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Leveraging code enforcement units to reduce crime: A difference-in-difference analysis of a targeted crime prevention intervention

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ABSTRACT

Police agencies are considering innovative, cost-effective strategies to reduce crime, particularly during a police staffing crisis. One potential strategy involves leveraging code enforcement units to abate vacant lots, buildings, and overgrown landscapes. This approach also offers a light-footprint mechanism to reduce crime with minimal contact between police and the public. The present study utilizes a rigorous quasi-experimental design of a targeted code enforcement crime prevention strategy implemented within a large Southeastern United States police agency. Findings from two-way fixed effects difference-in-difference analyses revealed a non-significant impact on shootings and violent crimes. However, there were significant reductions in total property crimes. This study provides promising evidence of a cost-effective low-contact property crime reduction strategy for police agencies. We discuss policy implications and future research directions.

1. Introduction

Problem-oriented policing (hereafter "POP") emerged in the 1970s (Goldstein, 1979) as an important police strategy to address underlying community problems (e.g., drug markets, homelessness). POP offers the potential to eradicate the underlying community problems, such as physical disorder that may be sourced from the physical environment (e.g., dilapidated buildings). Problems related to the physical environment inspire several theoretical frameworks that focus on adjusting the physical environment such that there are reduced signs of physical disorder (Kelling & Wilson, 1982), increase perceived physical guardianship (Cohen & Felson, 1979), and improve perceptions of territoriality, that the area is taken care of (Jeffery, 1971). For these reasons, addressing physical signs of disorder and cleaning up certain environments may potentially reduce crime. Some examples of changing the built environment to reduce crime include the cleaning and greening of vacant lots (Branas et al., 2011), repairing broken windows and doors on abandoned buildings (Kondo, Keene, Hohl, MacDonald, & Branas, 2015), and enhancing street lighting (Chalfin, Hansen, Lerner, & Parker, 2022). During the current police staffing crisis (Adams, Mourtgos, & Nix, 2023; Mourtgos, Adams, & Nix, 2022), abating physical disorder may alleviate strained police resources by reducing the number of calls for service, crime reports, and arrests. Further, leveraging code enforcement (hereafter referred to as "CE") units to clean up areas and decrease perceived disorder may offer a potentially cost-effective, light-footprint crime prevention strategy (Sadatsafavi, Sachs, Shepley, Kondo, & Barankevich, 2022). That is, abating physical disorder may impact offender decision calculus without any or minimal police presence. While some research exists showing the potential positive effects of code enforcement strategies (see Worrall & Wheeler, 2019) to reduce crime, more research is needed. Specifically, assessing various CE strategies across many contexts would highlight if and which code enforcement strategies are most effective.

The present study utilizes a rigorous quasi-experimental design to evaluate the effects of a 90-day targeted code enforcement strategy implemented within a large Southeastern United States police agency. The strategy focused on leveraging the CE unit as a proactive crime prevention tool for addressing physical disorder and compliance issues within high-crime areas. Results indicate that targeted code enforcement can have varying impacts across crime types. By integrating CE units into crime prevention strategies, we illustrate how non-traditional enforcement strategies can complement traditional policing efforts. In a

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time of persistent staffing shortages across law enforcement agencies in the United States, this research helps to understand the potential of CE units to alleviate some of the workload on other law enforcement units and enabling them to focus on other critical law enforcement tasks. Finally, our findings provide actionable insights for police leaders seeking innovative, resource-efficient methods to address crime and disorder in their communities.

2. Theoretical framework centered on code enforcement interventions

There is a strong body of theoretical literature supporting the impact of place-based strategies on crime, disorder, public safety, and community support (Hinkle, Weisburd, Telep, & Petersen, 2020; Weisburd, 2018). While not all encompassing, strategies that focus on impacting the urban environment often show promising results in impacting crime. For example, Chalfin et al. (2022) randomly assigned enhanced lighting to public housing communities and found significant reductions in serious crime at night, while observing noticeable reductions in arrests in these areas (see also Kaplan & Chalfin, 2022). Other studies have found similar effects on variations of such strategies, such as the impact of greening vacant lots on various crime types, on assaults and burglaries (Branas et al., 2018; Kondo, Hohl, Han, & Branas, 2016). Cleaning up vacant lots and blight has also improved community perceptions of crime, in addition to associated crime reductions (Cui, Jensen, & MacDonald, 2022; Garvin, Cannuscio, & Branas, 2013; Macdonald, Nguyen, Jensen, & Branas, 2021). While not all built environment policing strategies have found crime reductions, there remains a promising body of literature supporting their effects on crime and public safety.

Crime prevention strategies that focus on addressing built environment issues are grounded in several theoretical frameworks. Routine activity theory posits that three elements: a motivated offender, a suitable target, and a lack of capable guardianship, must converge in space and time for crime to occur (Cohen & Felson, 1979). In the context of place, areas of high physical disorder may draw in motivated offenders to those areas, thereby creating areas with enhanced crime opportunities due to low levels of perceived guardianship (Rengifo & Bolton, 2012). Place managers (i.e., a property owner, superintendent, or business operator) usually have control over the setting (J. E. Eck, 1994). Often, ineffective or resistant place managers may allow physical disorder or low levels of guardianship to persist (Cardwell, Tregle, Smith, & Anderson, 2025; Eck & Weisburd, 2015). CE officers and interventions can enhance, or even counter, ineffective place management by providing guardianship through image maintenance and providing overall care of a place, particularly places that show signs of disorder (Eck, Linning, & Herold, 2023; Sampson, Eck, & Dunham, 2010). These strategies may increase the overall perceived guardianship of an area.

Broken windows theory ("BWT") (Kelling & Wilson, 1982) similarly, suggests that areas presenting obvious signs of disorder (e.g., physical disorder) that are left unrepaired may signal a lack of care for the area, provoking offenders due to this perceived neglect. Thus, areas with dilapidated and abandoned buildings, unkept landscapes, broken windows, and other signs of physical disorder may attract potential offenders to the area. Criticisms of aggressive enforcement manifestations of BWT remain. For example, one iteration of broken windows that focuses on order maintenance policing, which focuses on the enforcement of misdemeanors and quality of life offenses to prevent more serious offenses, has been criticized for contributing to racial disparities by police (Boehme, Cann, & Isom, 2022; see also discussion in Braga, Schnell, & Welsh, 2024). However, repairing physical disorder (e.g., abating deteriorated housing, greening vegetation), similar to the intervention of the current study, may be less stigmatizing to the community, while showing evidence of crime reductions (Cui et al., 2022; Macdonald et al., 2021).

Crime prevention through environmental design ("CPTED") (Jeffery, 1971) also provides a relevant theoretical framework that inspires the CE strategy examined in this study. Through landscaping unkept vegetation, abating vacant lots and building, and providing greater care of an area, these initiatives can show signs of enhanced territoriality, natural surveillance, and access control (Jeffery & Zahm, 2017). These renewed positive changes to the built environment may deter motivated offenders and reduce criminal opportunities by increasing perceived are of the area. Further, CE officer presence in the community shows that there are more "eyes" on the area.

In some police agencies, code enforcement units are specialized units that focus on the enforcement of city/county ordinances to improve quality of life (Tillyer, Acolin, & Walter, 2023). While not all agencies have code enforcement units, code enforcement units can be leveraged to execute community-based interventions such as enforcing zoning laws, inspecting properties, addressing nuisance and noise complaints, cleaning up areas, abating buildings, and vacant lots, among others (Accordino & Johnson, 2000). Beyond mitigating physical disorder, CE units in geographic areas can increase the overall presence of the police department, which increases in police presence positively impacts crime rates (Boehme & Mourtgos, 2024; Weisburd, Wilson, Petersen, & Telep, 2023). Previous research has shown that implementing various CE strategies may have meaningful impacts on various crime types, including violent crimes. For example, Worrall and Wheeler (2019) evaluated a prosecution program targeting code enforcement violations and found that the total crime rate decreased in treated areas compared to control areas. Similarly, Tillyer et al. (2023) examined street segments across six cities and found that private investments via building permits and code enforcement efforts were associated with decreases in crime on those streets. The authors also observed the diffusion of crime reduction benefits across nearby affected streets (see also Acolin, Tillyer, & Walter, 2024). While some studies show no significant crime reductions, a growing body of promising evidence exists connecting CE with reductions in crime (Beam, Szabo, Olson, Hoffman, & Beyer, 2021; Hadavi, Rigolon, Gobster, & Stewart, 2021).

The present investigation presents findings from a quasi-experimental research design of a multi-pronged code enforcement crime prevention effort. We use difference-in-difference analyses to evaluate a 90-day code enforcement intervention of the treated areas in comparison to similar high-crime non-treated areas that did not receive the code enforcement treatment. This study will build on the existing body of literature on code enforcement-based crime prevention strategies. Further, this study explores whether targeted CE interventions provide more evidence on problem-oriented, built environment-focused police strategies, using a quasi-experimental design. Indeed, previous studies of related interventions have been critiqued for using correlational methods (see Braga et al., 2024). Additionally, this study will shed light on a multi-faceted intervention within a Southeastern United States context. Our results have implications for police agencies considering easy-to-implement, light-footprint crime prevention strategies. Further, we disaggregate crime types to assess which crimes were significantly impacted by such interventions. Below, we seek to test three hypotheses:

H^1. : Relative to control areas, areas receiving the code enforcement intervention will experience fewer shootings.

H^2. : Relative to control areas, areas receiving the code enforcement intervention will experience fewer violent crimes.

H^3. : Relative to control areas, areas receiving the code enforcement intervention will experience fewer property crimes.

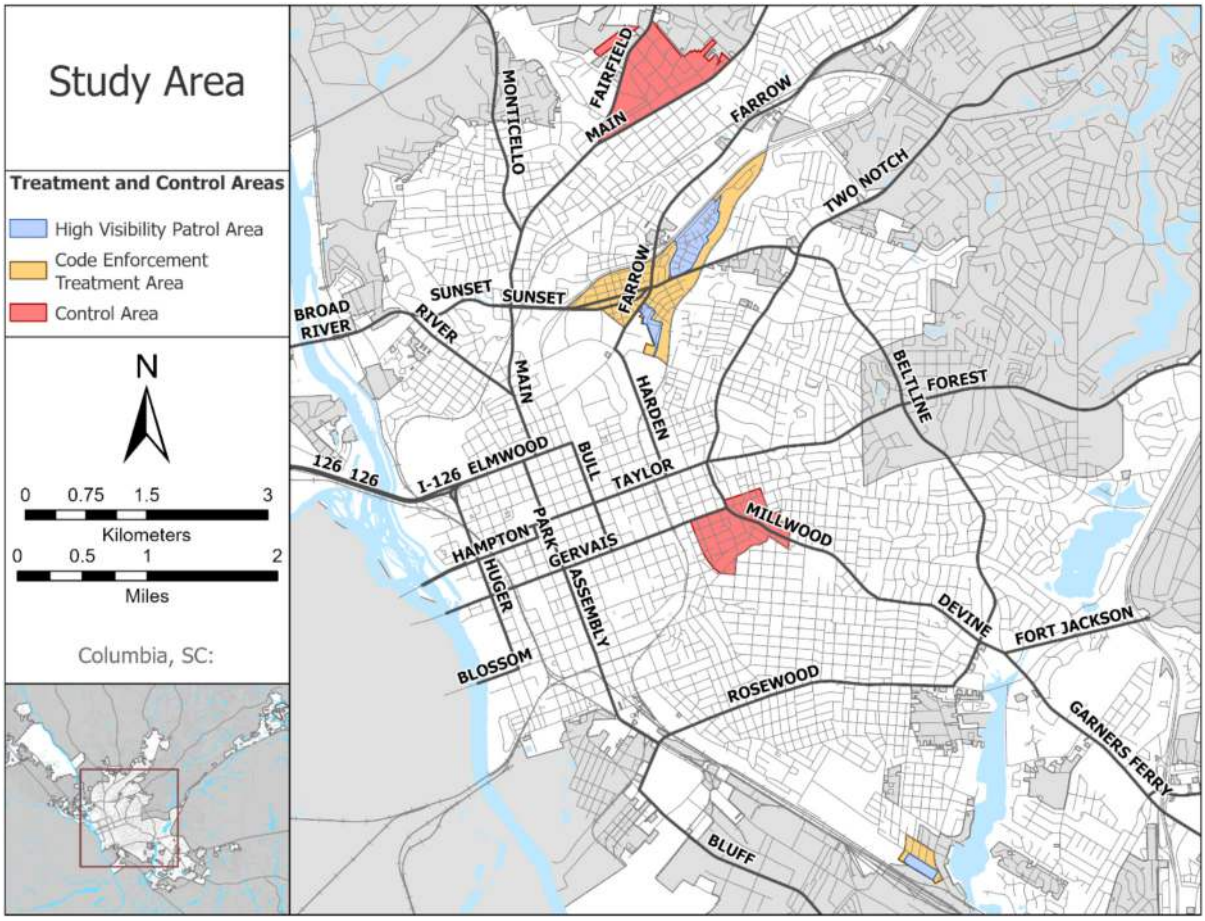

Fig. 1. Map of study area.

3. Methods

3.1. Study context

This study was conducted in Columbia, South Carolina, the capital of the state, which has a population just over 144,000. The city is racially and economically diverse, with approximately 50 % of residents identifying as white and 40 % as Black or African American. Columbia's median household income stands at $55,653, while about 23 % of its population live below the poverty line (United States Census Bureau, 2024). The Columbia Police Department (CPD) is the city's primary law enforcement agency and employs about 300 sworn officers. Like many U.S. urban centers, it faces ongoing staffing challenges (Adams et al., 2023). Over the past decade, CPD's sworn officer count has fluctuated between 285 and 375.

Violent crime remains a critical issue in Columbia, with the city's violent crime rates consistently surpassing national averages. Between 2012 and 2022, the city's average violent crime rate was 765.8 per 100,000 residents, though it has exhibited a gradual downward trend over the last decade. In recent years, CPD has prioritized innovative approaches to crime reduction to include POP, hot spots strategies, and acoustic gun detection technology. The research team has developed a co-productive relationship with CPD and consistently collaborates on various projects and data-sharing to implement evidence-based solutions, including the intervention presented in this study.

3.2. Intervention

Prior research has found that gun violence in American cities is spatially concentrated (Braga & Weisburd, 2020), and Columbia is no different. About 3% of the city's land area has experienced over 40% of the fatal and non-fatal shootings each year over the past six years. In 2024, CPD launched a gun-violence reduction plan targeting some of these areas of perennially concentrated gun violence. An area overlapping with three different police districts was targeted by CPD to execute the intervention. The intervention site was chosen in part because it had collectively experienced a larger number of fatal and non-fatal shootings than other high-violence areas in the first half of 2024. Therefore, CPD leadership set out to implement a two-pronged approach utilizing both CPD patrol and CPD code enforcement units.

The first component consisted of a directed high-visibility patrol strategy on a small number of streets in the treated area. CPD patrol officers were directed to go to high-crime areas during historically violent times and engage in highly visible proactive activity for 15 minutes once an hour. Officers mostly elected to increase vehicle patrols with their static light bars activated. The present study, however, investigates and evaluates the co-occurring code enforcement prong of the intervention. The intervention areas taken together are about 0.62 square-mile^2 in size. The CE treatment was applied to the entirety of the intervention area. The high-visibility patrol was confined to just a 0.15 square-mile^2 subset of the intervention area. Because about 75% of the

intervention area received CE treatment with no high-visibility directed patrol treatment, we are able to assess the impact of the CE prong of the intervention independently (see Fig. 1 depicting the study area). The red areas are the control areas, while the orange and blue areas in the center and bottom right of Fig. 1 are the treated areas.

The 90-day code enforcement intervention tasked non-sworn code enforcement officers to give sustained, systematic attention to identifying and remediating unsecured abandoned buildings and overgrown vacant lots. They were also encouraged to address any other issues that may benefit from abating various elements of the environment with the ultimate goal of crime reduction. In meetings CE unit that implemented the intervention and the research team, CE members discussed extensive knowledge of crime prevention through environment design (CPTED) concepts. CE stated that there was a larger presence in both CE officers (non-sworn) and CE trucks (marked with CPD emblem) in the treated areas during the early phases of the intervention. After identifying physical disorder in the areas, CE executed a multi-pronged code enforcement strategy during the 90-day intervention. Much of the strategy focused on vacant lots, vacant structures, and the landscape of the treated areas. CE officers secured vacant buildings by reboarding broken windows and doors, removed litter/trash from these areas, and secured rights-of-way. Additionally, the CE unit trimmed trees, mowed overgrown vegetation, and landscapes vacant lots/premises, including landscaping and cleaning nearby convenience stores.[1] Several code enforcement cases were opened in the targeted area due to code violations, such as front-yard parking, abandoned vehicles, illegal dumping, trespassing on vacant properties, and reporting homeless camps. These cases were later re-inspected, in which actions such as replacing missing "No Trespass" signs and other missing signs. In one case, a vacant building was demolished. Cases outside of CPD's jurisdiction were reported to the Ombudsman division of the county.

3.3. Fidelity

The code enforcement officers noted that the community acknowledged their presence in the community and expressed interest in CE activities. Since securing vacant lots, boarding broken windows and doors, and trimming trees/bushes can only be executed as the problems emerge, the CE unit pivoted to other strategies later in the 90-day intervention after initially abating these areas. For example, the CE unit focused on vehicle and structure violations later in the intervention. Of note, these actions required frequent follow-up from CE officers. If owners failed to correct violations, the case was turned over for court review for an injunction. Finally, CE officers stated that the intervention was not burdensome to implement, although they spent more time in the targeted areas rather than distributing services more widely across the jurisdiction. As indicated by the increase in the number of violations and officer follow-ups, the CE unit executed strong treatment fidelity throughout the 90-day intervention.[2]

3.4. Data

The research team obtained official CPD data on shootings, Part 1 violent crime, and Part 1 property crime. Shootings were examined separately as part of the researcher-agency partnership, as CPD was especially interested in the intervention's effect on shootings.[3] Relying on UCR codes, murder, robbery, and non-family related aggravated assault were aggregated into a *total violent crime* variable. We also disaggregated robbery and aggravated assaults to model them separately.[4] Murder was not analyzed separately due to the low number of occurrences in the dataset. Similarly, for property crimes, we aggregated burglary, larceny-theft, and motor vehicle theft into a *total property crimes* variable, while also analyzing these three variables separately.

Using ArcGIS Pro software, every crime incident was geocoded to the location of the crime, resulting in a 99.3 % geocoding "hit rate," which is well above the acceptable threshold for geocoding crime incidents (Ratcliffe, 2004). The CPD data analyst then calculated the distance of each crime incident to the closest border of the code enforcement treatment areas to test for displacement/diffusion of benefits.[5] Crime data in the treatment areas were aggregated into one group/cluster, while the three control neighborhoods' crime data were aggregated into one group/cluster. The data provided by CPD ranged from February 1, 2022, to October 8, 2024. This provided 981 days within each group, with a final sample of 1962 days in the data. The began on July 11, 2024 and ended on October 8, 2024, providing 90 intervention days, which is a common intervention period for many place-based crime interventions (Braga, Turchan, Papachristos, & Hureau, 2019b; Mitchell, 2019; Telep, Mitchell, & Weisburd, 2014).

For the main analysis, all outcomes were analyzed at the weekly level, providing 127 pre-intervention weeks and 12 post-intervention weeks (a total of 278 weeks in the data). Weekly counts are analyzed for the main analysis due to the sparsity inherent in daily counts and the potential volatility in models at the daily level with relatively low counts (Gelman & Carlin, 2014). To accommodate for this volatility of daily counts and more accurately assess underlying trends, data were binned at the week level, producing more consistent treatment estimates, eliminating "noise" present in daily data. However, as a robustness check, we report estimates at the daily level in the appendix. As will be seen, there is great alignment in weekly and daily results.

3.5. Methodology

As depicted in Fig. 1, the treatment areas consisted of two separate and geographically distant high-crime areas in CPD's jurisdiction. The areas receiving code enforcement treatment are residential areas of perennially concentrated gun violence that were purposely selected by CPD to receive treatment. Therefore, without the possibility of randomization, establishing a comparable control group is vital for a rigorous evaluation of treatment effectiveness (Spector, 1981). Three separate control neighborhoods were selected based on five important criteria: 1) historically high *violent* crime neighborhoods, 2) distantly apart/not directly adjacent to the treatment areas to avoid spillover, 3) similar land use/residential structures (e.g., vacant lots, mix of apartment complexes, residential houses, convenience stores), 4) no other known crime prevention interventions occurring in these areas (as validated by CPD), and 5) similar socio-demographics. Comparisons of treatment and control areas can be found in Appendix Table A1. The

[1] In discussions with code enforcement personnel who carried out the intervention, there were no cooperative or coercive relationships with businesses (e.g., third-party policing). Instead, they took care of businesses that did not address blight issues themselves.

[2] Looking at CE sections opened in 2024, there was a weekly average of 3.37 CE inspections opened in the pre-intervention period and 16 weekly CE inspections opened in the post-intervention period. *t*-tests indicated this weekly average was statistically significant (an over four-fold increase).

[3] This means any reported unlawful discharge of a firearm.

[4] We removed sexual assault, domestic violence, abuse of an adult, abuse of a child, knowingly exposing others to HIV, and tampering with food products from the aggravated assaults variable, as these crime types have been excluded in previous place-based crime interventions as they are not theorized to be impacted by code enforcement intervention (Smith et al., 2024; Tregle, Smith, Fahmy, & Tillyer, 2025). We estimated models including these crime types and findings did not significantly or substantively change from the main analyses.

[5] For each crime incident, there would be a distance column (in meters). If the distance was "0" – the crime occurred within the treated areas. If there was a "247" in the distance column, for example, the crime occurred 247 m from the targeted area and would be included in the 600-ft buffer displacement/diffusion tests.

treated areas were 0.47 square-mile^2, with 82 % Black residents, 30 % living in poverty, and 3180 residents per square mile. The control areas were 0.65 square-mile^2, with 65 % Black residents, 17 % living in poverty, and 3490 residents per square mile. Because the treated areas were purposely selected based on persistently high levels of violent crime (i.e., the most violent areas of the city), creating a control group that factored in all four other criteria, while having as high of violent crime levels as the treated group was unattainable. However, as can be seen in Appendix Table A1, there were no significant pre-intervention differences between treated and control areas on robbery, total property crimes, larceny-theft, and motor vehicle theft, while there were significant differences in shootings, total violent crimes, and burglaries during the 891 days before the intervention.[6] Therefore, we balanced the five criteria for comparison areas instead of crime counts alone. These decisions ensure that the comparison areas were as similar as possible in terms of land use, distance, socioeconomics, and absence of other crime prevention interventions.

An important quality of rigorous difference-in-difference analyses is meeting the parallel trends assumption. Parallel trends are satisfied if the trends of both treated and control groups are parallel before the intervention starts (Mitre-Becerril & MacDonald, 2024). To assess parallel trends, we rely on visual inspection, event study visualizations, and power analyses. Looking first at visual trends depicted in Fig. 2 below, the trends of the number of shootings, all violent crimes, and all property crimes within both groups follow a relatively similar pattern pre-intervention before diverging in the post-intervention period (also see disaggregated crime types in Fig. A1 of the Appendix). As will be addressed in the event study, there was a large spike in crimes in the treated areas about six weeks before the intervention.

To further assess parallel trends, we conducted event study and power analyses. Using the *pretrends* package in R (Roth, 2022), we conducted a power analysis of our parallel trends testing procedures, allowing us to determine a pretrend slope that we are powered to detect with 95 % confidence. The extensiveness of our pretrend data (127 weeks) provides a high level of statistical power, therefore, the analyses are powered to detect relatively small slopes. Comparing the slope that we are powered to detect with the actual pretrend slope for each dependent variable provides insight into the robustness of our power analysis, increasing or decreasing confidence in the parallel trends assumption. These slope comparisons can be found in Appendix Tables A2 and A3. All of our pretrend slopes are larger than the detectable threshold, with only robbery and shooting outcomes showing statistical significance across OLS and count models. These two dependent variables saw slopes of 0.0041 and 0.0112 in the pretrend, respectively, providing evidence of differences in slope that may have carried into the treatment period. While these slopes are small, they are vital to consider when interpreting results for these two outcomes. For the other outcomes of interest, the power of our pretrend analysis, paired with its identification of no statistically significant differences between treatment and control groups, increases our confidence in the parallel trends assumption (see full output for event study in Fig. A2 in the Appendix). In short, results for these outcomes can more confidently be attributed to the intervention (Callaway, 2023).

3.6. Analytic strategy

For the main analyses, we present estimates from both OLS and Poisson two-way fixed effects (area-specific and time-specific [week]) difference-in-difference models with heteroskedasticity-robust standard errors (Angrist & Pischke, 2009).[7] OLS models not only provide a more efficient estimator than count models, but also offer more interpretable results, as outputs are in terms of simple unit changes in the dependent variable (Angrist & Pischke, 2009). However, we recognize the count structure of our dependent variables, so we also include count models to account for the often-skewed distribution of the outcomes. For count models, we run both Poisson and negative-binomial fixed-effect models; however, negative binomial models consistently identify exceedingly large theta values (~1000). This suggests a closeness between mean and variance, and there is not enough overdispersion present to warrant negative binomial models. Therefore, Poisson modeling is used for count outputs and is reported in our results. As stated above, we present findings from weekly counts but also discuss daily level estimates as a robustness check. Next, as an additional robustness check, we estimate logistic two-way fixed effects difference-in-difference models, denoting 1 if a crime type occurred on a given day in the treatment/control areas, and 0 if that crime type did not occur. Finally, to test for displacement/diffusion of benefits for outcomes that are significant, we rely on the weighted displacement quotient proposed by Bowers and Johnson (2003) to test for displacement or diffusion of benefits.

4. Results

Fig. 2 demonstrates that shootings in the treated areas relative to control areas appeared to decrease across the intervention period, although they were already declining just before the intervention began. Meanwhile, violent crime dropped very early in the intervention before experiencing an increase across the remainder of the intervention period. Post-intervention, violent crime in the treated areas fluctuated in a similar pattern to that of the control areas. Property crimes in the treated areas experienced a noticeable drop and gradually increased throughout the intervention. The control areas showed an increase in property crimes across the majority of the intervention, with a decrease toward the end of the intervention period. Fig. A1 in the appendix visually depicts the disaggregated crime types, in which robbery and aggravated assault appeared to rise across the intervention period. However, burglaries declined initially, followed by an increase toward the end of the period. Thefts showed a gradual decrease across the intervention period, while motor vehicle thefts saw a gradual rise toward the end of the intervention.

Table 1 below shows the results of difference-in-difference analyses of shootings, total violent crimes, robberies, and aggravated assaults. Table 2 presents results of difference-in-differences on total property crimes, burglaries, larceny-thefts, and motor vehicle thefts. The main analyses showed a non-significant decrease in shootings and aggravated assaults. There was also a non-significant increase in total violent crimes and robbery in the treated areas relative to control areas.

Turning to property crimes, there was a significant decrease (B =

[6] Micro-synthetic controls require a large number of "donor" units. CPD's jurisdiction is relatively small compared to other "large" police agencies, whereby obtaining a large number of donor units is unfeasible. This also affects the use of propensity score matching, which has been called into question (King & Nielsen, 2019), particularly when there are limited units to choose from. Additionally, the treated areas intersect and crossover multiple administrative (bloc groups, census tracts) to generate the demographics necessary to create control groups using these methods. Nevertheless, we estimated a micro-synthetic control model as a robustness check using the property crime subtypes theft, burglary, and motor vehicle thefts. The donor pool consisted of the three control areas. The results indicated that there was a significant reduction in property crime (−1.212, $p = 0.000$).

[7] When conducting a TWFE analysis with a single treatment and single control unit, using unit-clustered standard errors becomes inaccurate and is generally considered invalid (Angrist & Pischke, 2009). Our procedures include heteroskedasticity-robust standard errors, and the presence of time-based fixed effects controls for autocorrelation affecting both units in the same period. However, this does leave the potential for autocorrelation that a single unit in a given period. Without the presence of additional treated and control units, fully addressing potential serial correlation is not feasible. When using clustered robust standard errors, findings in our analyses aligned with the main analyses.

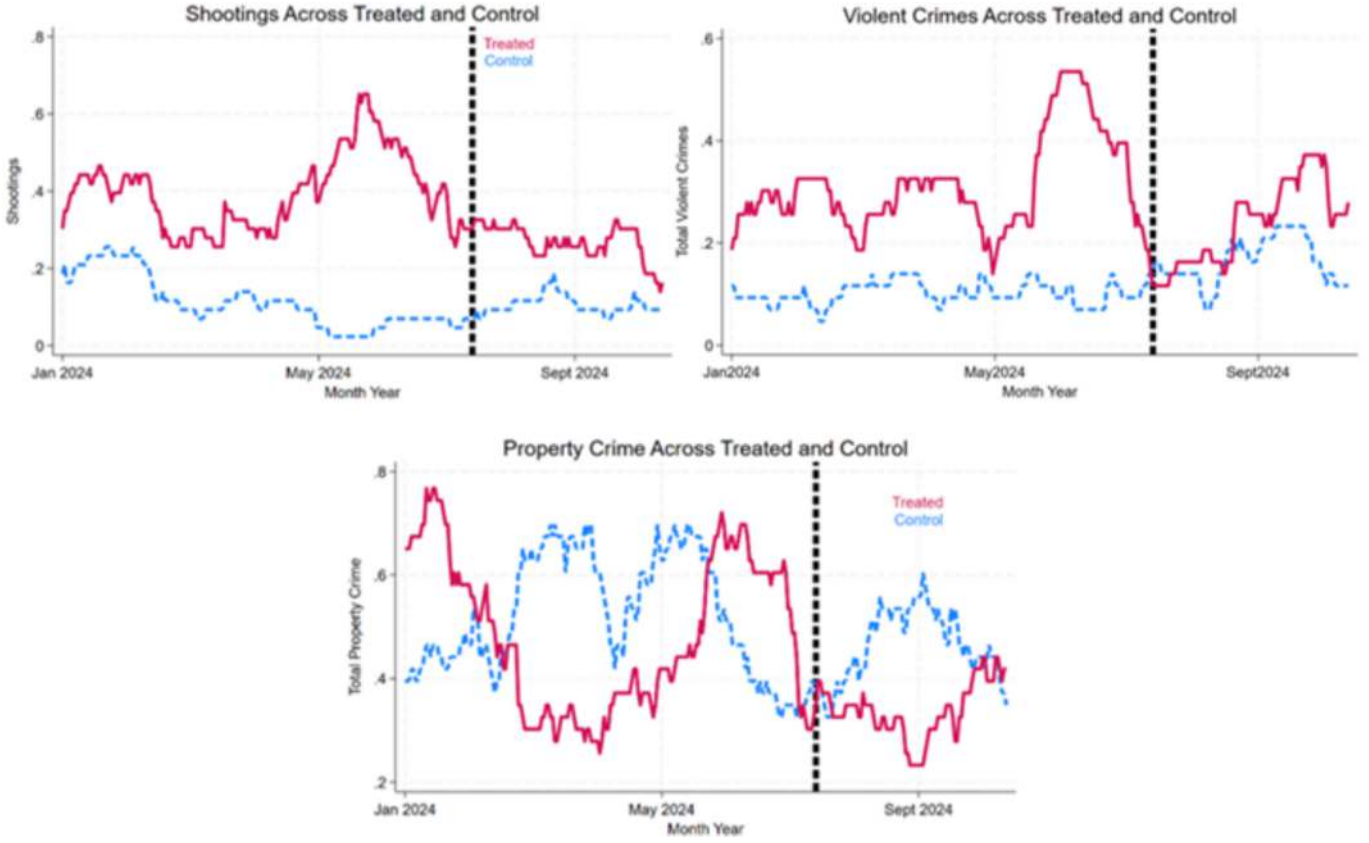

Fig. 2. Six-week rolling averages of shootings, all violent crimes, and all property crimes.

Table 1
Difference-in-difference results on violent weekly counts

	Violent Crime	Robbery	Agg. Assault	Shootings
	β	β	β	β
Intervention	0.135	−0.107	0.242	−0.581
S.E.	0.577	0.257	0.423	0.574
R^2 Adj.	0.102	−0.040	0.167	0.292
R^2 Overall	0.556	0.486	0.245	0.650
R^2 Within	0.001	0.002	0.002	0.007
RMSE	0.911	0.334	0.819	0.997
	AME	AME	AME	AME
Intervention	0.184	−0.204	0.294	−0.207
S.E.	0.698	0.393	0.583	0.835
Pseudo-R2	−0.128	−0.496	−0.128	−0.029

Notes: AME = average marginal effects, S.E. = robust standard error, R = r-square, RMSE = root mean square error. Model: two-way fixed effects, area and time-specific (week) fixed effects.

Table 2
Difference-in-difference results on property weekly counts

	Property Crime	Burglary	Theft	Motor Vehicle Theft
	β	β	β	β
Intervention	-1.323*	-0.310	-0.668	-0.344
S.E.	0.602	0.358	0.553	0.283
R^2 Adj.	-0.002	0.054	0.022	0.004
R^2 Overall	0.504	0.532	0.516	0.508
R^2 Within	0.017	0.003	0.011	0.009
RMSE	1.409	0.835	0.907	0.500
	AME	AME	AME	AME
Intervention	-1.270**	-0.231	-0.623	-0.446*
S.E.	0.463	0.636	0.454	0.215
Pseudo-R2	-0.106	-0.179	-0.188	-0.363

Notes: AME = average marginal effects, S.E. = robust standard error, R = r-square, RMSE = root mean square error. Model: two-way fixed effects, area and time-specific (month) fixed effects. *p < 0.05.

-1.323, $p < 0.05$; AME = 1.270, $p < 0.01$) in total property crimes in the treated areas relative to the control areas during the intervention period. That is, during the intervention period, there was a significant decrease of about 1.27 to 1.32 weekly property crimes in the treated areas. This results in a decrease of about five total property crimes per month and a decrease in about 15 total property crimes during the intervention period in the treated areas relative to the control areas. Disaggregated property crime types showed a decrease in all types; however, these decreases were non-significant with one exception. In the Poisson count model, there was a significant ($p < 0.05$) decrease in motor vehicle thefts (AME = -0.446) in the treated areas relative to control. However, based on our robustness checks discussed later, the finding on motor vehicle thefts was not robust, while the total property crime decreases were robust. Overall, our main analyses indicate no significant impact of the code enforcement intervention on shootings and violent crimes, while providing evidence of a significant impact on property crimes. Below, we discuss the robustness checks to verify our results.

5. Robustness checks

5.1. Robustness and sensitivity tests of the main analyses

In this section, we execute several robustness and sensitivity tests to inspect the consistency of our findings. First, to evaluate the robustness of the identified significant treatment effects, specifically the effect of code enforcement on total property crime. The *HonestDiD* package in R was utilized (Rambachan & Roth, 2023), with results visualized in Appendix Figs. A3 and A4. This analysis allows us to identify how large the parallel trend violations would need to be in the *post*-treatment periods for our significant effect to become a null effect. This procedure was

applied to both OLS and count models, identifying that the $\bar{M}$ or breakdown value is 1 for OLS and 1.5 for count models. This means that our detected significant effect is robust to post-treatment parallel trends violations up to 1.5 times as big as the max violation in the pre-treatment period. Although we did not find significance in our pre-period, if we consider the identified pre-period slope, our "max violation" allows us to consider how large post-treatment violations could be. Said differently, our identified treatment effect is robust to a post-intervention trend difference of up to −0.0073 for OLS models and − 0.0035 for count models. This analysis does not necessarily validate or invalidate any results but rather provides a robustness check for the identified effects.

Second, we used week fixed effects in the main analyses. Results using month fixed effects can be found in Appendix Tables A6 and A7. Findings using month fixed effects confirmed the main analyses that used week fixed effects. Third, while our main analyses on weekly counts remain an appropriate methodology to assess the effect of this intervention, we estimate robustness checks at the daily level to ensure that results from our main analyses do not vary by unit of analysis used, providing added confidence in our main results. Therefore, we mimic the two-way fixed effects difference-in-difference OLS and Poisson models for our main analyses, except on daily counts (Tables A6 and A7 in the Appendix, respectively). Findings from OLS and Poisson models confirm the non-significant impact of the intervention on shootings and violent crime.

OLS difference-in-difference models on daily counts show a significant decrease in total property crimes, burglaries, and motor vehicle theft. The Poisson difference-in-difference models also confirmed the significant decrease of total property crimes. As mentioned above, the volatility in examining daily counts as a rare event provides potential type S errors. Therefore, while OLS daily models showed that disaggregated burglaries and motor vehicle thefts experienced a significant decrease, OLS models may be mis-specified on rare count outcomes. Instead, the Poisson model on daily counts confirms the main analysis. In sum, robustness checks largely confirm the main models, with the most confidence in the significant effects found on total property crimes. Using the three control neighborhoods, we also generated a micro-synthetic control to examine the significant total property crime finding. The results indicated that there was a significant reduction in property crime (B = −1.212, $p = 0.000$, AME = −0.496, p = 0.000).

Fourth as an additional robustness check, we estimated logistic difference-in-difference regression models by transforming counts into binary variables indicating whether the various types of crime occurred (or not) each day (yes = 1, no = 0) pre- and post-intervention within treated and control areas (Table A8). We found a significant ($p < 0.01$) decrease of about 18 % in the likelihood of a property crime occurring within the treated areas relative to control areas during the intervention period. We also found that larceny-theft experienced a significant decrease in the risk that a larceny-theft would occur in the treated areas relative to control areas, post-intervention. There were no significant effects on shootings or violent crimes. In summary of these robustness and sensitivity tests, there is added confidence in the significant decreases in total property crimes, with some evidence that some disaggregated property crime types also significantly decreased. However, the most confidence can be found in the reduction of total property crimes.

Finally, code enforcement interventions may take several days to take effect (e.g., landscaping, repairing buildings). Therefore, we estimated one-, two-, and three-week lag models, moving the intervention period forward one, two, and three weeks after the immediate intervention time. Findings aligned with the main analyses.

5.2. Displacement tests

As with all place-based interventions, it is necessary to test for displacement of crime and the potential for diffusion of benefits. To test both, we examined weighted displacement quotients (Bowers & Johnson, 2003). It is important to note that we only estimated these tests on total property crimes, since we did not find significant effects of the intervention on other crime types (Bowers & Johnson, 2003). Weighted displaced quotients (Table A9) revealed no evidence of displacement of crime to other areas, consistent with previous place-based crime interventions.

6. Discussion

The present study utilized a quasi-experimental design to evaluate the impact of a code enforcement intervention in a historically high crime area of CPD's jurisdiction. Findings revealed a non-significant impact on violent crimes. However, through the main analyses and several robustness tests, we see that code enforcement reduced total property crimes in the treated areas relative to control areas. These nuanced findings and the policy considerations associated with them merit further discussion.

First, for violent crimes, we found a non-significant impact of the code enforcement intervention. Scholars have consistently documented that violent crime concentrates in a small number of micro-locations (Spencer & Schnell, 2022; Weisburd, 2015), which implies that police agencies should use surgical and strategic crime preventive interventions at micro-places (e.g., hot spots policing) to reduce violent crime (Braga et al., 2019b; Smith, Tillyer, & Tregle, 2024). However, in this case, the high visibility patrol portion of the intervention targeted the areas with the highest concentrations of gun violence, precluding the possibility of independently assessing the impact of the CE intervention on those locations. Instead, the isolatable portion of the CE intervention was diffused across a larger geographic area. While certainly POP strategies and CE strategies specifically have been linked to reductions in violent crimes (Hinkle et al., 2020; Worrall & Wheeler, 2019), this specific intervention may not be best suited to reduce violent crime. A geographically diffused CE strategy over a large geographic area may be misaligned with violent crime patterns.

While there were non-significant decreases in burglaries, larceny-theft, and motor vehicle thefts, there was a robust, significant decrease in total property crimes in the treated areas relative to control areas. Theoretically, we again draw on broken windows and routine activity theory (Cohen & Felson, 1979; Kelling & Wilson, 1982) to explain the causal mechanisms relating to this drop in property crimes. From a broken windows perspective, abandoned buildings, vacant lots, and unkept landscapes can attract motivated offenders due to the lack of care of the environment and the perceived limited visibility these areas can provide. Therefore, mitigating and abating these issues may create an environment with increased visibility by police and residents (Fisher, Maimon, & Berenblum, 2021), while simultaneously giving off a sense that the areas are supervised and not abandoned by the community (Chen & Rafail, 2020).

From a routine activity perspective, this intervention may show a sense of guardianship from the community and police agency through oversight, deterring motivated offenders by impacting offenders 'decision calculus. (Nagin, 2013). Improved perceived presence in the community can alter property crimes (Boehme & Mourtgos, 2024), arguably a crime type that is more opportunistic than violent crimes, whereby offenders may perceive a reduced sense of opportunities when an area appears "taken care of." Said previously, since this intervention was distributed across a larger geographic area, property crimes may be more easily generally deterred compared to violent crimes that need specific interventions in micro-locations. These findings align with previous research that has found a relationship between abated lots and structures with lower property crimes (Acolin, Tillyer, & Walter, 2024; Kondo et al., 2016).

Several policy implications emerge from our findings. First, we suggest that agencies with code enforcement or relevant community improvement units consider abating vacant lots and cleaning up overgrown landscape. These units offer the potential to alleviate patrol

resources by reducing the number of calls for service and reported property crimes, which account for a larger portion of calls for service than violence-related incidents. Similar to other potential low-cost property crime interventions, such as distributing information after crimes (e.g., door hangers) (Boehme, Tregle, & Schnell, 2025; Johnson et al., 2017), CE interventions are easy to implement, offering cost-saving interventions that can have meaningful effects on property crimes. The CE unit, which carried out the intervention, reported no added "burden" in executing this intervention. That is, the CE unit acknowledged that they were able to continue "business as usual" in non-treated areas, while devoting additional time and effort to the treated areas, without having to log additional hours during the intervention period. This adds more evidence of the cost-effective strategy, while also having the bandwidth, allowing them to continue regular attention to non-treated areas. Traditional enforcement strategies often require substantial training, legal authority, or intensive resource allocation. On the other hand, CE units already possess the expertise and authority to abate vacant lots, enforce property codes, and address environmental disorders. Further, these interventions do not need daily attention as abated lots and overgrown landscapes may take several days/weeks before they return to the visual cues of disorder.

Second, this is a light-footprint intervention whereby there is minimal to zero contact with residents, preventing perceptions of over-policing (Boehme et al., 2022). In fact, these interventions may improve residents' perceptions of the police agency since officers cared for surrounding areas. The CE unit reported that their trucks, marked with the CPD logo, were observed by citizens in the treated areas. This provided law enforcement presence without the direct engagement of armed officers. Additionally, this approach aligns with routine activity theory (Cohen & Felson, 1979) by increasing perceived guardianship to deter opportunistic offenses through perceived police presence. Unlike proactive, heavy-handed patrols, which may lead to concerns about aggressive enforcement, CE interventions subtly enhanced environmental order without increasing stops or arrests.

While we did not find positive effects on shootings and violent crime, our results suggest that CE-based interventions may not be a stand-alone solution for violent crime. However, they can play a valuable role in comprehensive crime reduction strategies that incorporate multiple levels of law enforcement personnel. Importantly, our results provided no apparent downside to CE interventions — they improved environmental conditions, reduced property crime, and potentially may have enhanced public trust — all without requiring increased officer presence or enforcement actions.

During a police staffing crisis (Mourtgos et al., 2022), innovative, light-footprint, and cost-effective strategies such as leveraging code enforcement units may have meaningful impacts on officer resources and community well-being. Leveraging non-sworn personnel within police departments to address community problems may allow limited patrol resources to execute their daily activities, without being tasked with responding to excessive numbers of calls for service. We suggest that researchers and policy agencies consider innovative, limited contact mechanisms to address community/crime problems by leveraging various police resources to exert levels of guardianship without excessive police presence in communities.

Although we executed a rigorous research design for causal inference, there remain limitations worth discussing. First, absent a randomized controlled trial, there remain threats to internal validity. However, with our design, we were able to better address the threat of history and seasonality by using comparable untreated control groups that were distantly located from the intervention. Second, the intervention only examined a 90-day intervention, and although this is a common length of crime interventions (Braga, Turchan, Papachristos, & Hureau, 2019a; Taylor, Koper, & Woods, 2011), assessing the long-term impacts of this intervention should be improved upon by future research. Due to this, on some of our outcomes, there was low statistical power, particularly on disaggregated crime types. Further, studies investigating a longer post-intervention period may help rule out threats of seasonality; however, we do not believe seasonality affected our findings since property crimes in the treated areas decreased during a time when property crime theoretically may increase (summer months). Third, while high-visibility intervention was co-occurring on a small number of streets of the treated area, and research has shown that preventative patrol can reduce property crime (Weisburd et al., 2023), code enforcement was still occurring in those areas. Although the supplementary analyses excluded the high-visibility patrol areas, in which findings aligned with the main analyses, there may still have been some slight spillover from the preventive patrol co-intervention. Further, CE personnel stated that their trucks with the CPD emblem were in the treated areas during the intervention, and the local residents took notice of their presence. Therefore, the presence of CE officers may have also contributed to the effect of the intervention. However, the added presence of non-sworn police personnel may not be seen as a negative, but an increase in perceived police personnel in the area. Further, since the CE unit was executing several code enforcement actions, disentangling which specific action (e.g, increase presence, abating vacant buildings) reduced property crime was not feasible. However, future research should assess the impact of both interventions with increased spatial distance to confidently rule out spillover effects. Overall, since this was a strategic non-randomized crime prevention strategy targeting the highest crime areas in the jurisdiction, these limitations can be improved upon by randomized controlled trials leveraging code enforcement units to aid in crime prevention.

7. Conclusion

This study highlights the potential of code enforcement as a crime prevention strategy. By addressing environmental disorder, such as vacant lots, abandoned buildings, and overgrown landscapes. Informed by broken windows, routine activity, and CPTED theoretical frameworks, this study contributes to these theoretical bodies of research as well as the crime prevention literature that focuses on targeting built environment features to reduce crime. CE can help in reducing crime while minimizing enforcement actions aimed at citizens in the area. CPD's intervention achieved significant reductions in property crime in an effort to alter the physical environment and reduce opportunities for potential offenders. While the effects on violent crime were mixed, the observed decline in aggravated assaults warrants further investigation regarding whether sustained CE efforts could provide broader crime prevention benefits.

Our findings underscore the practical value of integrating CE into larger public safety strategies. By providing reductions in property crime, CE units can assist police agencies in managing overall crime in at-risk areas without diverting patrol officers from other duties. As more agencies seek efficient approaches toward crime reduction, leveraging CE may provide a sustainable solution that meets both public safety and community engagement goals. Future research should explore the long-term effects of CE interventions to assess whether they contribute to enhanced perceptions of safety and trust between communities and local government and whether CE interventions affect other types of crime in treated areas.

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Availability of data and materials

Upon acceptance, data will be uploaded to the Open Science Framework database.

CRediT authorship contribution statement

Hunter M. Boehme: Writing – review & editing, Writing – original draft, Visualization, Validation, Software, Project administration, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Brandon Tregle:** Writing – review & editing, Writing – original draft, Supervision, Methodology, Formal analysis, Conceptualization. **Marc Olson:** Writing – review & editing, Writing – original draft, Visualization, Methodology, Formal analysis. **Cannon Fulmer:** Writing – review & editing, Writing – original draft, Data curation.

Declaration of competing interest

Cannon Fulmer (fourth author) is an employee (Investigator / Data Analyst) of the police agency that we examine in the manuscript. Mr. Fulmer was not involved in the data analysis of this manuscript.

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Appendix A. Supplementary data

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