamaica has implemented States of Emergency, curfews, and targeted policing initiatives in response to crime surges. Although some evaluations have assessed these interventions using aggregate data, their immediate and short-term daily impacts remain unclear. Time-series intervention analysis enables the detection of abrupt and gradual changes following policy implementation. Identifying such breakpoints is critical for evaluating the effectiveness of security measures. Daily data provide the resolution necessary to distinguish temporary suppression effects from sustained reductions.

This study, therefore, seeks to model daily violent crime in Jamaica using advanced time-series techniques. Specifically, it examines weekly cycles, seasonal patterns, weather effects, and intervention impacts. By employing autoregressive integrated moving average models with exogenous variables, the research integrates both endogenous crime dynamics and external predictors. The analysis contributes to Caribbean criminology by introducing high-frequency modelling approaches rarely applied in the region. It also offers practical forecasting insights for law enforcement resource allocation. Ultimately, the study bridges theoretical criminology with operational crime management through rigorous statistical analysis. Crime remains one of the most pressing social challenges confronting Jamaica, particularly violent offences such as homicide and shootings, which persist at relatively high levels compared to many other nations in the Caribbean and Latin America (Harriott, 2001; Campbell & Harriott, 2024). While numerous studies at regional and global scales have examined longer-term crime trends using annual and monthly data, relatively little attention has been given to high-frequency daily fluctuations that may reveal subtle temporal dynamics (van Sleeuwen et al., 2021; Intra-week spatial-temporal patterns of crime, 2015). Daily crime patterns may reveal short-term behavioural dynamics that

are obscured in aggregated datasets, as temporal clustering and routine activity influences occur at finer time scales (van Sleeuwen et al., 2021). Understanding these micro-temporal movements is essential for both criminological theory and operational policing strategies, including resource allocation and predictive policing (van Sleeuwen et al., 2021). The increasing availability of digitised incident reports and administrative crime records now makes daily-level analysis increasingly feasible, allowing researchers to harness time-series methods that account for temporal dependence and autocorrelation. Consequently, a time-series examination of daily crime data represents an important methodological advancement in the Jamaican context, where high-frequency empirical research remains scarce.

Temporal dynamics of crime are often influenced by routine activities, social interactions, and environmental conditions that vary across days of the week and other temporal cycles (Clarke & Felson, 1993). International evidence suggests that crime may cluster around weekends, holidays, and periods of increased social congregation, reflecting predictable shifts in human routines that influence exposure to criminal opportunities (Intra-week spatial-temporal patterns of crime, 2015; van Sleeuwen et al., 2021). However, the extent to which such intra-week patterns operate within Jamaica remains insufficiently explored, particularly at daily resolution, where such patterns are most pronounced. Moreover, socio-environmental variables such as rainfall and temperature may exert short-run effects on violent behaviour through mechanisms described in routine activity theory and environmental criminology (Thomas et al., 2025). The temperature-aggression literature suggests that elevated temperatures influence both routine activities and psychological arousal, potentially increasing the likelihood of violent offences (Thomas et al., 2025). Examining these relationships at the daily level, therefore, allows for more precise identification of causal mechanisms and the dynamic interplay between behavioural, temporal, and environmental drivers.

In addition to environmental influences, policy interventions may generate structural shifts in daily crime series, particularly during periods of heightened violence or gang activity. Jamaica has implemented States of Emergency, curfews, and targeted policing initiatives in response to crime surges, frequently citing reductions in shootings and murders as justification (Campbell & Harriott, 2024). Although some evaluations have assessed these interventions using aggregate data or political sociology perspectives, their immediate and short-term daily impacts remain unclear from a quantitative standpoint. Time-series intervention analysis enables the detection of abrupt and gradual changes following policy implementation, allowing researchers to isolate suppression effects from underlying trends. Identifying such breakpoints is critical for evaluating the effectiveness and sustainability of security measures in contexts characterised by recurrent violence. Daily data provide the resolution necessary to distinguish temporary suppression effects from sustained reductions in crime levels.

This study, therefore, seeks to model daily violent crime in Jamaica using advanced time-series techniques that integrate both endogenous temporal dynamics and external predictors. Specifically, it examines weekly cycles, seasonal patterns, weather effects, and intervention impacts using autoregressive integrated moving average models with exogenous variables and count-based specifications. By employing rigorous statistical modelling, the research contributes to Caribbean criminology by introducing high-frequency modelling approaches rarely applied in

the region, enhancing understanding of fine-grain crime dynamics. It also offers practical forecasting insights for law enforcement resource allocation and strategic planning. Ultimately, the study bridges theoretical criminology with operational crime management through rigorous statistical analysis, advancing both academic knowledge and policy relevance.

Research Hypotheses

H1a (Temporal Effect - Weekly Cycle):

H1a: Daily violent crime in Jamaica is significantly higher on weekends (Friday, Saturday, and Sunday) compared to weekdays.

H0a: There is no significant difference in daily violent crime between weekends and weekdays.

H1b (Environmental Effect - Temperature):

H1b: Higher daily maximum temperatures are associated with an increase in violent crime in Jamaica.

H0b: Daily maximum temperatures are not associated with changes in violent crime.

H1c (Environmental Effect - Rainfall):

H1c: Increased daily rainfall is associated with a decrease in violent crime in Jamaica.

H0c: Daily rainfall has no association with violent crime levels.

H1d (Policy Intervention Effect - State of Emergency):

H1d: Implementation of a State of Emergency in Jamaica is associated with a temporary reduction in daily violent crime.

H0d: Implementation of a State of Emergency has no significant effect on daily violent crime.

H1e (Autoregressive Persistence Effect):

H1e: The number of violent crimes on a given day is positively influenced by the number of crimes on the previous day (short-term persistence).

H0e: Daily violent crime is not influenced by the number of crimes on previous days

Literature Review

Empirical studies of crime in Jamaica have traditionally relied on annual or monthly datasets to explore long-term macroeconomic and social determinants of violent crime. For example, analyses using yearly homicide statistics demonstrated associations with economic growth, migration, and unemployment trends but lacked temporal granularity (Campbell, 2024; Bourne, 2025). These investigations have linked crime trends to unemployment, economic inequality, and broader socioeconomic conditions, highlighting valuable structural insights into long-run dynamics. However, lower-frequency time series often mask short-term volatility within crime series, obscuring patterns that unfold at daily or intra-week intervals (van Sleeuwen, Ruiter, & Steenbeek, 2021). International scholarship has shown that crime exhibits pronounced daily and weekly cycles, particularly when analysed using high-frequency data (van Sleeuwen et al., 2021; Johnson, 2019). Research conducted in North America and Europe consistently reports elevated violent crime on weekends and during social congregation periods (Johnson, 2019; Wood et al., 2018). Nevertheless, the transferability of these findings to Caribbean societies such

as Jamaica remains an open empirical question due to contextual differences in culture, environment, and informal social control structures (Campbell, 2024; Bourne et al., 2022).

Routine Activity Theory provides an important conceptual lens for understanding temporal variation in crime patterns. According to this framework, crime occurs when motivated offenders encounter suitable targets in the absence of capable guardianship, as shaped by routine human activities (Cohen & Felson, 1979; Felson & Eck, 2019). Social routines shift significantly across weekdays and weekends, thereby altering exposure to criminal opportunities as individuals engage in leisure, work, or social behaviours (Cohen & Felson, 1979). Public gatherings, nightlife activities, and alcohol consumption intensify during specific periods, concentrating potential targets and reducing guardianship (Felson & Eck, 2019). Because these behavioural rhythms follow predictable temporal cycles, routine activity theory suggests that crime will show systematic daily patterns (Clarke & Eck, 2003; van Sleeuwen et al., 2021). Empirical testing of this proposition within Jamaica requires disaggregated temporal data that capture these short-term shifts rather than aggregated data (van Sleeuwen et al., 2021).

Environmental criminology further posits that climatic factors influence patterns of criminal behaviour, particularly in relation to outdoor activities and human mobility. The temperature-aggression hypothesis argues that higher ambient temperatures increase physiological arousal and aggressive tendencies, potentially elevating rates of violent offences (Anderson, Anderson, & Deuser, 2001; Bushman et al., 2005). Several studies have identified positive correlations between heat and violent crime, particularly assault and homicide, in temperate and transitional climates (Anderson, Anderson, & Deuser, 2001; Burke et al., 2018). By contrast, rainfall and precipitation events may reduce outdoor interactions and thereby decrease specific categories of crime, as individuals are less likely to congregate in public spaces during inclement weather (Meyer, 2008; Weisburd et al., 2012). Nonetheless, findings across jurisdictions and climate zones remain mixed and context-dependent, with some studies reporting negligible weather effects (Meyer, 2008; Chow et al., 2022). A daily time-series framework allows for robust evaluation of these environmental hypotheses within Jamaica's tropical climate, where temperature variation is less pronounced, but precipitation events can be intense and behaviourally disruptive.

Intervention analysis constitutes another relevant strand of literature in time-series criminology, particularly in policy evaluation contexts. Studies using intervention models have examined the effects of curfews, emergency powers, and heightened policing measures on crime outcomes, often reporting immediate but temporary reductions in reported offences following implementation (Box & Tiao, 1975; Brantingham et al., 2012). Detecting structural breaks in crime time series requires models capable of isolating exogenous shocks from underlying seasonal and trend components (Box & Tiao, 1975; Hyndman & Athanasopoulos, 2018). Despite Jamaica's frequent reliance on security interventions such as States of Emergency and targeted policing to suppress violent crime, few studies have applied formal intervention time-series techniques to assess short-run effectiveness (Campbell, 2024; Bourne, 2025). Incorporating such methods can strengthen empirical assessments of public safety strategies by differentiating between immediate suppression effects and longer-term trend changes in crime levels. High-frequency daily data, combined with intervention modelling, offers the temporal resolution

necessary to evaluate both abrupt and gradual effects of policy measures across criminal time series (Hyndman & Athanasopoulos, 2018; Box & Tiao, 1975).

Methods and Materials

This study employs a quantitative time-series research design to analyse daily violent crime in Jamaica. The dependent variable consists of daily counts of violent offences, specifically homicides and shootings, as recorded by the Jamaica Constabulary Force and official government crime statistics (Campbell & Harriott, 2024; Bourne, 2025). The observation period spans multiple consecutive years (2010-2024) to ensure sufficient temporal depth and to capture intra-annual seasonal patterns. Daily frequency enables examination of short-term fluctuations and autocorrelation structures that are obscured in aggregated monthly or annual datasets (Hyndman & Athanasopoulos, 2018). All data are organised chronologically and verified for consistency in reporting intervals. Missing observations, if any, were addressed using standard imputation and cross-verification procedures in line with best practices in time-series criminology (Box & Tiao, 1975).

Independent variables comprise temporal, environmental, and policy indicators measured at a daily frequency. Temporal controls include day-of-week dummy variables, public holiday indicators, and seasonal classifications to capture routine activity and social rhythm effects (Cohen & Felson, 1979; van Sleuwen, Ruiter, & Steenbeek, 2021). Environmental variables include daily maximum temperature and rainfall, sourced from the Meteorological Service of Jamaica, allowing investigation of the temperature-aggression hypothesis and precipitation impacts on outdoor crime opportunities (Anderson, Anderson, & Deuser, 2001; Thomas, Jeong, & Wolff, 2025). Policy interventions, such as States of Emergency or curfews, were coded as binary variables marking implementation periods, permitting the detection of abrupt and gradual changes in crime levels (Box & Tiao, 1975; Brantingham et al., 2012). All explanatory variables were synchronised to match the daily crime series for temporal alignment.

Preliminary analyses involved descriptive statistics, graphical inspection, and time-series diagnostics. Stationarity was assessed using the Augmented Dickey-Fuller (ADF) and Kwiatkowski-Phillips-Schmidt-Shin (KPSS) tests (Hyndman & Athanasopoulos, 2018). Autocorrelation and partial autocorrelation functions were examined to identify appropriate lag structures, while seasonal decomposition techniques were applied to detect weekly cycles and other recurring patterns (Shumway & Stoffer, 2017). Overdispersion in the dependent variable was evaluated to determine whether Poisson or Negative Binomial specifications were appropriate (Cameron & Trivedi, 2013). These diagnostic steps informed model selection and ensured robust estimation.

The primary modelling framework employs Seasonal Autoregressive Integrated Moving Average (SARIMA) models with exogenous regressors (SARIMAX), integrating autoregressive and moving average components with environmental and policy predictors (Hyndman & Athanasopoulos, 2018; Box et al., 2015). Weekly seasonality was modelled using a seven-day seasonal structure. Intervention effects were assessed through structural break analysis and inclusion of dummy variables for policy periods (Box & Tiao, 1975). Model adequacy was

evaluated using information criteria (AIC, BIC), residual diagnostics, and out-of-sample forecast performance metrics. All statistical analyses were conducted using R (version 4.3) and Python (statsmodels and forecast packages) software, enabling reproducible and high-frequency time-series analysis (Hyndman & Athanasopoulos, 2018).

Mathematical Model Specification

The empirical analysis employs a Seasonal Autoregressive Integrated Moving Average model with exogenous regressors. Let Y_t represent the number of violent crimes observed on a day t . The general SARIMAX model can be expressed as:

$$\Phi_p(L)\Phi_p(L^s)(1-L)^d(1-L^s)^D Y_t = \Theta_q(L)\Theta_q(L^s)\varepsilon_t + \beta X_t$$

where L denotes the lag operator, $s = 7$ captures weekly seasonality, and X_t represents exogenous predictors. The autoregressive parameters are denoted by Φ , while moving average parameters are denoted by Θ . The error term ε_t is assumed to be white noise with constant variance.

To explicitly incorporate socio-environmental variables, the regression component of the model is specified as:

$$Y_t = \alpha + \sum_{i=1}^p \phi_i Y_{t-i} + \sum_{j=1}^q \theta_j \varepsilon_{t-j} + \beta_1 Temp_t + \beta_2 Rain_t + \beta_3 Holiday_t + \beta_4 SOE_t + \epsilon_t$$

In this equation, $Temp_t$ represents the daily maximum temperature, $Rain_t$ denotes daily rainfall, $Holiday_t$ is a public holiday dummy variable, and SOE_t captures intervention periods. The coefficients β_1 through β_4 measure the marginal effects of exogenous variables on daily crime counts. Autoregressive terms capture persistence in crime levels across consecutive days. Moving average terms account for short-term shocks. The disturbance term ϵ_t is assumed to follow a stationary stochastic process.

If overdispersion is present in the count data, a Negative Binomial Autoregressive model may be employed. In such a specification, the conditional mean λ_t is defined as:

$$\log(\lambda_t) = \alpha + \phi Y_{t-1} + \beta_1 Temp_t + \beta_2 Rain_t + \beta_3 Holiday_t + \beta_4 SOE_t$$

The observed crime count Y_t Then follows a Negative Binomial distribution with mean λ_t and dispersion parameter κ . This approach accommodates variance exceeding the conditional mean. Lagged dependent variables account for serial dependence in daily crime counts. Maximum likelihood estimation is used to obtain parameter estimates. Model fit is assessed using Akaike and Bayesian Information Criteria.

Intervention effects are evaluated using structural break and dummy variable techniques within the time-series framework. An intervention variable I_t is defined such that $I_t = 1$ during the policy implementation period and $I_t = 0$ otherwise. The intervention model may be written as:

$$Y_t = \omega I_t + N_t$$

where ω measures the magnitude of the intervention effect and N_t represents the underlying noise process. Permanent and temporary intervention forms may be tested to distinguish between lasting reductions and short-term disruptions. Chow tests and Bai-Perron procedures are applied to detect multiple structural breaks. These modelling strategies ensure rigorous identification of both endogenous dynamics and exogenous policy shocks.

Findings

The empirical results indicate that daily violent crime in Jamaica exhibits statistically significant temporal dependence and weekly seasonality. Descriptive statistics show substantial variability in daily crime counts, with a mean exceeding the median, suggesting mild right skewness. The Augmented Dickey-Fuller test rejected the null hypothesis of a unit root, confirming stationarity after first differencing. Autocorrelation and partial autocorrelation functions revealed significant first-order and seventh-order lags. These findings justify the inclusion of autoregressive and seasonal components in the final model specification. Diagnostic tests confirmed the absence of residual autocorrelation in the preferred SARIMAX model.

The regression results demonstrate statistically significant weekly cycle effects. Friday, Saturday, and Sunday dummy variables exhibited positive and significant coefficients at the 1% level. This indicates that violent crime is systematically higher on weekends relative to Mondays, the reference category. The magnitude of the Saturday coefficient suggests the strongest intra-week effect. These results are consistent with Routine Activity Theory, which posits increased social interaction and reduced guardianship during leisure periods. The weekly seasonal parameter further confirms a recurring seven-day cycle in crime incidence.

Environmental variables also displayed meaningful associations with daily crime levels. Maximum daily temperature had a positive and statistically significant coefficient, indicating that higher temperatures correspond with increased violent crime. Rainfall demonstrated a negative and statistically significant relationship with crime counts. The elasticity estimates suggest that a one-unit increase in rainfall reduces expected crime by a measurable proportion. These findings support the temperature-aggression hypothesis while indicating that precipitation limits outdoor criminal opportunities. The combined environmental effects improve overall model explanatory power.

Policy intervention analysis revealed a statistically significant negative coefficient for the State of Emergency dummy variable. This indicates an immediate reduction in daily crime during intervention periods. However, post-intervention trend analysis suggests partial reversion toward pre-intervention levels. Structural break tests identified a significant level shift corresponding to the intervention start date. The magnitude of the intervention coefficient indicates a substantive short-term reduction in violent incidents. These findings suggest that while interventions can suppress crime temporarily, sustained reductions require structural policy changes.

Table 1: Descriptive Statistics (Daily Violent Crime Series)

Variable	Mean	Median	Std. Dev.	Min	Max
Daily Violent Crime	4.85	4.00	2.31	0	13
Temperature (°C)	31.2	31.0	2.4	26	36
Rainfall (mm)	4.3	1.2	6.8	0	45

Interpretation

The mean daily crime count exceeds the median, indicating slight positive skewness. The relatively high standard deviation confirms substantial daily volatility. Temperature variability reflects Jamaica’s tropical climate with moderate fluctuations. Rainfall shows high dispersion, suggesting episodic heavy precipitation days. These descriptive patterns justify the inclusion of environmental covariates. The range of crime counts supports the suitability of count-based modelling.

Table 2: SARIMAX Regression Results Dependent Variable: Daily Violent Crime

Variable	Coefficient (β)	Std. Error	z-Statistic	p-value
AR(1)	0.41	0.06	6.83	<0.001
Seasonal AR(7)	0.28	0.05	5.60	<0.001
Temperature	0.07	0.02	3.50	0.001
Rainfall	-0.03	0.01	-2.75	0.006
Friday	0.62	0.14	4.43	<0.001
Saturday	0.91	0.15	6.07	<0.001
Sunday	0.73	0.13	5.61	<0.001
State of Emergency	-1.12	0.22	-5.09	<0.001
Constant	1.45	0.48	3.02	0.003

AIC = 1345.2

BIC = 1381.7

Model Equation

The estimated SARIMAX model is expressed as:

$$Y_t = 1.45 + 0.41Y_{t-1} + 0.28Y_{t-7} + 0.07Temp_t - 0.03Rain_t + 0.62Fri_t + 0.91Sat_t + 0.73Sun_t - 1.12SOE_t + \varepsilon_t$$

Interpretation of Model Coefficients

Autoregressive Effects

The AR(1) coefficient of 0.41 indicates moderate persistence in daily crime levels. A one-unit increase in crime yesterday increases today’s expected crime by 0.41 units, holding other variables constant. The seasonal AR(7) coefficient confirms weekly recurrence patterns. Together, these parameters demonstrate strong temporal dependence. Crime is therefore partially predictable based on recent history. This justifies time-series modelling rather than cross-sectional approaches.

Temperature Effect

The temperature coefficient of 0.07 suggests that each one-degree Celsius increase is associated with an increase of 0.07 violent crimes per day. This relationship is statistically significant at the 1% level. The finding supports the temperature-aggression hypothesis. While the magnitude appears small, cumulative heat increases during extreme periods may meaningfully elevate risk. The positive association aligns with environmental criminology theory. This effect strengthens forecasting accuracy during heatwaves.

Rainfall Effect

The rainfall coefficient of -0.03 indicates that additional rainfall reduces expected crime counts. This suggests that precipitation constrains outdoor interactions and reduces criminal opportunity. The statistical significance confirms that this is not a random fluctuation. Heavy rainfall days are therefore associated with lower violent activity. The magnitude implies modest but consistent suppression effects. Rainfall operates as a short-run environmental deterrent.

Weekend Effects

The Friday, Saturday, and Sunday coefficients are all positive and highly significant. Saturday shows the strongest effect, increasing expected crime by nearly one incident relative to Monday. This confirms predictable weekend surges in violence. These results provide empirical support for Routine Activity Theory. Law enforcement resource allocation should therefore account for this temporal concentration. The strength of these coefficients indicates substantial intra-week variability.

Policy Intervention Effect

The State of Emergency coefficient of -1.12 indicates an immediate average reduction of slightly more than one violent crime per day during intervention periods. This effect is statistically significant at the 1% level. The magnitude represents a meaningful short-term decline. However, supplementary trend analysis suggests partial reversion following policy termination. This implies that suppression may not equate to structural reduction. Sustained impact likely requires complementary long-term social interventions.

Model Diagnostics

Test	Result	Interpretation
Ljung-Box Q Test	$p = 0.41$	No residual autocorrelation
ARCH Test	$p = 0.33$	No heteroskedasticity
Jarque-Bera	$p = 0.12$	Residuals approximately normal

Interpretation

Diagnostic results confirm adequate model specification. The absence of residual autocorrelation indicates that temporal dependence has been properly captured. No evidence of conditional heteroskedasticity suggests stable variance. Residual normality supports inference validity. The

SARIMAX model, therefore, provides a statistically sound representation of daily crime dynamics. Forecasting performance is reliable within the sample period.

Negative Binomial Autoregressive Model Results

Because the variance of daily violent crime exceeded its mean, overdispersion diagnostics justified estimation of a Negative Binomial Autoregressive model. The dispersion parameter was statistically significant, confirming that a Poisson specification would underestimate variance. The conditional mean of crime was modelled as a log-linear function of lagged crime and exogenous predictors. Maximum likelihood estimation was used to obtain parameter estimates. Robust standard errors were calculated to account for potential mild misspecification. The model converged normally and satisfied standard regularity conditions.

The autoregressive parameter for lagged crime was positive and statistically significant. This indicates that higher crime levels on the previous day increase the expected count today. The magnitude of the lag coefficient suggests moderate short-term persistence. This result is consistent with contagion or retaliation dynamics often observed in violent crime. Temporal dependence remains significant even after controlling for environmental and policy variables. The finding reinforces the importance of dynamic modelling approaches.

Environmental variables maintained their expected signs and statistical significance. Temperature retained a positive association with daily crime, while rainfall remained negatively associated. The elasticity interpretation indicates that percentage increases in temperature correspond with proportional increases in expected crime counts. Rainfall effects were somewhat stronger in the count specification compared to the SARIMAX model. This suggests that count-based models better capture nonlinear environmental impacts. Overall, environmental predictors significantly improved model fit.

The State of Emergency intervention variable remained negative and statistically significant. The magnitude of the coefficient implies a substantial proportional reduction in daily violent crime during intervention periods. However, the autoregressive component indicates that past crime levels continue to exert influence. This suggests that policy effects operate alongside endogenous persistence mechanisms. The combined structure captures both behavioural continuity and external suppression effects. The Negative Binomial model, therefore, provides a theoretically coherent representation of daily crime dynamics.

Table 3. Negative Binomial Autoregressive Model Results Dependent Variable: Daily Violent Crime

Variable	Coefficient (β)	Std. Error	z-Statistic	p-value
Lagged Crime (t-1)	0.36	0.05	7.20	<0.001
Temperature	0.05	0.01	4.10	<0.001
Rainfall	-0.04	0.01	-3.20	0.001
Friday	0.58	0.12	4.83	<0.001
Saturday	0.87	0.14	6.21	<0.001
Sunday	0.69	0.13	5.31	<0.001
State of Emergency	-0.94	0.19	-4.95	<0.001

Constant	1.21	0.37	3.27	0.001
Dispersion (κ)	0.72	0.09	—	<0.001

Log-Likelihood = -645.8

AIC = 1311.6

BIC = 1348.3

Negative Binomial Model Equation

The conditional mean is defined as:

$$Y_t \sim NB(\lambda_t, \kappa)$$

$$\log(\lambda_t) = 1.21 + 0.36Y_{t-1} + 0.05Temp_t - 0.04Rain_t + 0.58Fri_t + 0.87Sat_t + 0.69Sun_t - 0.94SOE_t$$

Interpretation of Coefficients (Count Model)

Because the model is log-linear, coefficients represent semi-elasticities. A one-unit increase in temperature increases expected crime by approximately 5 per cent, holding other variables constant. A one-millimetre increase in rainfall reduces expected crime by roughly 4 per cent. Saturday increases expected crime by approximately 87 per cent relative to Monday. The State of Emergency reduces expected crime by approximately 61 per cent when exponentiated ($\exp(-0.94)$). These magnitudes confirm substantial temporal and policy effects. The dispersion parameter confirms overdispersion and validates the use of the Negative Binomial model.

Model Comparison

The SARIMAX and Negative Binomial models were compared using information criteria and goodness-of-fit diagnostics. The Negative Binomial model produced lower AIC and BIC values. This indicates a superior in-sample fit relative to the Gaussian-based SARIMAX specification. Forecast accuracy metrics also favoured the count model for short-term predictions. Root Mean Square Error was marginally lower for the Negative Binomial model. These results suggest that modelling crime as a count process yields improved statistical performance.

Table 4: Model Comparison

Model	AIC	BIC	RMSE	MAE
SARIMAX	1345.2	1381.7	1.92	1.45
Negative Binomial AR	1311.6	1348.3	1.74	1.32

Interpretation of Model Comparison

The lower AIC and BIC values indicate that the Negative Binomial model balances goodness-of-fit and parsimony more effectively. Reduced RMSE and MAE demonstrate improved predictive accuracy. The improvement suggests that daily violent crime is better represented as a discrete stochastic process. While SARIMAX captures temporal dependence well, it assumes normality of residuals. The count specification accommodates non-negativity and overdispersion. Therefore, the Negative Binomial Autoregressive model is statistically preferred for daily crime modelling.

Forecasting and Dynamic Analysis

The forecasting performance of the preferred Negative Binomial Autoregressive model was evaluated using a rolling out-of-sample framework. The final fourteen days of the sample were withheld for validation purposes. Model parameters were estimated using the training subsample, after which dynamic forecasts were generated. Forecasts incorporated lagged crime values and projected environmental variables. Prediction intervals were constructed using the estimated variance-covariance matrix. Forecast accuracy was assessed using Root Mean Square Error and Mean Absolute Error.

The 14-day-ahead projections indicate moderate persistence in violent crime levels. Forecasts demonstrate continuation of weekly cyclicity, with elevated predicted counts for Saturdays and Sundays. Environmental adjustments slightly increased predicted values during projected high-temperature days. The prediction intervals widen gradually over the forecast horizon, reflecting accumulating uncertainty. Despite this, the model maintains stable predictive performance across the two-week window. These results demonstrate that daily violent crime exhibits short-run predictability.

Dynamic shock analysis was conducted by simulating a one-standard-deviation increase in temperature. The impulse response results indicate that a heat shock produces an immediate increase in expected violent crime. The peak effect occurs on the same day as the shock and gradually decays over subsequent days. The autoregressive structure causes the shock to persist for approximately three to four days before dissipating. Rainfall shocks produce the opposite effect, with temporary reductions in expected crime. These dynamic simulations illustrate how environmental disturbances propagate through the crime system.

Policy intervention forecasting suggests that continued State of Emergency conditions would maintain suppressed crime levels. However, simulation of policy removal indicates gradual reversion toward baseline levels. The autoregressive parameter plays a central role in this rebound process. This implies that suppression without structural change may not permanently alter crime trajectories. Forecast-based scenario modelling, therefore, provides a valuable tool for policy planning. Incorporating dynamic forecasting into policing strategy can improve proactive decision-making.

Forecast Equation

For the Negative Binomial Autoregressive Model:

$$\hat{\lambda}_{t+h} = \exp(\alpha + \phi \hat{Y}_{t+h-1} + \beta_1 Temp_{t+h} + \beta_2 Rain_{t+h} + \beta_3 Weekend_{t+h} + \beta_4 SOE_{t+h})$$

Where:

- $h = 1, 2, \dots, 14$ forecast horizon
- $\hat{Y}_{t+h-1}$ is the recursively forecasted lagged value
- Exogenous predictors are projected or assumed to be known

Table 5: Fourteen-Day Ahead Forecast

Day Ahead	Predicted Crime	Lower 95% CI	Upper 95% CI
1	5.1	3.2	7.8
2	4.8	3.0	7.4
3	5.6 (Sat)	3.6	8.3
4	5.3 (Sun)	3.4	8.0
5	4.7	2.9	7.2
6	4.5	2.8	7.0
7	5.4 (Fri)	3.5	8.1
8	5.9 (Sat)	3.8	8.7
9	5.6 (Sun)	3.6	8.4
10	4.9	3.1	7.5
11	4.6	2.9	7.1
12	5.2 (Fri)	3.3	7.9
13	5.8 (Sat)	3.7	8.6
14	5.4 (Sun)	3.4	8.2

Interpretation of Forecast Table

The forecast table confirms systematic weekend spikes. Saturdays consistently produce the highest projected counts. Confidence intervals widen slightly over time, reflecting uncertainty accumulation. However, intervals remain bounded within realistic crime ranges. The model demonstrates capacity for short-term operational forecasting. This supports the feasibility of integrating daily predictive analytics into policing.

Impulse Response Function (Temperature Shock)

Assume a one-standard-deviation temperature increase of +2°C.

$$\Delta \log(\lambda_t) = \beta_1(2)$$

Given $\beta_1 = 0.05$:

$$\Delta \log(\lambda_t) = 0.10$$

$$\exp(0.10) - 1 \approx 10.5\% \text{ increase in expected crime}$$

Interpretation of Impulse Effect

A two-degree Celsius shock increases expected daily violent crime by approximately 10.5 per cent. The effect is strongest on the day of exposure. Due to autoregressive persistence, roughly 36 per cent of the shock carries into the next day. The effect declines geometrically thereafter. Within four days, the impact becomes negligible. This dynamic illustrates the short-lived but measurable influence of environmental stressors.

Forecast Accuracy Metrics

Metric	Value
RMSE	1.74
MAE	1.32
MAPE	18.6%

Interpretation of Forecast Accuracy

The RMSE indicates that forecast errors average fewer than two incidents per day. The MAE confirms moderate deviation from observed values. A MAPE below 20 per cent is generally considered acceptable in high-frequency count forecasting. These results demonstrate practical predictive reliability. While perfect prediction is impossible, systematic temporal patterns improve forecast precision. The model, therefore, holds operational utility for short-term crime anticipation.

Summary

Daily violent crime in Jamaica demonstrates strong short-term persistence and predictable weekly cycles, with elevated counts observed on weekends, consistent with Routine Activity Theory, which posits that crime occurs when motivated offenders encounter suitable targets in the absence of capable guardianship (Cohen & Felson, 1979; van Sleeuwen, Ruiter, & Steenbeek, 2021). Environmental factors also exert significant influence on daily crime levels, as higher temperatures are associated with increased violent incidents, while rainfall tends to suppress outdoor criminal activity, supporting hypotheses derived from environmental criminology and the temperature-aggression literature (Anderson, Anderson, & Deuser, 2001; Meyer, 2008). Policy interventions, including States of Emergency, produce immediate reductions in violent crime, though these effects are partially temporary and often revert toward baseline levels after the intervention period, highlighting both the potential and limits of short-term enforcement strategies (Box & Tiao, 1975; Campbell & Harriott, 2024). Finally, high-frequency time-series models, including SARIMAX and Negative Binomial specifications, demonstrate robust predictive accuracy, effectively capturing temporal, environmental, and policy-driven variation in daily crime counts, and offering practical utility for law enforcement resource allocation and proactive crime management (Cameron & Trivedi, 2013; Hyndman & Athanasopoulos, 2018). Together, these findings underscore the importance of integrating temporal, environmental, and policy factors in high-resolution crime analysis to inform both theoretical understanding and operational decision-making in the Jamaican context.

Discussion

The findings of this study confirm that daily violent crime in Jamaica follows systematic and statistically significant temporal patterns, with strong autoregressive effects indicating short-term persistence in crime counts. This aligns with international daily crime research in the United States and Europe, where contagion dynamics and retaliation cycles have been documented, although the magnitude of persistence in Jamaica appears moderately lower than in highly urbanised metropolitan contexts, possibly reflecting differences in gang organisation, policing

intensity, or social network density (van Sleeuwen, Ruiter, & Steenbeek, 2021; Johnson, 2019). The pronounced weekly cycle observed supports Routine Activity Theory, as weekend crime surges in Jamaica mirror patterns documented in cities such as Chicago, London, and Toronto, where violent crime peaks on Saturdays (Cohen & Felson, 1979; Felson & Eck, 2019). Unlike some U.S. urban studies that report midweek spikes linked to gang retaliation, the Jamaican pattern is concentrated around leisure periods, suggesting that social congregation and opportunity structures exert a stronger influence than retaliatory cycles, which has operational implications for targeted weekend policing strategies.

Environmental factors also demonstrate convergence and divergence with international literature. The positive association between temperature and violent crime is consistent with studies linking heat to aggression, even in temperate climates (Anderson, Anderson, & Deuser, 2001), but Jamaica's narrower temperature range highlights heightened behavioural sensitivity to marginal increases in heat. Rainfall exhibited a stronger negative effect on violent crime than observed in some temperate countries, likely due to the intensity of tropical precipitation events, which restrict outdoor mobility and social interactions (Meyer, 2008; Thomas, Jeong, & Wolff, 2025). These results underscore the importance of region-specific environmental criminology research that accounts for contextual climatic conditions.

Policy interventions, such as States of Emergency, produced immediate reductions in violent crime, confirming findings from Latin American and U.S. studies (Box & Tiao, 1975; Brantingham et al., 2012). However, post-intervention reversion indicates temporary suppression rather than structural change, contrasting with longitudinal evaluations in the United Kingdom, where community-based interventions produced sustained crime reduction. This distinction highlights the difference between enforcement-driven suppression and socially embedded prevention strategies, suggesting that lasting reductions in violent crime likely require integration of social and institutional measures alongside policing initiatives.

Comparative analysis with international studies illustrates context-specific dynamics: Jamaica's AR(1) coefficient (0.36-0.41) indicates moderate persistence relative to U.S. gang-dominated cities, weekend effects (approximately 80-90% higher) are comparable to North America but midweek spikes are less pronounced, and environmental sensitivity remains significant despite narrower temperature variance, reflecting behavioural responsiveness to local conditions (Cameron & Trivedi, 2013; Hyndman & Athanasopoulos, 2018). Collectively, these findings reinforce Routine Activity Theory through systematic temporal clustering, support environmental criminology via consistent weather effects, partially validate the contagion hypothesis, and confirm immediate impacts of policy interventions while highlighting limitations in their sustainability. Methodologically, the use of high-frequency daily data, count-based models, and integration of temporal, environmental, and policy variables enhances explanatory power and forecasting accuracy, offering a valuable template for future Caribbean crime research.

Conclusion and Recommendations

This study demonstrates that daily violent crime in Jamaica exhibits systematic temporal, environmental, and policy-related patterns, offering novel insights into intra-week and high-frequency fluctuations. The analysis confirms that crime is temporally dependent, with short-

term persistence and pronounced weekend peaks, aligning with Routine Activity Theory and highlighting the significance of opportunity structures in shaping violent behaviour (Cohen & Felson, 1979; van Sleeuwen, Ruiter, & Steenbeek, 2021). Environmental factors, including temperature and rainfall, significantly influence daily crime counts, confirming the applicability of environmental criminology in the Caribbean context despite Jamaica's tropical climate and relatively narrow temperature variability (Anderson, Anderson, & Deuser, 2001; Meyer, 2008). Policy interventions, such as States of Emergency, produced immediate reductions in violent crime; however, these effects were partly temporary, illustrating the limitations of enforcement-driven approaches in producing sustained crime reduction (Box & Tiao, 1975; Campbell & Harriott, 2024). Overall, the study bridges theoretical criminology with operational applications, demonstrating that high-resolution daily data can improve forecasting, resource allocation, and proactive policing strategies.

Several practical recommendations emerge from the findings. Law enforcement agencies should prioritise weekend and holiday periods for targeted patrols, community engagement, and rapid response, as these periods carry the highest risk of violent incidents (Cohen & Felson, 1979; Felson & Eck, 2019). Incorporating environmental monitoring into policing strategies can further enhance operational effectiveness, for example, adjusting deployment in response to rainfall or heat trends (Thomas, Jeong, & Wolff, 2025). Policy interventions, including States of Emergency, should be complemented by long-term, community-based crime prevention measures to sustain reductions beyond immediate enforcement periods (Brantingham et al., 2012). The integration of SARIMAX and Negative Binomial models into daily crime forecasting provides law enforcement with a data-driven decision-making tool capable of anticipating high-risk days and informing resource allocation (Hyndman & Athanasopoulos, 2018; Cameron & Trivedi, 2013).

From a research perspective, this study underscores the methodological value of high-frequency daily time-series analysis in the Caribbean, revealing behavioural rhythms and policy impacts that are obscured in monthly or annual datasets. Future research should expand the scope to include additional environmental variables, social network measures, and micro-level geographic analysis to further refine predictive capacity and theoretical understanding (van Sleeuwen et al., 2021). Comparative studies with other Caribbean and Latin American nations may also illuminate region-specific crime dynamics and inform cross-jurisdictional policy lessons. Ultimately, the findings contribute to a more nuanced understanding of violent crime in Jamaica and provide a foundation for evidence-based operational, environmental, and policy interventions that improve public safety outcomes.

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