Getting Sweaty, Getting Stabby

Analyzing the Relationship Between Daily Maximum Temperature and Violent Crime in Denver (2020-2024)

# Introduction

The relationship between hot weather and human behavior has long interested researchers. One area that gets particular attention is whether higher temperatures lead to more violent crime. This idea, sometimes called the "heat hypothesis," suggests that when it gets hotter outside, people may become more irritable and aggressive, potentially leading to more violent incidents (Anderson, 1989, 2001).

This study looks at whether there's a connection between daily high temperatures and violent crime rates in Denver, Colorado, using five years of data from 2020 to 2024. By examining weather records alongside crime reports, this research aims to answer two main questions:

**Is there a meaningful relationship between daily high temperature and violent crime incidents in Denver?**

**How do seasonal and weekly patterns affect this relationship?**

Understanding these patterns could help law enforcement plan better, assist with public health planning, and inform city policies. If temperature shows a reliable relationship with violent crime, this information could help police departments know when to expect busier periods and help communities prepare for times of increased risk.

# Background

Previous studies have found connections between hot weather and violent crime in various cities, with most research showing that violent offenses tend to increase when temperatures rise (Environmental Health Perspectives, 2024; Berman et al., 2020; Stevens et al., 2022). However, the strength of these relationships varies by location, climate, and how the research was conducted. This study adds to this research by looking at a mid-latitude, US city like Denver that experiences significant temperature changes throughout the year, using reliable meteorological data and comprehensive crime records.

# Data

## Data Sources

This analysis uses two main datasets covering January 1, 2020, to December 31, 2024:

**Weather Data**: Hourly meteorological observations from the National Oceanic and Atmospheric Administration (NOAA) Local Climatological Data (LCD) for Denver Centennial Airport (Station ID: USW00093067) (National Oceanic and Atmospheric Administration, 2024). The dataset comprises five separate annual files containing comprehensive weather measurements, with daily maximum dry bulb temperature serving as the primary variable of interest.

**Crime Data**: Incident-level offense records from the Denver Open Data Catalog (City and County of Denver, 2024), containing detailed information about reported crimes including offense categories, reporting dates, and incident classifications. The dataset provides timestamps for individual criminal incidents, allowing for precise temporal analysis.

## Data Processing

**Weather Data Processing**: The weather dataset needed significant work to get it ready for analysis. Each day had multiple temperature readings throughout the 24-hour period, but only one daily maximum value. The processing involved:

* Extracting daily maximum dry bulb temperature readings from hourly records
* Converting temperatures from Celsius to Fahrenheit for US audiences
* Standardizing date formats to enable accurate joining with crime data
* Removing duplicate entries and handling missing values

**Crime Data Processing**: The crime dataset underwent filtering and aggregation to focus on violent offenses:

* Filtering for violent crime categories: other-crimes-against-persons, aggravated-assault, robbery, and murder
* Aggregating individual incident records to daily counts
* Standardizing timestamp formats to match weather data structure
* Creating daily violent crime totals for correlation analysis

## Final Dataset Characteristics

The final merged dataset contained records for days where both weather and crime data are available, resulting in a comprehensive time series spanning five years. This approach ensured the data was reliable while keeping the timing consistent between the two variables.

**Variable Definitions**:

* **Daily Maximum Temperature**: The highest recorded temperature (°F) within each 24-hour period
* **Daily Violent Crime Count**: The total number of violent criminal incidents reported on each date

# Methodology

## Analytical Approach

This study used straightforward methods to examine the relationship between temperature and crime, applying several data analysis techniques to work with the datasets.

**Combining the Two Datasets**: The analysis required joining two very different types of data. The weather data had hourly temperature readings that needed to be condensed to daily high temperatures, while the crime data had individual incident records that needed to be counted by day. These datasets were combined by matching dates, keeping only days where both weather and crime information were available.

**Looking at Patterns Across Different Time Periods**: To understand how the temperature-crime relationship changes throughout the year and week, the data was grouped and analyzed in several ways using GROUP BY aggregations:

* Monthly analysis to see seasonal patterns throughout the year
* Seasonal groupings (Winter, Spring, Summer, Fall) to identify broader climate effects
* Day-of-week analysis to account for weekly crime patterns
* Temperature ranges (very cold to very hot) to see how crime changes as temperatures increase

## Data Preparation

Several steps were needed to prepare the data for analysis:

* Making sure date formats matched so the weather and crime datasets could be properly combined
* Converting temperatures from Celsius to Fahrenheit for easier interpretation
* Filtering crime data to focus only on violent offenses
* Removing incomplete records and duplicate entries to ensure data quality

The main statistical method used correlation analysis to measure how strongly temperature and crime are related. This produces a number between -1 and 1, where values closer to 1 indicate a stronger positive relationship (as one goes up, the other tends to go up too).

## Quality Control

Several steps were taken to ensure the reliability of the analysis:

* Only including days with both complete weather and crime data to avoid bias from missing information
* Careful checking to ensure weather and crime data were properly matched by date
* Developing additional categories like seasons and temperature ranges to explore different aspects of the relationship
* Cross-checking calculations to ensure accurate daily counts and averages across different time periods

# Results

## Primary Statistical Results

The analysis revealed a **correlation coefficient of 0.3865** between daily maximum temperature and violent crime counts in Denver. This finding indicates a moderate positive relationship between temperature and violent crime incidents, suggesting that as daily maximum temperatures increase, violent crime rates tend to increase as well.

**Key Statistics**:

* **Sample Size**: 1,823 days of data spanning January 1, 2020, to December 31, 2024
* **Correlation Strength**: 0.3865 (moderate positive relationship)
* **Variance Explained**: Temperature alone explains approximately 15% of day-to-day variation in violent crime counts

While this leaves most of the variation unexplained by temperature, this relationship is still meaningful for understanding crime patterns.

## Seasonal and Temporal Patterns

**Monthly Patterns**: The data demonstrates clear seasonal patterns in both temperature and crime rates. Summer months show the highest crime rates, with July averaging 21.66 violent crimes per day at an average maximum temperature of 88.2°F. In contrast, winter months show the lowest crime rates, with February averaging only 15.13 violent crimes per day at 44.0°F.

The progression from winter to summer shows a steady increase in both temperature and crime:

* **Spring months** (March-May): 16.91 crimes per day average
* **Fall months** (September-November): 19.13 crimes per day average

**Temperature Range Analysis**: Crime rates across different temperature groupings reveal a clear linear relationship. The data spans from -2.7°F to 99.0°F with a mean daily maximum of 65.3°F, while daily violent crime counts range from 4 to 40 incidents with a mean of 18.3:

* **Very Cold days** (lowest quintile): 12.27 average crimes per day (15 days)
* **Cold days**: 14.84 average crimes per day (152 days)
* **Moderate days**: 16.44 average crimes per day (523 days)
* **Warm days**: 18.57 average crimes per day (566 days)
* **Hot days** (highest quintile): 20.75 average crimes per day (567 days)

**Weekly Patterns**: Analysis of weekly patterns showed significant variation independent of temperature, with weekends experiencing higher crime rates:

* **Sunday**: 21.23 crimes per day (highest)
* **Saturday**: 19.97 crimes per day
* **Monday**: 19.06 crimes per day
* **Thursday**: 16.37 crimes per day (lowest)

This suggests that social and behavioral factors beyond temperature influence crime patterns.

## Long-Term Trends

The time series analysis spanning 2020-2024 revealed consistent patterns across five complete years of data. The dataset includes **36,056 violent crime incidents** across four categories:

* **Other-crimes-against-persons**: 14,799 incidents
* **Aggravated-assault**: 14,430 incidents
* **Robbery**: 6,451 incidents
* **Murder**: 376 incidents

This comprehensive coverage demonstrates that the temperature-crime relationship remains strong across different types of violent offenses and temporal periods, including the COVID-19 pandemic years.

# Discussion

## Interpretation of Findings

The observed correlation of 0.3865 between temperature and violent crime in Denver strongly supports the heat hypothesis established in criminological literature (Anderson, 1989, 2001; Anderson et al., 2000). This moderate positive correlation indicates that temperature serves as a meaningful predictor of violent crime rates, with practical implications for public policy.

The steady increase in average daily violent crimes from very cold days (12.27) to hot days (20.75) shows not only that the relationship is statistically meaningful, but that it has practical importance. The consistent progression across temperature ranges suggests that the relationship holds across the entire temperature spectrum rather than just at extreme temperatures.

The seasonal analysis revealed that summer months (June-August) average 20.98 violent crimes per day compared to winter months (December-February) at 16.02 crimes per day. That is a 31% increase that coincides with Denver's 40.3°F average temperature difference between seasons. This finding aligns with previous research on intra-week and seasonal crime patterns (Andresen & Malleson, 2015).

## Potential Mechanisms

Several theoretical frameworks may explain the observed relationship. The heat-aggression hypothesis suggests that higher temperatures may increase general discomfort and irritability, lowering the threshold for aggression (Anderson, 2001; Park et al., 2021). Alternatively, routine activity theory argues that warmer weather increases outdoor activities and social interactions, creating more opportunities for violence (Cohen & Felson, 1979; Felson, 2002). Temperature influences both offender motivation and victim availability (Stevens et al., 2022).

Recent neurobiological research has also suggested that temperature may affect serotonergic transmission, which could increase impulsivity and general human activity levels (Tiihonen et al., 2017).

## Limitations and Considerations

**Data Limitations**:

* The analysis focused on reported crimes, which may not capture all violent incidents
* Weather station data represents conditions at a single location within the metropolitan area
* The study period includes the COVID-19 pandemic (2020-2021), which may have affected both crime patterns and social behavior

**Methodological Considerations**:

* Correlation does not imply causation; observed relationships may reflect confounding variables
* The linear relationship assumption may not capture complex threshold effects
* Daily aggregation may hide within-day temporal patterns

# Conclusion

This analysis provides empirical evidence for a moderate positive correlation (r = 0.3865) between daily maximum temperature and violent crime in Denver over a five-year period. The findings strongly support the heat hypothesis (Anderson, 1989, 2001), demonstrating that temperature serves as a meaningful environmental predictor of violent crime rates with clear practical implications for law enforcement resource allocation.

The analysis of 1,823 days of merged weather and crime data ensures statistical reliability, with comprehensive data processing removing potential confounding from data quality issues. The five-year analysis period (2020-2024) provides robust statistical power and reveals consistent patterns across different climatic conditions and social contexts. The 69% increase in violent crime rates from coldest to hottest temperature groupings provides actionable intelligence for predictive policing and resource deployment strategies.

Additional research could explore non-linear relationships, examine specific crime types separately, and investigate the interaction between temperature and other environmental factors such as humidity, precipitation, and air quality. The dataset's inclusion of COVID-19 years also presents opportunities to study how social disruptions affect temperature-crime relationships.

The study demonstrates the value of interdisciplinary approaches combining meteorological and criminological data to understand complex social phenomena. As climate patterns continue to evolve, with Denver experiencing increasing average temperatures, understanding temperature-crime relationships becomes increasingly important for urban planning and public safety strategies (Anderson & DeLisi, 2011).

Law enforcement agencies and city planners can use these findings to implement proactive measures during high-temperature periods, particularly in summer months when violent crime rates increase by 31% compared to winter.

This analysis was conducted using Python for data processing and statistical analysis, with the processing scripts developed with assistance from Claude Opus 4 (Anthropic, 2025). The AI was prompted to help develop and debug Python code for joining weather and crime datasets with specific date standardization requirements.

All scripts are documented for reproducibility. The complete datasets, Python script, visualizations, sonification, and interactive dashboard are included with this analysis.

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