"Strategic Analysis of Crime Trends in Chicago: Insights for Enhanced Law Enforcement and Community Safety."

CAPESTONE PROJECT

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1) Introduction:

Problem Background:

Over the past two decades, Chicago has witnessed significant shifts in crime trends, marked by a general decline in overall crime rates. However, this reduction is uneven across different types of crimes and neighbourhoods. For instance, while theft, battery, and narcotics-related crimes have decreased, others, such as motor vehicle theft and robbery, have shown troubling upward trends, especially during the COVID-19 pandemic era. These patterns highlight the complex and evolving nature of crime in urban environments.

Furthermore, disparities in crime distribution across neighbourhoods suggest systemic issues that could affect residents' perception of safety and equality. High-crime areas, such as central business districts, often overshadow low-crime zones, creating a need for targeted interventions. Seasonal and temporal crime patterns, with peaks in summer months and weekend evenings, exacerbate these challenges, straining law enforcement's ability to effectively allocate resources and ensure public safety.

The project seeks to address these challenges by leveraging data-driven decision-making to analyse crime trends, identify underlying factors, and propose actionable strategies for enhancing law enforcement operations. By applying advanced analytical techniques, such as time series forecasting, regression models, and classification trees, this project aims to provide insights into crime dynamics and deliver recommendations that can improve policing strategies, resource planning, and community safety.

Need for Data-Driven Strategies: Chicago faces distinct challenges in managing diverse crime patterns across neighbourhoods. The trends highlight a mix of reductions in crimes such as theft and narcotics but troubling rises in motor vehicle theft and robbery.

Leveraging big data and analytics offers a pathway to enhance law enforcement strategies by identifying crime hotspots, seasonal peaks, and patterns in criminal activities.

Data-driven strategies can optimize resource allocation, improve public safety, and enable proactive policing measures tailored to Chicago's unique crime landscape.

Justification for Startup Collaboration with the Chicago Police Department:
The strategic use of crime data insights offers a transformative opportunity to improve public safety and optimize law enforcement efforts in Chicago.

startup collaboration can provide critical value to the Chicago Police Department (CPD):

1. Leverage Advanced Analytics for Proactive Policing
2. Develop Data-Driven Resource Allocation Tools
3. Enhance Community Engagement and Transparency
4. Automate Predictive Models for Sustainable Crime Management
5. Drive Cost-Effective Law Enforcement Innovations
6. Customized Training and Support for CPD

Vision for Collaboration

The startup envisions a long-term partnership with CPD, delivering sustained improvements in public safety through:

- **Integrated-Systems**
  The startup aims to create a centralized crime analytics hub that consolidates real-time data from various sources, enabling CPD to monitor crime dynamics as they unfold. This system will empower law enforcement leaders to make data-informed decisions quickly, enhancing their ability to respond to emerging threats effectively.
- **Evidence-Based-Policy-Recommendations**
  By leveraging advanced analytics, the startup will generate actionable insights that illuminate systemic issues contributing to crime trends, such as socio-economic disparities or infrastructure gaps. These insights will guide CPD and policymakers in formulating strategies and policies that address the root causes of crime, fostering long-term reductions.
- **Scalable-Solutions**
  The startup will develop flexible and adaptable frameworks for crime analytics that can be tailored to the needs of other cities and law enforcement agencies. This scalability will position Chicago as a pioneer in data-driven policing, setting an example of innovation and operational excellence that other urban areas can emulate.

2) Objective:

- Analyse crime trends and Patterns Utilize Chicago's crime dataset to uncover temporal and geographic crime patterns, identifying hotspots, seasonal variations, and trends across different crime types. This analysis will provide actionable insights to understand the dynamics of criminal activity and inform law enforcement strategies.

- Implement Time-Series Forecasting for Proactive Policing Apply time-series models to forecast future crime trends, enabling the Chicago Police Department (CPD) to anticipate potential surges in criminal activity. These predictions will guide resource allocation and policymaking to mitigate crime proactively.

- Classify High-Risk Areas Using Advanced Models Employ classification models, such as decision trees, to identify neighbourhoods and times with the highest risk of criminal incidents. This will allow CPD to focus patrols and interventions in areas most prone to specific crimes like motor vehicle theft or robbery.

- Examine Correlations Between Arrests and Crimes Conduct correlation analysis to understand the relationship between reported crimes and arrest rates. Insights from this analysis will help CPD evaluate the effectiveness of current enforcement efforts and identify gaps for improvement.

- Provide Tailored Recommendations for Resource Optimization Translate analytical findings into practical strategies for optimizing law enforcement operations, including deployment schedules and community outreach programs. These recommendations will enhance CPD's efficiency in addressing crime and improving public safety.

- Develop Community-Centric Safety Initiatives Integrate socio-economic data and crime insights to design targeted community programs aimed at preventing crime and fostering trust in law enforcement. These initiatives will focus on empowering neighbourhoods with tools and information to address root causes of crime.

3) Data Extraction:

Dataset Overview
The Chicago Police Department's 2023 crime dataset includes fields such as crime type, date, location, and arrest records, offering valuable insights into spatial and temporal crime trends. This comprehensive dataset provides a foundation for understanding patterns and informing strategic decision-making.

Data Source
The dataset was sourced from the City of Chicago's open data portal, ensuring access to reliable and up-to-date information for the analysis.

Data Cleaning Process
The dataset underwent cleaning processes such as removing missing or incomplete entries, standardizing date formats, and categorizing crime types to ensure consistency and accuracy for analytical purposes.
Data has been made ready for analysis and time series forecasting.

4) Data Exploration:

1.Crime Trends Over Two Decades

- Insight: A steady decline in annual crime rates was observed over a 20-year period, with a noticeable downward trend in theft, battery, and narcotics crimes. Conversely, motor vehicle theft and robbery have shown an upward trend in recent years, particularly during the pandemic era.
- Visualization: Trend lines and moving averages illustrating the decline and recent spikes in specific crime types.
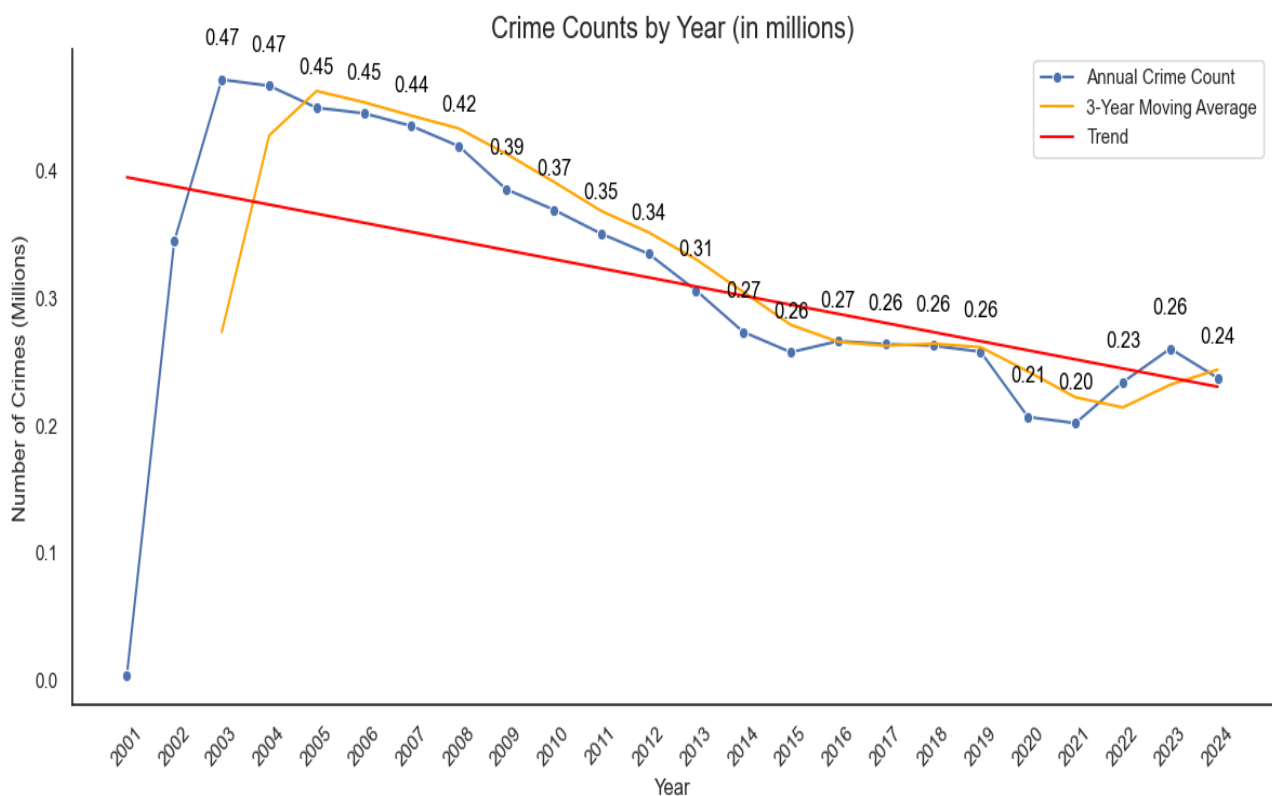

Decade-Long Decrease in Chicago's Crime Rate: A Closer Look

2. Crime Frequency by Category

Key Crime Types:

- Most Common: Battery, with "Domestic Battery Simple" as the most frequent subcategory.
- Second Most Common: Theft, divided into "Over $500" and "Under $500," highlighting property-related crimes.
- Motor Vehicle Theft: Dominated by "Automobile" thefts, indicating a growing concern for car-related crimes.
- Drug-Related Crimes: Focused on cannabis possession.
- Assaults: Predominantly "Simple Assaults," suggesting less involvement of weapons or vehicles.

Top 5 Primary Crime Types with Descriptions
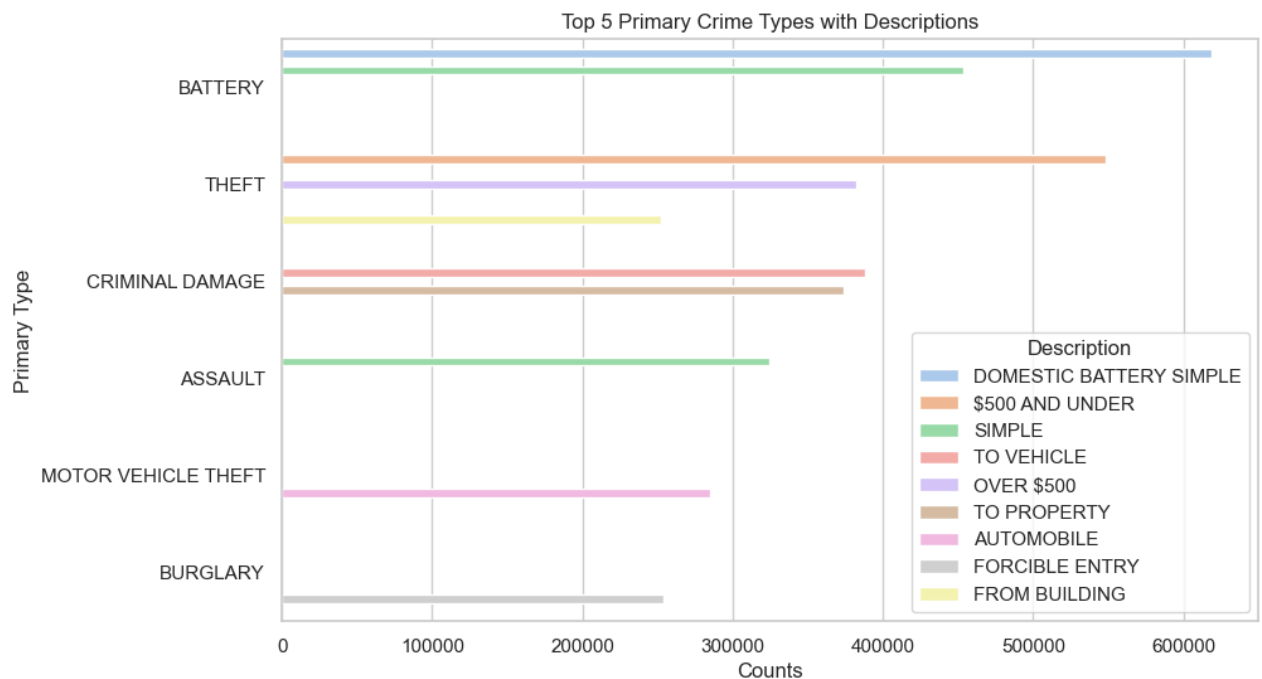
3. Seasonal Crime Patterns

- **Insight**: Crime rates peak during the summer months, with July being the highest. Conversely, February sees the lowest crime rate.
- **Implications**: Warmer weather correlates with increased crime, likely due to higher social activities and outdoor interactions.
- The bar chart suggests that crime rates tend to peak in the summer months, with the highest average occurring in July, followed by a secondary peak in May. Conversely, February is shown to have the lowest average crime rate.
- These trends may indicate that warmer weather correlates with increased criminal activity, which could be due to a variety of factors such as increased social activity, tourism, or other seasonal variables that potentially contribute to opportunities for crime. The data could be used to advocate for strategic law enforcement planning and community programs during these higher-risk periods.
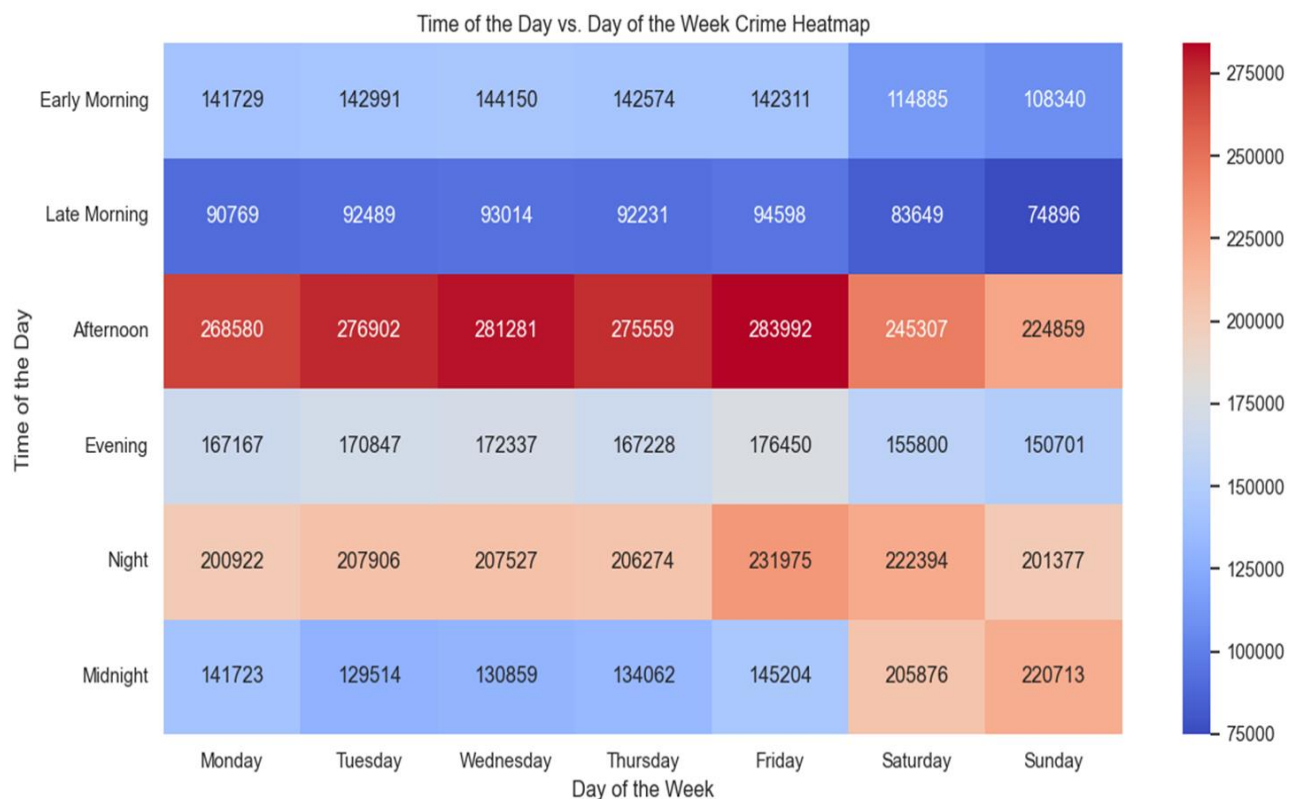

Monthly Average Number of Crimes
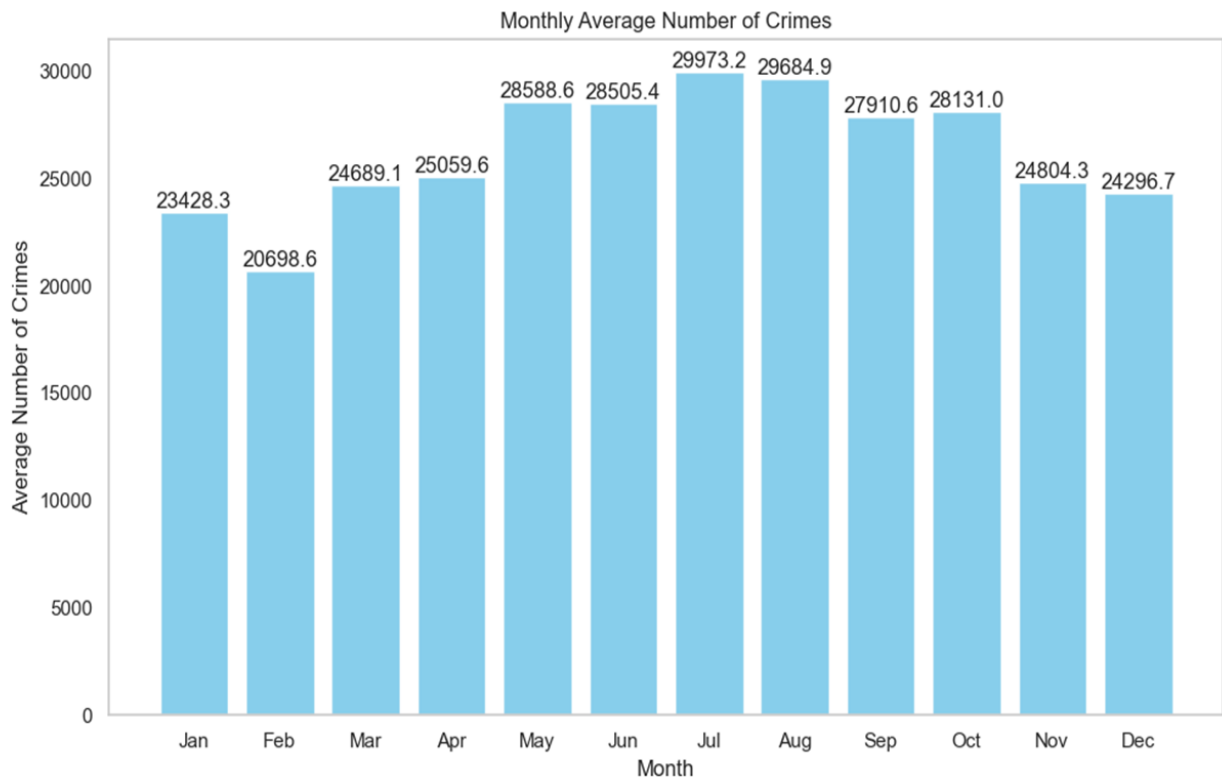
4.Crime Distribution Across Neighbourhoods

- **Insight**: Significant variability in crime counts between neighbourhoods. Blocks like Michigan Avenue and State Street have the highest crime counts, while Yates Boulevard and Randolph Street have the lowest.
- **Implications**: Higher crime concentrations in specific neighbourhoods can impact residents' and visitors' perceptions of safety.
- **Crime Distribution**:
- The chart shows a clear distinction between the top and bottom blocks in terms of crime count. The top blocks (e.g., 'MICHIGAN AVE', 'STATE ST') have significantly higher crime counts compared to the lower ones (e.g., 'yates Blvd.', 'RANDOLPH ST'), indicating a disparity in crime distribution across the neighborhoods.
- **Safety Perception**:
- The blocks with the highest crime counts may be perceived as more dangerous, while those with the lowest counts might be perceived as safer. This could impact on residents' and visitors' perception of safety in these areas.
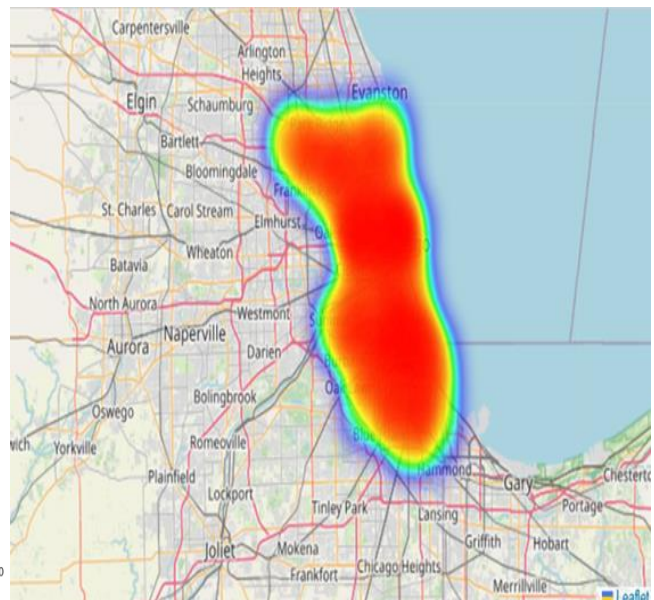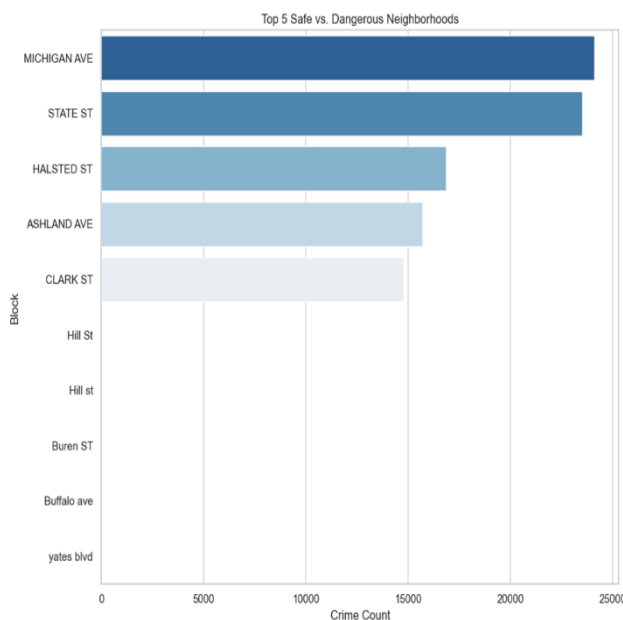
5.Time of Day and Week Analysis (Correlation Analysis)

- **Daily Patterns**:
  - Early mornings (Monday to Thursday) are the safest times.
  - Crimes peak in the evening and night, especially on Fridays and Saturdays.
  - A noticeable spike occurs after midnight going into early Sunday, reflecting weekend nightlife activity.
- **Weekly Patterns**: Fridays and Saturdays consistently show higher crime counts, attributed to social activities and gatherings.
- **Early Morning Safety**: Early Morning hours, especially from Monday to Thursday, appear to have the lowest crime rates, indicating these may be the safest times throughout the week.
- **Evening and Night Caution**: There's a noticeable increase in crime during the Evening and Night, peaking on Friday and Saturday nights, which suggests a need for heightened safety measures during these times.
- **Midnight Activity**: Interestingly, there is a spike in criminal activity after midnight going into early Sunday, which might reflect late-night weekend activities.

Time of the Day vs. Day of the Week Crime Heatmap

| Time of the Day	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
Early Morning	141729	142991	144150	142574	142311	114885	108340
Late Morning	90769	92489	93014	92231	94598	83649	74896
Afternoon	268580	276902	281281	275559	283992	245307	224859
Evening	167167	170847	172337	167228	176450	155800	150701
Night	200922	207906	207527	206274	231975	222394	201377
Midnight	141723	129514	130859	134062	145204	205876	220713

Day of the Week

6. Crime and Arrest Relationship

High Correlation: A Reflective Analysis of Crime Incidents and Arrest Rates

Correlation Between Number of Crimes and Arrests
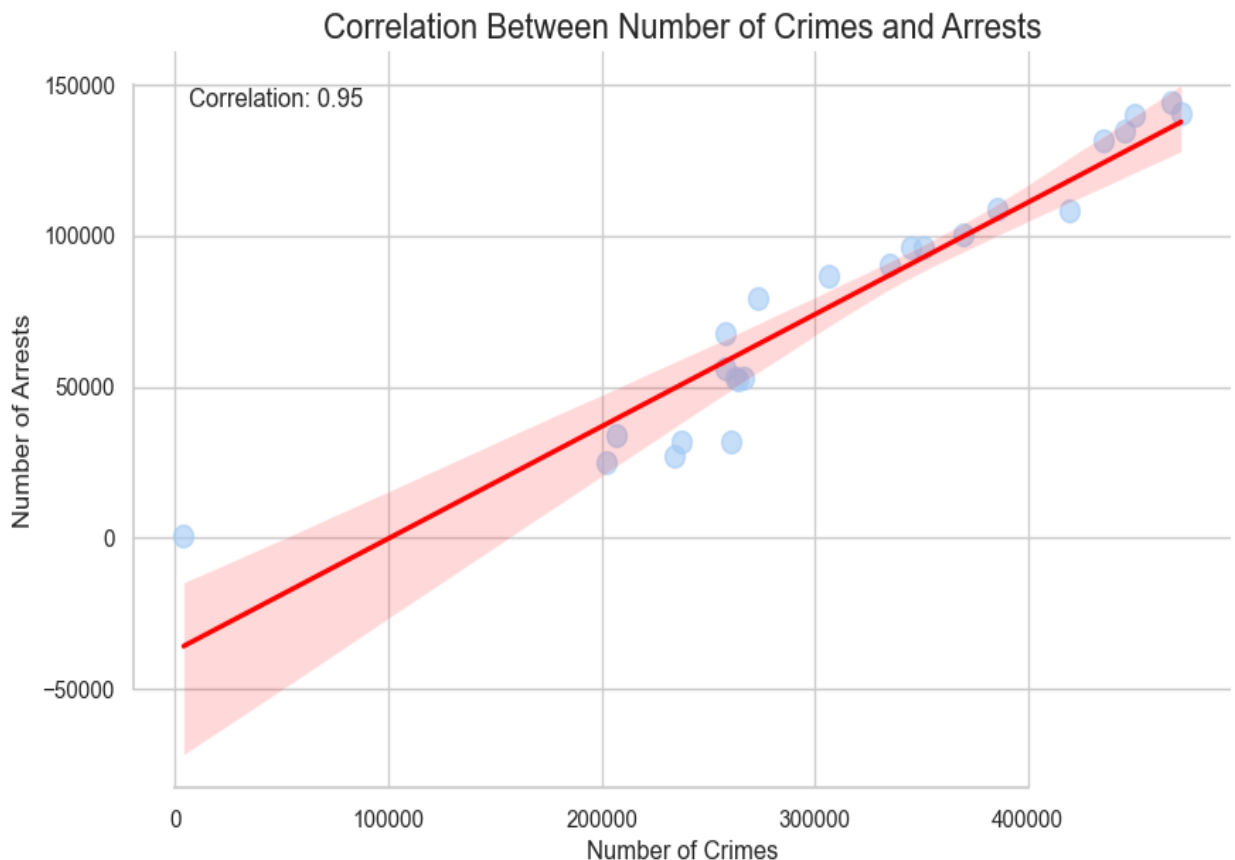
- **Correlation**: A strong positive correlation (0.96) exists between the number of crimes and arrests, suggesting that increased criminal activity typically results in proportional arrests.
- **Implications**: Arrests closely follow crime trends, reflecting law enforcement responsiveness but also highlighting areas where enforcement could be optimized.
- The graph shows a scatter plot with a regression line, illustrating the relationship between the number of crimes and the number of arrests. A correlation coefficient of 0.97 is extremely high, indicating a very strong positive relationship between the two variables. This means that as the number of crimes increases, the number of arrests tends to increase proportionally, and vice versa

Shifting Crime Dynamics: A Two-Decade Perspective

Monthly Crime Count Heatmap (From 2003)
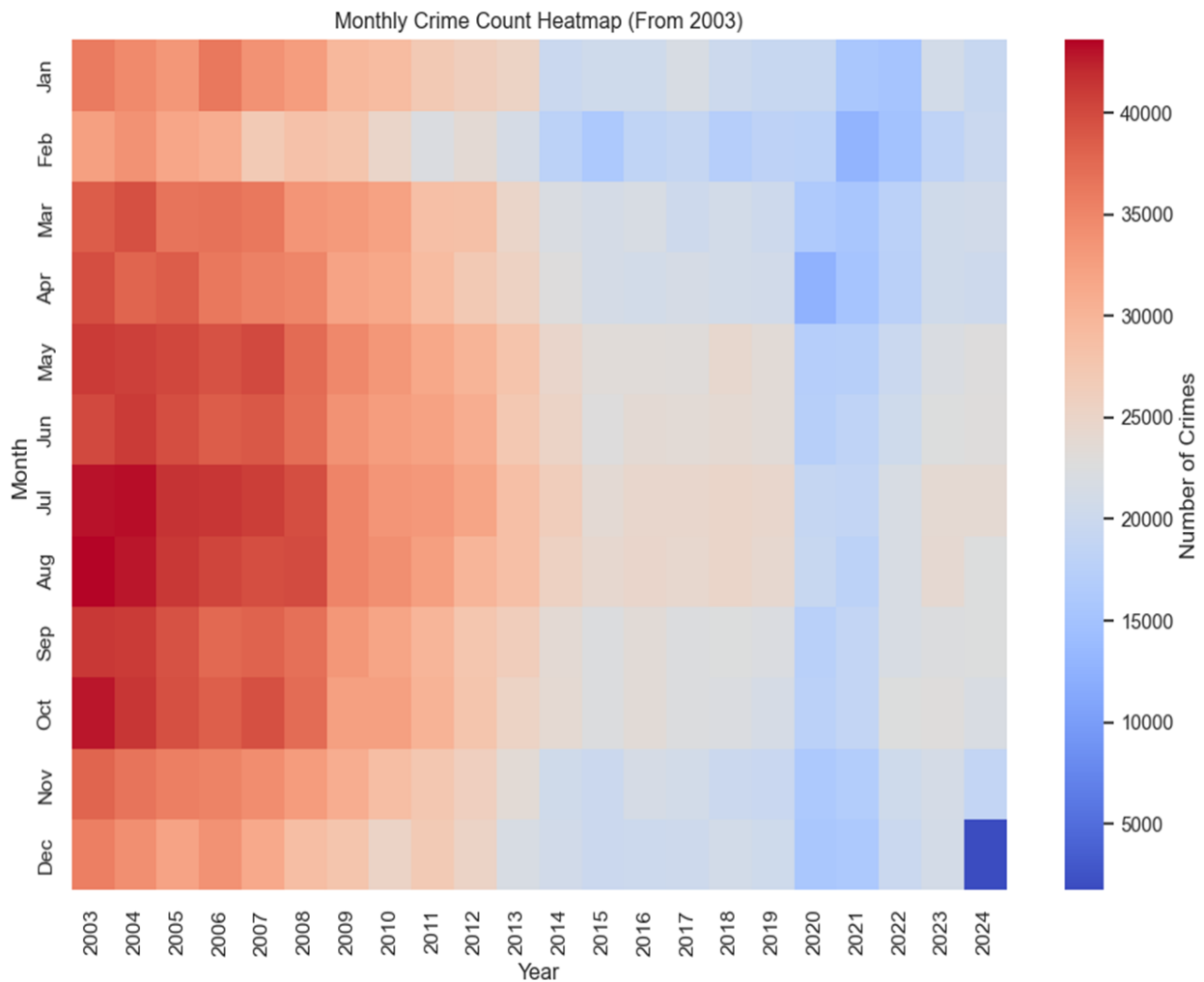
The heatmap suggests a long-term decrease in crime since 2003, with particularly high crime rates in earlier years that gradually taper off. The color gradient indicates that crime rates were consistently higher from 2003 to around 2010-2011, after which there is a noticeable shift to lower crime rates across all months.

When connecting this with the previous picture, which showed monthly averages, it's apparent that while crime has decreased overall, the seasonal pattern within each year remains. Crime still peaks in the summer months, but the total volume of crime in those peak periods is lower in recent years compared to the early and mid-2000s.

5. Model Building: Time Series Forecasting for Crime Prediction

We have implemented a **Time Series Forecasting Model** to predict crime trends for the year **2025**. For this purpose, I utilized the **SARIMA (Seasonal Auto-Regressive Integrated Moving Average)** model, which is particularly well-suited for data exhibiting both **trend** and **seasonality**—characteristics often observed in crime data.

Why SARIMA?
The SARIMA model was selected due to its ability to:
- Capture **seasonal patterns** such as crime spikes during summer months.
- Account for **temporal dependencies** in crime rates over time.
- Provide reliable short-term forecasts based on historical trends.

Model Details
- **Dataset**: The crime dataset from the City of Chicago (2001–2023), aggregated to monthly crime counts.
- Preprocessing:
    - Missing values were addressed.
    - The time series was checked for stationarity using the ADF test and made stationary through first-order differencing (d=1) and seasonal differencing (D=1 with seasonality lag of 12 months).
- Model Parameters:
  Using ACF and PACF plots, combined with parameter tuning, the SARIMA model was configured as:
  SARIMA (1,1,1) (0,1,1) [12].

Predicted Monthly Crime Counts for 2025
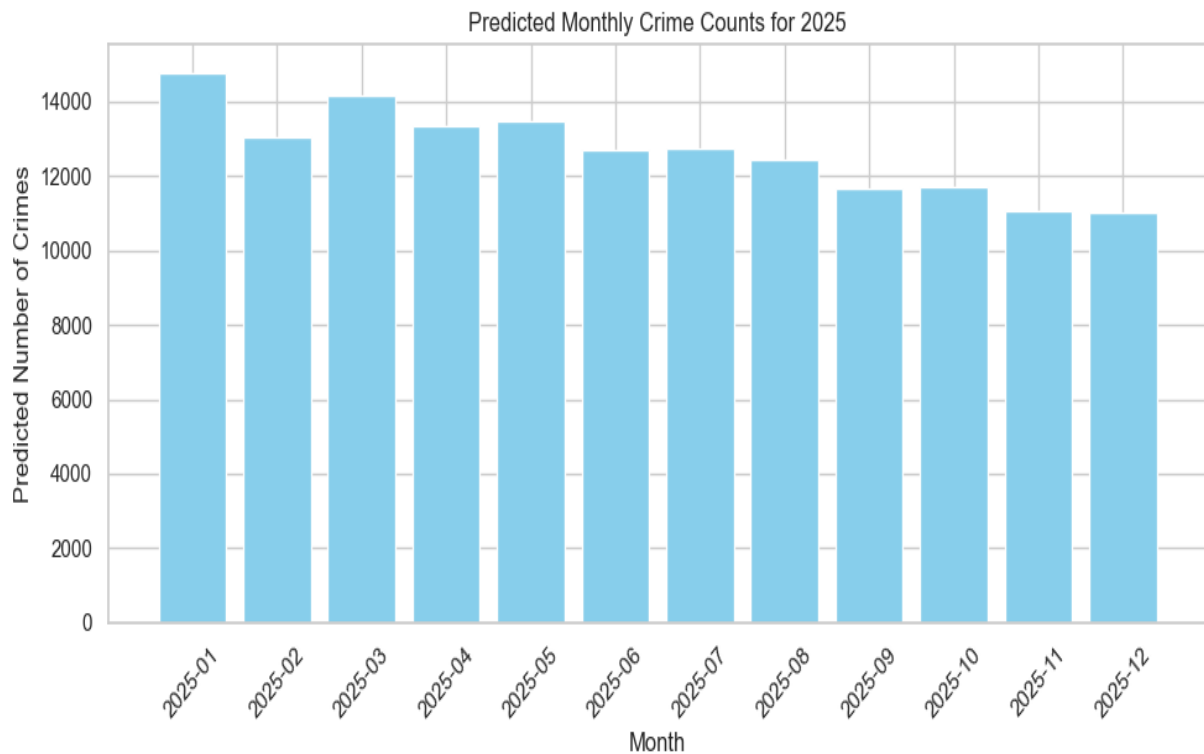
The graph indicates a consistent forecast of crime throughout 2025, with predicted monthly crime counts relatively stable, fluctuating slightly but remaining around the 11,000 to 14,000 range. The first week of January shows the highest predicted daily crimes, suggesting a need for increased vigilance and policing during this period. Overall, the forecast suggests that while crime remains a concern, there are no significant spikes expected in any month, allowing for steady resource allocation throughout the year.

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Monthly crime predictions for 2025:
2025-01-31    14788.455038
2025-02-28    13066.434313
2025-03-31    14154.808801
2025-04-30    13327.212290
2025-05-31    13468.381646
2025-06-30    12690.723484
2025-07-31    12731.436808
2025-08-31    12454.964416
2025-09-30    11677.764253
2025-10-31    11726.551851
2025-11-30    11044.676492
2025-12-31    11030.261392
Freq: ME, Name: predicted_mean, dtype: float64
```

```
Days with highest predicted crimes for 2025:
2025-01-03    498.554916
2025-01-04    496.635298
2025-01-10    496.022332
2025-01-11    494.102709
2025-01-17    493.489741
2025-01-18    491.570117
2025-01-24    490.957149
2025-01-25    489.037525
2025-01-31    488.424557
2025-02-01    486.504934
Name: predicted_mean, dtype: float64
```

6)Recommendations:

1)Trend Analysis:
- Multi-year crime data indicates a downward trend in overall crime rates with seasonal peaks during summer months and on Friday evenings.

2)Predictive Modeling:
- Stable crime rates projected for 2025, enabling consistent resource planning without the need for sudden allocation changes.

3)Crime and Arrest Correlation:
- High correlation (0.97) suggests arrests follow crime rates closely; however, opportunities exist for strategic improvements during periods of arrest rate lag.

4)Strategic Recommendations:
- **Optimized Patrols:** Align police patrols with identified peak crime times to deter incidents effectively.
- **Community Programs:** Implement community outreach during lower crime periods to maintain the downtrend and build public trust.

5)Literature Integration:
- A review of related studies emphasizes the impact of socio-economic factors and supports the adoption of a data-driven approach to policing. Below is the link which supports this type of approach

7)References:

Dataset Source:
[Crimes - 2001 to Present - Map | City of Chicago | Data Portal](#)