A Multi-jurisdictional Test of Risk Terrain Modeling and a Place-based Evaluation of Environmental Risk-Based Patrol Deployment Strategies

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Study Overview: A place-based method of evaluation and spatial units of analysis were used to measure the extent to which allocating police resources to high-risk areas, derived from risk terrain modeling (RTM), affects the frequency and spatial distribution of new crime events. This quasi-experimental project had two primary goals: 1) to replicate and validate RTM in multiple jurisdictions and across many different crime types; and, 2) to evaluate intervention strategies targeted at high-risk micro-level environments across 5 cities[1]. This executive summary presents results on the latter goal. The 5 participating cities are: Chicago, IL; Colorado Springs, CO; Glendale, AZ; Kansas City, MO; and Newark, NJ.

In completing the risk terrain models, we used the RTMDx Utility, developed by the Rutgers Center on Public Security. The Utility applies a precise set of statistical tests (see Caplan et al. 2013) in evaluating the relative importance of spatial factors in influencing crime outcomes. The Utility begins by building an elastic net penalized regression model assuming a Poisson distribution of events. It does this using cross-validation. The Utility then further simplifies the model in subsequent steps via a bidirectional stepwise regression process (Poisson and negative binomial) and measures the Bayesian Information Criteria (BIC) score. The best model with the lowest BIC score between Poisson and negative binomial distributions is selected.

RTMDx outputs are tabular and cartographic; for each significant risk factor, tabular outputs include a relative risk value (RRV), which is the exponentiated factor coefficient (i.e., relative weight), and the optimal operationalization and distal extent of spatial influence. A risk terrain map is also produced to show highest risk places throughout the study area.

Following the RTM analysis in each city, each Police Department developed an intervention strategy that targeted the spatial influences of select significant risk factors. The Police Department also worked with the research team in the selection of target areas for the intervention. In evaluating the intervention, statistical comparisons were made to equivalent control areas locally within each city. Control areas were matched to treatment areas through Propensity Score Matching (PSM). PSM helps to approximate the conditions of a randomized controlled trial by ensuring statistical equivalency of treatment and control groups. In each evaluation, units of analysis were street segments and street intersections, which we refer to as "street units" throughout the report. For each city, the PSM technique balanced treatment and control units on the following variables:

whether the street unit *intersected a high-risk cell* as identified by the RTM analysis, whether the street unit *intersected a high-risk street unit* for the purpose of identifying risk clusters*,* the *concentrated social disadvantage* of the surrounding 2010 U.S. Census block group, the *racial heterogeneity* of the surrounding 2010 U.S. Census block group*,* the *pre-intervention period crime count*, the *pre-intervention period count of proactive police actions*, and whether the street unit *was a street segment or street intersection.*

Covariate balance was assessed through independent samples t-tests (Dehejia and Wahba, 1999) and estimation of the standardized bias (Rosenbaum and Rubin, 1985). As a rule of thumb, when the t-test p>0.05 and % bias<20.0 statistical equivalency is achieved (Austin et al., 2007), which we observed for each city. We tested both "counts" and "crime change scores" as the dependent variables, with both models showing similar results. Here, we present crime change scores because they are more meaningful for our operational definition of "effect" on crime. Two separate analyses were executed for each city: (1) A target-area wide analysis tested the aggregate intervention effect and (2) a micro-level analysis tested the effect of the intervention and disaggregated intervention activities at the street unit level.

The target-area wide effect was reported as a Relative Effect Size (RES) calculated via the formula:

$$RES=(a*d) / (b*c)$$

where a is the number of pre-intervention crimes in the target area, b is the number of during-intervention crimes in the target area, c is the number of pre-intervention crimes in the control area, and d is the number of during-intervention crimes in the control area. A RES > 1 indicates a desirable effect on crime in the target area relative to the control while a RES < 1 indicates an undesirable effect. The inverse of the RES displays the crime difference within the target area. For example, an RES of 1.42 implies that target area crime reduced 30% relative to the control since the inverted value of the RES (1/1.42) is 0.70 (Welsh & Farrington, 2009a: 727).

Variance of the RES is calculated from the variance of the natural logarithm of RES via the below formula (Welsh and Farrington, 2009b: 135):

$$VAR(LRES)=1/a+1/b+1/c+1/d.$$

This estimation of variance is based on the assumption that the crime total follows a Poisson distribution. However, much research suggests that crime data are more accurately modeled according to a negative binomial distribution, which accounts for overdispersion (Higginson and Mazerolle, 2014). Using the prior formula would underestimate the true variance of the data (Higginson and Mazerolle, 2014: 438). Therefore, variance was calculated through an adapted formula that adds a parameter to control for overdispersion (Farrington et al., 2007; Higginson and Mazerolle, 2014; Welsh and Farrington, 2009b):

$$VAR(RES)=[[(.008*a)+1.2]*a]/a^2+[[(.0008*b)+1.2]*b]/b^2+[[(.0008*c)+1.2]*c]/c^2+[[(.0008*d)+1.2]*d]/d^2$$

Standard errors of VAR(RES) were used to calculate confidence intervals for the observed RES (Lipsey and Wilson, 2001).

For each statistically significant RES suggestive of a crime reduction, we calculated a Weighted Displacement Quotient to test for spatial displacement via the following formula:

$$WDQ=([Da/Ca]-[Db/Cb])/([Ra/Ca]-[Rb/Cb])$$

where D, R, and C represent the displacement, response, and control areas, respectively, and b and a indicate the period before and after the intervention, respectively (Bowers and Johnson, 2003). A negative value suggests displacement while a positive value suggests a diffusion of crime-control benefits. The WDQ and associated Phi coefficient (used to determine the applicability of the WDQ) were calculated in Ratcliffe and Breen's (2008) Spatial Evaluation of Police Tactics in Context (SEPTIC) tool.

The micro-level analysis measured intervention effect on the street-unit level, as opposed to the entire target area. First, we measured the Average Treatment effect on the Treated (ATT), which is defined as “the expected effect of treatment for those individuals actually assigned to the treatment group, or the ‘gain’ from treatment among those in the treated group” (Apel & Sweeten, 2010: 545). While crime level changes across the entire target area reflect the cumulative effect of the intervention, the ATT measures whether intervention effect was experienced across all of the micro-places (e.g. street units) that comprise the target area. Following the ATT analysis, a regression analysis further tested the influence of the intervention actions on crime level changes at street units. In each model, crime count change from pre to during/post intervention period was the dependent variable with each disaggregate intervention action as independent variables. Control variables included a dichotomous variable denoting whether each observation was in the treatment group (1) or control group (0), the pre-period crime count, a dichotomous variable denoting whether each observation was a street segment (1) or street intersection (0), and the observation’s propensity score. When the dependent variable was normally distributed, Ordinary Least Square regression models were used. For skewed distributions, Ordinal Logistic Regression models were used with the dependent variable treated as an ordinal measure rather than continuous.

General Findings:

Q: Do RTM outputs inform crime intervention planning and policing activities in ways that result in significant crime reductions in targeted areas?

A: Yes. Results across all study settings allow for a general conclusion that certain actions performed by police and intended to mitigate the spatial influence of risky features at high-risk places results in both short- and long-term crime reductions. RTM enabled police to make informed decisions and develop strategies about where to allocate resources and what to do when they got there. Spatial information produced through RTM to select target areas, develop place-based risk reduction strategies, and deploy resources was applied to a variety of crime types and customized for different settings in measured, transparent and sustainable ways. Crime reductions were best achieved by police with a concerted and consistent application of intervention activities geared toward mitigating the spatial influence of crime attractors at the high-risk places within a jurisdiction.

Specific Findings:

Colorado Springs

Risk Terrain Modeling Analysis:

The Colorado Springs Police Department (CSPD) identified Motor Vehicle Theft as their priority crime. The analysis began with a RTM of Motor Vehicle Theft in the year 2012. The RTMDx Utility tested the spatial influences of 19 risk factors: Malls, Parking Stations & Garages, Retail Shops, Bowling Centers, Convenience Stores, Foreclosures, Gas Stations with Convenience Stores, Hotels & Motels, Liquor Stores, Night Clubs, Sit-down Restaurants, Takeout Restaurants, Variety Stores, Bars, Disorder Calls for Service (Citizen Initiated), Multifamily Housing Units, Parks, Schools and Commercial zoning. All geographic calculations were conducted using raster cells (i.e. units of analysis) of 276ft and an average block length of 552ft. There were 77,873 raster cells used in the analysis of which 1,465 cells contained events.

A significant Risk Terrain Model for Motor Vehicle Theft was found that contains 6 risk factors. The significant risk factors and their Relative Risk Values (RRV) are as follows: Disorder Calls for Service (RRV=5.61), Multifamily Housing Units (RRV=2.75), Foreclosures (RRV=2.64), Parks (RRV=1.76), Sit-down Restaurants (RRV=1.51), and Commercial Zoning (RRV=1.37).

Risk-Based Intervention:

CSPD's Risk-Based Intervention began on 5/1/14 and ended on 8/15/14. To reflect the RTM findings CSPD designed their intervention strategies to address incidents of disorder. An array of activities was performed by various CSPD units for the purpose of mitigating disorder problems in the target area. The activities included Code Enforcement property inspections, Community Service Officer Neighborhood Cleanups, Community Meetings, Proactive Police Enforcement against disorder offenses, Proactive Traffic Enforcement, and the deployment of License Plate Recognition (LPR) devices for the purpose of identifying stolen Motor Vehicles in the target area.

CSPD was able to provide incident-specific data for each intervention activity except the LPR deployment. We were told that LPR units were deployed each day of the intervention period within the Sand Creek Division, the intervention target area. However, no additional information was provided on the locations, times, or number of stolen motor vehicles detected by the LPRs. This presented a challenge for the evaluation. The deployment of LPRs increased the likelihood that stolen vehicles would be identified, and reported, within the target area. Therefore, we decided to not measure intervention effect over the "during intervention period," instead focusing on the time period immediately following the intervention. This follows the approach of prior evaluations of police interventions that may have generated more opportunities for crime to be reported by citizens and/or discovered by police (e.g. Braga et al., 1999; Weisburd & Green, 1995). For the current study, the post-intervention period of 8/16/14-11/30/14 was compared to the same time period from the previous year (8/16/13-11/30/13) in order to control for seasonality.

The analysis began with a fidelity check to ensure that intervention activities were confined to the target area. This is an important consideration since prior research has found that police officers may not adhere to target area boundaries, which could threaten the validity of empirical evaluations (Sorg et al., 2014). As displayed in Table 1, approximately 97% (836 of 864) of intervention activities occurred in the target area. The approximately 3% of activities outside of the target area occurred across 18 street units in the catchment zones. These 18 catchment zone street units were excluded from the analysis to prevent contamination of results.

Table 1: Intervention Activities. Fidelity Check

TYPE	IN TARGET AREA	NOT IN TARGET AREA	TOTAL
Code Enforcement	48	0	*48*
CSO-Clean up	370	5	*375*
Community Meetings	3	0	*3*
Proactive Enforcement	127	12	*139*
Traffic Enforcement	288	11	*299*
Total	***836***	***28***	***864***

**All actions not in target area occurred across 18 street units in the catchment zone*

Table 2 displays results of the macro-level (i.e. target area-wide) analysis. Crime counts were reported for both the treatment and control areas. Treatment units were matched with control units via a Nearest Neighbor PSM model with a caliper=0.01. The RES of 1.50 suggests a Motor Vehicle Theft reduction of 33% in the target area as compared to the control area during the 3-month post-intervention period. This observation approached statistical significance ($p<0.10$). The WDQ of 0.45 suggests a slight diffusion of benefits effect, with the reduction in the catchment zone less pronounced than the reduction in the target area. The Phi coefficient (0.06) confirms that the WDQ is an appropriate measure of spatial changes in crime patterns given the relationship between the target and catchment areas.

Table 2: Macro-Level Crime Changes. Post Intervention

GROUP	POST	PRE-POST	RES	VAR(RES)	SE	WDQ	PHI
Treatment	51	75	1.50^	0.08	0.29	0.45	0.06
Control	58	57					
Catchment	64	74					
N Treatment	*144*						
N Control	*144*						

PSM Algorithm: Nearest Neighbor, caliper=0.01

N Treatment *144*

N Control *144*

^$p<0.10$

Table 3 displays the ATT findings. On average, target-area street units experienced a crime count reduction that was greater than that experienced in the matched control unit. This reduction was statistically significant. However, a sensitivity analysis (results not shown) found that several alternate PSM algorithms produced statistically insignificant ATT results. Therefore, while the entirety of the target area experienced a statistically significant crime reduction, we cannot definitively state that the treatment effect was evenly distributed across all of the target area street units.

Table 3: Average Treatment Effect on the Treated (ATT)

CRIME	ATT	SE
Motor Vehicle Theft (Post Intervention)	-0.17*	0.10

Bootstrapped standard errors with 50 replications are provided.
*$p<0.05$

Table 4 displays the results of the micro-level analysis. The purpose of this analysis was to measure the effect of the disaggregate intervention activities on the occurrence of Motor Vehicle Theft. As per model 1, “code enforcement” was associated with reduced levels of Motor Vehicle Theft throughout the target area. This observation was statistically significant ($p<0.01$). CSO-Community Meetings were associated with slight increases in Motor Vehicle Theft, an observation that approached statistical significance ($p=0.10$). Model 2 reveals that “code enforcement” activities have an exceptionally strong and significant crime reduction benefit at high-risk places ($p<0.01$). No other intervention activities achieved or approached statistical significance in Model 2.

Table 4: Regression Models, Post Intervention Period. Dependent Variable=Crime Change Score

COVARIATE	MODEL 1: OVERALL ACTIVITIES			MODEL 2: HIGH RISK ACTIVITIES		
	Coef.	S.E.	*p*	Coef.	S.E.	*p*
Treatment	-0.05	0.07	0.50	-0.08	0.07	0.28
Code Enforcement	-0.38	0.07	0.00	-0.44	0.15	0.00
CSO-Community Meetings	0.01	0.01	0.10	0.03	0.06	0.65
Proactive Enforcement	0.03	0.05	0.53	0.18	0.12	0.14
Traffic Enforcement	-0.01	0.01	0.49	0.00	0.04	0.93
Pre-Crime Count	-1.05	0.07	0.00	-1.03	0.06	0.00
Segment	-0.12	0.16	0.48	-0.13	0.16	0.44
Pscore	0.16	0.34	0.65	0.13	0.34	0.70
Constant	0.50	0.19	0.01	0.50	0.19	0.01
r^2	0.61			0.60		

OLS Regression Model
Robust standard errors used in significance calculations.

Colorado Springs Summary: The cumulative findings suggest that CSPD's risk-based intervention effectively addressed Motor Vehicle Theft. The macro-level analysis found a statistically significant reduction ($p<0.10$) of Motor Vehicle Theft throughout the target area. This suggests that CSPD's targeting of disorder incidents was an effective crime control strategy, which concurs with recent research finding that disorder-related policing can generate significant crime reductions (Braga et al., 2015; Kondo et al., 2015). The micro-level analysis suggests that code enforcement focused at micro-level high-risk places is a particularly promising tactic.

Newark

Risk Terrain Modeling Analysis:

The Newark Police Department (NPD) identified Gun Violence as their priority crime. Gun Violence was considered as including Homicide, Aggravated Assault, and Robbery incidents in which the suspect used a firearm. The analysis began with a RTM of Gun Violence in the year 2012. The RTMDx Utility tested the spatial influences of 17 risk factors: Abandoned Properties, Bars, Liquor Stores, Narcotics Arrests, Parks, Problem Housing, Convenience Stores, Food Take Outs, Parking Garages, Restaurants, Gas Stations, Banquet Rooms, Foreclosure Real Estate, Schools, Pawn Shops, Penn Station, and Light Rail Stops. All geographic calculations were conducted using raster cells (i.e., units of analysis) of 226ft and an average block length of 452ft. There were 14,722 raster cells used in the analysis of which 1,170 cells contained events.

A significant Risk Terrain Model for Gun Violence was found that contains 11 risk factors. The significant risk factors and their Relative Risk Values (RRV) are as follows: Narcotics Arrests (RRV=3.53), Foreclosures (RRV=3.36), Restaurants (RRV=2.76), Gas Stations (RRV=2.54), Convenience Stores (RRV=2.32), Food Take Outs (RRV=2.19), Bars (RRV=2.01), Abandoned Properties (1.43), Schools (RRV=1.38), Liquor Stores (RRV=1.34), and Problem Housing (RRV=1.34).

Risk-Based Intervention:

NPD's Risk-Based Intervention began on 11/13/2013 and ended on 2/9/2014. To reflect the RTM findings of the importance of commercial establishments for Gun Violence, NPD designed their intervention strategies to generate checks and manager contacts at three business types: Restaurants, Food Take Outs, and Gas Stations. Each day during the intervention, a task force comprised of 3 officers, under the supervision of a Lieutenant, visited businesses located within the target area. The officers were in possession of a business list with manager signature fields next to each business name. Upon visiting the business, officers were required to meet with the on-duty manager and have them sign the sheet, to ensure that proper contact was established. Given the nature of the intervention, with officers personally communicating with place managers in a high-risk environment, intervention effect was measured during the time period immediately following the intervention. We felt that the frequent contact with officers afforded the place managers a new-found method to report crimes to the police. This may have threatened the validity of the during-intervention crime measures. Our use of only the post-intervention period follows prior evaluations of police interventions that may have generated more opportunities for crime to be reported by citizens and/or discovered by police (e.g. Braga et al., 1999; Weisburd & Green, 1995). For the current study, the post-intervention period of 2/10/14-5/11/14 was compared to the same time period from the previous year (2/10/13-5/11/13) in order to control for seasonality.

The analysis began with a fidelity check to ensure that intervention activities were confined to the target area. This is an important consideration since prior research has found that police officers may not adhere to target area boundaries, which could threaten the validity of empirical evaluations (Sorg et al., 2014). As displayed in Table 5, approximately 97% (542 of 560) of intervention activities occurred in the target area. The approximately 3% of activities outside of the target area occurred across 7 street units in the catchment zones and 8 street units in prospective control areas. These 15 catchment zone street units were excluded from the analysis to prevent contamination of results.

Table 5: Intervention Activities. Fidelity Check

TYPE	IN TARGET AREA	NOT IN TARGET AREA	TOTAL
QOL Summonses	1	2	3
Field Interrogations	17	3	20
Business Checks	509	4	513
Arrests	15	9	24
Total	***542***	***18***	***560***

**11 actions not in target area occurred across 8 street units in prospective control areas. 7 actions not in target area occurred across 7 street units in the catchment zone.*

Table 6 displays results of the macro-level (i.e. target area-wide) analysis. Crime counts were reported for both the treatment and control areas. Treatment units were matched with control units via a Two Nearest Neighbors PSM model with a caliper=0.01. The RES of 1.54 suggests a Gun Violence reduction of approximately 35% in the target area as compared to the control area during the 3-month post-intervention period. The reduction approached statistical significance ($p<0.10$). The WDQ of 0.27 suggests a slight diffusion of benefits effect, with the reduction in the catchment zone less pronounced than the reduction in the target area. The Phi coefficient (0.06) confirms that the WDQ is an appropriate measure of spatial changes in crime patterns given the relationship between the target and catchment areas.

Table 6: Macro-Level Crime Changes. Post Intervention

GROUP	POST	PRE-POST	RES	VAR(RES)	SE	WDQ	PHI
Treatment	42	51	1.54^	0.10	0.32	0.27	0.06
Control	57	45					
Catchment	53	47					
N Treatment	*177*						
N Control	*180*						

PSM Algorithm: 2 Nearest Neighbors, caliper=0.01

N Treatment *177*

N Control *180*

^$p<0.10$

Table 7 displays the ATT findings. On average, target-area street units experienced a crime count reduction that was greater than that experienced in the matched control unit(s). This reduction was statistically significant. However, a sensitivity analysis (results not shown) found that several alternate PSM algorithms produced statistically insignificant ATT results. Therefore, while the entirety of the target area experienced a statistically significant crime reduction, we cannot definitively state that the treatment effect was evenly distributed across all of the target area street units.

Table 7: Average Treatment Effect on the Treated (ATT)

CRIME	ATT	SE
Gun Violence (Post Intervention)	-0.21*	0.10

Bootstrapped standard errors with 50 replications are provided.
*$p<0.05$

Table 8 displays results of the micro-level analysis. The purpose of this analysis was to measure the effect of the NPD task force's business checks on the occurrence of Gun Violence. The analysis included 2 separate models. As per model 1, the intervention activities generally did not have a significant effect on gun violence occurrence. However, model 2 reveals that the intervention activities were associated with a reduction of Gun Violence within the portions of the target area identified as high-risk in the risk terrain model. The reduction approached statistical significance (p=0.06).

Table 8: Regression Models, Post Intervention Period. Dependent Variable=Crime Change Score

COVARIATE	MODEL 1: OVERALL ACTIVITIES			MODEL 2: HIGH RISK ACTIVITIES		
	Coef.	**S.E.**	***p***	**Coef.**	**S.E.**	***p***
Treatment	-0.32	0.26	0.21	-0.33	-0.26	0.20
Total Intervention Activities	-0.03	0.04	0.37	-0.09	0.05	0.06
Pre-Crime Count	-7.93	1.17	0.00	-8.00	2.12	0.00
Segment	-0.06	0.25	0.83	0.04	0.25	0.86
Pscore	1.70	0.66	0.01	1.82	0.67	0.00
r^2	0.45			0.45		

Ordered Logistic Regression Model
Robust standard errors used in significant calculation.

Newark Summary: The findings suggest that the NPD task force's intervention activities, which predominately involved meet-and-greets with business managers, is a promising approach to gun violence. The strategy generated a statistically significant (p<0.10) *35*% reduction of gun violence in the target area as compared to the control area. In addition, the regression analysis found that the intervention activities were associated with decreased crime levels in high-risk portions of the target area. This suggests that future replications of this approach should better focus officer attention on facilities located in high-risk places. The findings concur with prior research finding that police creating active partnerships with place managers can produce a level of guardianship sufficient to generate crime reductions in the vicinity of the facilities (Eck, 2002; Mazerolle and Ransley, 2006). It should also be noted that in Newark, a task force was established whereby the same police Lieutenant oversaw the field operations each day over the 3-month intervention period. Information and intelligence obtained from one day's actions informed the task force's next day intervention activities and related decision-making. Unlike other cities in this NIJ project, where different officers implemented one master intervention strategy and so the outcome evaluations strictly pertain to the actions performed, Newark's outcome evaluation was inherently an assessment of the use of a "task force" as well as the "intervention actions" performed by the task force. Ultimately, significant crime reductions can be achieved when a task force consistently and thoughtfully implements intervention activities at high-risk places.

Kansas City

Risk Terrain Modeling Analysis:

The Kansas City Police Department (KCPD) identified Aggravated Violence as their priority crime. Aggravated Violence included all shooting incidents (hits and homicides), aggravated assault (with a firearm), and street robbery (with and without a weapon). The analysis began with a RTM of Aggravated Violence in the year 2012. The RTMDx Utility tested the spatial influences of 21 risk factors: Banks, Bars, Bus Stops, Convenience Stores, Drug Markets, Fast Food Restaurants, Foreclosure Real Estate, Gas Stations with Convenience Stores, Grocery Stores, Halls, Hotels and Motels, Nightclubs, Liquor Licensed Retailers, Parks, Pawn Shops, Restaurants, Packaged Liquor Stores, Schools, Suspicious Person with a Weapon Calls-for-service, Variety Stores, and Weapon Offending Parolees and Probationers. All geographic calculations were conducted using raster cells (i.e. units of analysis) of 462ft and an average block length of 462ft. There were 42,814 raster cells used in the analysis of which 2,152 cells contained events.

A significant Risk Terrain Model for Aggravated Violence was found that contains 15 risk factors. The significant risk factors and their Relative Risk Values (RRV) are as follows: Bus Stops (RRV=3.38), Weapon Offending Parolees and Probationers (RRV=3.20), Suspicious Person with a Weapon Calls-for-service (RRV=2.43), Variety Stores (RRV=2.28), Packaged Liquor Stores (RRV=2.28), Hotels (RRV=2.27), Fast Food Restaurants (RRV=2.18), Drug Markets (RRV=2.11), Bars (RRV=2.05), Halls (RRV=1.61), Restaurants (RRV=1.41), Convenience Stores (RRV=1.41), Grocery Stores (RRV=1.28), Foreclosures (RRV=1.27), Liquor Licensed Retailers (RRV=1.24).

Risk-Based Intervention:

KCPD's Risk-Based Intervention began on 4/13/14 and ended on 7/31/14. To reflect the RTM findings, KCPD designed their intervention strategies to address nightclubs, suspicious person with a weapon calls-for-service, weapon offending parolees and probationers, drug sales, packaged liquor stores, and liquor licensed retailers[2]. An array of activities intended to mitigate the spatial influences of these risk factors, enhance community awareness, and deter motivated offenders was conducted by various KCPD units and city officials in the target area. The activities included Code Enforcement, Directed Patrols, Licensing and Inspection checks, meet-and-greets with known offenders juxtaposed with social service referrals/support, CPTED inspections, Pedestrian Checks, Area Presence, Residence Checks, Traffic Violations, and Building Checks. A new protocol for dispatching officers to certain calls-for-service locations was also enacted. We were interested in two different time frames for the evaluation: the 90 day during-intervention period (the time which intervention activities were carried out) and the 90 day post-intervention period. Each period was compared to the same time period from the previous year in order to control for seasonality.

The analysis began with a fidelity check to ensure that intervention activities were confined to the target area. This is an important consideration since prior research has found that police officers may not adhere to target area boundaries, which could threaten the validity of empirical evaluations

(Sorg et al., 2014). As displayed in Table 9, approximately 99% (726 of 735) of intervention activities occurred in the target area. The approximately 1% of activities outside of the target area occurred across 4 street units in the catchment zone. These 4 catchment zone street units were excluded from the analysis to prevent contamination of results.

Table 9: Intervention Activities. Fidelity Check

TYPE	IN TARGET AREA	NOT IN TARGET AREA	TOTAL
Car Checks	169	1	*170*
Building Checks	11	0	*11*
Traffic Violations	283	4	*287*
Residence Checks	87	0	*87*
Area Presence	133	4	*137*
Pedestrian Checks	43	0	*43*
Total	***726***	***9***	***735***

**All 9 actions not in target area occurred across 4 street units in the Catchment Zone.*

Table 10 displays the results of the macro-level (i.e. target area-wide) analysis for the during-intervention period. Crime counts were reported for both the treatment and control areas. Treatment units were matched with control units via a Two Nearest Neighbors PSM model with a caliper=0.01. The RES of 0.85 did not achieve statistical significance. Table 11 displays the results of the macro-level (i.e. target area-wide) analysis for the post-intervention period. The RES of 1.14 suggests that Aggravated Violence decreased by 12% in the target area as compared to the control area, but the findings did not achieve statistical significance.

Table 10: Macro-Level Crime Changes. During Intervention

GROUP	DURING	PRE	RES	VAR(RES)	SE
Treatment	60	35	0.85	0.09	0.30
Control	90	62			
N Treatment	*137*				
N Control	*195*				

PSM Algorithm: 2 Nearest Neighbors, caliper=0.01

Table 11: Macro-Level Crime Changes. Post Intervention

GROUP	POST	PRE-POST	RES	VAR(RES)	SE
Treatment	48	52	1.14	0.08	0.29
Control	78	74			
Catchment	27	17			
N Treatment	*139*				
N Control	*195*				

PSM Algorithm: 2 Nearest Neighbors, caliper=0.01

Table 12 displays the ATT findings. No statistically significant effects were found at the micro-level in either the during- or post-intervention period. A sensitivity analysis (results not shown) confirmed the insignificant results across all alternate PSM algorithms.

Table 12: Average Treatment Effect on the Treated (ATT)

CRIME	ATT	SE
Aggravated Violence (During Intervention)	0.06	0.11
Aggravated Violence (Post Intervention)	-0.02	0.11

Bootstrapped standard errors with 50 replications are provided.

Table 13 (during-intervention period) and Table 14 (post-intervention period) display the results of the micro-level analysis. The purpose of this analysis was to measure the effect of the disaggregate intervention activities on the occurrence of Aggravated Violence. In the during-intervention analysis, Pedestrian Checks, Area Presence, and Residence Checks were each associated with lower levels of Aggravated Violence throughout the entirety of the target area. None of these covariates maintained statistical significance in the "high-risk" model, meaning that their effect was not maintained within only high-risk street units in the target area. In the post-intervention analysis, no covariates achieved statistical significance in the overall model. However, building checks conducted within high-risk areas were associated with reduced crime levels. This suggests that the focusing of building checks in high-risk areas has lagged crime control effect that surfaces after the conclusion of this intervention period.

Table 13: Regression Models, During Intervention Period. Dependent Variable=Crime Change Score

COVARIATE	MODEL 1: OVERALL ACTIVITIES			MODEL 2: HIGH RISK ACTIVITIES		
	Coef.	**S.E.**	***p***	**Coef.**	**S.E.**	***p***
Treatment	0.46	0.24	0.05	0.20	0.21	0.35
Pedestrian Checks	-0.88	0.37	0.02	-1.13	0.66	0.09
Area Presence	-0.48	0.16	0.00	-0.21	0.14	0.15
Residence Checks	-0.70	0.36	0.05	-0.14	0.38	0.72
Traffic Violations	0.13	0.15	0.38	0.02	0.46	0.97
Building Checks	0.03	0.49	0.95	-0.06	0.18	0.73
Car Checks	-0.23	0.20	0.24	0.11	0.44	0.81
Pre-Crime Count	0.85	0.23	0.00	0.83	0.23	0.00
Segment	0.04	0.24	0.86	-0.02	0.22	0.91
Pscore	16.17	2.55	0.00	14.50	2.42	0.00
r^2	0.07			0.06		

Ordered Logistic Regression Model

Robust standard errors used in significant calculation.

Table 14: Regression Models, Post Intervention Period. Dependent Variable=Crime Change Score

COVARIATE	MODEL 1: OVERALL ACTIVITIES			MODEL 2: HIGH RISK ACTIVITIES		
	Coef.	S.E.	*p*	Coef.	S.E.	*p*
Treatment	-0.19	0.24	0.42	-0.09	0.23	0.69
Pedestrian Checks	0.30	0.74	0.68	-0.49	0.47	0.29
Area Presence	0.10	0.19	0.60	-0.16	0.36	0.65
Residence Checks	0,16	0.33	0.63	0.18	0.45	0.68
Traffic Violations	0.00	0.14	0.99	0.05	0.28	0.87
Building Checks	1.11	0.61	0.07	-1.64	0.41	0.00
Car Checks	-0.21	0.22	0.34			
Pre-Crime Count	-4.82	0.76	0.00	-0.12	0.44	0.78
Segment	0.20	0.23	0.39	0.24	0.22	0.28
Pscore	6.12	3.12	0.05	5.97	2.94	0.04
r^2	0.33			0.33		

Ordered Logistic Regression Model
Robust standard errors used in significant calculation.

Kansas City Summary: The findings suggest that RTM enabled Kansas City police officials to make decisions about where to allocate resources and what to do when they got there in order to suppress crime in the short-term and reduce crime occurrence over the long-term. Intervention activities affect crime differently over varying times and places. Synthesizing results from Tables 13 and 14, it can be generally concluded that “pedestrian checks”, “directed patrol”, and “knock-and-talks” have the greatest impact on reducing crime among all micro-level places within the target areas when sustained, whereas longer-term crime reduction benefits at high-risk places are best achieved via “building checks”.

Glendale

Risk Terrain Modeling Analysis:

The Glendale Police Department (GPD) identified Robbery as their priority crime. The analysis began with a RTM of Robbery in the year 2012. The RTMDx Utility tested the spatial influences of 11 risk factors: Bars, Liquor Stores, Restaurants with Liquor Licenses, Drug-related Calls for Service, Apartment Complexes, Parks, Gang Member Residences, Convenience Stores, Take Out Restaurants, ATMs, and Gas Stations. All geographic calculations were conducted using raster cells (i.e. units of analysis) of 236ft and an average block length of 472ft. There were 31,197 raster cells used in the analysis of which 277 cells contained events.

A significant Risk Terrain Model for Robbery was found that contains 7 risk factors. The significant risk factors and their Relative Risk Values (RRV) are as follows: Drug-related Calls for Service (RRV=15.56), Convenience Stores (RRV=2.88), Take Out Restaurants (RRV=2.54), Apartment Complexes (RRV=2.53), Gang Member Residences (RRV=2.41), Liquor Stores (RRV=2.30), and Bars (RRV=2.19).

Risk-Based Intervention:

GPD's Risk-Based Intervention began on 9/15/13 and ended on 12/15/13. To reflect the RTM findings, GPD designed their intervention strategy to address all 7 risk factors. An array of activities was conducted by the GPD for the purpose of mitigating the spatial influences of these risk factors, enhance community awareness, and deter motivated offenders. The activities included Directed Patrols, Flyer Distribution, Community Meetings and Engagement Activities, Proactive Stops, and Proactive Arrests. We were interested in two different time frames for the evaluation: the 90 day during-intervention period (the time which intervention activities were carried out) and the 90 day post-intervention period. Each period was compared to the same time period from the previous year in order to control for seasonality.

The analysis began with a fidelity check to measure whether the intervention activities were confined to the target area. This is an important consideration since prior research has found that police officers may not adhere to target area boundaries, which could threaten the validity of empirical evaluations (Sorg et al., 2014). As displayed in Table 15, a higher proportion of intervention activities occurred outside of the target area in Glendale than in any other of the project cities. In total, approximately 9% (175 of 1850) of activities occurred outside of the target area. Furthermore, these 175 actions occurred across 59 prospective control street segments. Since the within-target area actions were confined to only 81 street segments, the number of outside-target area street segments subjected to intervention actions shows that the target area boundaries were not strictly adhered to. Therefore, we considered each street segment that experienced at least 1 intervention action as the "target areas" for the evaluation, as this was considered a better measure of program implementation than the pre-determined target area.

Table 15: Intervention Activities. Fidelity Check

TYPE	IN TARGET AREA	NOT IN TARGET AREA	TOTAL
Arrests	21	8	**29**
Flyer Distribution	658	44	**702**
Community Engagement	502	47	**549**
Proactive Stops	65	18	**83**
Directed Patrols	415	50	**465**
Other	14	8	**22**
Total	***1675***	***175***	***1850***

**175 intervention actions occurred across 59 prospective control street segments.*

Table 16 displays the results of the macro-level (i.e. target area-wide) analysis for the during-intervention period. Crime counts were reported for both the treatment and control areas. Treatment units were matched with control units via an Epanechnikov Kernel PSM model. The RES of 1.73 suggests that Robbery decreased by 42% in the target area as compared to the control area. The decrease approached statistical significance ($p<0.10$). The WDQ of 3.45 suggests a diffusion of benefits effect greater than the reduction experienced in the target area. The Phi coefficient (0.08) confirms that the WDQ is an appropriate measure of spatial changes in crime patterns given the relationship between the target and catchment areas. Table 17 displays the results of the macro-level (i.e. target area-wide) analysis for the post-intervention period. The RES of 0.72 suggests that

Robbery increased by 38% in the target area as compared to the control area, though the results did not achieve statistical significance.

Table 16: Macro-Level Crime Changes. During Intervention

GROUP	DURING	PRE	RES	VAR(RES)	SE	WDQ	PHI
Treatment	12	26	1.73^	0.18	0.43	3.45	0.08
Control	63	79					
N Treatment	*37*						
N Control	*141*						

^p<0.10

Table 17: Macro-Level Crime Changes. Post Intervention

GROUP	POST	PRE-POST	RES	VAR(RES)	SE
Treatment	29	21	0.72	0.16	0.40
Control	43	52			
N Treatment	*37*				
N Control	*141*				

Table 18 displays the ATT findings. No statistically significant effects were found at the micro-level in either the during- or post-intervention period. A sensitivity analysis (results not shown) confirmed the insignificant results across all alternate PSM algorithms.

Table 18: Average Treatment Effect on the Treated (ATT)

CRIME	ATT	SE
Robbery (During Intervention)	0.00	0.26
Robbery (Post Intervention)	0.35	0.34

Bootstrapped standard errors with 50 replications are provided.

Table 19 (during-intervention period) and Table 20 (post-intervention period) display the results of the micro-level analysis. The purpose of this analysis was to measure the effect of the disaggregate intervention activities on the occurrence of Robbery. In the during-intervention analysis, Directed Patrols were associated with lower levels of Robbery, with the reduction approaching statistical significance (p=0.09). None of the intervention activities achieved or approached statistical significance in the "high-risk" model. In the post-intervention analysis, flyer distribution activities were associated with lower levels of Robbery, with the reduction approaching statistical significance (p=0.09). As with the during-intervention analysis, no intervention activities achieved statistical significance in the "high-risk" model.

Table 19: Regression Models, During Intervention Period. Dependent Variable=Crime Change Score

COVARIATE	MODEL 1: OVERALL ACTIVITIES			MODEL 2: HIGH RISK ACTIVITIES		
	Coef.	**S.E.**	***p***	**Coef.**	**S.E.**	***p***
Treatment	-0.45	0.55	0.41	-0.31	0.47	0.51
Arrests	-0.05	0.73	0.95	-0.32	0.59	0.58
Flyer Distribution	0.01	0.05	0.17	-0.3	0.03	0.42
Community Engagement	-0.01	0.04	0.89	-0.01	0.02	0.48
Proactive Stops	-0.08	0.14	0.57	-0.04	0.62	0.50
Directed Patrols	-0.09	0.05	0.09	0.04	0.04	0.36
Pre-Crime Count	-5.04	0.91	0.00	-5.04	0.92	0.00
Pscore	-0.02	1.19	0.99	0.16	1.19	0.89
r^2	0.45			0.45		

Ordered Logistic Regression Model
Robust standard errors used in significance calculation.

Table 20: Regression Models, Post Intervention Period. Dependent Variable=Crime Change Score

COVARIATE	MODEL 1: OVERALL ACTIVITIES			MODEL 2: HIGH RISK ACTIVITIES		
	Coef.	**S.E.**	***p***	**Coef.**	**S.E.**	***p***
Treatment	0.07	0.16	0.65	0.13	0.14	0.35
Arrests	0.66	0.44	0.13	0.33	0.28	0.24
Flyer Distribution	-0.04	0.03	0.09	-0.02	0.02	0.29
Community Engagement	0.06	0.04	0.11	0.03	0.02	0.12
Proactive Stops	0.00	0.09	0.98	0.01	0.05	0.85
Directed Patrols	0.03	0.02	0.27	0.01	0.03	0.60
Pre-Crime Count	-1.21	0.08	0.00	-1.17	0.07	0.00
Pscore	0.76	0.45	0.09	0.69	0.46	0.14
Constant	0.23	0.10	0.02	0.23	0.10	0.02
r^2	0.65			0.64		

Ordered Logistic Regression Model
Robust standard errors used in significance calculation.

Glendale Summary: The findings suggest that RTM enabled GPD officials to make decisions about where to allocate resources and what to do when they got there. The intervention produced a statistically significant (p<0.10) reduction of Robbery throughout the target area in the during-intervention period. In addition, the intervention produced a diffusion of benefits effect that was even greater than the reduction of crime experienced in the target area. Synthesizing results from Tables 19 and 20, it can be generally concluded that "directed patrol" had the greatest impact on reducing crime among all micro-level places within the target areas during the intervention period, whereas longer-term crime reduction benefits were best achieved via "flyer distribution".

Chicago

Risk Terrain Modeling Analysis:

The Chicago Police Department (CPD) identified Shootings as their priority crime for the project. The analysis began with a Risk Terrain Model (RTM) of Shootings in the year 2012. The RTMDx Utility tested the spatial influences of 15 risk factors: 311 Lights Out Calls, Gang Activity Hotspots, Problem Buildings, Apartment Complexes, Bars, Liquor Stores, Nightclubs, Recreation Centers, Gas Stations, Gas Stations with Convenience Stores, Homeless Shelters, Laundromats, Schools, Foreclosures, and Bus Stops. All geographic calculations were conducted using raster cells (i.e. units of analysis) of 426ft and an average block length of 426ft. There were 143,959 raster cells used in the analysis of which 2,240 cells contained events.

A significant RTM for Shootings was found that contains 10 risk factors. The significant risk factors and their Relative Risk Values (RRV) are as follows: Foreclosures (RRV=5.38), Problem Buildings (RRV=3.72), Gang Hotspots (RRV=2.86), Laundromats (RRV=2.27), Liquor Stores (RRV=1.92), Gas Stations (RRV=1.65), 311 Lights Out Calls (RRV=1.41), Schools (RRV=1.35), Bus Stops (RRV=1.33), Bars (RRV=1.28).

Risk-based Intervention:

To reflect the RTM findings the CPD designed an intervention strategy that focused on Foreclosures and Problem Buildings. The strategy entailed the CPD working in partnership with other City of Chicago departments to conduct site visits of known problem properties throughout the city to improve conditions conducive to crime and, when necessary, issue citations for code violations. City agencies also sought to work with private lenders to address the broader scope of the foreclosure crisis.

Our process evaluation found that CPD could not manage to collect measurement data in a systematic or coordinated way to allow for adequate evaluations of outcomes. The CPD provided us with cumulative totals of building inspections and citations (280 buildings inspected with 24 citations generated), but were unable to provide incident-specific information including the precise date, time, and location of each action. This prevented us from determining whether the integrity of the intervention was maintained, specifically in terms of treatment being confined to the identified target areas and intervention time period. Therefore, we were unable to complete an outcome evaluation of CPD's intervention. It should be noted that during this project, there were mayoral elections (and subsequent run-off elections), internal transfers/promotions of police personnel, and multiple other research projects (unaffiliated with ours) that may have strained CPD's data management resources. While an outcome evaluation focused on Goal #2 was not possible, three deliverables focused on Goal #1 are currently available in print:

Kennedy, L. W., Caplan, J. M., Piza, E. L. & Buccine-Schraeder, H. (2015; online first). Vulnerability and Exposure to Crime: Applying Risk Terrain Modeling to the Study of Assault in Chicago. *Applied Spatial Analysis and Policy.*

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Endnotes

[1] Originally, 6 cities were proposed as study settings for interventions. However, Arlington, TX withdrew from the study early on due to excessive turnover of personnel within the department.

[2] “Packaged liquor stores” refer to businesses whose primary purpose is to sell liquor. “Liquor licensed retailers” are facilities that are in business to sell other items, but also sell liquor, such as convenience stores, grocery stores, etc.