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Do police stations deter crime?

Rémi Boivin[1*] and Silas Nogueira de Melo[2]

Abstract

Purpose The introduction of community policing led to a significant increase in the number of police stations, particularly in urban settings. Police stations are largely assumed to have an impact on crime but there are few studies dedicated to the issue.

Methods The concept of deterrence suggests a negative relationship between police and crime: an increased police presence should lead to a reduction of crime. While it is difficult to directly test that relationship, the present study takes advantage of two recent events in Montreal (Canada) to test the hypothesis that the closure of a police station causes an increase of crime in the surrounding area. Andresen's Spatial point pattern tests and Wheeler and Ratcliffe' weight displacement difference tests were conducted.

Findings While tests suggest that crime geographic patterns were dissimilar pre- and post-closure, none of those differences support the deterrence hypothesis because the number of areas in which an increase in crime was recorded is lower than would be expected by chance. Similarly, decreases in breaking and entering, mischief, theft in or on vehicles and total crime were found, which does not support the deterrence hypothesis.

Conclusions The study of hotspot policing led to the belief that police presence needs to be concentrated in both time and space if it is to have a significant preventive impact on crime. It also led to the development of strategies of concentrated policing that encompass a variety of prevention actions aimed at specific individuals, specific crime types, and/or specific areas. Police stations provide something different: a concentrated presence at one point location with the ability to deploy to respond to any crime, at any time, in a particular area.

Keywords Police stations, General deterrence, Crime, Causality

Introduction

In January 2022, the chief of the Montreal Police Services (MPS) announced that he was beginning consultations that would lead to the closure of several police stations around the city. The resulting outcry was almost unprecedented. Both his political rivals and residents of the areas that would be affected insisted that carrying out this plan would increase inequity and a lack of transparency in police services, as well as leading to an increase in violent crime in the city. The mayor, who had publicly supported the action, eventually backed off and asked that the initiative be postponed; the chief announced his retirement before any action was taken. As in this case, closing police stations is sometimes seen as a way to rebalance public finances, particularly in the wake of the costs of the recent COVID-19 pandemic (Blesse & Diegmann, 2022).

Despite general acceptance of the idea that there is causal link between the number of police stations and crime, there is no clear empirical evidence to support this view. In the following article, one of the few studies to look at the deterrent effect of police stations, we review relevant theoretical perspectives that link police stations and crime, and then review the few available empirical

*Correspondence:
Rémi Boivin
remi.boivin@umontreal.ca
[1] School of Criminology (Université de Montréal), International Centre for Comparative Criminology, Université de Montréal, C.P. 6128, succursale Centre-ville, Montréal, QC H3C 3J7, Canada
[2] Universidade Estadual do Maranhão, Campus, São Luís, Brazil

studies of the effect of this link. We then analyze the impact of two recent closures of police stations in Montreal on crime in neighboring areas.

Theoretical perspectives on the effect of police visibility on crime

Marvell & Moody, (1996) discuss "specification problems" in police-crime studies, arguing that tests of the theoretical relationship between police and crime suffers from unclear specification of causal direction. Are the level and kinds of crime affected by the number of and activity by police or are police activities affected by the level and kinds of crime? Is it possible to determine whether the presence of a police station influences the level of crime in an area, the level of crime influences the location of police stations, or the presence of stations and level of crime have a reciprocal effect? While researchers have tended to find that police have only a small impact on crime (e.g. Levitt, 1997), recent studies suggest that in some cases the effect of concentrated policing may be substantial.

Most discussions and expectations of the impact of police on crime are based on the concept of deterrence—the idea that the threat of punishment affects the behavior of potential offenders by deterring them from crime, eventually reducing the level of criminality in society. Three elements are central to the deterrence perspective: certainty, severity, and celerity (rapidity of application) (Nagin et al., 2015). While empirical knowledge about celerity is small—some researchers do not even consider it when discussing deterrence—there are many studies on certainty and severity. Reviewing that literature is beyond the scope of the current manuscript, but in general studies suggest that (1) certainty has a greater impact on crime than severity and (2) the impact of deterrence on crime is relatively small (Pratt et al., 2008).

One challenge in understanding deterrence is determining how to measure its elements. Police presence is often used as an indicator of the certainty of punishment, i.e. it is expected that there will be less crime when police are more present because of perceived increased risks of being apprehended. Several empirical studies of the impact of police presence on crime, often over a defined period, found that changes in the level of policing in an area lead to corresponding changes in the level of crime. For example, Ratcliffe et al., (2011) studied foot patrol by police in Philadelphia. They conducted a randomized trial of 120 patrol beats, half of which had additional foot patrols (experimental group), while others had no change in the number of police on foot patrol (control group). After twelve weeks, beats with additional foot patrols recorded a reduction of 23% in crime compared to the control group. Change in the level of police intervention available apparently led to a decrease in (violent) crime, a finding that is useful for planning future police deployment.

The Ratcliffe et al. study is representative of efforts made to focus preventive police action on "hotspots", areas in which crime is more concentrated. A recent review (Braga et al., 2019a) suggests that "[t]he extant evaluation research provides fairly robust evidence that hotspots policing is an effective crime prevention strategy" (p. 289). In all 78 studies of hotspot policing interventions discussed in this review, results were explained in terms of deterrence, defined as increased certainty of punishment: the possibility of police interventions, including simple police presence, influenced potential offenders, leading them to refrain from criminal activity and therefore to a decrease in crime rates. Unlike most crime prevention initiatives, hotspot policing has been extensively researched since the 1980s (e.g. Sherman et al., 1989) and has led many observers to discuss crime in terms of geography. Researchers have tended to focus on smaller geographic units and on the development of what Weisburd, (2015) called the "law of crime concentrations". This focus on smaller geographic units has led away from the study of environmental explanations of crime, in part because of data availability, and therefore of communities and neighborhoods as place level explanations. Instead of focusing on "environmental" explanations of crime, place level explanations are based on the idea that offenders' decisions to offend or not can be explained in terms of costs and benefits, much like the assumptions behind the logic of deterrence -and individual explanations of crime. As such, the study of crime at the level of place is a straightforward match with theories of deterrence and rational choice. Following that literature, police stations are considered "coldspots" by many, even if the empirical support for that definition is lacking.

To consider place and crime, Patricia and Paul Brantingham, (1993) created a classification of places that is still used today. "Crime generators" are places that attract many people, some of whom can be expected to commit opportunistic crimes. Crimes are therefore expected to be more frequent in neighborhoods that attract large numbers of visitors and crime-related trips toward these areas can be expected to occur more often. Similarly, Bichler et al., (2014) identified "magnetic places," such as shopping complexes with nearby movie theaters, where crime was higher than expected because youths often gathered in these areas in their free time. Brantingham & Brantingham, (1993) also suggest that areas that are crime attractors have characteristics that

are particularly attractive to highly motivated offenders. They may, for instance, be "under-policed" or provide criminal opportunities or places where individuals with histories of repeat offending can meet.

The third type of place that Brantingham & Brantingham, (1993); see also Brantingham & Brantingham, (2008) identified—crime detractors—is less frequently discussed in the literature. Crime detractors are the exact opposite of crime generators and attractors: they are places that discourage people from committing crimes because they present few attractions or criminal opportunities. Other authors have suggested that they are "risky places" for potential offenders (Bichler et al., 2014), based on the theory that places with particular characteristics could discourage crime in an area. Boivin & D'Elia, (2017) further suggest that some factors could affect anyone ("visit detractors"), while others might have a greater effect on potential offenders ("offense detractors"). They found, for example, that people were less likely to travel longer distances to visit places, thus decreasing the number of trips to an area and eventually the number of (opportunistic) crime events in that area. They also found that potential offenders took fewer trips toward neighborhoods with a higher proportion of residents from visible minorities.

The impact of police stations on crime

Increasing the number of police stations has been central to community policing strategies. Police stations were expected not only to be focal points for police-community relationships but also served as signs that the police were present in a neighborhood and positively oriented toward the community (Skogan, 2006). The introduction of community policing therefore led to a significant increase in the number of police stations, particularly in urban settings. For example, the number of police stations in Montreal increased from 24 in 1996 to 49 in 1997. (Today, because of mergers, Montreal has 31 stations.) Police stations are also expected to have a deterrent impact on crime and their locations are therefore usually carefully chosen (Fondevilla et al., 2021), often, among other reasons, as a way to reduce crime in an area.

To our knowledge, only two studies have looked specifically at the deterrent effect of police stations (Blesse & Diegmann, 2022; Fondevilla et al., 2021).[1] The first (Fondevilla et al., 2021) looked at the effect of distance decay related to 43 police stations in Buenos Aires (Argentina). Distance decay—the idea that offenders are less likely to commit crimes close to their own homes—has been well documented (Hipp & Williams, 2020) and is generally explained by the principle of least effort as well as the assumption of strategic rationality on the part of offenders. Fondevilla et al., (2021) conclude that "[f]rom this analysis, it can be inferred that shorter distances from police stations reduce the incidence of crime, thus creating spaces of less risk. This effect is observed until a certain point or buffer of influence of each station and varies by the type of crime. Nevertheless, the observed effect appears to remain: the closer to a police station, the lower the crime frequency." (p. 1). In other words, police stations have a deterrent effect.

The second study is based on a different logic: Blesse & Diegmann, (2022) start by discussing the public reform that began in Germany in 2003 and resulted in the closure of police stations as a way to cut expenses and centralize the provision of public goods. 232 stations out of a total of 579 were closed, meaning that 40% of police stations in the country were closed over an eight-year period. Blesse and Diegmann recognize that, while policy makers close police stations mainly for budgetary reasons and to improve efficiency of policing, "shutting down entire police agencies may have ambiguous effects on crime" (p. 2), effects that were not considered when the reform was designed. Blesse and Diggman studied the impact of police stations closures on recorded crime and found that municipal levels of car theft and burglary in residential properties increased following closures, also suggesting that police stations have a deterrent effect.

While both studies provide information on the deterrent effects of police stations on crime, they demonstrate that it is difficult to find a way to examine the relationship directly. The study by Fondevilla et al. is static, in the sense that it looks at existing police stations to determine their impact on crime, operating on the logic that if police stations have a deterrent impact on crime, crime should occur further from police stations than from other points in the area. It uses a geographic framework, within which crime events, modelled as points and distances from various places, including police stations, are calculated. Blesse & Diegmann, (2022), which was published in a journal about economics, took advantage of closures related to public policy—not to deterrence—to test the impact of the presence of police stations in an area. The authors of both studies emphasize that police stations are usually not randomly located, so other factors might affect the level of crime in the area. For example, it is common to see police stations located in high-crime areas as tool to reduce the number of crimes in the immediate surroundings.

[1] As pointed out by one reviewer, there is a small literature on "police storefronts", the most recent empirical contribution being Piza et al. (2020). Storefronts are essentially counters or substations where sworn and civilian agents receive community members and, most importantly, increase police visibility. Police storefronts have been associated with deterrent effect for a while (Sherman et al., 1997) but are not standalone facilities, which is why that literature is not presented here.

Current study

That police stations have an impact on crime is largely assumed but there are few studies dedicated to the issue. Police stations are an important public expense and thus an easy target when public officials are looking to rebalance budgets. Two recent studies, however, suggest that police stations have a deterrent effect on crime so closing them might be associated with an increase of crime, an outcome that is obviously problematic for both communities and police organizations.

Contrary to traditional criminological research, studies of the impact of police stations on crime attempt to specify the relationship between police and crime, looking for causality, not just correlation. It is more difficult to establish causation than correlation because three conditions must be met: (1) covariation: factors are correlated across space and time, (2) temporal precedence: the cause precedes the consequence, and (3) exclusion: alternative explanations for the observed relationship can be ruled out. Failure to demonstrate any of these conditions means that causality between two variables cannot be established. Criminological research is complicated because it is often not possible or ethical to conduct experimental studies on areas of interest. Experimental design (with randomization) is believed to be the gold standard of research, but in some fields it is often difficult to ensure both the quality of the research and the safety of the public. For instance, while empirical research might require random closures of police stations, this obviously cannot be done without a detailed analysis of the costs and benefits involved.

The present study takes advantage of two recent events in Montreal (Canada) to test the hypothesis that the closure of a police station causes an increase in crime in the surrounding area. To our knowledge, those two closures were not random but motivated by a variety of factors, including political motives, the level of crime in the area and a general feeling that the territories covered by those stations were "quiet" ones that could easily be merged with close-by stations. First, on January 30, 2018, station 11, located on the west side of the city, was permanently merged with a neighboring station. Second, on January 15, 2019, station 24, located closer to the center of the city, was also merged with a neighboring station. This second closure made it possible to test the same hypothesis again to determine if it was possible to validate the results of the first study. Rather than testing whether the opening of a police station reduces the number of crimes in the area, as predicted by deterrence theory, the present study tests whether the closure of a police station leads to an increase in crime in the surrounding area. A quasi-experimental design was used, with the level of crime prior to the closure compared to the level after the station was closed. Following Wheeler & Ratcliffe, (2018), control groups—areas where police stations remained without change—are included in the analysis in an attempt to establish the causal effect of police stations on crime.

Methods

Data

Our study is based on open data from the city of Montreal, retrieved from https://donnees.montreal.ca/ville-de-montreal/actes-criminels. This site provides relatively detailed information on six types of crime—breaking and entering, theft in or on vehicles, car theft, mischief, robbery, and homicide—recorded by the Montreal Police Services (MPS) since January 1, 2015. (Homicide, because of its low occurrence, was excluded from our analysis.) The majority of the reports (82.4% or 133,278 out of a total of 161,857 events) included the X and Y geographical position of the event at one of the intersections of the street segment where the event took place.[2] Events not associated with geographical coordinates (28,579) were excluded from the analysis. The rate of geocoding increased slightly over time.

Unit of analysis

Two separate tests of the hypothesis were conducted. In both tests, an experimental area and experimental period were defined as well as a control area and control period. Crime in Montreal, like that in any area with a temperate climate, is subject to significant seasonal differences, with more crimes committed during the summer (June through September) than during the winter (December through April). However, because both of the stations in our analysis were closed in January, the pre- and post-closure periods were similar in seasonal distribution. Figure 1 shows a map of both areas, situated within the city of Montreal.

Study 1

At present, Montreal has 31 police neighborhoods. On January 30, 2018, Police Station 11 was merged with Station 9: Station 11 was permanently closed and the area covered by Station 9 was increased to include the territory previously covered by Station 11. The experimental area in our analysis is thus the area covered by Station 9 before and after the closure of Station 11.

[2] This matching rate is below the largely used estimate provided by Ratcliffe (2004) of 85%. However, a more recent paper by Andresen et al. (2020) suggested that "when the number of events begins to be greater than the number of areas, the [acceptable] minimum geocoding match rate does not need to be as conservative" (p.1316). In our cases, the number of events is considerably larger than the number of areas -overall, there are more than 50 times more events than areas-, which is why we believe that an 82.4% match rate is acceptable.

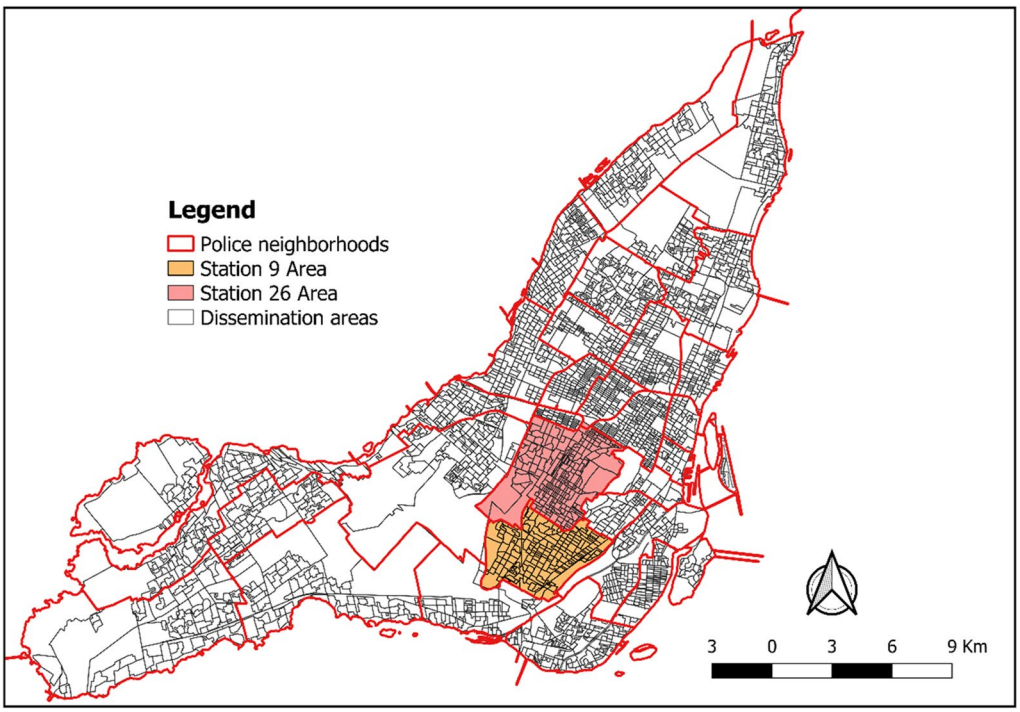


Fig. 1 Areas 9 and 26 in Montreal

Data for the period beginning March 13, 2020 (when the COVID-19 pandemic officially began) was excluded to avoid bias. The pre-closure period was considered to be from December 17, 2015, to January 29, 2018 (774 days) and the post-closure period was January 30, 2018, to March 12, 2020 (774 days). The area covered by Station 8 was chosen as a control because the station is located in the same general area of the city as Station 11 and has similar urban characteristics.

Study 2

Station 24 was closed and merged with Station 26 on January 15, 2019. The pre-closure period used in our analysis is November 11, 2017, to January 14, 2019 while the post-closure period is January 15, 2019, to March 12, 2020. Station 38, which is located in an urban area similar to Station 26, was chosen as a control area.

Analytical strategy

Three tests—Andresen's local spatial point pattern test (SPPT), Andresen's global spatial point pattern test, and Wheeler & Ratcliffe' weight displacement difference test (WDDT)—were conducted for each closing, not only to determine if the results could be replicated but also because each test has different limitations and advantages We chose to use the SPPT with only one area pre- and post-closure to determine if the spatial pattern of crime changed after the closure. This level of analysis corresponds to level 2 (out of a possibility of 5) on the Maryland Scientific method scale developed by Sherman et al. (1997) to determine the validity of empirical findings about crime prevention programs. Level 2 (before and after measure of crime) is often thought to be below the minimum design considered adequate for drawing valid conclusions but is still considered to be useful in the absence of alternative explanations (Farrington, 2003). While the SPPT, as used here, compares similar areas over time, the WDDT includes both an experimental and control group, as well as a pre- and post-closure design, but obtains only a level 3 on the Maryland scale. It was therefore decided that combining these three tests would provide more valid conclusions about the directed causality of the relationship between police stations and crime.

Local spatial point pattern test

Andresen, (2009, 2016) developed a conceptually simple "spatial point pattern test" (SPPT) to determine the similarity of two point patterns in a common territory. The SPPT is appealing because it requires only two event files (one base data set and one test data set) and an area-based file. It is easy to use as it is available either as an R package (Steenbeek et al., 2017) or as a graphical user interface developed in Java by Nick Malleson (https://

github.com/nickmalleson/spatialtest). The SPPT computes a local indicator of spatial similarity for each geographic unit in the analysis. Any pair of (relevant) sets of events can be compared, at any geographical unit level (e.g. street segments, countries), as long as each event point can be assigned to an individual area unit. This indicator can be effectively mapped to allow visual analysis and identification of problem areas (e.g. Andresen, 2009; Wu & Lum, 2017). The SPPT compares areas, which means that dissemination, rather than points or street intersections, are the unit of analysis.

The SPPT made it possible to determine if crime in the area under discussion increased, decreased, or remained stable post-closure periods, relative to the pre-closure period [3]. As discussed above, the deterrence hypothesis specifies a causal relationship between the presence of police stations and crime, with an increase in crime, rather than a decrease or stability, expected after closure. The calculation of significance levels was based on chi-squared (χ^2) tests and used to determine if the observed distribution was significantly different from the predicted distribution. To answer that question, the classic chi-squared formula was used: $\chi^2 = \sum(Oi-Ei)2/Ei$, where Oi is the observed value (actual value) and Ei is the expected value. The value of chi-squared is equal to the sum of the squared differences (Oi–Ei) divided by the expected value. The chi-squared value was then compared to the theoretical value obtained from a table of contingency, which provided values of 5.991 ($p < 0.05$) and 9.210 ($p < 0.01$). In other words, chi-squared values between 0 and 5.990 should be considered non-significant, while those between 5.991 and 9.209 are significant at $p < 0.05$ and significant at $p < 0.01$ if the value is higher or equal to 9.210.

Study 1 includes 203 dissemination areas: if variations across categories were completely random, approximately 68 (203/3) areas would experience an increase after closure of the station and the same number would show stability or a decrease. In the territories under study, a decrease was observed in the crime category mischief for 78 areas, with 87 stable and 38 showing an increase. The value of chi-squared is thus $[(78–67.7)^2 + (87–67.7)^2 + (38–67.7)^2]$ divided by 67.7, or a value of 28.3. Because that value is higher than the theoretical one (9.210), it can be concluded that the observed distribution of pre- and post-closure changes for mischief differs from chance at $p < 0.01$.

[3] This presentation of SPPT assumes that there is no trend in the data, i.e. that there is no significant variation of overall crime in the city, which is why a control area is needed to further test the hypothesis of a change

Global spatial point pattern test

The test also calculates a global index of similarity (S) based on local indicators that provides information on the similarity or dissimilarity of spatial patterns. The test provides an overall value between 0 (perfect dissimilarity) and 1 (perfect similarity), with a value over 0.80 usually considered to be indicative of global similarity. The test uses a Monte Carlo resampling procedure with 100% replacement to estimate a confidence interval around the proportion in each area of the test data set and after determines whether the base data set proportion falls inside (similarity) or outside (dissimilarity) of the confidence interval for the set. Because the lowest number of events is lower than the number of areas, and thus because the existence of perfect similarity between the two periods is not possible, a refined version of the original test, the generalized S-index, was used (Boivin & de Melo, 2019). In the current case, the test would suggest that police stations had a deterrent effect if pre- and post-closure spatial patterns were different, with an increase in crime in the post-closure spatial pattern; i.e. if the S-index value was lower than 0.80.

Weight displacement difference test

The Wheeler & Ratcliffe, (2018) test has two main advantages over Andresen's SPPT. First, it includes both a control area and a control period, which are considered important in ensuring more valid conclusions—in the Maryland scientific scale, having a control group gives a default level-3 design, which is the minimum level often used in evaluating research (Farrington, 2003). As Farrington says, "crime counts will always fluctuate up or down by some amount simply by chance" (Farrington, 2003, p. 1). Having a control group is a recognized way to ensure that any changes found differ significantly from those that are the result of chance. It also controls for the potential effect of displacement. The most frequent criticism of evaluation research is that displacement—the possibility that a crime will occur someplace else, at another time, or in a different manner—is not being considered. Even if it is not always complete (Guerette & Bowers, 2009), displacement should be taken into account because it can lessen the impact of the change being studied.

Contrary to the SPPT, the WDDT uses areas and points to measure differences. In this study we used crime points within a defined area, in this case an area of influence of 500 m with an additional 200 m buffer to account for displacement (see Fig. 2). Both control and treatment areas and their respective displacement zones had an average area of 700,000 square meters. On the same logic, the time analyzed before and after the closing of the police stations was similar for control and

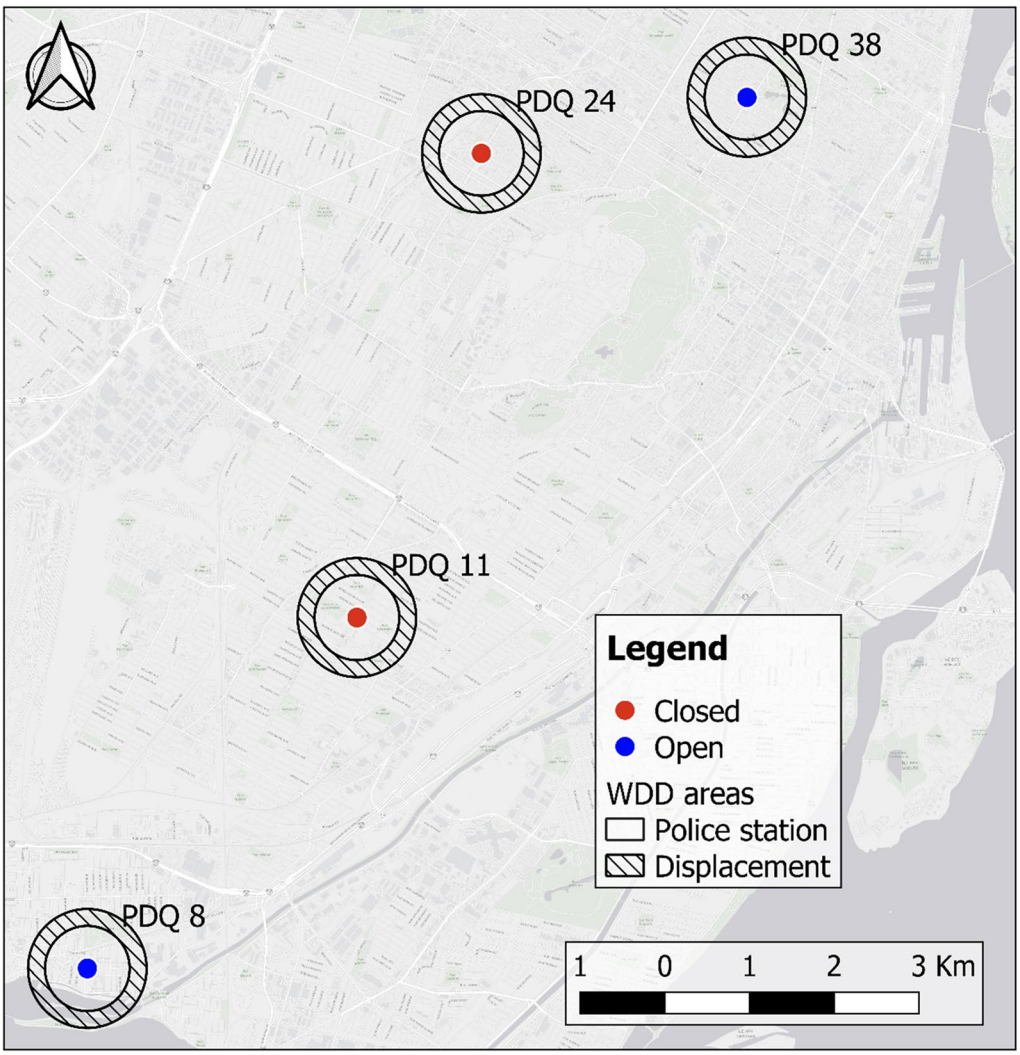


Fig. 2 Areas used in WDDTs

treatment areas and did not extend beyond March 20, 2020, the official start of the COVID lockdown in Montreal. For post-closure, crimes were counted in the period from the closure of the police station until lockdown; for pre-closure, crimes were counted for the same number of days as in the post-closure period.

Wheeler & Ratcliffe's WDD gives a simple test statistic to determine the existence of a relationship between two variables. Consistent with the deterrence hypothesis, it provides one-tailed and two-tailed statistical significances for the relationship. In this analysis, WDD tests were conducted separately for both studies.

Results

Study 1

Table 1 presents the results of SPPTs conducted to assess the impact of the closure of Station 11.

All differences are statistically significant, which means that the observed distribution in the areas being studied differs from chance in terms of changes in crime rate. However, none of those differences support the deterrence hypothesis because the number of areas in which an increase in crime was recorded is lower than would be expected by chance.

Table 2 presents the value of the S-index: remember that the threshold value for this test is 0.80. Because statistical significance is included, the test does not require additional calculations to determine it.

Five of the six tests, including the "Total" category, point to dissimilarity, i.e., that spatial patterns of crime before and after the closure were different. However, local SPPT shows that more areas recorded crime decreases than increases. In other words, even

Table 1 Local SPPT for station 11 (n = 203 dissemination areas)

Crime type	Decrease	Stability	Increase	Chi-squared value and significance
Mischief	78 dissemination areas	87	38	20.11**
Breaking and entering	88	78	37	21.59**
Theft in/on vehicles	82	81	40	16.98**
Car theft	67	100	36	30.28**
Robbery	37	158	8	187.10**
Total	76	77	50	6.93*

** $p < 0.01$

* $p < 0.05$

Table 2 Global SPPT for station 11 (n = 203 dissemination areas)

Crime type	Generalized S-Index
Mischief	0.443
Breaking and entering	0.360
Theft in/on vehicles	0.481
Car theft	0.666
Robbery	1.000
Total	0.335

if the Global SPPT generally suggests dissimilarity, the results do not support the deterrence hypothesis.

Table 3 presents a summary of the results for WDDTs. A detailed table with values for all four areas is provided as an Appendix.

Table 3 shows that results differed according to type of crime. There were significant decreases in mischief, theft in or on vehicles, and total crime, but only one result supported the deterrence hypothesis—an increase in breaking and entering.

Study 2

Table 4 presents the results of local SPPTs used to assess the impact of the closure of Station 9.

Five differences out of six are statistically significant, meaning that the observed distribution in areas under study is different from chance. However, it should be noted that, again, none of those differences support the deterrence hypothesis because the number of areas in which an increase in crime was recorded is lower than would be expected by chance.

Table 5 presents the values of the S-index, which has a threshold of 0.80. As it includes statistical significance, no additional calculations are required.

Contrary to Study 1, four of the six tests conducted for Study 2 point to similarity. However, it should be noted that figures in the "Total" category suggest dissimilarity, as crime before and after the closure appears to follow different spatial patterns. However, similar to Study 1, these results are largely due to the fact that crime decreased in a significant number of the areas under study. Again, even if the Global SPPT generally

Table 3 WDDT for station 11 (n = 203 areas)

Crime type	WDD value and two-tailed significance	Standard error	Confidence interval ($p < 0.05$)
Mischief	− 30*	17.20	− 63.72 to 3.72
Breaking and entering	63**	17.972	27.77 to 98.22
Theft in/on vehicles	− 70**	14.00	− 97.43 to − 42.56
Car theft	− 1	9.50	− 20.5 to 18.5
Robbery	− 9	7.55	− 23.79 to 5.79
Total	− 47^{t}	31.16	− 108.07 to 14.07

** $p < 0.01$

* $p < 0.05$

^{t} $p < 0.10$

Table 4 Local SPPT for station 9 (n = 237 areas)

Crime type	Decrease	Stability	Increase	Chi-squared value and significance
Mischief	70 dissemination areas	136	31	99.37**
Breaking and entering	81	98	58	11.34**
Theft in/on vehicles	63	139	35	85.28**
Car theft	69	152	16	284.57**
Robbery	38	190	9	653.53**
Total	83	85	69	2.07

** $p < 0.01$

* $p < 0.05$

Table 5 Global SPPT for station 9 (n = 237 areas)

Crime type	Generalized S-Index
Mischief	0.804
Breaking and entering	0.485
Theft in/on vehicles	0.947
Car theft	1.000
Robbery	1.000
Total	0.387

suggests dissimilarity, it does not support the deterrence hypothesis.

Table 6 presents a summary of the results for WDDTs and a detailed table with values for all four areas is provided as an Appendix.

Again, the results point to differences in crime rate according to type of crime. Statistically significant decreases in breaking and entering, theft in or on vehicles, and total crime were found, which does not support the deterrence hypothesis.

By crime types

The current analysis found striking differences by crime types. This is consistent with previous work: indeed, Fondevilla et al., (2021) found a greater deterrent impact on homicides and auto robberies than on theft, robbery and auto theft. Blesse & Diegmann, (2022) go even further by finding deterrent effects only on car theft and residential burglary, but not on personal theft, robbery and commercial burglary. Because this paper is based on two studies, two general patterns must be underlined. First, there is consistent evidence in the case of theft in/on vehicles, car theft, robbery and total crime. As stated above, that evidence does not support the existence of a deterrent effect of police stations. Second, in the case of mischief and breaking-and-entering, the evidence is mixed: for example, the WDD evidence for breaking-and-entering is that of an increase of crime in Study 1, but of a decrease in Study 2. Further research is needed to clarify the situation. However, the results presented here support a point made by other authors: if police stations influence crime, it is likely to vary by crime type.

Table 6 WDDT for station 9 (n = 237 areas)

Crime type	WDD value and two-tailed significance	Standard error	Confidence interval ($p < 0.05$)
Mischief	− 20	16,25	− 51.84 to 11.84
Breaking-and-entering	− 36*	17,20	− 69.72 to − 2.27
Theft in/on vehicles	− 18^{t}	13.56	− 44.58 to 8.58
Car theft	3	7.68	− 12.05 to 18.05
Robbery	7	7.00	− 6.71 to 20.71
Total	− 64*	29.19	− 121.20 to − 6.79

** $p < 0.01$

* $p < 0.05$

^{t} $p < 0.10$

Table 7 Summary of findings for both studies

Test	Expected (theoretical) support for the deterrence hypothesis	Observed results
Experiment 1		
Local SPPT	Local increases	Small proportion of increases
Global SPPT	Dissimilarity due to increases	Dissimilarity but because of decreases
WDDT	Significant positive relationships	One (out of six) positive relationship
Experiment 2		
Local SPPT	Local increases	Small proportion of increases
Global SPPT	Dissimilarity due to increases	Dissimilarity but because of decreases
WDDT	Significant positive relationships	Significant decreases only

Discussion

The number of police stations increased in the late 1990s and early 2000s, largely due to increased interest in community policing, which included the belief that a greater number of stations would enhance police-community relations and help the police provide services that were more appropriate to local social needs. Police stations were often located in problematic areas where an increase in police presence was seen as one aspect of crime prevention, despite little empirical evidence to support this view. However, decisionmakers soon realized that police stations require important monetary and human investment and began considering reducing the number of police stations in their territories as a way to increase productivity and reduce costs. Police stations were (and will continue to be) closed. The whole process is, however, based on little empirical evidence about the effect the presence of police stations has on crime.

Two previous studies investigated the deterrent effect of police stations (Blesse & Diegmann, 2022; Fondevilla et al., 2021), using completely different approaches and methodologies; both suggest that police stations have a deterrent impact on crime. In the present study, available crime data made it possible to look at the results of two recent closures of police stations in Montreal. We used a quasi-experimental strategy to analyze the impact of closures on the geographical pattern of crime in a given area to test the hypothesis that closing a police station increases crime in the surrounding area. As noted in Table 7, we did not find support for this hypothesis: neither closure was followed by an increase in crime in the area under study.

Our findings suggest that if there is an effect from the closure of police stations, it is more likely to be associated with decreases in crime rates, results that are inconsistent with the crime deterrence hypothesis but might be explained by the possible impact of police stations on crime reporting. The number of crimes reported might be expected to decrease following the closure of a police station and, consequently, official crime rates would also decrease, especially for less serious forms of crime. It is well-known that official crime statistics underestimate the number of infractions, a phenomenon referred to as the "dark figure of crime". Several empirical studies have also shown that the number of crimes reported to the police is closely related to the seriousness of the bodily injury, economic loss, emotional damage, or other negative outcomes suffered by victims as serious infractions are more likely to be reported to the police [see, for example, Boivin & Leclerc (2016)]. There are, however, only a limited number of studies on the impact of macrolevel contexts on crime reporting, although some researchers have argued for the development of multilevel models of help-seeking (see Xie & Baumer, (2019) for a review). There is evidence that contextual factors should be considered in studies of crime reporting and help-seeking behaviors, but the literature is far from definitive about their effect. The effect of geographical distance in particular remains a neglected area of research: a limited number of studies have shown, for example, that rural and urban victims have different reporting behaviors and access to services—which could be interpreted as the effect of distance on crime reporting—but the relationship between these variables (crime reporting and access to services) is correlational at best (Weisheit & Wells, 1996).

Two limitations of the current study deserve explicit mention. First, the study focused on the city of Montreal, Canada. Blesse & Diegmann, (2022) conducted a similar study in Germany and Fondevilla et al., (2021) looked at the city of Buenos Aires, Argentina. All available studies on the impact of police stations on crime, including ours, thus come from outside the United States, which is uncommon in police studies. For example, in the Lee et al., (2017) review of 44 studies of crime concentration, more than half (59.1% or 26 studies) came from the US. More importantly, Lee

et al. showed that studies based on American datasets reached different conclusions than studies done in other contexts, which suggests that it is important to study the impact of police stations on crime both in the US and in other countries. It is even more important to conduct research in different settings because data availability varies from one country to another: for example, the major deterrent effect found by Fondevilla et al., (2021) is on homicide and auto robbery, two crime types that are not analyzed neither by Blesse & Diegmann, (2022) nor by us.

Second, it could be argued that the current study investigated the short-term impact of closures only, what Sherman, (1990) refers to as "initial deterrence" as opposed to "residual deterrence". Both closures took place relatively recently and pre- and post-periods were short (774 days and 442 days, respectively). It would be interesting to see if crime in these areas shows different spatial patterns in 10 or 15 years. However, it should also be noted that crime prevention programs that do not lead to significant initial (short-term) deterrence generally do not provide residual (long-term) deterrence either. Furthermore, both police stations were closed just before the COVID-19 pandemic. A growing number of studies is showing that the pandemic had a significant impact on crime, with some types decreasing, others increasing, and still other remaining stable [see for example, Regalado et al., (2022)]. What remains unknown is the impact of the pandemic on long-term crime trends: will the short-term changes that have been documented continue or will crime levels go back to "normal"? Whatever the answer, it will complicate the development of studies that involve that period.

Conclusion

The study of hotspot policing led to the belief that police presence needs to be concentrated in both time and space if it is to have a significant preventive impact on crime (Braga et al., 2019a). It also led to the development of strategies of concentrated policing that encompass a variety of prevention actions aimed at specific individuals, specific crime types, and/or specific areas (Braga et al., 2019b). Police stations provide something different: a concentrated presence at one point location with the ability to deploy to respond to any crime, at any time, in a particular area. Consequently, the (limited) available literature that concludes that police stations have a general deterrent effect should be viewed somewhat sceptically. The results of the current study, which do not support the existence of a deterrent effect of police stations, contradict the findings of the two other studies that have dealt explicitly with that topic. More studies are obviously needed to validate or invalidate the hypothesis that police stations have an impact on crime rates.

The main goal of police stations may not, however, be deterrence. Women-led police stations are an example of a focus on other goals. These stations differ from other stations in at least two important ways (Carrington et al., 2022). First, they employ largely (not exclusively) women, typically around 90%. Second, they focus on a few types of crimes, for instance, events related to gender and domestic violence rather than, like traditional stations, dealing with all types of situations. Interestingly, women-led police stations are associated with an increase in crime reporting but not necessarily with deterrence: a recent study in India found a 29% increase in reports of domestic violence but a stable incidence rate, a result that is attributed to victimized women feeling safer and more empowered and therefore more likely to report such crimes (Amaral et al., 2021). The current study also suggests that expectations that police stations have a general deterrent effect may be unreasonable.

Appendix

Values for all four areas, Study 1

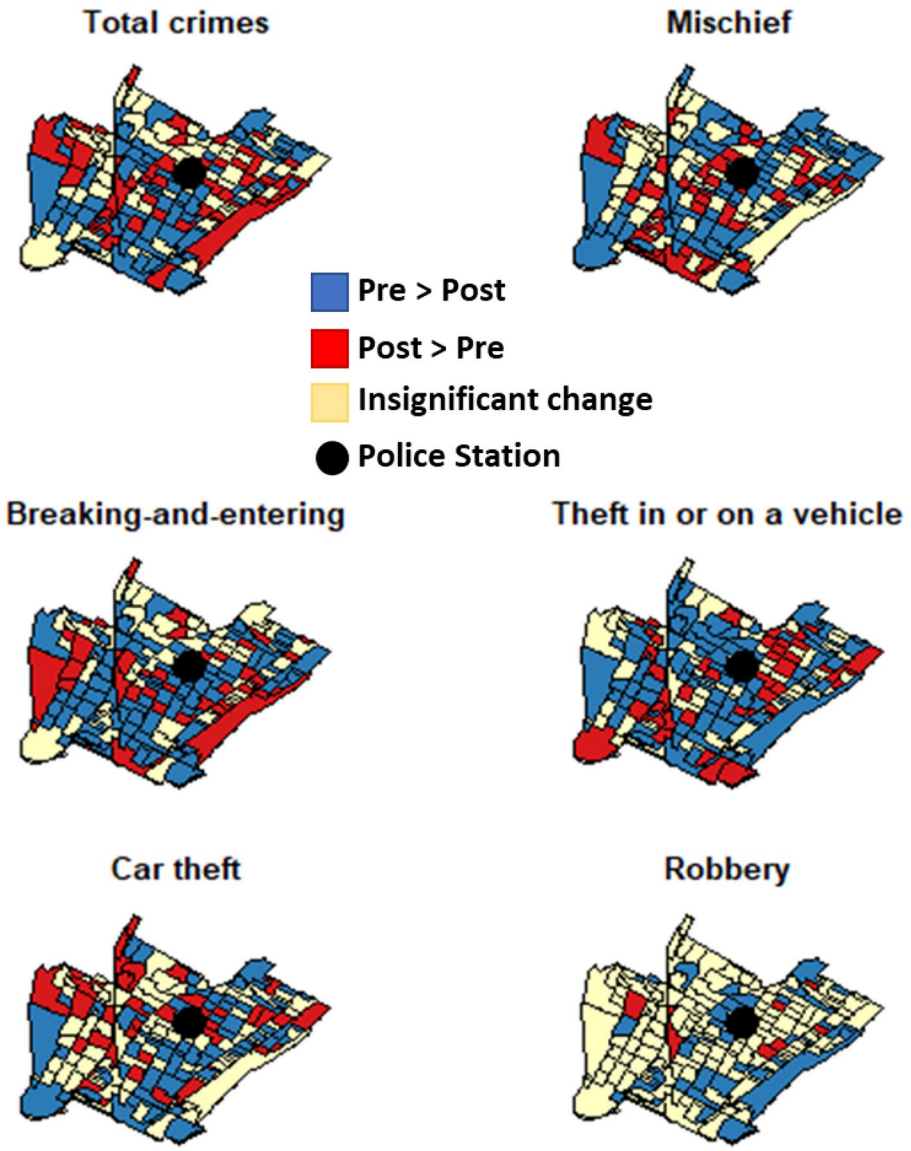
Station	**11**		**8**	
Area	**Treated**	**Treated displacement**	**Control**	**Control displacement**
Size (m^2)	785,300	754,200	785,300	754,200
Pre-closure period (774 days)				
Mischief	40	46	42	31
Breaking and entering	37	39	106	45
Theft in or on a vehicle	39	22	31	10
Car theft	5	13	11	11
Robbery	10	10	11	1

Station	11		8	
Area	**Treated**	**Treated displacement**	**Control**	**Control displacement**
Total	131	130	201	98
Post-closure period (774 days)				
Mischief	33	27	48	29
Breaking and entering	15	27	38	16
Theft in or on a vehicle	12	10	46	26
Car theft	18	9	16	16
Robbery	6	6	10	3
Total	84	79	158	90

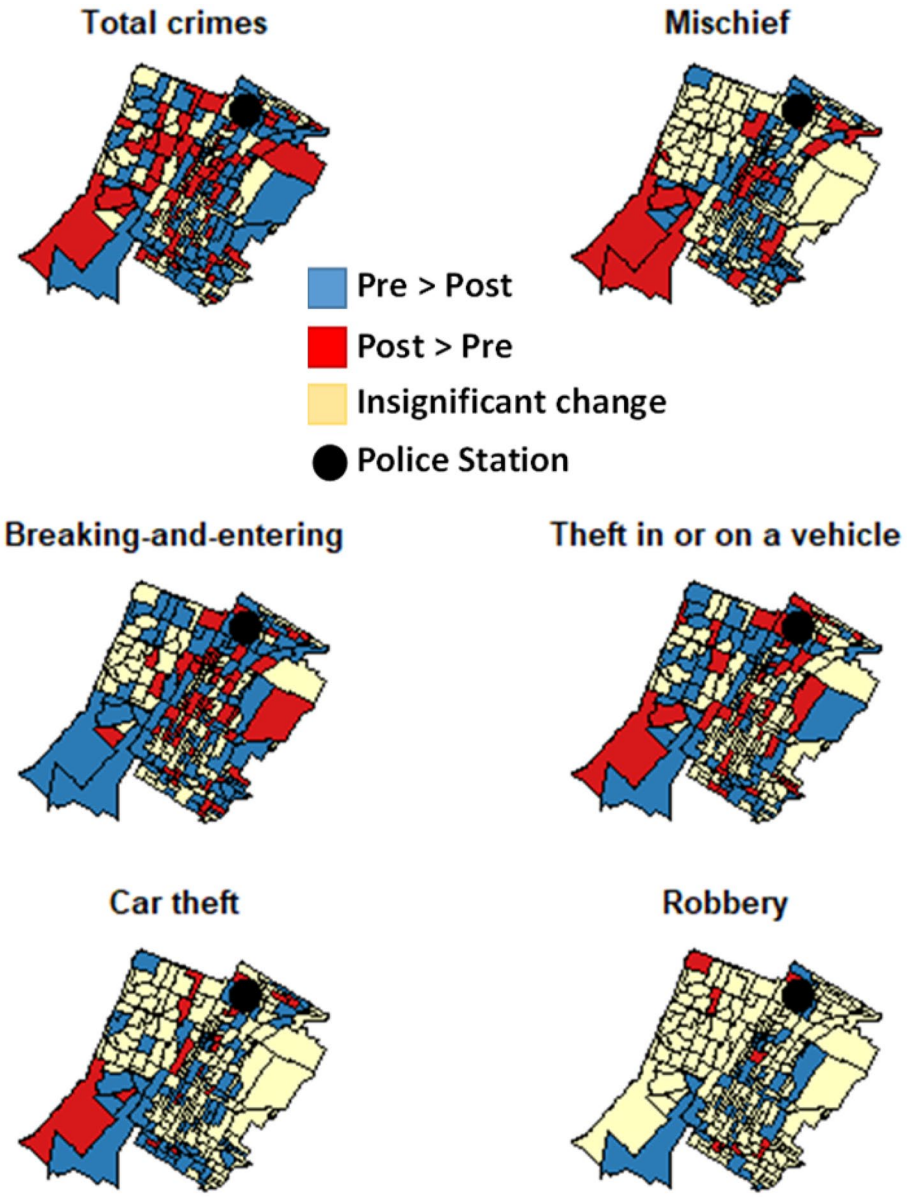
Values for all four areas, Study 2

Station	24		38	
Area	**Treated**	**Treated displacement**	**Control**	**Control displacement**
Size (m^2)	785,300	754,200	785,300	754,200
Pre-closure (774 days)				
Mischief	20	10	67	23
Breaking-and-entering	28	15	44	62
Theft in or on a vehicle	19	10	20	23
Car theft	4	6	4	7
Robbery	3	3	13	9
Total	74	44	148	124
Post-closure (774 days)				
Mischief	27	5	63	49
Breaking-and-entering	17	7	54	69
Theft in or on a vehicle	22	18	30	42
Car theft	15	5	6	12
Robbery	5	1	8	7
Total	86	36	161	179

Results of SPPT, area 9



Results of SPPT, area 26



Abbreviations

SPPT Spatial point pattern test
WDDT Weight displacement difference test

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References

Amaral, S., Bhalotra, S. & Prakash, N. (2021). *Gender, crime and punishment: Evidence from women police stations in India*. CESifo Working Paper no 9002. https://doi.org/10.2139/ssrn.3827615.

Andresen, M. A. (2009). Testing for similarity in area-based spatial patterns: A nonparametric Monte Carlo approach. *Applied Geography, 29*(3), 333–345.

Andresen, M. A. (2016). An area-based nonparametric spatial point pattern test: The test, its applications, and the future. *Methodological Innovations, 9*(1), 1–11.

Andresen, M. A., Malleson, N., Steenbeek, W., Townsley, M., & Vandeviver, C. (2020). Minimum geocoding match rates: An international study of the impact of data and areal unit sizes. *International Journal of Geographical Information Science, 34*(7), 1306–1322.

Bichler, G., Malm, A., & Enriquez, J. (2014). Magnetic facilities: Identifying the convergence settings of juvenile delinquents. *Crime & Delinquency, 60*(7), 971–998.

Blesse, S., & Diegmann, A. (2022). The place-based effects of police stations on crime: Evidence from station closures. *Journal of Public Economics, 207*, 104605.

Boivin, R., Leclerc, C. (2016). Domestic violence reported to the police: Correlates of victims' reporting behavior and support to legal proceedings. *Violence and Victims*, *31*(3), 402–415.

Boivin, R., & D'Elia, M. (2017). A network of neighborhoods: Predicting crime trips in a large Canadian city. *Journal of Research in Crime and Delinquency, 54*(6), 824–846.

Boivin, R., & Melo, S. N. (2019). Comparing global spatial patterns of crime. *Policing: An International Journal of Police Strategies, 42*(6), 1097–1106.

Braga, A. A., Turchan, B. S., Papachristos, A. V., & Hureau, D. M. (2019a). Hot spots policing and crime reduction: An update of an ongoing systematic review and meta-analysis. *Journal of Experimental Criminology, 15*, 289–311.

Braga, A. A., Weisburd, D., & Turchan, B. (2019b). Focused deterrence strategies effects on crime: A systematic review. *Campbell Collaboration Reviews*. https://doi.org/10.1002/cl2.1051

Brantingham, P. J., & Brantingham, P. L. (1993). *Environment, routine, and situation: Toward a pattern theory of crime*. Transaction Publishers.

Brantingham, P. L., & Brantingham, P. J. (2008). Crime pattern theory. In R. Wortley & L. Mazerolle (Eds.), *Environmental criminology and crime analysis* (pp. 78–93). Willan.

Carrington, K., Sozzo, M., Ryan, V., & Rodgers, J. (2022). Women-led police stations: Reimagining the policing of gender violence in the twenty-first century. *Policing and Society, 32*(5), 577–597.

Farrington, D. P. (2003). Methodological quality standards for evaluation research. *The ANNALS of the American Academy of Political and Social Science, 587*(1), 49–68.

Fondevilla, G., Vitalta-Perdomo, C., Galindo Pérez, M. C., & Cafferata, F. G. (2021). Crime deterrent effect of police stations. *Applied Geography, 134*, 102518.

Guerette, R. T., & Bowers, K. J. (2009). Assessing the extent of crime displacement and diffusion of benefits: A review of situational crime prevention evaluations. *Criminology, 47*(4), 1331–1368.

Hipp, J. R., & Williams, S. A. (2020). Advances in spatial criminology: The spatial scale of crime. *Annual Review of Criminology*. https://doi.org/10.1146/annurev-criminol-011419-041423

Lee, Y., Eck, J. E., O, S., & Martinez, N. N. (2017). How concentrated is crime at places? A systematic review from 1970 to 2015. *Crime Science*. https://doi.org/10.1186/s40163-017-0069-x

Levitt, S. D. (1997). Using electoral cycles in police hiring to estimate the effects of police on crime. *The American Economic Review, 87*(3), 270–290.

Marvell, T. B., & Moody, C. E. (1996). Specification problems, police levels, and crime rates. *Criminology, 34*(4), 609–646.

Nagin, D. S., Solow, R. M., & Lum, C. (2015). Deterrence, criminal opportunities, and police. *Criminology, 53*(1), 74–100.

Piza, E. L., Wheeler, A. P., Connealy, N. T., & Feng, S. Q. (2020). Crime control effects of a police substation within a business improvement district: A quasi-experimental synthetic control evaluation. *Criminology & Public Policy, 19*(2), 653–684.

Pratt, T. C., Cullen, F. T., Blevins, K. R., Daigle, L. E., & Madensen, T. D. (2008). The empirical status of deterrence theory: A meta-analysis. In F. T. Cullen, J. P. Wright, & K. R. Blevins (Eds.), *Taking stock: The status of criminological theory (Advances in Criminological Theory, volume 15)*. Routledge.

Ratcliffe, J. H. (2004). Geocoding crime and a first estimate of a minimum acceptable hit rate. *International Journal of Geographical Information Science, 18*(1), 61–72.

Ratcliffe, J. H., Tanigushi, T., Groff, E. R., & Wood, J. D. (2011). The Philadelphia foot patrol experiment: A randomized controlled trial of police patrol effectiveness in violent crime hotspots. *Criminology, 49*(3), 795–831.

Regalado, J., Timmer, A., & Jawaid, A. (2022). Crime and deviance during the COVID-19 pandemic. *Sociology Compass, 16*, e12974.

Sherman, L. W. (1990). Police crackdowns: Initial and residual deterrence. *Crime and Justice: A Review of Research, 12*(1), 1–48.

Sherman, L. W., Gartin, P. R., & Buerger, M. E. (1989). Hot spots of predatory crime: Routine activities and the criminology of place. *Criminology, 27*(1), 27–56.

Sherman, L. W., Gottfredson, D., MacKenzie, D., Eck, J., Reuter, P., & Bushway, S. (1997). *Preventing crime: What works, what doesn't, what's promising: A report to the United States Congress*. National Institute of Justice.

Skogan, W. G. (2006). *Police and community in Chicago: A tale of three cities*. Oxford University Press.

Steenbeek, W., Vandeviver, C., Andresen, M., Malleson, N. (2017). *sppt: Spatial point pattern test*. R package version 0.1.4. https://github.com/wsteenbeek/sppt

Weisburd, D. (2015). The law of crime concentration and the criminology of place. *Criminology, 53*, 133–157.

Weisheit, R. A., & Wells, L. E. (1996). Rural crime and justice: Implications for theory and research. *Crime & Delinquency, 42*(3), 379–397.

Wheeler, A. P., & Ratcliffe, J. H. (2018). A simple weighted displacement difference test to evaluate place based crime interventions. *Crime Science*. https://doi.org/10.1186/s40163-018-0085-5

Wu, X., & Lum, C. (2017). Measuring the spatial and temporal patterns of police proactivity. *Journal of Quantitative Criminology, 33*(4), 915–934.

Xie, M., & Baumer, E. P. (2019). Crime victims' decisions to call the police: Past research and new directions. *Annual Review of Criminology, 2*, 217–240.

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