The impact of a hot spot policing program in Montevideo, Uruguay: An evaluation using a quasi-experimental difference-in-difference negative binomial approach

Corresponding author: Spencer P. Chainey. Department of Security and Crime Science, University College London, 35 Tavistock Square, London, England. s.chainey@ucl.ac.uk Twitter: @SpencerChainey

Rodrigo Serrano–Berthet. Citizen Security Cluster, Innovation for Citizen Services Division, Inter-American Development Bank, 1300 New York Avenue, NW, Washington DC, 20577, USA. rodrigose@iadb.org Twitter: @RSerranoBerthet

Federico Veneri. Department of Statistics, Iowa State University, 2438 Osborn Drive, Ames, IA, USA. federico.veneri@gmail.com

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Abstract

Hot spot policing has proven to be effective in reducing crime in cities in North America, Europe and Australasia, but to date its application and evaluation in Latin American settings has been limited. PADO (Programa de Alta Dedicación Operativa) is a large scale hot spot policing program implemented by the Uruguay Police in April 2016 in the city of Montevideo. Using an evaluation technique that compares the differential effect between areas where

PADO was deployed and control areas, a 23 percent reduction in the rate at which robberies occurred was experienced in the PADO areas, with no significant displacement to neighboring areas, or other areas of the city during the study period. The study indicates that hot spot policing programs can be effective in reducing crime in Latin American urban environments and illustrates how targeted police interventions can be robustly evaluated when control areas are not established at the outset of an intervention.

Key words: hot spot policing, difference-in-difference, robbery, Montevideo, Latin America

1. Introduction

Hot spot policing programs have had a significant impact in reducing crime in many cities and towns in the North America, Europe and Australasia (Braga et al., 2012; Braga et al., 2014). Hot spot policing aims to counter the pattern of crime concentration by targeting the deployment of patrols to specific areas that have previously experienced high levels of crime (Braga and Weisburd, 2010; Sherman et al., 1989; Weisburd and Telep, 2014). There is limited application, however, of hot spot policing in Latin American urban contexts. This is due to the tendency of police agencies in Latin American countries to dedicate the allocation of resources to response duties rather than considering prevention opportunities, and is often complicated further by the militarised nature of police service deployment and a focus towards repressive activities (Bergman, 2018; IDB and the Uruguay Ministry of Interior, 2017). Furthermore, little attention has been paid in Latin American policing environments to the use of analysis of crime patterns to inform police resource deployment (Beato, 2008; Bergman, 2018).

In recent years, the Uruguay Police have been undergoing a program of reform that has included investing in the development of the police's analysis capabilities and designing intervention programs that aim to more effectively reduce crime. One such program is PADO (Programa de Alta Dedicación Operativa), a large-scale hot spot policing program in Montevideo. While other police agencies in Latin American countries have attempted to implement hot spot policing, often these programs have not been specific in the areas they have targeted (e.g., deploying police officers to neighborhoods rather than specific streets[1]), and have been insufficient in their evaluative rigor (i.e., most programs have only conducted simple before and after measures of crime rather than using statistical evaluation techniques with control groups). This article provides findings of the impact of the PADO hot spot policing program in Uruguay using a quasi-experimental evaluation approach, and in-so-doing offers one of the first rigorous examinations of a hot spot policing program that has been implemented in a Latin American setting. More generally, the study contributes to the global evidence-base on the impact of hot spot policing programs.

Before the results are provided, section 2 of the article provides a concise summary of the research evidence on the impact of hot spot policing, describes the main challenges in applying and evaluating hot spot policing programs in Latin American contexts, and provides information about the hot spot policing program in Montevideo. Section 3 describes the data that were used and the difference-in-difference negative binomial models that were applied to measure the impact of the PADO intervention. After the presentation of results in section

[1] See Blattman et al., 2017 for an example.

4, a discussion of these results and their implications then follows in section 5. Section 6 provides conclusions.

2. Hot spot policing impact, its application in Latin America, and PADO in Montevideo, Uruguay

Hot spot policing involves the deployment of police officers to specific streets, street junctions or locations (e.g., train stations) where crime is known to highly concentrate, with the objective of reducing the high levels of crime at these locations. Hot spot policing provides a means of helping to reduce crime by focusing police resources in a more efficient and effective manner. A substantial body of research shows that hot spot policing can have an impact on reducing a number of different types of crime, such as robberies (Sherman and Weisburd, 1995), violent crime (Ratcliffe et al., 2011), disorder and mischief incidents (Andersen and Lau, 2014), drug offences (Lawton et al., 2005), non-domestic firearm assaults (Rosenfeld et al., 2014; Sherman and Rogan, 1995), the burglary of commercial premises (Weisburd and Green, 1995; Andersen and Lau, 2014), and the number of incidents reported to the police (Andersen and Lau, 2014; Ariel et al., 2016; Haberman, 2016; Sherman and Weisburd, 1995). For example, the Philadelphia Foot Patrol Experiment reduced violent crime by 23% (Ratcliffe et al., 2011) and a hot spot policing program in Minneapolis reduced robberies by 20% (Sherman and Weisburd, 1995). The overall evidence on hot spot policing has also shown that it does not result in an offset of crime displacement from the targeted patrol areas to other areas, or displacement to other crime types (Braga et al., 2014; Ratcliffe et al, 2011). Indeed, some evidence suggests that hot spot policing interventions can result in a diffusion of benefit effect to surrounding areas (Bowers et al., 2011).

Whilst there is a substantial body of research evidence on the impact of hot spot policing, less is currently known about the mechanisms and moderating factors that influence and explain how hot spot policing works. This includes limited understanding about the optimal dosage of hot spot police deployment (such as the number of patrol officers necessary and the frequency of their visits to the hot spots for maximising their effect) when applied in different settings (identifying reference); whether foot patrols work better than car, motorbike or bicycle patrols (Ratcliffe and Sorg, 2017); the cost-benefit of hot spot policing, and; if the activities that police officers perform in hot spots, such as engaging in conversation with members of the community and conducting stop checks, matter (identifying reference; Haberman, 2016). Additionally, the research evidence on the impact of hot spot policing primarily draws from studies from the United States, Canada and the United Kingdom, with very little known about its use and impact in Latin American countries.

The limited use of hot spot policing in Latin America is due in part to the dominant tendency of policing in the Latin American region to follow a reactive response model rather than being prevention minded (Frühling, 2012). Additionally, the use of analysis of crime data by police agencies in Latin American countries has been limited (Beato, 2008; Bergman, 2018), albeit recent improvements have begun to be made in accurately geographically referencing these crime records and using them to study patterns of crime (identifying reference). The limited use of crime analysis has, however, also been a reflection of the culture in most police agencies in Latin America where officer rank and experience rather than analysis findings, criminal intelligence and evidence are the main influencing factors in deciding where to deploy patrols. Additionally, incentives and the performance of police officers in Latin American police agencies are often measured and rewarded more in relation to the speed of

response to a crime and the number of arrests made, rather than by reductions in crime (Bergman, 2018). A further challenge has been that targeted police deployment activities are often greeted with pessimism by officers from Latin American police agencies who consider displacement to be inevitable and argue that any efforts that involve targeting specific areas is of little value (Muggah et al., 2017).

One example of hot spot policing in the Latin America region is from Santiago, Chile, involving the targeting of police patrols to specific high crime areas (Tudela et al., 2014). A similar approach was also used in Bogotá, Colombia, where crime data were analysed to determine areas of high crime incidence (Mejía et al., 2015). This program in Bogotá resulted in the calibration of quadrants that each consisted of over one hundred street segments to which a pair of officers in vehicles were deployed across each of the three daytime shifts. The results from an evaluation of the Bogotá program showed it to have very limited impact in reducing crime (Blattman et al., 2017). The low level of treatment dosage of the Bogotá program does, though, bring into question this program's validity as a hot spot policing initiative. Instead, the Bogotá program has characteristics that are more similar to quadrant policing. Quadrant policing is an approach that has been implemented in several Latin American cities with the aim of improving the speed in which the police respond to citizen's concerns and calls for service (Blattman et al., 2017), tends to follow principles of community policing rather than hot spot policing (Frühling, 2012), and involves deploying police officers to patrol areas that consist of many streets rather than targeting police deployment to specific *hot spot* streets. Combined with the lack of any robust findings on the impact of hot spot policing in Latin American urban contexts, the tendency towards a reactive response policing model rather than one that is prevention minded, the limited use of crime analysis, and police officer

pessimism towards the inevitability of displacement, it has been difficult for hot spot policing programs to gain traction in the region.

Whilst the implementation of hot spot policing programs in Latin American countries has been limited, there is a growing body of research that illustrates that patterns of crime concentration are as evident in Latin American cities as they are in cities in North America, Europe and Australasia (identifying reference). The notion that crime concentrates in places is a well-established observation in geographical studies of crime (see Lee et al., 2017). This has led Weisburd (2015) to propose a law of crime concentration, oriented to micro-places (such as street segments[2]), which is considered to be universally applicable to all crime types and in all settings (Braga et al., 2017; Weisburd, 2015). Weisburd (2015) states that crime concentrates amongst micro-places within certain spatial bandwidths: for a cumulative proportion of 25 percent of crime, the bandwidth for the proportion of micro-places is between 0.4 and 1.6 percent; and for a cumulative proportion of 50 percent of crime, the bandwidth for the proportion of micro-places is between 2.1 and 6 percent. To date, the examination of crime concentration at micro-places has mainly been confined to a number of US-based studies (e.g., Lee et al.'s, 2017 systematic review of the crime concentration literature did not include any studies from Latin America). However, there is growing evidence that shows these crime concentration patterns are also observed in Latin American urban contexts (Chainey et al., 2019; Jaitman and Ajzenman, 2016; Mejia et al., 2015; de Melo et al., 2015; Pereira et al., 2016; identifying reference). For example, Chainey and Monteiro (2019) found that across five cities in Brazil, 25 percent of all robberies were concentrated in less

[2] A street segment is the part of a street between two street junctions.

than 1 percent of all micro-places and 50 percent were concentrated in less than 4 percent of these areas. If crime is highly concentrated in Latin American settings, this then indicates that hot spot policing programs are likely to provide the opportunity to help reduce crime in Latin American cities in a manner similar to how these programs have contributed to reductions in crime in the North America, Europe and Australasia.

PADO, a hot spot policing program in Montevideo, was introduced in April 2016. PADO is the first hot spot policing program in Latin America that involves the use of a large number of police officers to solely perform the task of patrolling crime hot spots (IDB and the Uruguay Ministry of Interior, 2017). Different from the quadrant policing approach reported above that has been used in other cities in Latin America, the PADO intervention involved the precise targeted deployment of police patrols to specific small areas (i.e., to 1-5 streets) – a key feature of hot spot policing. The objective of the PADO intervention was to reduce robbery. The robbery of a person's possessions[3] while they are on a street or other area of public space is a crime type of major concern in Latin American countries. This is because robbery is high in volume and is typically 5-10 times greater in most Latin American cities than in cities in North America and Europe (UNODC, 2017). In 2015, there were over 17,000 recorded robbery incidents in Montevideo[4]. Robbery had also been increasing year on year for over a decade in Montevideo, increasing by at least 10 percent on the previous year for the five years prior to

[3] Robbery involves the act of violence or the threat of violence in the commission of the offence. The main types of robbery in Montevideo are theft from a pedestrian (typically representing 57 percent of all robberies; 'rapiña a transeunte' in Spanish), theft from a motorcyclist (11 percent of all robberies; rapiña a motociclista), theft from a commercial business, such as a convenience store (8 percent; rapiña comercio), theft from a car driver (6 percent; rapiña a automovilista) and theft from a delivery driver (5 percent; rapiña a repartidor).

[4] Montevideo has a population of 1.4 million people. In comparison, the similar sized cities of Munich (Germany) recorded 560 robberies in 2015 (https://www.bka.de/EN/CurrentInformation/PoliceCrimeStatistics/policecrimestatistics_node.html) and Dallas (USA) recorded 3,991 robberies (https://www.neighborhoodscout.com/tx/dallas/crime)

the implementation of PADO. Also, prior victimization of robbery is a major influencing factor of people's fear of crime and their trust in the police (Dammert and Malone, 2006). If many people are victims of robbery, or know of people who have recently been a victim of robbery, the attempts the police make to improve their relationship with the public can be undermined. Therefore, reducing robbery was a major priority that was adopted by the Uruguay Police in 2016, with PADO considered to be a way to achieve reductions in robbery.

In 2015, the Uruguay Police created a crime analysis unit, and one of the unit's first tasks was to examine patterns of robbery across Montevideo. The analysis involved examining patterns of robbery at the street level and identified the areas where a hot spot policing program could be deployed. Following a consultation between the analysis unit and senior police officers, 120 locations (comprising of a small number of street segments[5] and street junctions, covering small micro-place areas) were identified as the locations to deploy the new PADO patrols (see Figure 1). The patrol locations were arranged into 28 circuits, with the circuits defined as areas that were logical to the supervision of the PADO patrols (i.e., in size and neighborhood coverage). Groups of two or three officers were assigned to patrol each location on foot, and were supported in each circuit by two to four dedicated motorbike police patrols and a car patrol in which a supervising officer was assigned. The PADO patrols operated between 17.00 – 01.00 hours (informed by a temporal analysis of robbery patterns) and required the officers assigned to foot patrol to remain within their assigned street segment(s) for the evening (except when one of the PADO patrol officers accompanied a person who had been arrested to the local police station).

[5] The average length of street segments in Montevideo was 104 meters

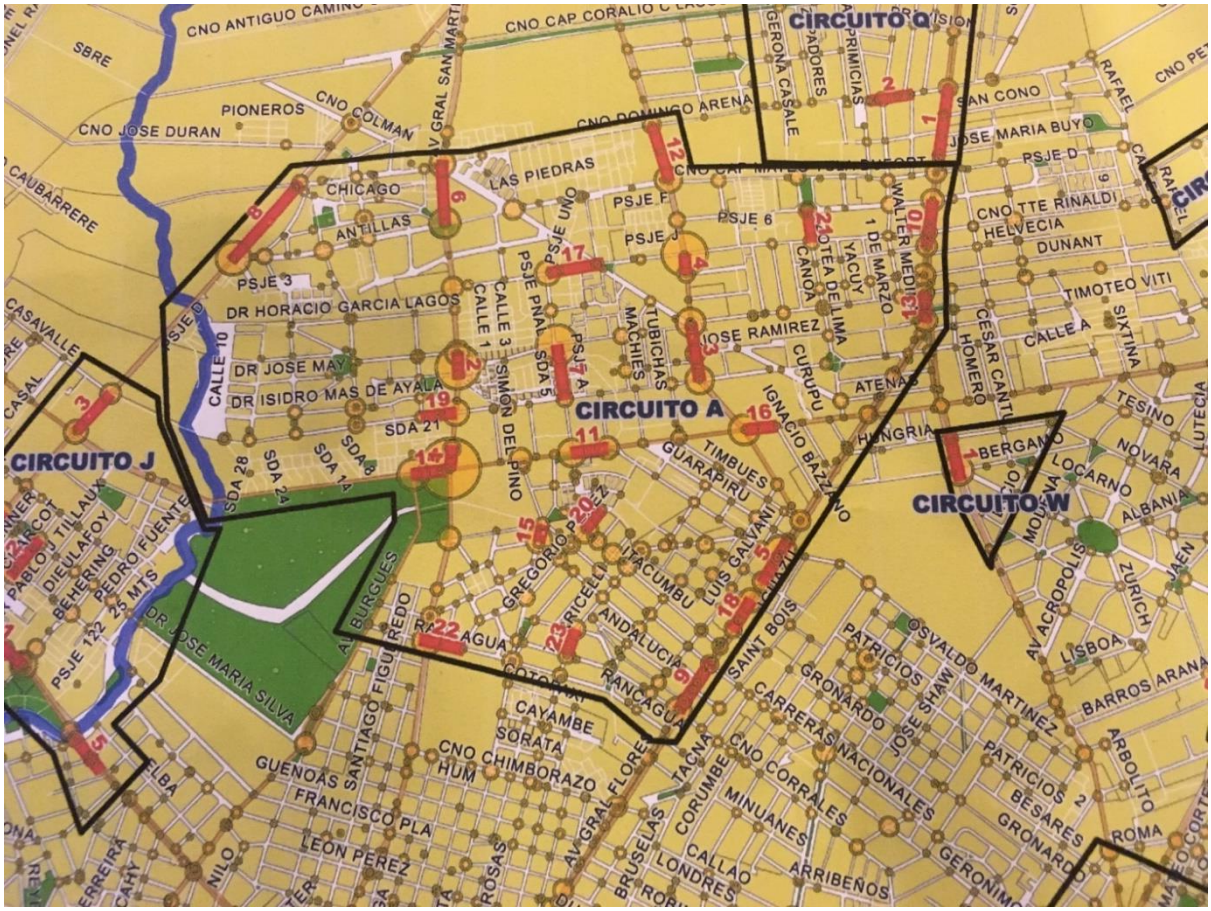

Figure 1. Street segments (highlighted as the thickened lines) and circuits ('circuitos' in Spanish) to where PADO was deployed. The circular symbols are indicative of the number of robberies that previously occurred on each street segment.

When present in the location where foot patrol officers were assigned, the primary purpose of the police patrols was to act as a visible deterrence to offending behaviour. Their purpose was not necessarily to be more active in making arrests and performing stops and searches, but instead make would-be offenders perceive it was now riskier for them to commit robberies in the locations where the foot patrols had been deployed. In essence, the hot spot police patrols were attempting to restrict opportunities for would be offenders to commit robberies in the areas where robberies had previously concentrated. The police officers on foot patrol were often rotated around segments from shift to shift. In total, 525 police officers

were dedicated to PADO daily when the program was implemented on the 11 April 2016. Many of the officers selected or who took the option to be assigned to PADO were young officers recently appointed following their training from the police academy. As an incentive to join PADO, PADO officers received a US$200 per month bonus to their US$700 per month salary. PADO was a program that was designed to take advantage of the existing police resource that was available, and to use this resource in a more dedicated, targeted and well-coordinated manner.

At the time when street segments were selected for the PADO hot spot police foot patrols, little consideration was given to how the program could be evaluated. As the hot spot policing program progressed, more attention was then placed on measuring the impact of the program. However, because control areas had not been established from the outset, nor had the program been implemented as a randomised controlled trial (e.g., where 60 of the 120 locations were randomly selected as treatment areas and the other 60 were selected as control areas), there were challenges in robustly evaluating the impact of the program. After a review of evaluation techniques, a difference-in-difference evaluation approach was chosen as the technique to measure the impact of the program. A difference-in-difference approach involves examining the change in outcome (e.g., the change in robberies) in a group of non-participants (e.g., control areas where PADO was not deployed) to estimate what would have been the change in outcome if the program did not exist. The approach then compares the differential effect between areas where PADO was deployed and the control areas. A difference-in-difference approach has been used in a number of other evaluations of hot spot policing (e.g., Braga et al., 2012; MacDonald et al, 2016), therefore helping the authors to replicate the approach of previous studies and to generate results for Montevideo that could

be compared to the results of hot spot policing programs from cities in North America, Europe and Australasia. Other techniques were considered, including bivariate analysis, but due to limitations associated with the data available to measure the impact of PADO and the value of replicating an approach used in other evaluations of hot spot policing, the difference-in-difference approach was chosen as the method to use. At the time, it was also considered beyond the scope and objectives of the evaluation of PADO[6] to examine the impact of the intervention against demographic, land use and other factors such as the urban morphology of the areas where PADO was and was not deployed. This was mainly due to the study's focus to replicate other studies on hot spot policing, but in a Latin American urban context, and the limited availability of data for examining these other factors. We discuss these points further in a later section of this paper.

The current research provides an examination of the impact of the PADO hot spot policing program in Montevideo. We hypothesize that statistically significant reductions in robbery have been experienced in the areas where PADO hot spot police patrols were deployed. The research also examines if there has been evidence of geographic displacement. We hypothesize that, similar to experiences in North America, Europe and Australasia, the reductions in robbery were not wholly offset by displacement to neighboring areas, or other areas of the city during the study period has not occurred.

3. Data and methods

[6] This current study evaluates the impact of PADO from the point of intervention to the end of December 2016. PADO is still implemented in Montevideo (at the time of publication), and future evaluations using more sophisticated methods are in progress.

Police recorded crime data on robbery for the period January 2013 to December 2016 were used to examine the impact of the PADO hot spot policing program. These data were geographically referenced to street segments and street junctions. The geocoding hit rate[7] for the robbery records was 94 percent, above the 85 percent minimum threshold for reliability suggested by Ratcliffe (2004).

Prior to the start of the program, Montevideo had experienced consecutive annual increases in robberies for over a decade. These increases were not due to any specific changes in recording practice but were due to genuine increases in crime[8]. These increases are illustrated in Table 1 showing that, in 2014 and 2015, the increase in robberies was over 10 percent the level of the previous year.

Table 1. Robberies in Montevideo from 2013-2015

	2013	2014	2015
Robberies in Montevideo	13577 (-)	15502	17135
(*n* and change on previous year)		(14.2 %)	(10.5 %)

The robbery data were assigned to one of three groups: a group representing the treatment areas (street segments and street junctions covered by the PADO hot spot policing foot patrols); and two control groups – control group 1 (street segments and street junctions from

[7] The percentage of crimes that were accurately geographically referenced (see Chainey and Ratcliffe, 2005 for details on the method to measure geocoding hit rate)

[8] Data used in the research underwent significant review and checking to ensure these data were sufficiently suitable in their accuracy, precision and content for the analysis that was conducted. This included reviewing if any changes in recording practice by the Uruguay Police had taken place over the previous decade. The most recent changes to crime recording practices were in 2005.

1 metre to within 300 metres of a treatment area, covering those areas immediately surrounding PADO areas), and control group 2 (street segments and street junctions more than 300 metres from a treatment area). These control areas were selected to examine if the intervention resulted in causing geographic displacement to surrounding areas and other areas, a major concern voiced by many Latin American police officers. Each crime record was then aggregated into monthly crime counts for the forty-eight one month periods between January 2013 to December 2016 for each street segment or street junction and were used as the input data for the evaluation models. This meant that each street segment or junction was coded with data representing the number of robberies that took place at each segment or junction for each month across the four-year time period. Several descriptive statistics were calculated from these data (such as the average number of robberies in treatment and control areas for each year). This data assignment process resulted in 1,385 street segments and street junctions being assigned to the treatment group, 9,476 street segments and street junctions being assigned to control group 1, and 37,915 street segments and street junctions being assigned to control group 2 (see Table 2). In total, 48,776 units of analysis were used in the current study, with robbery data assigned to each unit from the forty-eight months of data (i.e., 48,776 * 48). Most previous studies of hot spot policing have used less than one hundred treatment areas and control areas, and only three months of data before and after the intervention (Braga et al., 2014). The current study of PADO in Montevideo is the largest known sample of data used in an evaluation of a hot spot policing program.

Table 2. Units of analysis - PADO treatment street segments and junctions, and control areas

	PADO areas (treatment)	Control areas 1	Control areas 2	Total
Distance (meters)	0	1-300	> 300	
Street segments	736	5561	22550	28847
(% of all segments)	(2.5 %)	(19.3 %)	(78.2 %)	(100 %)
Street junctions	649	3915	15365	19929
(% of all junctions)	(3.3 %)	(19.6 %)	(77.1 %)	(100 %)

A difference-in-difference method was used to measure the impact of the PADO hot spot policing program. The difference-in-difference method can be used in circumstances for robustly measuring the impact of an intervention when control areas are not determined at the outset of the intervention (Braga et al., 2012). This method was used to compare the average change over time of the number of crimes in the treated areas to the changes in crime in the control areas. In following a difference-in-difference method, we estimated the impact of the hot spot policing program using a negative binomial panel data approach, using Equation (1).

$$Y_{it} = \alpha + \beta_1 D_{PADO} + \beta_2 T_{Period} + \beta_3 (T_{Period} * D_{PADO}) + \gamma_{year} X_{year} + \sum_{month=2}^{12} \theta_{months} D_{month} \quad (1)$$

A dummy variable was created to indicate whether the unit (a street segment or street junction) was treated ($D_{PADO} = 1$) or not ($D_{PADO} = 0$). The variable T_{Period} identified if the observation was from a pre-intervention period ($T_{Period} = 0$) or after the intervention had begun ($T_{Period} = 1$). The difference-in-difference estimate is given by β_3, the coefficient

associated with the interaction of D_{PADO} and T_{Period}. Yearly trend (γ_{year}) and seasonal trend (θ_{month}) variables were included as controls. Three versions of this model were run. The first compared PADO treatment areas to units in control area 1, the second compared PADO treatment areas to units in control area 2, and the third model compared PADO treatment areas to all control units. Estimates from this model are reported as Incidence Rate Ratios (IRR) and can be interpreted as the rate at which the dependant variable occurs whilst controlling for other factors. In our case, a 0.9 coefficient for β_3 would suggest that the treatment (the PADO hot spot police patrols) was associated with a 10 percent decrease in the rate at which crime occurs. The model was run a fourth time to compare differences between units in control area 1 and units in control area 2 (by adjusting the input to the dummy variable to compare Control 1 to Control 2) to further examine any evidence of displacement effects.

In order to additionally examine the geographic displacement of robberies between treatment and control areas, a second model was developed (using Equation 2). In Equation 2, the dummy variable D_{disp} was used to indicate if the units belonged to control area 1 ($D_{disp} = 1$) or not ($D_{disp} = 0$). If the β_5 result produced a negative coefficient this would indicate that displacement had occurred to the areas immediately surrounding the areas where PADO was deployed. If the β_5 result produced a positive coefficient it would indicate a diffusion of benefit effect to these surrounding areas. Calculating β_5 includes a test to determine if the coefficient (negative or positive) is significant i.e., determining if the displacement or diffusion of benefit effects to the areas surrounding the PADO areas were significant.

$$Y_{it} = \alpha + \beta_1 D_{PADO} + \beta_2 T_{Period} + \beta_3 (T_{Period} * D_{PADO}) + \beta_4 D_{disp} + \beta_5 (T_{Period} * D_{disp}) + \gamma_{year} X_{year} + \sum_{month=2}^{12} \theta_{month} D_{month} \quad (2)$$

To ensure that the parallel trend assumption was valid, placebo tests were performed. The placebo tests considered the PADO intervention began in the same month in previous years. The equation for the placebo test is shown in Equation 3, which includes a *time stamp* variable $T_{placebo}$, that refers to a specific point in time. The model was first run by setting the time stamp variable to April 2015, and using data from April 2015 to December 2015. The model was then repeated by setting the time stamp variable ($T_{placebo}$) to April 2014, and using data from April 2014 to December 2014. Using Equation 3 meant we could determine if a meaningful change in crime had occurred prior to the introduction of the actual intervention in April 2016. If the coefficient β_3 was negative this would indicate there had been a decrease in the rate at which the robberies had occurred in the treatment areas prior to the introduction of PADO. A positive β_3 coefficient would indicate that the treatment areas experienced an increase in the crime rate before the intervention.

$$Y_{it} = \alpha + \beta_1 D_{PADO} + \beta_2 T_{placebo} + \beta_3 (T_{placebo} * D_{PADO}) + \gamma_{year} X_{añoyear} + \sum_{month=2}^{12} \theta_{month} D_{month} \quad (3)$$

Finally, monthly crime counts for each unit were aggregated to counts for the periods of April to December for each year to run reduced models as robustness checks using a binomial and a linear model[9].

[9] The results from these reduced models produced the same results to the full models. The results are available upon request from the authors.

4. Results

In 2015, the year prior to the implementation of PADO, each PADO treatment unit experienced an average of 2.46 robberies (see Table 3). This compared to an average of 0.34 robberies in Control 1 areas in 2015 (i.e., those areas within 300 metres of a PADO treatment area) and an average of 0.28 robberies in Control 2 areas (those areas that were more than 300 metres from a PADO treatment area). These results provide a preliminary indication of the differences in robbery levels between the areas where the PADO patrols were to be deployed and all other areas, with the proposed PADO treatment areas experiencing robbery levels that were on average at least seven times greater than other street segments and street junctions in Montevideo.

Between 2013 and 2015 (i.e., prior to the implementation of PADO) the average levels of robbery increased by a small amount in the non-PADO areas (from 0.26 to 0.34 robberies in Control 1 areas and from 0.24 to 0.28 robberies in Control 2 areas). This compared to a robbery increase of 74 percent between 2013 and 2015 in the PADO areas (increasing from an average of 1.41 robberies in all PADO areas in 2013 to an average of 2.46 robberies in 2015). This increase in robberies in the period before the implementation of PADO is also observed in Table 4. Table 4 shows the results of the placebo tests (following Equation 3) that considered the intervention began in April 2014 or April 2015 (rather than April 2016). These results show that prior to the implementation of PADO a significant positive trend was present (i.e., robberies were increasing) in the areas where PADO was deployed in April 2016, with a differential risk ratio of 9.4 percent ($p < 0.05$) when comparing 2014 to 2013 and a differential risk ratio of 27.8 percent ($p < 0.01$) when comparing 2015 to 2014. Thus, the parallel trend hypothesis was rejected, the implications of which are discussed in the next

section. In 2015, there were 17,135 recorded robberies in Montevideo, an increase of 10.5 percent on the previous year (recall from Table 1).

Table 3. Robbery in PADO and non-PADO areas in Montevideo (2013-2016)

	Robbery	2013	2014	2015	2016
PADO areas (treatment)	*n*	1958	2486	3403	2338
	Per cent change	-	27.0%	36.9%	-31.3%
	Average per month (per unit of analysis)	1.41	1.79	2.46	1.69
Non-PADO Control 1 (1 - 300 meters)	*n*	2501	2971	3215	3147
	Per cent change	-	18.8%	8.2%	-2.1%
	Average per month (per unit of analysis)	0.26	0.31	0.34	0.33
Non-PADO Control 2 (> 300 meters)	*n*	9118	10045	10517	10676
	Per cent change	-	10.2%	4.7%	1.5%
	Average per month (per unit of analysis)	0.24	0.27	0.28	0.28
Non-PADO areas (control areas 1 and 2)	*n*	11619	13016	13732	13823
	Per cent change	-	12.0 %	5.5 %	0.7 %
	Average per month (per unit of analysis)	0.25	0.27	0.29	0.29
Total	*n*	13577	15502	17135	16161
	Per cent change	-	14.2%	10.5%	-5.7%

Average per month (per unit of analysis)	0.28	0.32	0.35	0.33

Table 4. Placebo tests (following Equation 3) that considered the intervention had begun in April 2014 or April 2015 (rather than April 2016)

	Placebo 2014	Placebo 2015
PADO placebo impact (β_3)	1.094**	1.278***
($T_{placebo} = 1$ & $D_{PADO} = 1$)	(0.0397)	(0.0380)
Placebo period	0.867***	0.913***
($T_{placebo} = 1$)	(0.0249)	(0.0167)
PADO unit	1.068	1.002
($D_{PADO} = 1$)	(0.1460)	(0.0985)
Observations (number of units times 48 months)	232,728	431,316
Units[10]	9,697	11,981

Standard errors are shown in brackets. Coefficients are expressed as incident rate ratios (IRR).

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

In 2016, there were 16,161 recorded robberies in Montevideo, a reduction of 5.7 percent on the previous year, and the first year in over a decade when robberies had reduced in the city. In PADO areas, the number of robberies reduced by 31.3 percent in comparison to the

[10] Units in which no robbery occurred during the entire study period were not used for this estimate

previous year, reduced by 2.1 percent in Control 1 areas and increased by 1.5 percent in Control 2 areas (see Table 3). When comparing PADO areas to the Control 1 areas using the model represented in Equation 1, there was a statistically significant IRR of 0.789 ($p < 0.01$), equivalent to a 21.1 percent reduction in the rate at which robberies occurred in the treatment areas compared to neighbouring areas (shown in Table 5 as β_3 and indicated by an IRR of 0.789). Similarly, when comparing PADO areas to Control 2 areas, there was a statistically significant IRR of 0.769 ($p < 0.01$), equivalent to a 23.1 percent reduction in robbery in PADO areas compared to the rest of Montevideo. When comparing PADO areas to all non-PADO areas of Montevideo, there was a statistically significant IRR of 0.774 ($p < 0.01$), equivalent to a 22.6 percent reduction in the rate at which robberies occurred.

Table 5 also shows that the IRR of 0.974 between control area 1 and control area 2 (using Equation 1 to model for a displacement effect) was not significant, indicating there was no evidence of geographic displacement from PADO treatment areas to non-PADO areas (i.e., the IRR was less than 1). Table 5 also shows the results from applying Equation 2 that incorporated a term that additionally considered displacement to the areas immediately surrounding the PADO areas. These results also show the absence of any significant displacement effects and, if anything at all, areas immediately surrounding PADO areas marginally benefited from the intervention (although not significant, the IRR of 0.974 indicated a reduction of 2.6 percent in the rate at which robberies occurred). Under this model (represented by Equation 2), the reduction in the rate at which robberies occurred in PADO areas remained statistically significant and was equivalent to a 23.1 percent reduction (IRR of 0.769, $p < 0.01$).

Table 5. A comparison of changes in PADO treatment areas to control areas in Montevideo following Equations 1 and 2

	PADO vs Control 1	PADO vs Control 2	PADO vs all controls	Control 1 vs Control 2	Additional displacement model (equation 2)
PADO impact (β_3)	0.789***	0.769***	0.774***		0.769***
($T_{Period} = 1$ & $D_{PADO} = 1$)	(0.0311)	(0.0258)	(0.0255)		(0.0258)
PADO unit	1.311***	1.111	1.160*		0.878***
($D_{PADO} = 1$)	(0.132)	(0.0910)	(0.0879)		(0.0145)
Treatment period	0.780***	0.879***	0.873***	0.909***	0.878***
($T_{Period} = 1$)	(0.0235)	(0.0152)	(0.0134)	(0.0155)	(0.0145)
Displacement effect				0.974	0.974
($T_{Period} = 1$ & $D_{disp} = 1$)				(0.0269)	(0.0269)
Control 1 unit				0.866	0.868
($D_{disp} = 1$)				(0.0843)	(0.0844)
Observations (number of units times 48 months)	150,192	544,944	667,104	639,072	667,104
Units[11]	3,129	11,353	13,898	13,314	13,898

Standard errors are shown in brackets. Coefficients are expressed as incident rate ratios (IRR).

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

[11] Units in which no robbery occurred during the entire study period were not used for this estimate

5. Discussion

PADO is the first large-scale hot spot policing program involving the dedicated deployment of police patrols that has been implemented in Latin America. Similar to how many other police interventions are implemented in Latin America, PADO was devised with little initial attention to its evaluation, which in turn created challenges when determining suitable techniques for examining the impact of a program of this type. The analysis technique used in the current research study was a difference-in-difference quasi-experimental approach, an approach used in several other studies that have evaluated the impact of hot spot policing programs. By using this approach, the results from the current study show that, in the PADO treatment areas, the rate at which robberies occurred was reduced by 23 percent, no significant displacement to neighbouring areas was evident, whilst robbery levels remained unchanged in all other areas of Montevideo.

To date, the few hot spot policing programs that have been implemented in Latin America have often not been sufficiently precise in the areas to which patrol officers have been deployed, have often used vehicle patrol rather than foot patrols, have been weak in their dosage, and have been poorly sustained. There is also a general pessimism within police agencies in Latin America about using analysis to inform resource allocation. This pessimism is alongside the general impression that crime patterns in Latin American cities are different than elsewhere and that any targeting of police resources to reduce crime will only displace crime to neighboring areas. The evidence from the current study has illustrated the value in using analysis for determining where police interventions can be targeted, that crime concentration patterns in Latin America most likely mirror those observed in many other cities across the world (where other studies of crime concentration have been conducted), and that

geographical displacement as a result of an area-targeted intervention is far from inevitable. Within Latin America, Montevideo is, however, considered more socio-economically developed than other cities in the region. Whilst recognising that differences do exist between cities in the Latin American region, the current study provides a valuable example that is more generalizable to the urban context of Latin American cities than previous studies on the impact of hot spot policing that have mainly been confined to cities from the United States, the United Kingdom, and Australasia. Studies on the impact of hot spot policing programs in other Latin American settings would, however, be of great value to add to the initial evidence base that the current study provides.

PADO has involved the allocation of a large number of police officers, dedicated to the task of hot spot policing, being deployed to specific areas where robberies have previously highly concentrated in Montevideo. Prior to the implementation of PADO, robbery levels had been increasing for many years. Due to the quasi-experimental approach that was used to evaluate the impact of PADO, and whilst there are limitations relating to the difference-in-difference technique used (discussed further below), it is likely that the reductions observed in the areas where PADO patrols were deployed was due to the targeted police presence in these areas, rather than other explanations. During the study period there was no change in government or significant change in the economy. Even if there had been changes in political, criminal justice, social development or economic circmumstances that could have had an influence in reducing the number of robberies, these factors would have also most likely been experienced in many other areas where PADO was not deployed. The significant reductions in robbery were in the areas where PADO was deployed. The results also show there was no displacement of robbery offending to other areas. Displacement can, though, come in many

forms (such as displacement to the commission of other crime types), however, another study that examined the preliminary impact of PADO in Montevideo showed little evidence for this and instead a reduction in other types of theft offences (Chainey, 2016). Future evaluations of PADO plan to examine in greater detail the displacement and diffusion of benefit effects for other crime types, and to examine for evidence of temporal displacement in PADO treatment areas (i.e., when PADO patrols are not active in these areas) in comparison to control areas.

In the absence of the Uruguay Police determining control areas from the outset of PADO, the current study created two sets of control areas and employed a quasi-experimental difference-in-difference approach to evaluate the impact of the hot spot policing program in Montevideo. In large part, the choice of this approach was informed by previous studies that had experienced similar hot spot policing evaluation dilemmas. Whilst the difference-in-difference approach provides a robust means for determining if treatment areas have experienced differences in crime trends in comparison to control areas, the rejection of the parallel trend hypothesis from Equation 3 could mean that the true effect of the program could have been underemphasized. The results from Equation 3 showed that robberies had been significantly increasing in the areas where PADO was to be deployed prior to its implementation, and that the trend was likely to continue if no action was taken. The implementation of PADO not only resulted in halting this significant increase in the areas where PADO was deployed, but also led to a significant reduction in robberies in these areas. In non-PADO areas, robbery levels remained very much the same over the duration of the study period, albeit reducing slightly in 2016. For an evaluation to be fully robust, the trends in crime in the areas to be treated and the trends in crime in the areas that form controls

should be of the same direction and magnitude prior to the implementation of the intervention. In practice, this can be difficult to do in studies of crime due to the nature of crime to cluster and the tendency for increases and decreases in crime to be most apparent in areas where crime highly concentrates (Braga et al., 2010; Braga et al., 2011; Chainey and Monteiro, 2019; Curman et al., 2015). These limitations can be addressed if plans are made at the outset of area-targeted police interventions on how the intervention will be evaluated, and by using randomized experimental approaches to minimize this technique weakness.

The areas that were used as control areas for the current study were primarily selected in order to examine if geographic displacement had occurred from the targeted areas. Whilst these control areas were not perfect in that they did not exactly match with the crime levels experienced in the treatment areas prior to the implementation of PADO, they were important areas to use in this current study in order to answer the specific concerns of displacement that are voiced by many Latin American police officers. Whilst the study showed that no displacement had occurred, future evaluations of PADO aim to use statistical methods that avoid an unbiased counterfactual expectation. These methods for testing for the selection of control areas include propensity score matching and the use of a weighted jackknife resampling approach to simulate control groups drawn from the entire universe of units. In addition, future studies that examine the impact of PADO over longer periods (and any other evaluations of hot spot policing programs that operate for over a year) should control for variables such as socio-economic development measures and changes in land use in order to test the validity of competing hypotheses for the reduction of crime.

Another limitation of the current study was its focus to all robberies, rather than specific types of robbery. Robbery against pedestrians represents over a half of all robberies in Montevideo, with this type of robbery being the crime that PADO mainly focuses on attempting to reduce. This is due to the predominance of foot patrol as the main operational deployment tactic of PADO. Foot patrols are less likely to have an impact on a motorcyclist being robbed by another motorcyclist, or robbery from a store inside a shopping mall when the foot patrols are focused to urban street settings. It would be beneficial for future studies to examine more specifically the impact of hot spot policing on types of robbery, and in turn inform the nature of the targeted patrol. For example, if robberies from motorcyclists, robberies from car drivers and robberies from delivery drivers persist after the implementation of a hot spot policing program that mainly consists of foot patrols, the hot spot policing program could be adapted (and subsequently evaluated) by deploying mainly motorbike police patrols (rather than foot patrols) to these particular hot spots.

As result of the evaluation and the reduction in robberies in Montevideo, PADO has been strengthened by making changes to street segments where PADO foot patrols are deployed. This has included identifying PADO areas that have not experienced significant reductions in robbery (and determining how the patrols in these areas can be improved), and directing patrols to other (new) street segments where PADO should be deployed. This strengthening process has involved investing in training programs so that analysts based in the Uruguay Police's crime analysis unit can apply more advanced spatial analysis techniques than were originally used to help design PADO. In turn, the new skills the analysts have developed has helped them to provide better recommendations on where changes should be made to where PADO patrols are deployed, and generate more timely performance monitoring reports on

the impact of PADO. The results from the current study have also highlighted to the Uruguay Police the value in using control groups when wanting to measure the impact of their interventions, and in turn have begun to encourage the police to adopt more evidence-based policing principles. This includes being more experimental in the interventions that are adopted, such as experimenting with the dosage levels of hot spot policing patrols (e.g., rotating patrols between three PADO areas rather than having a patrol assigned to each PADO area) to help determine the optimum levels of police patrol resource that are required for achieving the largest impact. Additionally, the selection of certain PADO areas may in the future be more flexible, chosen on a weekly or daily basis based on examining near repeat victimization patterns and using these patterns to help predict high robbery risk areas. In 2016, the Uruguay Police also started a skills development programme in problem oriented policing (POP) for neighborhood police officers. POP is an approach that employs a problem solving method for helping to reduce the causes of crime (Goldstein, 1990). One of the objectives in developing POP skills was to complement PADO by helping to address the underlying reasons why crime concentrates in certain parts of Montevideo. This has begun to include analysis of the demographic, socio-economic, landscape (e.g., street lighting) and land use characteristics of areas and their relationship with the distribution of crime so that neighborhood police officers can engage in local problem solving projects that address the factors that contribute to crime in high crime areas.

Whilst the PADO hot spot policing program has had a significant impact in reducing robberies, what is not known is the specific mechanism through which these reductions have been achieved. In theory, hot spot police patrols can deter would be offenders through the presence of police officers in the areas where crime has previously concentrated. The

activities these police officers perform in the hot spots where they are deployed could also have a disruptive effect on offending behavior (e.g., through the use of stops and searches), or remove offenders (through the activity of arrests) from the areas where crime levels were previously high. Furthermore, the engagement between police officers and members of the public may help raise the public's consciousness of the issues of robbery in the area, resulting in these people taking extra precautions to minimize their risk of victimization. To date, PADO has primarily operated in a deterrence capacity, through the visible presence of police foot patrols in the areas where robberies previously highly concentrated. This suggests the results from the current study are likely to be more related to the deterrence mechanism rather than anything else; however, more research is required to determine more accurately the differences in the crime reduction effect of the specific mechanisms through which hot stop policing works.

6. Conclusions

Hot spot policing is an operational police resource targeting strategy that has been effective in reducing crime in a number of North American, European and Australasian settings. Whilst hot spot policing approaches have begun to receive more attention amongst police agencies in Latin America, to date many of these programs have not been sufficiently precise in targeting where police patrol officers are deployed and have been limited in their evaluation robustness.

PADO is a large scale hot spot policing programme in Montevideo that was introduced by the Uruguay Police in April 2016 to reduce robberies. Prior to the implementation of PADO, robbery had increased year on year by approximately 10 percent. In 2016, the number of

robberies reduced for the first time in over a decade. Using a quasi-experimental evaluation approach, it was found that PADO likely contributed to a 23 percent reduction in the rate at which robberies occurred in the areas where the police patrols were deployed. Furthermore, there was no evidence of any nearby or wider geographic displacement of robberies in Montevideo. The results offer promise that hot spot policing programs can be effective in reducing crime in the challenging environments of Latin American cities and how the application of robust statistical evaluation methods can produce findings that importantly contribute to the evidence-base on what works in reducing crime in the Latin America region. Additionally, the findings contribute to the global evidence-base on hot spot policing, and in particular do so by using the largest known sample of data used in an evaluation of a hot spot policing program.

PADO continues to operate in Montevideo, with results from the current study helping to strengthen the program by identifying areas where additional reductions in robbery could be achieved. Future research includes further evaluations on the program's impact, and surveys capturing the opinions and experiences in doing hot spot policing of the police officers who perform the PADO patrols. PADO has also inspired the implementation of new hot spot policing programs in other parts of Latin America, in particular in Argentina, Mexico, and Brazil, with lessons learned from these programs expected to contribute further to the evidence-base on hot spot policing.

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