Journal of Experimental Criminology (2024) 20:1225–1251
https://doi.org/10.1007/s11292-023-09576-8

Evidence on the impact of the Prudential Center on crime in downtown Newark

Gian Maria Campedelli[1] · Eric L. Piza[2] · Alex R. Piquero[3] · Justin Kurland[4]

Accepted: 22 May 2023 / Published online: 15 June 2023
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Abstract

Objectives Evaluate the effects that Prudential Center events had on crime in downtown Newark from 2007 to 2015 in terms of incident counts and spatial characteristics.

Methods We evaluate the effects of events held at the Prudential Center on crime counts via negative binomial regression. Through the Fasano-Franceschini test, we assess whether crimes that occurred during events spatially differ compared to the incidents in no-event hours. Finally, we employ logistic regression to assess the correlation between crime locations and activity at the center.

Results Five event types (out of nine) are statistically associated with increases in crime. Spatially, differences in the distribution of incidents when the facility is active partially emerge. Two out of six location types (streets and parking lots) correlate with activity at the center.

Conclusions The complex array of crime-related effects that the center has on downtown Newark suggests tailored policies discriminating between event and location types for enhancing public safety.

Keywords Crime · Super facilities · Entertainment venues · Prudential Center · Sport

✉ Eric L. Piza
e.piza@northeastern.edu

[1] Department of Sociology and Social Research, University of Trento, Trento, Italy

[2] School of Criminology and Criminal Justice, Northeastern University, 401 Churchill Hall, 360 Huntington Ave, Boston, MA, USA

[3] Department of Sociology and Criminology, University of Miami, Miami, FL, USA

[4] New York, NY, USA

Introduction

Environmental criminology focuses on the role that the immediate environment plays in the performance of crime (Wortley & Townsley, 2017). This body of research has consistently found crime patterns to be influenced by a range of facility types, inclusive of schools (Murray & Swatt, 2013), bars (Ratcliffe, 2012), check cashing stores (Bernasco & Block, 2011), bus stops (Loukaitou-Sideris, 1999), and railway stations (Irvin-Erickson & La Vigne, 2015). The typical facility types that are analyzed can be considered crime generators, places to which people are attracted for reasons unrelated to criminal motivation but nonetheless may offer increased crime opportunities (Brantingham & Brantingham, 1995).

Recent scholarship has focused on the effect of macro crime generators, very large facilities that can accommodate many more people than the smaller facilities that have typically been considered crime generators previously. Examples of macro crime generators include amusement parks (Han et al., 2021), casinos (Johnson & Ratcliffe, 2017), and sports arenas and stadiums (Kurland et al., 2014; Kurland, 2019). Macro crime generators typically have a time-specific effect that coincides with their opening/closing times and/or peak hours of operation (Newton, 2018). The time-specific nature of macro crime generators helps address a common challenge associated with the cross-sectional nature of environmental criminology research. The criminogenic influence of a particular facility, or group of facilities, is assumed (analytically at least) to be constant. Consequently, causal inference is not entirely possible because there is no way to establish that cause (i.e., crime generator operations) precedes effect (i.e., increased crime levels). Macro crime generators, conversely, provide the necessary conditions to circumvent this challenge as their episodic usage allows researchers to contrast times when they are used, and large numbers of people gravitate to them, with those days and times when no event is scheduled.

Sports arenas/stadiums are perhaps the most well-researched macro crime generator (Humphreys, 2019). Research has demonstrated that arenas are associated with heightened levels of crime (Breetzke & Cohn, 2013; Kurland, 2014; Kurland et al., 2018; Marie, 2016; Menaker & Chaney, 2014; Montolio & Planells-Struse, 2019), as well as additional negative externalities such as traffic congestion, air pollution, and related negative health outcomes (Cardazzi et al., 2020; Humphreys & Pyun, 2018; Humphreys & Ruseski, 2019), during their hours of operation. Some studies have further demonstrated that different event types (e.g., sporting events and concerts) exhibit heterogeneous effects on observed crime levels (Breetzke & Cohn, 2013; Yu et al., 2016; Kurland, 2019). Less understood is whether spatial crime patterns in the surrounding area of arenas/stadiums differ across event types. Given that recent scholarship has found the effect of crime generators and attractors can differ across time of day (Haberman & Ratcliffe, 2015), seasons (Szkola et al., 2021), and neighborhood context (R. W. Jones & Pridemore, 2019), we find it plausible that spatial crime patterns around sports arenas/stadiums may shift according to the type of event taking place.

The current study seeks to advance the extant literature on macro crime generators' effects on crime by studying the impact that events held at the Prudential Center had on the surrounding area of downtown Newark, New Jersey over the period 2007–2015. We first employ negative binomial regression to assess the effect of nine distinct event types on crime counts, at the hourly level in the area under analysis. Second, we leverage the Fasano-Franceschini test, a statistical measure that emerged originally in astrophysics, to assess whether events across crime categories are spatially distributed differently when distinguishing between event and no-event time units at the center. Third, logistic regression models investigate whether there exists a relationship between the type of location in which a crime incident occurred and the presence or absence of events at the Prudential Center, providing insights on potential qualitative differences in the geographic distribution of crime incidents across the event and no-event time units.

Results suggest that five out of nine event types are associated with statistically significant crime increases within the Newark downtown area, ranging from a minimum of 33% increase to a maximum of 61.9% increase. In terms of spatial distributions of crimes, incidents are distributed differently when they are not disaggregated by category. However, when considering crime typologies separately, out of six crime categories, only thefts and auto thefts exhibit distinct spatial locations. Finally, concerning location types, out of six typologies, only street locations and parking lots are statistically related to the presence of events at the Prudential Center. As for the former, the likelihood of a crime on the streets is about 30% lower when no events are held at the facility. Regarding the latter, the odds that crimes are committed in parking lots are 73% higher when no events are in place at the center.

Background literature

The current work fits into the rich empirical area on crime and place, which demonstrates how crime clusters in specific areas within an urban context. In particular, we frame our work in the context of the literature on crime generators and attractors. Crime generators are defined as those places characterized by a high flow of people leading to the spatial concentration of crime incidents (Brantingham & Brantingham, 1995). Crime attractors are those places that attract offenders due to the presence of significant crime opportunities.

Over time, crime generators may become crime attractors—places well known to offenders as providers of suitable crime targets—by establishing reputations for the crime opportunities they provide (Clarke & Eck, 2005), in line with the concept of multiplicative interaction effects proposed by Cohen and Felson (1979). Studies concerned with the relationship between crime and particular locations have been largely situated in three theoretical traditions: (a) crime pattern theory (Brantingham & Brantingham, 1995), which explains how individuals interact with the built environment and highlights the relevance of the particular characteristics of each place in determining crime risks; (b) routine activity theory (Cohen & Felson, 1979), which states that the spatial and temporal convergence of suitable targets and likely

offenders in the absence of capable guardians offers optimal conditions for crime; and (3) the principle of least effort (Zipf, 1949), which argues that offenders tend to prefer shorter trips compared to longer ones, hence implying that the probability of crime commission will be higher in the area surrounding a given facility.

Within the boundaries of these theoretical frameworks, Groff and Lockwood (2014) practically categorize research on facilities and crime into three distinct areas. The first one is concerned with the mechanisms through which social structure and land use influence the opportunity for crime occurrence across areal units such as city blocks. The second addresses the same question but focuses on smaller units of analysis, such as street segments, analyzing this link across multiple urban contexts. The third area instead examines the relationship between crime and facilities in the area surrounding said facilities. This work aligns with this third area of scholarly inquiry.

Previous works have extensively examined the crime-generating as well as crime-attractor natures of many different locations and facilities across cities around the world (Bernasco & Block, 2011; Tillyer et al., 2021; Wuschke & Kinney, 2018). More recently, a growing body of evidence also demonstrated the positive relationship between sporting events that take place at arenas and other types of mass gathering facilities and crime. Despite contrasting settings and methods of inquiry, findings are remarkably consistent in that they repeatedly highlight statistically significant increases in the incidence (or expected counts) of crime and disorder in those locations and during those times that sporting and other entertainment events occur. Significantly, greater levels of crime have been observed in multiple cities across the USA (Decker et al., 2007; Yu et al., 2016; Kurland & Piza, 2018; Kurland, 2019; Menaker et al., 2019; Pyun, 2019; Ristea et al., 2020; Block & Kaplan, 2022) and the UK (Kurland et al., 2010, 2014; Kurland, 2014; Marie, 2016; Kurland et al., 2018). Significant crime increases associated with arenas/stadiums have further been observed in Barcelona, Spain (Montolio & Planells-Struse, 2016, 2019); Montevideo, Uruguay (Munyo & Rossi, 2013); and Tshwane, South Africa (Breetzke & Cohn, 2013).[1]

A subset of this literature has analyzed how an arena's effect on crime differs across event types. Breetzke and Cohn (2013) found that overall crime increased in the 1/2-mi, 1-mi, and 2-mi buffers around South Africa's Loftus Versfeld Stadium on rugby and soccer match days in which the home team won. Conversely, crime significantly increased only within the 1-mi buffer on match days in which the home team lost. Yu et al. (2016) incorporated hourly data on robbery incidents to test the criminogenic effect of arena events in Memphis. Findings indicate that NBA Grizzlies and Memphis University Tigers basketball games were associated with significant robbery increases over the hours immediately prior to, during, and immediately

[1] A noteworthy exception to this literature is the recent study by Piquero and co-authors (2021), which found that the 2018 Formula 1 Grand Prix in Austin, TX did not lead to any significant crime increases during the weekend of the race. However, the small temporal window, examined in this particular study, is more temporally constrained than those investigated in the other above-mentioned studies, as is the case that the race track itself is 12 mi away from the city center and is surrounded by farmland with virtually no development. This may go some way toward explaining the absence of a significant effect.

following the events. Interestingly, robbery did not increase during the hours associated with Grizzlies and Tigers away games. This finding suggests arena activity, rather than the general behavior of fans in Memphis viewing sporting events remotely, as a key driver of the observed robbery increases. Particularly relevant to the current study, Kurland (2019) incorporated a similar hourly approach in his analysis of Newark's Prudential Center and found that New Jersey Devils ice hockey games, concerts, and Disney-themed events were all associated with increases in robbery. The largest effects were observed for Disney-themed events. Conversely, events such as circuses, NBA/WNBA basketball games, boxing matches, and mixed martial arts matches were not associated with robbery increases.

In an effort to further capture the disamenities produced by sporting events, a new line of scientific inquiry has begun to quantify the nature and extent of congestion externalities including additional vehicular traffic, CO_2 emissions in cities, the local air quality index (AQI), and even the increased levels of airborne particulate matter generated during the sports facility construction projects in cities that have led to an increase in maternal prenatal visits and lower infant birth weights (Humphreys and Ruseski, 2019; Humphreys & Pyun, 2018; Locke, 2019). The negative public health consequences of sporting and entertainment events have also been empirically documented in the recent literature (Cardazzi et al., 2020; Stoecker et al., 2016). The evidence base that has been assembled, particularly over the previous decade, across various disciplines on the effects linked both to the construction of such sports and entertainment venues, and their persistent role as generators of negative externalities in the form of traffic, pollution, public health outcomes, and crime and disorder in the communities they are meant to serve is extensive. In what follows, a brief summary on the case of the Prudential Center is provided to set the stage for the analysis and the associated policy recommendations that stem from a combination of the empirical base outlined above and the results that follow.

The case of the Prudential Center

The Prudential Center is a nearly 20,000-seat arena in downtown Newark, NJ, accessible by public transport (rail, light rail, and bus). The Prudential Center opened for business on October 25th, 2007, with ten shows by New Jersey–native John Bon Jovi attended by close to 140,000 individuals and generating over $16 million in ticket revenues. The opening of the Prudential Center was the result of many years of political negotiating and planning by the city of Newark officials (Farber, 2007). The idea to build an arena in New Jersey's largest city was first advanced by Sharpe James, Newark mayor from 1985 to 2006, who like many other mayors across the USA envisioned the development of an arena as an economic generator and job creator for the city. The Prudential Center was built at a cost of approximately $375 M of which the city subsidized $220 M (Kaske, 2007). While spearheaded by the James administration, the Prudential Center would not open until the new Mayor (and now US Senator) Cory Booker took office.

While celebrated as a positive development by city leaders, the opening of an arena in New Jersey's largest (and highest crime) city, and second most socioeconomically

deprived city in the nation, initially worried some observers. Many wondered whether public safety concerns would prevent middle-class and more affluent suburban residents from frequenting the Prudential Center (R. G. Jones, 2007). Such concern was articulated by Berry Melrose, a hockey analyst for the ESPN television network. In describing the newly opened Prudential Center during a webcast, Melrose stated "It looks great on the inside but don't go outside, especially if you got a wallet or anything else because the area around the building is awful" (Mays, 2007).

Despite the worry, public officials ensured that Prudential Center patrons would be safe during their time in the city. Periodically, statistics released by the Newark Police Department supported claims that downtown Newark was a safe environment for visitors. For example, over the 4-day period in 2011, the NCAA East Regional Basketball Tournament was held at the Prudential Center, and police data suggested that crime was "virtually non-existent" in the downtown area (Queally, 2011). However, high-profile crime events that did occur around the Prudential Center called into question the true safety afforded to event attendees. For example, six people walking to a parking lot were assaulted by a group of at least a dozen teenagers after a Britney Spears concert (Adarlo, 2009), and five people were beaten and robbed about two blocks from the arena following a Red Hot Chili Peppers concert (Queally, 2012). While high-profile acts of crime were not reported following any hockey games, the most frequently occurring events at the Prudential Center, the implications of crime in the city of Newark when events take place were not lost on the local media. Indeed, reports of serious crime occurring in Newark often described these events as occurring "within close proximity" or "nearby" the Prudential Center, irrespective of their connection to arena events (Queally, 2011, 2012).

With the above-mentioned in mind, Kurland and Piza (2018) sought to build on the growing research base related to the nature of crime and disorder patterns in and around large-scale sports and entertainment venues but did so with a focus on New Jersey Devils hockey games that took place at the Prudential Center. The research provided the foundation for further inquiry in that it established that the crime patterns that were generated across days that the arena was used for hockey and a set of comparison days were significantly different for numerous crime categories at various spatial resolutions. More specifically, aggravated assaults, auto theft, burglary, robbery, theft, and theft from the vehicle all had a significantly higher count of crime across the city of Newark, across the downtown area of Newark, and at the street segment-level across numerous areas of the city that were not proximal to where the arena was located. These underlying differences in the count for these crime categories were systematic and importantly only represented a relatively small proportion of the number of large-scale crowd-related events that take place at the Prudential Center. Thus, the underlying difference in the overall count of crime when events take place remained, at least in part, unknown. In a follow-up study that sought to extend the initial work, Kurland (2019) conducted an econometric analysis of 11 different categories of sporting and entertainment events that took place at the Prudential Center to explore the influence, if any, that each event category had on hourly robbery counts across the entire city of Newark. Results from the study suggested the hourly count of robberies increased significantly during Devils hockey, concerts, and Disney-themed events at 25%, 21%, and 32%, respectively.

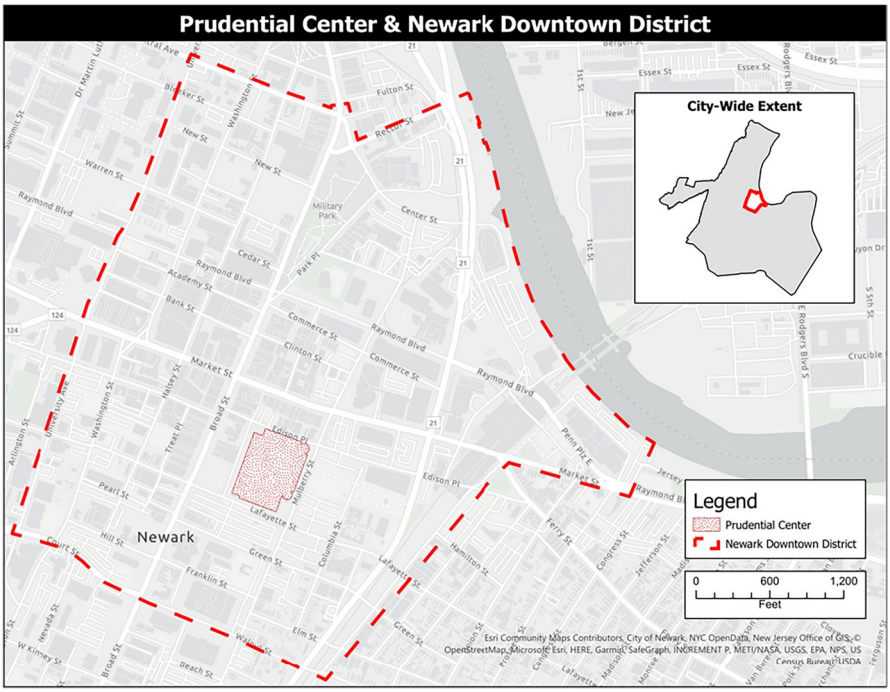


Fig. 1 Map of the area under analysis for evaluating the impact of events held at the Prudential Center in Newark, NJ. Dashed red line indicates the boundaries of the area. The Prudential Center is highlighted with the dotted red area

Current focus

Professional sports stadiums and arenas bring with them a promise of jobs, new sources of revenue for nearby businesses, and a place where fans can attend a wide range of events. Extant research has provided some indication that one adverse by-product of these facilities, their events, and the crowds that may attend is an increase in certain types of crime during "game" or "event" days. Herein, we seek to build on this previous work by providing a more complete picture of the impact of the Prudential Center on crime patterns through the analysis of all the crimes and events that have taken place at the venue from opening day through 2015. The analytical focus will concentrate on the Newark Downtown District as shown in Fig. 1. The downtown district measures about 0.54 mi^2 in size and houses the Prudential Center as well as several commercial parking lots that cater to arena event attendees. Newark Penn Station, the primary public transportation hub in the city, sits about three blocks east of the arena. The downtown district further offers a large concentration of restaurants and drinking establishments for arena patrons to attend prior to or following the events.

The effects of events held at the center will be investigated in terms of crude impact on crime counts as well as on the spatial characteristics of crimes that occurred during event times, to offer not only a quantitative assessment of the

marginal effect of such events on crime, but also an analysis of crime in qualitative terms, responding to the three following questions:

- Expanding on previous research (Kurland and Piza, 2018; Kurland, 2019) that focused on city-wide crime trends, do events held at the Prudential Center have an impact on the hourly number of crimes that occurred in the surrounding Newark Downtown area?
- Are the effects on crime trends of events held at the center homogeneous across event types?
- Does crime change in its spatial distribution and location characteristics, when the Prudential Center is active?

Methodology

Data

To measure the effect of the various sporting and entertainment events that take place at the Prudential Center, a dataset of the times for all events that took place at the venue from its opening in 2007 through 2015 was identified using the official website of the Prudential Center (www.prucenter.com) as well as the Internet Archive Wayback Machine (https://archive.org/web/) and was cross-checked for accuracy using an event dataset for this same period provided by Newark PD. In addition, an hourly crime count dataset for all five general crime categories[2] for the city of Newark over this same 12-year period was constructed. These data provide a large number of hours that no events take place. Consequently, sufficient data is available for testing the effect of different event categories on the underlying crime patterns that may, or may not be, associated with each type of event. A more comprehensive explanation of each of the respective datasets that were utilized in the model is described in the subsections that follow.

Crime data

The Newark Police Department provided a dataset of all crime events that took place for a 9-year period between 2007 and 2015. The data was cleaned and aggregated into hourly counts. All five crime categories were used for the study in order

[2] These are aggravated assault (which comprises "aggravated assault—hit," "aggravated assault—no hit," "aggravated assault—knife," "aggravated assault—other weapon," "aggravated assault—physical force," "aggravated assault—PO," "aggravated assault—pointing," "aggravated assault—EMS," "aggravated assault—no hit," "aggravated assault—no hit robbery—carjacking—strong arm"), auto theft, burglary, robbery (including "robbery—carjacking—gun," "robbery—gun," "robbery—knife," "robbery—no hit," "robbery—carjacking—strong arm," "robbery—bank," "robbery—other weapon"), theft, and other (a marginal category including various crimes with low numerosity. There are "murder—shooting," "murder—stabbing," "murder," "possession of weapon," "found property," "criminal mischief," "unfounded," "shots fired," "rape," "weapon recovered").

to estimate the total crime-generating effect of the different types of events that occur at the Prudential Center. The opportunity theories that frame this research suggest that various crime types will increase as a direct consequence of a greater number of potential targets. That is, fans attending sporting and entertainment events, their belongings, the vehicles they may have taken to get to the venue, and the number of motivated offenders who may take advantage of serendipitous opportunities that are furnished in this environment provide suitable conditions for forms of acquisitive crime. Furthermore, because of the great number of additional interactions, and likely provocations, that occur between fans and other stakeholders on event/game days, additional expressive crime is also likely to occur.

Prudential Center schedule

The schedule for all sporting and entertainment events that includes the date and event/game starting time that took place at the Prudential Center between 2007 and 2015 was assembled. To best model the ecological change that takes place when the facility is used, a dummy coding scheme was implemented. The approach enables us to capture spectators' tendencies to arrive and assemble around and inside the Prudential Center at different rates, but also, their dispersal all at once shortly after events/games are over. More specifically, the 2 h leading up to the event/game, the hour that the event/game takes place, and the 2 h after the event/game concluded were coded as 1 and 0 otherwise.[3] This was done for all hours in the dataset that included the 24 h of every day from 2007–2015. The following event dummy variables were created: New Jersey Nets (NBA), New Jersey Devils (NHL), Seton Hall Pirates (NCAA men's basketball), New York Liberty (WNBA), boxing (including mixed martial arts), other sports, concerts, circus, Cirque du Soleil, Disney, and other entertainment.[4]

Controls

Empirical research has repeatedly found relationships between particular temporal, lighting, and meteorological conditions and crime patterns. These factors known to influence crime patterns have been included in the model to control for their potential influence. More specifically, the hour of the day (Felson & Poulsen, 2003), the day of the week (Cohn, 1993), the month of the year (Ranson, 2014), and even the year (Cohen & Felson, 1979) were assembled to take stock of the different seasonalities that have been found to be associated with

[3] We recognize that some events might last longer than 1 h, but we precisely chose to consider a 5-h window which represents a reasonable time window for capturing arrival, the event itself, and the spectators' dispersal. For instance, one could think of the distribution of these three moments as 1.5 h or arrival, 2 h of event, and 1.5 h of post-game activity or, alternatively, 1.5 h of arrival, 1.5 h of event, and 2 h of post-game activity. Different event types will have different mobility patterns, and modeling this over a total of 5 h allows to meaningfully map the heterogeneity in such patterns.

[4] This represents a residual category that includes all events that could not be meaningfully associated with the other event categories, including skateboarding competitions, musicals, or variety shows.

crime patterns. The absence of light is believed to hinder surveillance that in turn affects guardianship, a protective factor, against some crime types (Rotton & Kelly, 1985; Van Koppen & Jansen, 1999; L. Tompson & Bowers, 2013) and to control for a possible relationship between darkness and criminal activity—hours of darkness were coded as 1, and 0 otherwise.[5] Meteorological conditions such as ambient temperature have also been found to influence crime patterns with lower temperatures increasing the use of particular clothing items such as winter hats and balaclavas that increase anonymity but do not increase suspicion during this period (Cohn, 1990; Field, 1992; L. A. Tompson & Bowers, 2015). Hourly temperature data (°F) for Newark from 2007 to 2015 was obtained from the National Climatic Center and used to construct the temperature control variable. Furthermore, it is worth noting that while socio-economic characteristics are generally relevant in inferential studies on crime and place, in the current study, we chose not to include them because the entire study area (i.e., Downtown Newark) only intersects two census tracts and represent one contiguous, socially homogeneous area. Hence, no variation in socio-economic characteristics could be meaningfully leveraged.

Analysis

The analysis herein can be broken into three distinct phases. The initial stage makes use of a commonly used econometric approach for modeling crime count data (Osgood, 2000) and at sporting and entertainment venues at the city-level more specifically (Kurland, 2019; Yu et al., 2016). The approach enables the amount of additional crime that can be confidently attributed to each of the respective crime/event categories while controlling for other factors that might influence crime patterns to be calculated.

The second stage utilizes the Fasano-Franceschini test (Fasano & Franceschini, 1987) to evaluate whether the spatial distribution of crimes differs when comparing crimes that occurred during event stages at the Prudential Center versus crimes that occurred when no events were in place at the center. Finally, the third analytical stage concerns the assessment of the impact that event times had on the different locations in which crimes occurred. Such investigation leverages a set of logistic regression models using location types as binary dependent variables: the rationale is to disentangle the possible correlation between event times and specific locations in crime generation.

[5] To compute the binary measure of darkness, we have retrieved sunlight data from the "suncalc" package in R. The package allows to capture day-to-day variation in daylight, capturing differences across weeks, months, and seasons. We have specifically coded two measures of darkness and tested our models with both. The main one takes as reference dawn and dusk, with all crimes occurring between these two having darkness = 0. The alternative measure uses sunrise and sunset as references, with all incidents occurring between these two having darkness = 0.

GLM with negative binomial distribution

Given the count nature of the dependent variable (hourly crime counts), the associated distribution most closely resembling a Poisson distribution, and a variance that exceeded the mean indicating over-dispersion, we estimate a negative binomial regression model, a specific type of generalized linear model. The approach is more appropriate than a regular Poisson for hypothesis testing given its flexibility in relation to over-dispersion (Long & Freese, 2006). We have empirically motivated our decision by comparing residual plots across a negative binomial model and a Poisson model and computing a likelihood ratio test (p-value < 0.0001, indicating that the negative binomial model is more appropriate for the data under consideration). The results of the residual plots are visualized in the Supplementary Materials (Figure A 1 and Figure A 2).

The model utilized for investigating the relationship between crimes and sporting and entertainment events is calculated as per Eq. (1):

$$\begin{aligned}\#\text{HourlyCrime} = {} & \beta_0 + \beta_1 \text{Nets} + \beta_2 \text{Devils} + \beta_3 \text{Pirates} + + \beta_4 \text{Liberty} \\ & + \beta_5 \text{Boxing} + \beta_6 \text{OSports} + \beta_7 \text{Concerts} + \beta_8 \text{Circus} \\ & + \beta_9 \text{CirqueduSoleil} + \beta_{10} \text{Disney} + \beta_{10} \text{OEntertainment} \\ & + \sum_{j+1}^{k} \beta_j \text{Control} + \varepsilon \end{aligned} \tag{1}$$

With the dependent variable, Y (#HourlyCrime) is the count of crime for each hour across the 9-year data period.

Fasano-Franceschini test

To assess whether crimes that occurred during events hosted at the Prudential Center differ in their spatial distribution compared to those that happened in other time frames, we leverage the Fasano-Franceschini (FF) test (Fasano & Franceschini, 1987). The FF test assesses the null hypothesis that independent and identically distributed random samples of points are drawn from the same distribution. In other words, it tests whether two random samples are statistically indistinguishable based on their distribution in a k-dimensional space. The FF test expands on the popular univariate Kolmogorov–Smirnov (KS) test, a non-parametric test developed to investigate whether two samples come from the same underlying distribution (Kolmogorov, 1933a, 1933b; Smirnov, 1944, 1948). Specifically, in one dimension, the KS statistic maps the maximum absolute difference between the cumulative density functions of data and model (when one sample is involved) or between two datasets, when two samples are analyzed. In the case of the KS test, however, distributions

are unidimensional. In our context, conversely, the spatial distribution of crimes is characterized by multidimensionality and is particularly defined in a 2-dimensional space. The FF test precisely provides a way to carry out this task.

The dimensionality problem of the KS test was first examined by Peacock (1983) and then by Fasano and Franceschini in a later paper. Peacock addressed it by defining a 2D test statistic as the largest difference between the empirical and theoretical cumulative distributions, once all possible ordering combinations are taken into account. As explained by Puritz et al. (2022), the test calculates the total probability in each of the four quadrants around all possible tuples in the data. To exemplify, given n points in a 2D space, the empirical cumulative distribution is calculated in the $4n^2$ quadrants of the plane defined by all pairs (X_i, Y_i). Given that there are n^2 (X_i, Y_i) pairs, and each can define four quadrants in the 2D space, by considering them all, the 2-dimensional statistic is the maximal difference of the integrated probabilities between samples.

The FF variation only considers quadrants centered on each observed (X_i, Y_i), instead of focusing on all possible n^2 points, for a total of $4n$ quadrants. After the algorithm loops through every point in one sample to define the origins of all quadrants, the fraction of points in each sample is calculated per quadrant, and the quadrant with the maximal difference is assigned to the maximum for the specified origin. By iterating the overall points and related quadrants, the test statistic D_{FF1} is given by the maximal difference of the integrated probabilities between samples in all quadrants for all origins from the first sample of data points. The procedure is repeated using the other sample to obtain D_{FF2}: the two are then averaged ($D_{\text{FF=}}\frac{D_{\text{FF1}}+D_{\text{FF2}}}{2}$) for the purpose of hypothesis testing. Via the Monte Carlo simulation, the authors processed an associated look-up table of critical values of D_{FF} taking into account the sample size and coefficient of correlation r. For the two-sample case, the approximate fit to the look-up table is

$$\mathbb{P}(d_{\text{FF}} > D_{\text{FF}}) = \Phi\left(\frac{D_{\text{FF}}\sqrt{\frac{n_1 n_2}{n_1+n_2}}}{1+\sqrt{1-r^2}\left(0.25-0.75/\sqrt{\frac{n_1 n_2}{n_1+n_2}}\right)}\right) \tag{3}$$

with r defined as the usual correlation coefficient (trivially, when $r=1$, the points would form a single line, and thus, the 1-D KS test could be applied on the marginal distributions). Given the equation above, when the test statistic is found to be statistically significant, distributions are found to be statistically different.

To the best of our knowledge, the test has yet to be applied in the criminological context; hence, we also seek to demonstrate its potential for future studies concerned with the spatial analysis of crime and deviance. Assessing and understanding the distribution of different crime incidents or other crime-relevant events are of paramount importance for the criminological literature. Are violent and nonviolent offenses distributed differently within a given city? Are homicides against minorities distributed differently from homicides against whites in a given county? Does crime emerge across different locations during the weekends? These are a few of the many questions that can be addressed through the use of the FF test. While

other approaches exist to compare the distribution of points in spatial contexts represented in two-dimensional spaces (e.g., kernel density estimation), these often involve hyperparameter optimization and are not easily interpretable. By leveraging the FF test, instead, we can easily and flexibly tackle such problems. In fact, the test, especially through its implementation through the Fasano-Franceschini.test in R, is extremely computationally efficient. Furthermore, data can be of any dimension (although in criminology, scholars are mostly interested in the 2D case) and of any type (i.e., continuous, discrete, and mixed). These two characteristics present criminologists with important opportunities which we exploit in this work to investigate the spatial effects that the Prudential Center has on crime in Downtown Newark.

Regression models for location analysis

Finally, the last analytical step aims at gathering additional knowledge of the spatial characteristics of crime in the Prudential Center area in Newark in the event vs. no-event timeframes. This third analytical step adds a further layer of results to the statistical analysis of spatial differences in crime incidents across the event and no-event time units. Specifically, location analysis seeks to provide additional qualitative findings highlighting what type of spatial patterns emerge when the Prudential Center is active. Understanding whether some types of locations attract more or less crime during sporting and entertainment events is relevant for both theory and practice. Empirical findings would contribute to the literature on the complex effects of stadiums and arenas on crime as well as inform crime control and prevention policies and interventions to allocate special resources to specific areas, buildings, and premises. For this purpose, we performed statistical analyses via logistic regression to evaluate the relationship between the type of time unit (IV) and different types of location (DV). Since location types are our dependent variable, characterized by eight (six, in practice) different categories, one natural candidate was multinomial logistic regression.[6] However, with multinomial logistic regression, one level has to be selected as a baseline, such that effect sizes have to be interpreted in reference to such baseline. Given that no theoretically meaningful baseline could be established, and given the relatively low level of interest in comparative accounts across locations, we relied on a different strategy. Particularly, we designed our models as a set of "one vs. rest" logistic

[6] The location types are (1) street, (2) non-residential building, (3) parking lot, (4) commercial, (5) dwelling, (6) hotel/motel, (7) other, and (8) unknown. These categories are coded by combining similar location types in original labeling of the dataset. Street comprises "sidewalk," "driveway," and "street." Non-residential building comprises "church," "building under construction," "school," "stadium," "city hall," and "public building." Commercial comprises "store," "bank," "salon," "restaurant," "clothing store," "tavern," "bakery," "business," "department store," "gym," "office," "store," and "commercial." Dwelling includes "public housing," "apartment," "residence," "house," and "dwelling." Hotel/motel comprises "hotel/motel," "hotel," "hotel room," "hotel & motel." Other refers to "service station," "lot/yard," "garage," "park," "transportation facility," "building under construction," "dock or wharf," "playground," "building," "bus," "construction site," "gas station," "lot," and "YWMCA.".

Table 1 Summary statistics—number of hours and crimes in the main dataset, divided per event type

Event	Total *N* of hours	Avg. crimes	Standard deviation
All hours	74,926	0.062	0.255
No events	69,744	0.061	0.252
All events	5182	0.079	0.252
Boxing	201	0.069	0.255
Circus	294	0.081	0.298
Cirque du Soleil	101	0.049	0.219
Concert	765	0.083	0.291
Devils	1870	0.073	0.277
Disney	497	0.066	0.249
Liberty	280	0.132	0.345
Nets	410	0.112	0.345
Other entertainment	313	0.073	0.273
Other sports	472	0.066	0.280
Seton Hall men's basketball	675	0.065	0.266

The sum of event and no-event hours exceed the total sum of hours (74,926) because there were cases in which multiple events where simultaneously staged at the Prudential Center

regression, encoding binary target variables for all location types and therefore fitting as many separate models as the number of location types. The rationale of such models is thus to independently evaluate whether the presence or absence of an event hosted at the Prudential Center has a relationship with the occurrence of a crime in a particular location category.

Results

Summary statistics

Summary statistics for the main variables are provided in Table 1. Out of the 74,926 hourly time units considered in the 2007–2015 period, 94.11% ($N = 70{,}515$) recorded no crimes in the Prudential Center area of Newark. The range of known crimes per hour goes from a minimum of 1 ($N = 4173$, 5.56%) to a maximum of 4 ($N = 1$, 0.00001%) crimes. On average, the area under analysis registered 0.062 crimes per hour, with a total of 4655 known offenses. When disaggregating per event type, Liberty and Nets events have the largest mean number of crimes, 0.132 and 0.112 respectively, while the highest number of hours devoted to specific events regards Devils ($N = 1{,}870$) and concerts ($N = 765$). The event type accounting for the lowest average number of crimes is Cirque du Soleil (mean = 0.049), which is also the event type with the lowest sum of hours dedicated at the Prudential Center ($N = 101$).

Table 2 Results of the negative binomial models for the impact of the different events scheduled at the Prudential Center

Event	IRR	Robust SE	*p*-value	95% CI
Boxing	1.167	0.320	0.550	[0.682; 1.997]
Circus	1.569*	0.332	0.037	[1.035; 2.379]
Cirque du Soleil	0.768	0.348	0.550	[0.316; 1.869]
Concert	1.482**	0.199	0.003	[1.139; 1.928]
Devils	1.330**	0.122	0.002	[1.111; 1.592]
Disney	1.248	0.227	0.195	[0.874; 1.782]
Liberty	1.453*	0.250	0.020	[1.037;2.035]
Nets	1.618**	0.251	0.002	[1.193;2.194]
Other entertainment	1.207	0.259	0.366	[0.793; 1.839]
Other sports	1.223	0.226	0.314	[0.851; 1.757]
Seton Hall men's basketball	1.222	0.193	0.215	[0.897; 1.665]

While not presented here for the sake of space, all controls are included in the regression mode (see Supplementary Materials

$*p<0.05, **p<0.01, ***p<0.001$

Negative binomial regression model

Estimation results are given inTable 2.[7] The dataset is structured at the hourly level, with the number of crimes that occurred in a given hour as the dependent variable. Coefficients are reported in the form of incident rate ratio (IRR), mapping the relative rate of change in the number of crimes for each event type, and are to be interpreted as the percent change in the number of crimes when a certain event is held at the Prudential Center compared to the baseline scenario with no events hosted at the facility. The results reveal five statistically significant event effects. The effects associated with circus, concerts, Devils, Liberty, and Nets are all positive, ranging between 1.330 (Devils) and 1.618 (Nets). At the same time, the effect is not statistically significant for boxing, Cirque du Soleil, Disney, other entertainment, other sports, and Seton Hall men's basketball events. Concerning statistically significant results, they are all above one, with the smallest—and yet positive—IRR magnitude related to Devils. The IRR equal to 1.330 (95% CI [1.111; 1.592], p-value = 0.002) suggests a 33% increase in the number of crimes when Devils' games are held at the Prudential Center. Given the baseline of 0.061 crimes occurring on average in the area under analysis when no events are hosted at the Prudential Center, this increase amounts to an additional 0.02 crimes in Downtown Newark. Magnitude-wise, New York Liberty games have the second-smallest positive effect (IRR = 1.453, 95% CI [01.037; 2.035], p-value = 0.020). When such events are held at the Prudential Center, the model estimates a 45.3% increase in the number of crimes, amounting

[7] In an effort to economize space, we have not shown the numerous control variables; however, these are all included in the Supplementary Materials (Table A1).

to additional 0.027 crimes. Concerts have slightly higher effects, corresponding to a 48.2% increase in the number of crimes, translated to an additional 0.029 incidents (IRR = 1.482, 95% CI [1.139;1.928], p-value = 0.003). Circus events lead to a 56.9% increase in crimes amounting to 0.035 crime occurrences (IRR = 1.569, 95% CI [1.035;2.379], p-value = 0.037). Finally, the event type with the highest effect in terms of crime is New Jersey Nets games, signaling a 61.8% increase in crimes which can be converted to an additional 0.04 crime events (IRR = 1.618, (95% CI [1.193;2.194], p-value = 0.002). All the presented outcomes hold when robustness tests are performed (as reported in the Supplementary Materials, see Table A 1). We have specifically performed three additional models: a negative binomial with an alternative measure of darkness and two Poisson models, one using the main measure of darkness and the other using the alternative one (as explained in the "Methodology" section). These results suggest that the crime-generating effect of different event/game types are not all equal in their crime generation and, in some cases, there are types of games/events that are less prone to producing this particular negative externality. Indeed, this finding is reflective of similar research that has found that contrasting patterns emerge for the same sports and entertainment facility when different event types occur within them (e.g., for example, see Kurland et al., 2014).

Assessing differences in spatial distributions

Figure 2 reports the distribution of crimes in the area surrounding the Prudential Center in Newark. Figure 2A simply visualizes the distribution of crimes as points, divided between crimes that occurred during event times held at the center and crimes that happened in other hourly time units. Mirroring the same division, Fig. 2B shows a more aggregated measure through hexagonal bins, with 40 different levels. What emerges from the figure is that, besides differences in the overall quantity of crimes between the two categorizations, the geographical distribution of the two seems to slightly differ. In both cases, the areas in the north-west of the center appear to be the ones with the most crime prevalence. Yet incidents in event time units seem to cluster more in specific micro-areas, especially southeast of the center.

When the distributions of crime divided by category are statistically compared, the overall tendencies signaled in Fig. 2 become even more evident. The FF test, which has been described in the dedicated subsection, precisely aims at evaluating whether we can detect differences in the 2-dimensional distributions, as crimes are represented as points in the geographical space under analysis. In other words, the test evaluates whether two random samples come from the same underlying distribution. The outcomes of the test, for crimes overall, and the different crime categories are provided in Table 3.

Firstly, the FF reveals statistical differences in the geographical distributions of the 4295 crimes that occurred in no-event hourly time slots and the 412 crimes that occurred during the events at the Prudential Center (D-stat = 2.219, p-value = 0.009), in line with the graphical evidence shown in Fig. 2. When the specific crime categories are taken into account, however, only thefts and auto thefts—the two most prevalent crime categories in the data—seem to differ in terms of spatial distributions

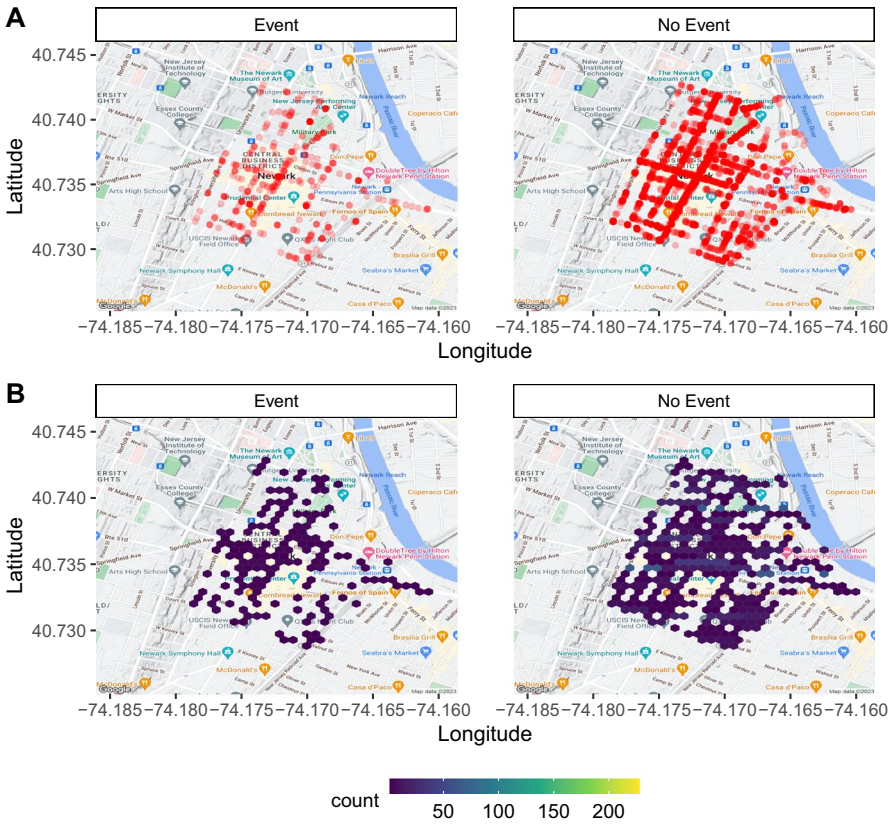


Fig. 2 Spatial distribution of crimes in the Prudential Center area. **A** The distribution of crimes as simple points on the map. **B** More aggregate localized measures using hexagonal bins ($n = 40$)

Table 3 The Fasano-Franceschini test results for the spatial distribution of all crime categories

Crime category	*N* crimes (no events)	*N* crimes (events)	*D*-stat	*p*-value
All crimes	4295	412	2.219**	0.009
Aggravated assault	217	24	1.074	0.396
Auto theft	647	61	1.857*	0.029
Burglary	306	10	1.055	0.426
Other	107	11	1.104	0.257
Robbery	620	69	1.388	0.138
Theft	2398	237	1.734*	0.019

$*p < 0.05, **p < 0.01, ***p < 0.001$

between the two categories (D-stat = 1.734, p-value = 0.019 and D-stat = 1.857, p-value = 0.029, respectively). For all the other categories, no statistically significant differences are found. These findings, overall, indicate that there is only a partial displacement effect of crime due to the events held at the Prudential Center.

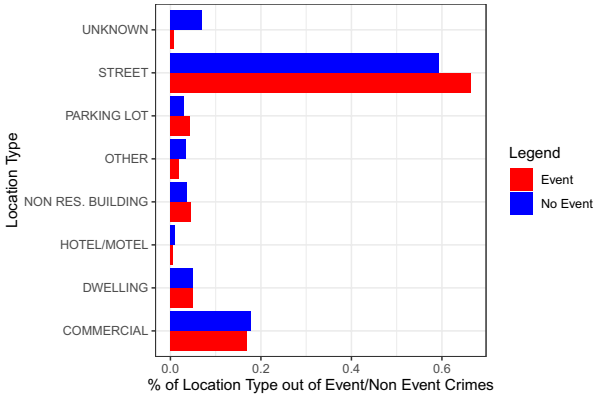


Fig. 3 Percentage distribution of crime by location type, grouped by crimes occurred during events at the Prudential Center vs. crimes occurred in other hourly time slots

Interestingly, in fact, these statistical differences in crime incidents are not universal across crime types. This partial displacement may be explained by the shocks introduced by spectators in the structure of crime opportunities and generators around Newark Downtown. The inflow and outflow of people from the area, along with the modified patterns of formal and informal guardianship, provide offenders with new opportunities and risks which require partial adaptation to the event circumstances.

Location analysis

Figure 3 indicates the percentage distribution of crime by location type, grouped by the hourly time slots in which they occurred. Percentages sum to 1 when they are added for each category (event vs. no-event hourly time slots). This first graphical evidence seems to indicate no major differences in the distribution of location types for crimes that occurred during events and on other days and hours. Crimes committed in the streets represent the vast majority in both cases, followed by crimes perpetrated on commercial premises.[8]

Also, in this case, the visual evidence is generally in line with the statistical one produced by the set of independent logistic regression models reported in Table 4. All models control for darkness and temperature and consider single offenses as the unit of analysis. Unknown locations (which are mostly related to crimes that occurred in 2007) and hotel/motel are excluded. The rationale for the former is that the unknown category does not provide any meaningful indication regarding the incident. The motivation for the latter, instead, is that out of 45 incidents in hotel/motel locations, only 1 occurred during events. Out of the six location types represented in the six different models, four are found to be statistically unrelated to the presence or absence of events at the Prudential Center, reinforcing the evidence that points in the direction of the absence of quantitative and qualitative spatial effects of the facility on crime, and two are found to be significantly correlated with this

[8] It is important to note that the commercial category includes alcohol-selling premises such as restaurants and taverns.

Table 4 One vs. rest logistic regression models—DVs are location types (standard errors between parentheses)

	Commercial	Dwelling	Parking lot	Non-res building	Street	Other
Intercept	0.456***	0.049***	0.034***	0.045***	1.101	0.038***
	(0.088)	(0.016)	(0.014)	(0.022)	(0.173)	(0.014)
No event	1.214	1.438	1.731 +	1.706	0.707**	0.703
	(0.181)	(0.371)	(0.561)	(0.685)	(0.084)	(0.180)
Darkness	0.582***	1.149	1.100	0.570**	1.402***	1.064
	(0.051)	(0.162)	(0.181)	(0.117)	(0.098)	(0.188)
Temp	0.989***	0.997	0.994	0.989*	1.011***	1.005
	(0.002)	(0.004)	(0.004)	(0.005)	(0.002)	(0.005)
N	4392	4392	4392	4392	4392	4392
AIC	4286.4	1900.6	1493.1	1233.2	5737.0	1385.7
BIC	4312.0	1926.2	1518.7	1258.8	5762.5	1411.3
Log. lik	−2139.222	−946.301	−742.556	−612.605	−2864.495	−688.862
F	19.397	1.108	1.515	4.730	20.353	1.000
RMSE	0.39	0.23	0.20	0.18	0.48	0.19

$+p<0.1$, $*p<0.05$, $**p<0.01$, $***p<0.001$

measure. The lack of events at the Prudential Center is positively correlated with offenses committed in parking lots (OR = 1.731, St. error: 0.561), although the coefficient is only statistically significant at the 90% threshold. The "no event" coefficient indicates that the odds of crimes committed in parking lots are 73% higher when no events are held at the center. On the other hand, the probability of crimes committed in the streets decreases in the absence of events at the Prudential Center (OR = 0.707, St. error: 0.084). The likelihood of a crime on the streets is almost 30% lower in no-event hourly units.

Discussion and conclusions

The literature on the relationship between stadiums, super facilities, and crime, as well as the tangential scholarship studying the link between sports and entertainment events and crime, is growing and becoming heterogeneous in terms of temporal, geographical, and methodological characteristics (Kurland et al., 2010; Breetzke & Cohn, 2013; Kurland et al., 2014; Marie, 2016; Yu et al., 2016; Montolio & Planells-Struse, 2016; Kurland & Piza, 2018; Kurland et al., 2018; Menaker et al., 2019; Montolio & Planells-Struse, 2019; Block & Kaplan, 2022). Despite this heterogeneity in this line of inquiry, most studies over the years highlighted that activity at such facilities, as well as sports and entertainment events, are generally associated with increases in crime prevalence and frequency. Several theoretical lenses explain this convergence of findings. Among these, the change in the opportunity structure of offending due to the influx of people and services brought in a given environment during events (and in the surroundings of hosting facilities) and the presence

of crime attractors and precipitators that often raise the risk of victimization (Brantingham & Brantingham, 1982, 1995; Farrell, 2015). In this study, we have sought to advance the extant literature on this topic by focusing on a specific urban context, namely, the Downtown Newark, New Jersey district, where an important subsidized super facility is located: the Prudential Center, by building upon previous research with respect to this arena.

Our work, which considers the 2007–2015 period, expands the previous scholarship in several ways. First, instead of considering the entire city, we have focused on the area surrounding the Prudential Center, namely, the downtown district of Newark. This decision limited the potential for noise in our data and subsequent results, avoiding implausible assumptions about the fact that crimes occurring far away from the facility are related to the events taking place at the center. Second, we have considered all event types and all available crime categories instead of only focusing on one particular sport or team or one particular crime type. Third, not only have we investigated the effect that heterogeneous event types have on crime counts—similarly to what was done at the city-level in Kurland (2019)—we have also analyzed the quantitative and qualitative spatial characteristics of crime incidents that occurred during event times versus those that occurred when the Prudential Center was not active. In doing so, we have showcased the relevance of the Fasano-Franceschini test, a measure of statistical similarity for 2D distributions, a novel approach within the field of criminology. Fourth, unlike previous studies and besides pointwise comparisons, we have explored whether crimes during event time units occurred at qualitatively different locations. Fifth, to the best of our knowledge, this is the first criminological work exploring the use of the Fasano-Franceschini test to compare the distribution of geographical events. We have demonstrated how it could be meaningfully deployed in the analysis of crime incidents and how it could be used as an alternative to other techniques, such as kernel density estimation, when interested in understanding whether crime patterns in a given area vary over time or due to exogenous shocks.

As a collective, these methodological choices allowed us to gather a more comprehensive and less noisy understanding of the crime dynamics occurring as a consequence of the influence of the Prudential Center in the urban area of Newark that is mainly affected by the facility.

The results of the three analytical components of the work (i.e., the influence of events on crime counts, the similarity in spatial distributions of crime that occurred during event times versus all the others, and the study of the relationship between crime occurring at particular locations and the absence/presence of events) are heterogeneous. Regarding the effect that different events have on crime counts, we observed that five event types (out of eleven) are statistically associated with significant increases in crime incidents. These are New Jersey Devils hockey games (associated with a 33% increase in crime), NY Liberty basketball games (+45.3%), concerts (+48.2%), circus exhibitions (+56.9%), and, finally, New Jersey Nets basketball games (+61.8%). Conversely, boxing (including MMA matches), Cirque du Soleil exhibitions, other entertainment events, other sports, Seton Hall Men basketball games, and Disney-related events do not exhibit any statistical relationship with

crime counts and thus do not have an impact on the number of crimes that occurred in Downtown Newark over the period under analysis.

Importantly, the results of the study stimulate possible conjectures on why different events impact crime in different ways. Albeit speculative, two main hypotheses (that can be intended as complementary) can be set forth. The first concerns the fact that different events attract different types of spectators with different characteristics and lifestyles, thus modifying the underlying risk for crime commission or victimization. The second, instead, refers to the possibly different security and crime control strategies deployed for different event types. For instance, it might be possible that for events attended mostly by families, less security personnel and police are allocated, thus reducing guardianship and increasing crime opportunities.

In terms of spatial distributions, we analyzed the point-wise occurrence locations for six crime categories, plus all crimes aggregated together. We proposed the use of the Fasano-Franceschini test, a statistical test that originally emerged in the field of astronomy for expanding the Kolmogorov–Smirnov test and assessing whether two random samples are drawn from the same distribution in a *k*-dimensional space. In our case, we focused on the distribution of crime incidents in a two-dimensional space, mapped by latitude and longitude, to investigate whether the distribution of crime incidents differs in Downtown Newark between event and no-event time units. The outcomes of the Fasano-Franceschini test indicated a complex picture. The spatial distribution for overall crimes statistically differs comparing event versus no-event time units, and the same pattern emerges comparing the spatial distribution of auto thefts and thefts (the two most prevalent crime categories in the data). Conversely, no statistical differences are appreciated in relation to aggravated assaults, burglaries, other crimes, and robberies.

Finally, investigating crime at the incident level to assess the relationship between six location types and the moment when a crime occurred (again, discriminating event versus no event), statistical outcomes suggest that for four of these location types, no statistical correlation was detected. The only two exceptions were streets and parking lots. Concerning the former, the odds that crimes are committed in the streets are 29.3% lower when no events are in place at the Prudential Center. The odds that crimes are committed in parking lots are instead 73.1% higher when the facility is not active (although the coefficient is only significant at the 90% level). The results of the location type analysis align with those found after comparing spatial distributions, showing that the Prudential Center only partially qualitatively modifies the characteristics of crimes in the area for most crimes and most location types. Concerning the two significant results, some interpretations can be advanced. The increase in the likelihood of crime incidents on the streets when the facility is active might be explained by the higher number of potential targets visiting the area. This aspect can be further enriched by the confluence of adversarial groups of people, especially in sporting events with harsh rivalries between teams. With regards to parking lots, the fact that crime incidents in parking lots are more likely when the facility is not active can be also read in terms of variation in guardianship: while such lots are under continuous guardianship during events, due to the continuous flow of people parking and leaving, in no-event timeframes, such guardianship is

significantly diminished, creating more opportunity for crime commission (both at the property and instrumental levels).

A few limitations warrant highlighting. First, focusing on the downtown portion of Newark has theoretical as well as logical justification, given that it would be challenging to assume that changes in crime occurring miles away from the Prudential Center are precisely influenced by activity at the facility. Yet we acknowledge that we chose clear, fixed boundaries for circumscribing the area under analysis, and there may be crime events occurring just a few feet over those boundaries still being influenced by the center, or alternatively, there may be premises—such as restaurants or taverns—outside the boundaries having an impact on crime patterns in the area. The results should thus be interpreted keeping this aspect in mind, namely, that the fixed nature of the boundaries might escape residual crime dynamics. Second, no disaggregation per crime type is provided in the analysis of crime trends via the negative binomial models. We acknowledge that, in principle, disaggregating crime data would have provided helpful information on specific dynamics, bearing practical and not only empirical relevance. However, several crime categories are particularly sparse, and this would have provoked significant power issues, thus offering an incomplete and unstable set of results. Third, although we manually tried to extrapolate attendance data from the Prudential Center website using the Wayback Machine, we could not gather systematic information on the number of people attending each event. In fact, we obtained a non-representative sample of attendance information that accounted for around 65–70% of the events, while around a third were missing, hence invalidating any possibility for analytical scrutiny. The hypothesis that attendance might in principle play a role in crime variation when events in place align with previous work by Marie (2016) and Mares and Blackburn (2019), which showed that, expectedly, the higher the number of spectators attending sporting events, the higher the (positive) impact on crime. Although we empirically demonstrated that the type of event has a differential impact on crime, it may be that the number of people attending an event could also impact crime rates, opening up avenues of future inquiry. In fact, previous works by Marie and Mares and Blackburn only focus on unique types of events (i.e., soccer and baseball games), thereby leaving unanswered questions surrounding the interaction between event typology and attendance. Better understanding the dynamics governing the interplay between quality and quantity of spectators should be a priority in future research on the link between sports, entertainment, and crime.

In general, the heterogeneity of results stimulates theoretical as well as policy reflections. Theoretically, this study highlights how analyzing crime dynamics without proper disaggregation poses the effect of shadowing critical micro-processes peculiar to specific crime categories, locations, or surrounding environmental conditions. While the literature on sports, entertainment, and facilities is abundant, it is essential to consider the nuances and specificities that may emerge in different cities and for different event types, as this case study clearly suggests. The Prudential Center certainly affects crime incidence in the surrounding Newark area. However, it would be simplistic to say that the negative externalities of activity held at the facility are universal: only some events are more prone to be associated with an increase in crime, and only some venues are more prone to be the target of crime when events are in place. This speaks to the importance of theoretical reasoning that considers

the complexity of crime in all its facets. Additionally, when compared with the study by Kurland (2019), our results diverge in terms of the event-crime link. This is due to our choice of focusing on the area surrounding the Prudential Center, suggesting that scrutinizing the entire urban area might lead to spurious results.

Relatedly, the heterogeneity that emerged from this study also bears relevance to policy matters. That different event types have different effects across crime types calls for tailored programs and policies structured to optimally allocate resources considering the risk of crime increases relative to each event typology. Some types of events will require more resources to optimize crime reduction efforts. At the same time, patrolling and monitoring by law enforcement during event times should take into account the fact that, while most crimes occur in the exact spatial locations, robberies seem to differ, and streets and parking lots exhibit different probabilities of being victimized in event versus no-event time units. Law enforcement should thus respond to the changing dynamics emerging in robberies when events are in place, as well as prioritize monitoring streets which appear to be the riskiest locations for crime when the facility is active.

Future scholarship in this area of inquiry should investigate whether the heterogeneity and complexity of dynamics revealed by the present study of Downtown Newark also apply to other urban contexts across the USA, as well as abroad, in line with other recent calls in this direction (Block & Kaplan, 2022). Applying our analytical framework—which focuses not only on crime counts and incidence but also on spatial characteristics of crime—across cities will provide essential knowledge on the variety of effects that facilities and stadiums have on crime at different levels. This type of comprehensive focus will thus equip scholars with a more solid understanding of the facility-crime relationship as well as policy- and decision-makers with an array of usable evidence-based indications of the possible negative consequences of such buildings in an attempt to design urban development plans that consider security as an important asset to protect in impacted urban contexts.

Supplementary Information The online version contains supplementary material available at https://doi.org/10.1007/s11292-023-09576-8.

Funding Open access funding provided by Northeastern University Library

Data availability All data and scripts used in the current work are publicly stored at the following link: https://doi.org/10.5281/zenodo.7429566

Declarations

Disclosure The analyses and conclusions presented here are those of the authors and should not be attributed to the Bureau of Justice Statistics or the U.S. Department of Justice.

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References

Adarlo, S. (2009). Gay couple claims attack in Newark was bias related. The Star Ledger: Newark, NJ. https://www.nj.com/news/2009/03/gay_couple_claim_that_brtiney.html

Askey, A. P., Taylor, R., Groff, E., & Fingerhut, A. (2018). Fast food restaurants and convenience stores: Using sales volume to explain crime patterns in Seattle. *Crime & Delinquency, 64*(14), 1836–1857. https://doi.org/10.1177/0011128717714792

Bernasco, W., & Block, R. (2011). Robberies in Chicago: A block-level analysis of the influence of crime generators, crime attractors, and offender anchor points. *Journal of Research in Crime and Delinquency, 48*(1), 33–57. https://doi.org/10.1177/0022427810384135

Block, K., & Kaplan, J. (2022). An analysis of National Hockey League playoff games and city-level crime counts. *Crime & Delinquency*, 001112872211188. https://doi.org/10.1177/00111287221118879

Boehme, H. M., Malhotra, R., & Mulrooney, T. (2022). More gas, more crime: A geospatial examination of the concentration of gas stations and predatory crime. *Southeastern Geographer, 62*(1), 59–78. https://doi.org/10.1353/sgo.2022.0005

Brantingham, P., & Brantingham, P. J. (1982). Mobility, notoriety and crime: A study of crime patterns in urban nodal points. *Journal of Environmental Systems, 11*(1).

Brantingham, P., & Brantingham, P. (1995). Criminality of place. *European Journal on Criminal Policy and Research, 3*(3), 5–26. https://doi.org/10.1007/BF02242925

Breetzke, G., & Cohn, E. G. (2013). Sporting events and the spatial patterning of crime in South Africa: Local interpretations and international implications. *Canadian Journal of Criminology and Criminal Justice, 55*(3), 387–420. https://doi.org/10.3138/cjccj.2012.E20

Cardazzi, A., Humphreys, B. R., Ruseski, J. E., Soebbing, B., & Watanabe, N. (2020). *Professional sporting events increase seasonal influenza mortality in US cities* (SSRN Scholarly Paper No. 3628649). https://doi.org/10.2139/ssrn.3628649

Clarke, R. V., & Eck, J. E. (2005). *Crime analysis for problem solvers in 60 small steps*. Office of Community Oriented Policing Services (COPS).

Cohen, L. E., & Felson, M. (1979). Social change and crime rate trends: A routine activity approach. *American Sociological Review, 44*(4), 588–608. https://doi.org/10.2307/2094589

Cohn, E. G. (1990). Weather and crime. *The British Journal of Criminology, 30*(1), 51–64. https://doi.org/10.1093/oxfordjournals.bjc.a047980

Cohn, E. G. (1993). The prediction of police calls for service: The influence of weather and temporal variables on rape and domestic violence. *Journal of Environmental Psychology, 13*(1), 71–83. https://doi.org/10.1016/S0272-4944(05)80216-6

Decker, S. H., Varano, S. P., & Greene, J. R. (2007). Routine crime in exceptional times: The impact of the 2002 Winter Olympics on citizen demand for police services. *Journal of Criminal Justice, 35*(1), 89–101. https://doi.org/10.1016/j.jcrimjus.2006.11.018

Farber, J. (2007). *Just makin' a memory Bon Jovi Perfect fit for arena's opener*. New York Post.

Farrell, G. (2015). Crime concentration theory. *Crime Prevention and Community Safety, 17*(4), 233–248. https://doi.org/10.1057/cpcs.2015.17

Fasano, G., & Franceschini, A. (1987). A multidimensional version of the Kolmogorov-Smirnov test. *Monthly Notices of the Royal Astronomical Society, 225*(1), 155–170. https://doi.org/10.1093/mnras/225.1.155

Felson, M., & Poulsen, E. (2003). Simple indicators of crime by time of day. *International Journal of Forecasting, 19*(4), 595–601. https://doi.org/10.1016/S0169-2070(03)00093-1

Field, S. (1992). The effect of temperature on crime. *The British Journal of Criminology, 32*(3), 340–351. https://doi.org/10.1093/oxfordjournals.bjc.a048222

Garcıa, G., Silveira, J., Poco, J., Paiva, A., Nery, M. B., Silva, C. T., Adorno, S., & Nonato, L. G. (2021). CrimAnalyzer: Understanding crime patterns in São Paulo. *IEEE Transactions on Visualization and Computer Graphics, 27*(4), 2313–2328. https://doi.org/10.1109/TVCG.2019.2947515

Groff, E. R., & Lockwood, B. (2014). Criminogenic facilities and crime across street segments in Philadelphia: Uncovering evidence about the spatial extent of facility influence. *Journal of Research in Crime and Delinquency, 51*(3), 277–314. https://doi.org/10.1177/0022427813512494

Groff, E., & McCord, E. S. (2012). The role of neighborhood parks as crime generators. *Security Journal, 25*(1), 1–24. https://doi.org/10.1057/sj.2011.1

Haberman, C. P., & Ratcliffe, J. H. (2015). Testing for temporally differentiated relationships among potentially criminogenic places and census block street robbery counts: Time and the relationship between crime and place. *Criminology, 53*(3), 457–483. https://doi.org/10.1111/1745-9125.12076

Han, S., Nobles, M. R., Piquero, A. R., & Piquero, N. L. (2021). Crime risks increase in areas proximate to theme parks: A case study of crime concentration in Orlando. *Justice Quarterly, 38*(6), 1210–1229. https://doi.org/10.1080/07418825.2019.1677935

Humphreys, B. R. (2019). Should the construction of new professional sports facilities be subsidized? *Journal of Policy Analysis and Management, 38*(1), 264–270. https://doi.org/10.1002/pam.22099

Humphreys, B. R., & Pyun, H. (2018). Professional sporting events and traffic: Evidence from U.S. cities. *Journal of Regional Science, 58*(5), 869–886. https://doi.org/10.1111/jors.12389

Humphreys, B. R., & Ruseski, J. E. (2019). *Geographic determinants of infant health: The impact of sports facility construction projects* (SSRN Scholarly Paper No. 3467702). https://doi.org/10.2139/ssrn.3467702

Irvin-Erickson, Y., & La Vigne, N. (2015). A spatio-temporal analysis of crime at Washington, DC Metro Rail: Stations' crime-generating and crime-attracting characteristics as transportation nodes and places. *Crime Science, 4*(1), 14. https://doi.org/10.1186/s40163-015-0026-5

Johnson, L. T., & Ratcliffe, J. H. (2017). A partial test of the impact of a casino on neighborhood crime. *Security Journal, 30*(2), 437–453. https://doi.org/10.1057/sj.2014.28

Jones, R. W., & Pridemore, W. A. (2019). Toward an integrated multilevel theory of crime at place: Routine activities, social disorganization, and the law of crime concentration. *Journal of Quantitative Criminology, 35*(3), 543–572. https://doi.org/10.1007/s10940-018-9397-6

Jones, R. G. (2007, October 26). For former Newark mayor, arena's opening is tough to savor. *The New York Times*. https://www.nytimes.com/2007/10/26/nyregion/26arena.html

Kaske, M. (2007). *Newark housing authority to sell $178M to complete hockey area*. The Bond Buyer.

Kautt, P. M., & Roncek, D. W. (2007). Schools as criminal "hot spots": Primary, secondary, and beyond. *Criminal Justice Review, 32*(4), 339–357. https://doi.org/10.1177/0734016807311559

Kolmogorov, A. N. (1933a). Sulla Determinazione Empirica di Una Legge di Distribuzione. *Giornale Dell'istituto Italiano Degli Attuari, 4*, 83–91.

Kolmogorov, A. N. (1933b). Über die Grenzwertsätze der Wahrscheinlichkeitsrechnung. *Bulletin de l'Académie Des Sciences de l'URSS. Classe Des Sciences Mathématiques Et Na, 3*, 363–372.

Kurland, J. (2014). *The ecology of football-related crime and disorder*. Doctoral dissertation, University College London: University of London.

Kurland, J. (2019). Arena-based events and crime: An analysis of hourly robbery data. *Applied Economics, 51*(36), 3947–3957. https://doi.org/10.1080/00036846.2019.1587590

Kurland, J., & Piza, E. L. (2018). The devil you don 't know: A spatial analysis of crime at Newark's Prudential Center on hockey game days. *Journal of Sport Safety and Security*, *3*(1).

Kurland, J., Johnson, S. D., & Tilley, N. (2010). *Late weekend kick-offs at premier football matches and their possible link to increased levels of alcohol-related ASB and disorder*. UCL Department of Security and Crime Science.

Kurland, J., Johnson, S. D., & Tilley, N. (2014). Offenses around stadiums: A natural experiment on crime attraction and generation. *Journal of Research in Crime and Delinquency, 51*(1), 5–28. https://doi.org/10.1177/0022427812471349

Kurland, J., Tilley, N., & Johnson, S. D. (2018). Football pollution: An investigation of spatial and temporal patterns of crime in and around stadia in England. *Security Journal, 31*(3), 665–684. https://doi.org/10.1057/s41284-017-0123-0

LaGrange, T. C. (1999). The impact of neighborhoods, schools, and malls on the spatial distribution of property damage. *Journal of Research in Crime and Delinquency, 36*(4), 393–422. https://doi.org/10.1177/0022427899036004003

Locke, S. L. (2019). Estimating the impact of major league baseball games on local air pollution: Mlb games and local air pollution. *Contemporary Economic Policy, 37*(2), 236–244. https://doi.org/10.1111/coep.12404

Long, J. S., & Freese, J. (2006). *Regression models for categorical dependent variables using Stata* (Vol. 7). Stata press.

Loukaitou-Sideris, A. (1999). Hot spots of bus stop crime: The importance of environmental attributes. *Journal of the American Planning Association, 65*(4), 395–411. https://doi.org/10.1080/01944369908976070

Loukaitou-Sideris, A., Liggett, R., & Iseki, H. (2002). The geography of transit crime: Documentation and evaluation of crime incidence on and around the Green Line Stations in Los Angeles. *Journal of Planning Education and Research, 22*(2), 135–151. https://doi.org/10.1177/0739456X02238443

Mares, D., & Blackburn, E. (2019). Major league baseball and crime: Opportunity, spatial patterns, and team rivalry at St. Louis Cardinal games. *Journal of Sports Economics, 20*(7), 875–902. https://doi.org/10.1177/1527002518822702

Marie, O. (2016). Police and thieves in the stadium: Measuring the (multiple) effects of football matches on crime. *Journal of the Royal Statistical Society: Series A (statistics in Society), 179*(1), 273–292. https://doi.org/10.1111/rssa.12113

Mays, J. (2007). *ESPN hockey analyst apologizes for comments on arena*. The Star Ledger. https://www.nj.com/news/2007/11/espn_hockey_analyst_calls_pru.html

Menaker, B. E., & Chaney, B. H. (2014). College football game day stadium incidents: Policy and environmental effects on alcohol-related ejections and crime. *Journal of Policy Research in Tourism, Leisure and Events, 6*(2), 119–134. https://doi.org/10.1080/19407963.2014.895286

Menaker, B. E., McGranahan, D. A., & Jr, R. D. S. (2019). Game day alters crime pattern in the vicinity of sport venues in Cleveland, OH. *Journal of Sport Safety and Security*. https://www.scinapse.io/papers/3033187504

Montolio, D., & Planells-Struse, S. (2016). How time shapes crime: The temporal impacts of football matches on crime. *Regional Science and Urban Economics, 61*, 99–113. https://doi.org/10.1016/j.regsciurbeco.2016.10.001

Montolio, D., & Planells-Struse, S. (2019). Measuring the negative externalities of a private leisure activity: Hooligans and pickpockets around the stadium. *Journal of Economic Geography, 19*(2), 465–504. https://doi.org/10.1093/jeg/lbx041

Munyo, I., & Rossi, M. A. (2013). Frustration, euphoria, and violent crime. *Journal of Economic Behavior & Organization, 89*, 136–142. https://doi.org/10.1016/j.jebo.2013.02.005

Murray, R. K., & Swatt, M. L. (2013). Disaggregating the relationship between schools and crime: A spatial analysis. *Crime & Delinquency, 59*(2), 163–190. https://doi.org/10.1177/0011128709348438

Newton, A. (2018). Macro-level generators of crime, including parks, stadiums, and transit stations (G. J. N. Bruinsma & S. D. Johnson, Eds.; Vol. 1). *The Oxford handbook of environmental criminology,* pp. 497–517. Oxford University Press. https://doi.org/10.1093/oxfordhb/9780190279707.013.16

Osgood, D. W. (2000). Poisson-based regression analysis of aggregate crime rates. *Journal of Quantitative Criminology, 16*(1), 21–43. https://doi.org/10.1023/A:1007521427059

Peacock, J. A. (1983). Two-dimensional goodness-of-fit testing in astronomy. *Monthly Notices of the Royal Astronomical Society, 202*(3), 615–627. https://doi.org/10.1093/mnras/202.3.615

Piquero, A. R., Piquero, N. L., & Riddell, J. R. (2021). Do (sex) crimes increase during the United States Formula 1 Grand Prix? *Journal of Experimental Criminology, 17*(1), 87–108. https://doi.org/10.1007/s11292-019-09398-7

Pridemore, W. A., & Grubesic, T. H. (2013). Alcohol outlets and community levels of interpersonal violence: Spatial density, outlet type, and seriousness of assault. *Journal of Research in Crime and Delinquency, 50*(1), 132–159. https://doi.org/10.1177/0022427810397952

Puritz, C., Ness-Cohn, E., & Braun, R. (2022). *fasano.franceschini.test: An implementation of a multidimensional KS test in R* (arXiv:2106.10539). arXiv. https://doi.org/10.48550/arXiv.2106.10539

Pyun, H. (2019). Exploring causal relationship between Major League Baseball games and crime: A synthetic control analysis. *Empirical Economics, 57*(1), 365–383. https://doi.org/10.1007/s00181-018-1440-9

Queally, J. (2011). *Newark crime around prudential center is nonexistent during NCAA East Regional games, police say*. The Star Ledger: Newark, NJ. https://www.nj.com/news/2011/03/newark_crime_drops_to_nil_duri.html

Queally, J. (2012). *Group of 10 or 15 'Thugs' rob and beat 5 people following prudential center concert, cops say*. The Star Ledger: Newark, NJ. https://www.nj.com/news/2012/05/5_teens_embark_on_crime_spree.html

Ranson, M. (2014). Crime, weather, and climate change. *Journal of Environmental Economics and Management, 67*(3), 274–302. https://doi.org/10.1016/j.jeem.2013.11.008

Ratcliffe, J. H. (2012). The spatial extent of criminogenic places: A changepoint regression of violence around bars. *Geographical Analysis, 44*(4), 302–320. https://doi.org/10.1111/j.1538-4632.2012.00856.x

Ristea, A., Al Boni, M., Resch, B., Gerber, M. S., & Leitner, M. (2020). Spatial crime distribution and prediction for sporting events using social media. *International Journal of Geographical Information Science, 34*(9), 1708–1739. https://doi.org/10.1080/13658816.2020.1719495

Rotton, J., & Kelly, I. W. (1985). Much ado about the full moon: A meta-analysis of lunar-lunacy research. *Psychological Bulletin, 97*, 286–306. https://doi.org/10.1037/0033-2909.97.2.286

Smirnov, N. V. (1944). Approximate laws of distribution of random variables from empirical data. *Uspekhi Mat. Nauk, 10*, 179–206.

Smirnov, N. V. (1948). Table for estimating the goodness of fit of empirical distributions. *The Annals of Mathematical Statistics, 19*(2), 279–281. https://doi.org/10.1214/aoms/1177730256

Speer, P. W., Gorman, D. M., Labouvie, E. W., & Ontkush, M. J. (1998). Violent crime and alcohol availability: Relationships in an urban community. *Journal of Public Health Policy, 19*(3), 303–318. https://doi.org/10.2307/3343538

Spelman, W. (1993). Abandoned buildings: Magnets for crime? *Journal of Criminal Justice, 21*(5), 481–495. https://doi.org/10.1016/0047-2352(93)90033-J

Stoecker, C., Sanders, N. J., & Barreca, A. (2016). Success is something to sneeze at: Influenza mortality in cities that participate in the Super Bowl. *American Journal of Health Economics, 2*(1), 125–143. https://doi.org/10.1162/AJHE_a_00036

Szkola, J., Piza, E. L., & Drawve, G. (2021). Risk terrain modeling: Seasonality and predictive validity. *Justice Quarterly, 38*(2), 322–343. https://doi.org/10.1080/07418825.2019.1630472

Taylor, R. B. (2015). *Community criminology: Fundamentals of spatial and temporal scaling, ecological indicators, and selectivity bias*. NYU Press.

Tillyer, M. S., Wilcox, P., & Walter, R. J. (2021). Crime generators in context: Examining "place in neighborhood" propositions. *Journal of Quantitative Criminology, 37*(2), 517–546.

Tompson, L., & Bowers, K. (2013). A stab in the dark?: A research note on temporal patterns of street robbery. *Journal of Research in Crime and Delinquency, 50*(4), 616–631. https://doi.org/10.1177/0022427812469114

Tompson, L. A., & Bowers, K. J. (2015). Testing time-sensitive influences of weather on street robbery. *Crime Science, 4*(1), 8. https://doi.org/10.1186/s40163-015-0022-9

Van Koppen, P. J., & Jansen, R. W. J. (1999). The time to rob: Variations in time of number of commercial robberies. *Journal of Research in Crime and Delinquency, 36*(1), 7–29. https://doi.org/10.1177/0022427899036001003

Wortley, R., & Townsley, M. (Eds.). (2017). *Environmental criminology and crime analysis* (2nd ed.). Routledge.

Wuschke, K. and Kinney, B. (2018). Built environment, land use, and crime. (G. J. N. Bruinsma & S. D. Johnson, Eds.; Vol. 1). *The Oxford handbook of environmental criminology,* pp. 475–496. Oxford University Press. https://doi.org/10.1093/oxfordhb/9780190279707.013.16

Yu, Y., Mckinney, C. N., Caudill, S. B., & Mixon, F. G. (2016). Athletic contests and individual robberies: An analysis based on hourly crime data. *Applied Economics, 48*(8), 723–730. https://doi.org/10.1080/00036846.2015.1085645

Zipf, G. K. (1949). *Human behavior and the principle of least effort* (pp. xi, 573). Addison-Wesley Press

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Gian Maria Campedelli is a postdoctoral research fellow in Computational Criminology and Sociology at the University of Trento, in Italy. His research focuses on the study of homicide, organized crime and terrorism through the development and application of computational and statistical methods. He is the author of the book "Machine Learning for Criminology and Crime Research: At the Crossroads", published with Routledge in 2022.

Eric L. Piza is Professor of Criminology & Criminal Justice. Director of Crime Analysis Initiatives, and Co-Director of the Crime Prevention Lab at Northeastern University. His research is centered on the spatial analysis of crime patterns, evidence-based policing, crime control technology, and the integration of academic research and police practice.

Alex R. Piquero is Professor in the Department of Sociology & Criminology and Arts & Sciences Distinguished Scholar at the University of Miami (on public service leave while he is the Director of Bureau of Justice Statistics). His research interests include criminal careers, criminological theory, public policy, and quantitative methods. He is Fellow of both the American Society of Criminology and the Academy of Criminal Justice Sciences. In 2019, he received the ACJS Bruce Smith Sr. Award for outstanding contributions to criminal justice and in 2020 he received the ASC Division of Developmental and Life Course Criminology Distinguished Achievement Award.

Justin Kurland currently works as a Principal Data Scientist in financial services, and prior to his current role was a Senior Lecturer in the Department of Computer Science at the University of Waikato (New Zealand). There hetaught several foundational graduate level courses on data analysis, methods, and security, in addition to serving as a principal investigator on numerous large-scale security related grants.