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Different places, different problems: profiles of crime and disorder at residential parcels

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Abstract

Certain places generate inordinate amounts of crime and disorder. We examine how places differ in their nature of crime and disorder, with three objectives: (1) identifying a typology of profiles of crime and disorder; (2) assessing whether different forms of crime and disorder co-locate at parcels; and (3) determining whether problematic parcels explain crime and disorder across neighborhoods. The study uses 911 and 311 records to quantify physical and social disorder and violent crime at residential parcels in Boston, MA ($n = 81{,}673$). K-means cluster analyses identified the typology of problematic parcels and how those types were distributed across census block groups. Cluster analysis identified five types of problematic parcels, four specializing in one form of crime or disorder and one that combined all issues. The second cluster analysis found that the distribution of problematic parcels described the spectrum from low- to high-crime neighborhoods, plus commercial districts with many parcels with public physical disorder. Problematic parcels modestly explained levels of crime across neighborhoods. The results suggest a need for diverse intervention strategies to support different types of problematic parcels; and that neighborhood dynamics pertaining to crime are greater than problematic properties alone.

Keywords: Urban criminology, Communities and crime, Criminology of place, Problem properties, Quantitative methods

Introduction

Recent years have seen growing attention to "problem properties." This interest has been scientific, as such places exhibit inordinate concentrations of crime and disorder (e.g., Eck et al., 2007; O'Brien & Winship, 2017; Sherman et al., 1989), as well as practical, with municipalities developing targeted intervention strategies (LISC, 2015; Way et al., 2013). Work to date has revealed striking differences in the quantity of crime and disorder across properties but has looked less at how they might vary in terms of the types of crime and disorder they experience. This leaves open the possibility that all problematic properties experience all types of problems (i.e., a property that experiences violence would also feature physical and social disorder), or, alternatively, that there are multiple types of properties, some with violence but no disorder, others with social disorder but no physical disorder, and so on. Understanding such diversity would be a substantive advance that could also inform problem properties interventions.

The current study develops an empirical typology of "problematic" parcels (similar to properties or addresses) in Boston, MA based on their expression of multiple indicators of physical disorder, social disorder, and violent crime drawn from administrative records. In these regards, the analysis has two goals. The first is an original demonstration of whether all problematic parcels exhibit crime and disorder in similar ways or whether they differentiate into multiple profiles of crime and disorder. Second, the typology will reveal the extent to which different types of crime and disorder tend to co-occur at the

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same parcels. The results of these two analyses then create a third opportunity related to the interplay of high-crime places and communities. Given that high-crime places tend to account for an overwhelming proportion of a city or community's crime and even its temporal fluctuations (e.g., Braga et al., 2010; Lee et al., 2017; O'Brien et al., 2021), it might be assumed that they drive variation in the diversity and level of crime across neighborhoods. Thus, the third goal of this study is to examine not just the prevalence of problematic parcels in each neighborhood but their variety. From this we will evaluate the extent to which the clustering (or lack thereof) of different types of problematic parcels account for the levels of crime and disorder in each neighborhood. Before proceeding to the data and analyses, the remainder of this section. (1) Summarizes existing evidence on problematic places and (2) further details the empirical logic of the current study.

Are there different types of problematic properties?

Research on problem properties emerged from the subfield of criminology of place, which has focused on how crime and disorder concentrate at a small number of streets and addresses.[1] Namely, 1–3% of addresses and 4–6% of streets in a city account for over 50% of crimes, regardless of the type or size of the city (Andresen & Malleson, 2011; Braga et al., 2010; Lee et al., 2017; Sherman et al., 1989; Weisburd, 2015). The work has also demonstrated that concentrations of crime on a given street persist over time (Curman et al., 2015; Groff et al., 2010) and that the rise and fall of crime on hotspot streets are the bellwether for citywide trends in crime (Braga et al., 2010, 2011). Parallel research on repeat victimization has similarly shown that a small proportion of properties experience many burglaries over time (Farrell & Pease, 2001; Johnson et al., 2007; Trickett et al., 1992).

In its focus on levels of crime and disorder, criminology of place has said less about variations in the nature of crime and disorder. Do hotspot streets and problem properties in the same neighborhood express the same types of crime and disorder, or does each feature its own characteristic types and levels of issues that occur there—what we might refer to as profiles of crime and disorder? Theoretical perspectives on crime and place would support the latter. These perspectives are generally rooted in routine activities theory, which stipulates that all crimes require three minimal elements: a motivated offender, a suitable target or victim, and the absence of capable guardians (Cohen & Felson, 1979). Crime pattern theory (also known as environmental criminology) has extended this concept, arguing that the activities and individuals associated with a particular place determines the frequency and manner with which offenders, victims, and guardians do or do not interact with each other. This in turn shapes the likelihood and nature of crime and disorder that are likely to occur (Brantingham & Brantingham, 1984). Relatedly, situational crime prevention emphasizes the effectiveness of small alterations to places that will alter its opportunity structure (Clarke, 1995). For example, securing potential targets lowers their attractiveness to offenders (e.g., Hirschfield et al., 2010) and enhanced sightlines can make guardians more effective (e.g., Newman, 1973). Additionally, Eck (2018) has noted the prominent role of "place managers," including owners and their delegates, not only because they can play the direct role of guardian, but because they shape the opportunity structure of places through the way they organize space, control access to it, and regulate the conduct of those who are there. Together, these ideas suggest that problem properties might express different profiles of crime and disorder according to specific individuals that manage and frequent them and the resultant opportunities.

To illustrate, we might compare two problematic properties: a poorly managed pub and a rental property with an absentee landlord and delinquent tenants. The former might feature many intoxicated patrons who could be either motivated offenders or suitable targets as well as a lack of capable guardians. The latter might feature much more physical disorder owing to negligence by the landlord. Although the tenants are delinquent, the frequency of social disorder or violence might be less than at the pub given the lower foot traffic and opportunities for crime. This illustration of two problematic properties with distinct profiles of crime and disorder may appear somewhat obvious as the opportunity structures in question might directly arise from land use (though see Lee et al., 2021 for an empirical counter-argument emphasizing place management). The activities associated with a pub are more vulnerable to social disorder and violence than those of a rental property. Similarly, Eck et al. (2007) have highlighted "risky facilities" that generate large amounts of crime issues that are characteristic of their opportunity structure, such as shoplifting at retail stores. Likewise, risk terrain modeling leverages land use, including the types of businesses and institutions that are nearby, to differentiate risk levels for various forms of crime (Kennedy et al., 2011). There is the possibility, however, that distinctions in opportunity structure could

[1] The term itself arises from "problem properties interventions," crime-enforcement strategy that has grown in popularity in recent years LISC. 2015. "Addressing problem properties and their impacts.", Way, Heather K., Stephanie Trinh, and Melissa Wyatt. 2013. "Addressing problem properties: Legal and policy tools or a safer Rundberg and safer Austin." Austin, TX: The Entrepreneurship and Community Development Clinic, University of Texas Law School.

create variations in profiles of crime and disorder even within a particular land use.

Studying the profiles of crime and disorder across a set of places requires an analysis of combinations of issues. This has rarely been done. Although many studies have examined multiple types of crime and disorder, they have almost always analyzed them in aggregate as "crime", or identified hotspots and patterns of concentration for each issue separately (e.g., Andresen et al., 2017; Sherman et al., 1989; e.g., Weisburd et al., 2004). The few studies that have examined combinations of issues, however, offer some empirical justification for multiple profiles of crime and disorder, above and beyond "places with all issues" and "places with no issues." Weisburd et al. (2018) distinguished between "drug hotspots," "violent hotspots," and places with both types of issues. Likewise, Yang (2010) found that only ~30% of streets with high disorder also had high violence. This work provides implicit, preliminary evidence that variations in activities, visitors, and opportunity structures might give rise to multiple profiles of crime and disorder across the properties of a city.

Current study

The current study analyzes the distribution of six types of crime and disorder across the residential parcels in Boston, MA. We draw the measures from the City of Boston's administrative records. 911 dispatches offer two measures each of social disorder and violent crime, and reports received by the 311 system offer two measures of physical disorder, providing a full range of types and severity of events. These are the same data sets used by the City of Boston's Problem Properties Task Force (PPTF) to investigate properties, ensuring that the analysis will generate practical insights of immediate utility. The reader will note the use of the term "parcel" from here on. It is a technical term for a single, ownable plot of land that contains one or more properties and is akin to the colloquial "address." It is the scale at which "problem properties" interventions are often exacted.

Limiting the analysis to residential parcels makes for a strong test of our hypothesis that properties can exhibit distinct profiles of crime and disorder even within a specific type of land use. There are indeed multiple types of residential parcels, ranging from single-family houses to apartment buildings. Apart from variations in the volume of residents and visitors, however, these will feature activity patterns that are more similar to each other than they are to, say, those of pubs, retail outlets, or industrial zones. Thus, an omnibus analysis of all parcels would potentially overstate the role of land use in determining profiles of crime and disorder and obscure the possibility that such variation might exist between properties with the same zoning as well. From this logic, we selected residential land use it is the most common in the city (~80% of parcels) and the one most often intervened upon by Boston's PPTF (69% of designated "problem properties").

The study has three objectives. First, we identify a typology of problematic parcels. In contrast to work that focuses on a single measure of crime and disorder, we will be able to observe different profiles of crime and disorder that combine one or more forms of crime and disorder. This would be an original contribution that could also support more nuanced strategies for problem properties interventions (LISC, 2015; Way et al., 2013). We do note the long-standing debate regarding the conceptual and methodological strengths and weaknesses of typologies (Eggleston et al., 2004; Nagin, 2004; Nagin & Tremblay, 2005; Sampson & Laub, 2005; Sampson et al., 2004). Specifically, there must be theoretical reason to believe that a typology in fact exists. Otherwise, the methods used to generate typologies will "find" them in the data even if no such groupings actually exist or have real-world meaning. We have made this theoretical case in the previous section, but there are also statistical safeguards that we take, as we elaborate under "Descriptive Statistics" in the "Results". After identifying the typology, our second step is to use it to better understand which forms of crime and disorder tend to co-locate at parcels (i.e., do they correlate at the parcel level), thereby giving rise to these profiles.

The third goal of the study is to use the newfound typology of problematic parcels to understand the extent to which these localized variations shape the landscape of crime and disorder across neighborhoods. Studies on the localized concentration of crime and disorder often imply that these places, be they hotspots or problem properties, are responsible for the characteristic variety and level of issues in each neighborhood. More recent work, however, has suggested a complementary role between communities and places in determining the distribution of crime and disorder across a city (e.g., Boessen & Hipp, 2015; O'Brien, 2019; Schnell et al., 2017; Steenbeek & Weisburd, 2016; Tseloni, 2006). We bring the typology of problematic properties to bear on this conversation by evaluating whether the distribution of the multiple profiles of crime and disorder accounts for neighborhood-level variations between various types of crime and disorder.

Methods

Data sources

The study utilizes two administrative archives from the City of Boston in 2018: (1) 911 dispatches, including both constituent- and emergency responder-generated cases; (2) requests for government services made to the 311

system. All records include date and time when the issue was reported, the location of the event, and a case type categorizing the issue.

Geographic coordination of data and unit of analysis

We analyze land parcels (i.e., lots that contain one or more properties and an approximation of the colloquial "address"), as identified by the City of Boston's Tax Assessor (Ristea, et al., 2020). Land parcels are nested in census block groups (CBGs).[2]

In 2018, the City of Boston made 664,604 911 dispatches and received 263,105 requests for service through 311. For 911 dispatches, precise address or intersection was not always provided and often reflected the shorthand of the reporter or dispatchers. We thus used latitude and longitude, which were collected separately, to spatially join to the nearest land parcel. This process attributed 616,137 dispatches to an address (93% geocoding rate; 6% of records lacked a lat-long and 1% fell outside city boundaries). Each 311 report was mapped to the nearest known parcel at the time of data entry using lat-long coordinates.[3]

We limited the analysis to the 81,673 parcels classified as a residential land use by the City of Boston's Tax Assessor (of 98,136 total; see Additional file 1: Table S1), including R1, R2, R3, and R4 classification (i.e., single-unit, two-unit, etc.), apartment buildings, and condominiums. As noted in the "Current study" section, we do so to avoid the possibility that the typological analysis would differentiate primarily on land use. To substantiate this concern we provide a brief comparison of event types between residential and commercial land uses in Additional file 1: Table S1, highlighting that the latter have higher overall levels of crime and disorder events.

Data measures

We used six measures of physical disorder, social disorder, and violent crime drawn from administrative records (see Additional file 1: Table S2 for all relevant case types and their frequencies). We drew two indices of physical disorder from 311 requests: private neglect (e.g., housing issues, dilapidation); and public denigration (e.g., graffiti, loose trash). Measures of social disorder and violent crime were drawn from 911 dispatches. The two indices of social disorder were public social disorder (e.g., panhandlers, public drunkenness) and private conflict arising from personal relationships (e.g., landlord-tenant conflicts). The indices of violent crime were public violence that did not involve a gun (e.g., fight) and prevalence of guns (e.g., shootings). The items for all six measures were selected based on substance and confirmed using factor analysis (O'Brien & Sampson, 2015; O'Brien, et al., 2015). In 2018, 1303 calls for service referred to social disorder, 4492 referred to private conflict, 6296 referred to public violence, 1504 referred to the prevalence of guns, 7856 referred to private neglect, and 15,628 referred to public denigration.

At the close of the analysis we examine neighborhood-level variation in and correlations between the six measures of crime and disorder. To maintain consistent interpretations regarding land use, we construct these measures based on events occurring exclusively at residential parcels (i.e., excluding other land uses). As with convention in previous studies, the measures of social disorder and violence are calculated as rates per 1,000 residents at the neighborhood level.[4]

Analysis plan

Typologies of properties

We created typologies of the profile of crime and disorder at residential properties using K-means clustering. K-means is an unsupervised machine learning technique that categorizes a collection of n entities (i.e., parcels in this case) into a pre-determined number of groups (k) based on a set of variables. Estimation begins with an initial set of randomly-generated k means, or centroids, for the input variables, and then categorizes every point in n according to the nearest of these means (by squared Euclidean distance; that is, partitioning space into k Voronoi cells). It adjusts each of the k means to be the centroid of the cases now attributed to it and uses the new means to reclassify all objects in n. This process repeats until there is no change in the categorization of any member of n. Here the features were the six categories of disorder and crime, each normalized before analysis.

There is no definitive way to determine the optimal number of clusters, but the algorithm generates diagnostics for every value of k up to 10. We used three popular

[2] Parcels contain one or more properties (e.g., condo buildings are parcels with a separate property for every unit). However, in official records of events the most granular piece of information is the street address, which does not distinguish between properties within a parcel. For this reason, it is necessary to treat parcels as the most fundamental unit available to analysis. The corpus of land parcels is based on the City of Boston's list of land parcels, which was then condensed slightly by combining distinct land parcels with the same postal address that are sufficiently close to each other as to be indistinguishable in the data.

[3] 100% of reports had a lat-long coordinate attached to them. However, 65,199 cases were mapped to City Hall by default owing to lack of specificity in the information provided. This accounted for 8% of private neglect reports and 20% of public denigration reports. We do not consider this error in geocoding as these cases lacked any meaningful geographic information in the first place.

[4] Analyses were replicated with all measures as counts and as rates. All results are the same; available upon request from the authors.

Table 1 Descriptive statistics for and correlations between the six measures of crime and disorder for parcels

	Neighborhood—level					
	Social disorder	**Private conflict**	**Violence**	**Guns**	**Private neglect**	**Public denigration**
Parcel—level						
Social disorder	1	0.09***	0.15***	0.10***	0.04***	0.07***
Private conflict		1	0.17***	0.10***	0.11***	0.06***
Violence			1	0.14***	0.11***	0.07***
Guns				1	0.05*	0.02***
Private neglect					1	0.20***
Public denigration						1
Mean (range)	0.02 (0–12)	0.06 (0–17)	0.08 (0–25)	0.02 (0–31)	0.09 (0–31)	0.19 (0–71)
% Total parcels	1.32	4.20	5.10	1.46	5.74	9.60

81,673 residential land parcels

***p < 0.001

techniques for interpreting this information—the "elbow test", the silhouette score, and Tibshirani's Gap-Statistics. There is also, as with all data reduction techniques, the need for the analyst to make judgments based on domain knowledge. We provide more details on these techniques and the evidence that informed the final number of clusters in Additional file 1.

Spatial distribution of types of problematic properties

Our final research objective is how different types of problematic parcels cluster systematically across the city. We again used K-means clustering. This time, CBGs acted as the unit of analysis and the prevalences of each type of problematic parcel identified in the parcels-level cluster analysis were the features of interest.[5] The prevalence of a given type of parcel was calculated as the proportion of residential parcels in a CBG falling into that category, which we then normalized using mean and standard deviation.

Results

Descriptive statistics

All six types of crime and disorder occurred at only a small proportion of parcels, ranging from 1.3% of parcels for public social disorder to 9.1% of parcels for public denigration (see Table 1). Meanwhile, correlations between types of crime and disorder across parcels were modest at best (see Table 1 for all parameters). The highest were between private conflict, public violence, and gun-related events (r's = 0.10–0.17, all p-values < 0.001), and others were even smaller (r's = 0.01–0.15, all p-values < 0.001). Albeit, all correlations were significant, but this is owed to the large number of parcels. Between the rarity of events and the low correlations between them, it would not only seem feasible that problematic parcels express one of multiple profiles of crime and disorder—justifying a typological approach—but that they might even specialize in a single type of issue.

Types of problem properties

To identify different profiles of crime and disorder across parcels, we applied K-means clustering to the six measures of interest. Using diagnostic tests, we determined that six was the optimal number of clusters (see Additional file 1: Section B for these and an assessment of the empirical justifiability of the clusters). The six clusters, whose characteristics are described in Table 2, might be organized into three groupings, ordered in terms of their prevalence.

- 93.28% of parcels generated little or no crime or disorder.
- About 6% of parcels fell into one of four "single-issue" groupings. These featured elevated levels of either private conflict (3.7% of parcels), gun-related events (1.4% of parcels), public denigration (1.0% of parcels), or private neglect (0.6% of parcels), but very few instances of other types of issues. Confirming the characterization of each of these groups as specializing in a single-issue, we note that properties in these four categories rarely experienced other types of issues (see Table 2). Overall, these multi-issue overlaps were typically in the range of 10% of parcels in a category or lower, and almost always under 30%, and featured very low frequencies (all such overlaps averaged < 1 event per parcel).

[5] We excluded the most common type of parcel, which featured no disorder or crime, in order to prevent a singularity because the proportion of all types would otherwise add up to 100% in every CBG.

Table 2 Frequencies of types of parcels generated by K-means cluster analysis and their average expression of six indicators of crime and disorder (and percentages of parcels with any such events)

Cluster	No. of parcels	Social disorder	Private conflict	Violence	Guns	Private neglect	Public denig.
Violent hubs	138	1.66 (62.3%)	1.39 (49.3%)	6.51 (96.4%)	0.53 (32.6%)	0.55 (25.4%)	0.77 (33.3%)
Private neglect	504	0.05 (4.6%)	0.39 (22.2%)	0.40 (24.2%)	0.02 (2.2%)	4.60 (100%)	0.98 (48.4%)
Public denigration	827	0.07 (5.6%)	0.11 (8.6%)	0.17 (11.7%)	0.02 (2.2%)	0.60 (32.9%)	7.18 (100%)
Guns	1,112	0.09 (8.0%)	0.23 (17.1%)	0.45 (26.8%)	1.25 (100%)	0.19 (13.6%)	0.18 (13.0%)
Private conflict	2,989	0.04 (4.0%)	1.26 (100%)	0.27 (18.3%)	0.001 (0.3%)	0.17 (13.7%)	0.19 (14.8%)
No patterns	76,103	0.01 (0.9%)	0	0.05 (3.9%)	0	0.05 (4.4%)	0.11 (8.1%)

Table 3 Percentages of each parcel type in each CBG cluster

	Violent Hubs (%)	Public Denigration (%)	No Patterns (%)	Private Conflict (%)	Private Neglect (%)	Guns (%)
Minimal crime and disorder	0.1	0.5	96.4	2.0	0.4	0.5
Moderate-to-higher crime	0.2	0.7	83.8	7.7	2.3	5.3
Moderate crime	0.2	0.6	89.6	6.5	0.6	2.5
Highest crime	3.7	3.3	77.7	10.9	2.3	2.1
High public denigration	0.2	16.6	78.2	4.0	0.3	0.8

- The least common profile consisted of violent hubs that experienced a mixture of violence, public social disorder, private conflict, and gun-related events, sometimes accompanied by either form of physical disorder (0.2% of parcels).

It is worth noting that residential parcels come in multiple forms, which can have implications for the distribution of the profiles of crime and disorder (see Additional file 1: Table S3 for distribution of types of parcels across land use categories). Buildings with more units, especially those with 7 or more apartments, were substantially less likely to fall in the "no problems" grouping. Most notably, these large apartment buildings were nearly 10 times as likely to be violent hubs as other types of residential parcels, while also having elevated proportions of all other profiles of crime and disorder. This is likely a product of the greater number of people living in and visiting a parcel with more units but could also be associated with the socioeconomic status of individuals living in buildings with more units; the latter would explain why condo buildings had a distribution of profiles more similar to other residential types, despite having as many units as apartment buildings. Nonetheless, all profiles of crime and disorder were represented in each category of residential land use. Also, parcels with fewer units are more common, meaning that there are nearly as many violent hubs at single- or two-family houses as apartment buildings. Thus, while there are differences across residential land uses, they do not appear to have driven the typology generated by the K-means cluster analysis.

The co-location of types of problem properties in neighborhoods

The typology of properties developed in the previous subsection offers a new vantage point for describing neighborhoods. To leverage this we conducted a second K-means cluster analysis for CBGs using five measures, one for the proportion of residential parcels exhibiting each of the five problematic profiles (excluding the group with no meaningful crime or disorder; see details in the "Methods" section).

The K-means analysis revealed five types of neighborhoods (see Table 3 for percentages of each parcel type in each neighborhood cluster; see Additional file 1: Section B for choice of five neighborhoods). The most common grouping (53% of CBGs) had no meaningful concentration of problematic parcels. Among the other four, three appear to create a traditional spectrum for levels of crime and disorder. The second most common grouping (28% of CBGs) featured a moderate concentration of two types of problematic parcel: those that primarily generated issues of private conflict (6.5% of parcels) and those with gun-related events (2.5% of parcels). The next most common grouping (12% of CBGs) had higher levels of each of these types of problematic parcels as well as a higher number of parcels that primarily generated issues of private neglect (7.7%, 5.3%, and 2.3% of parcels,

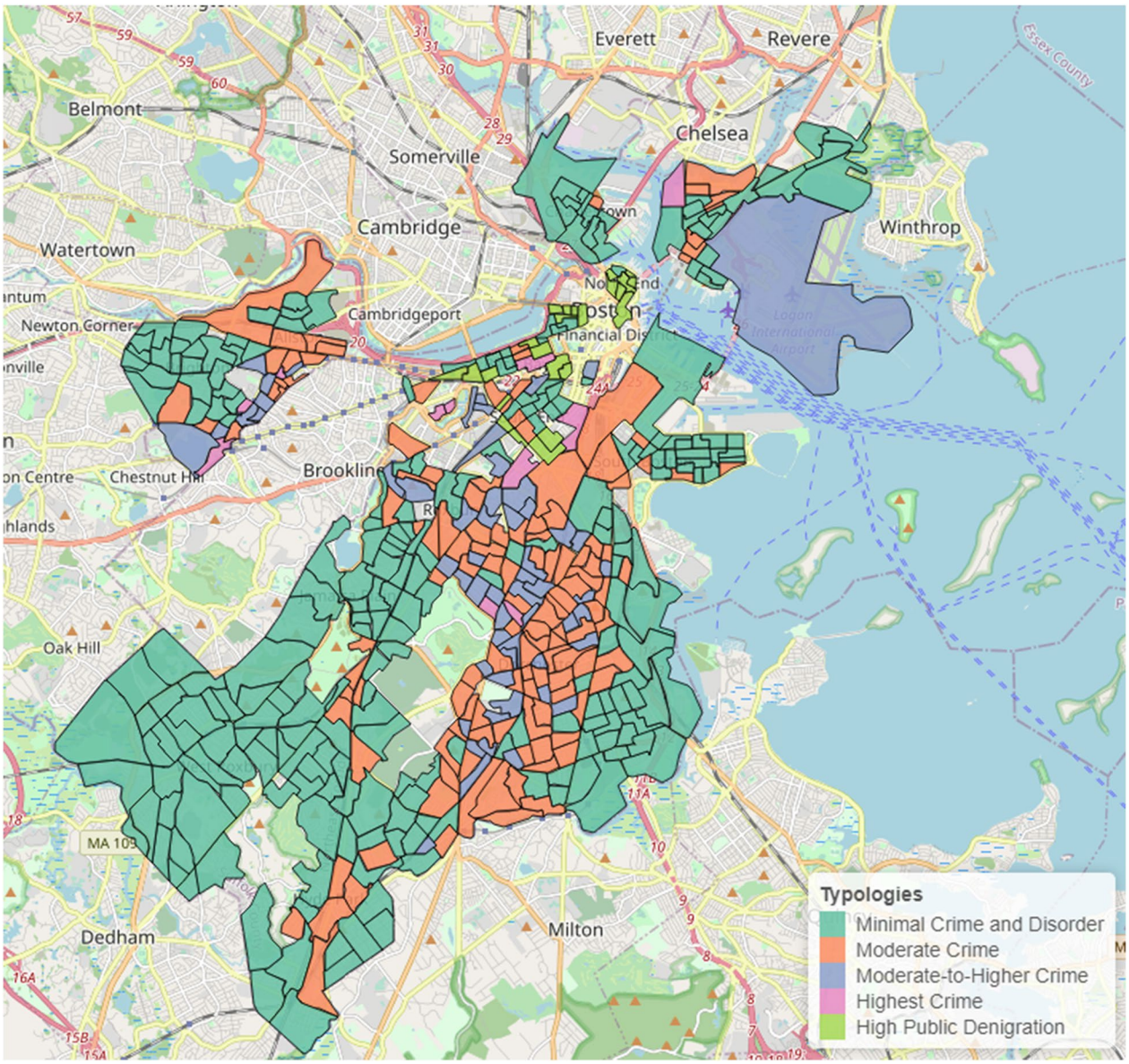

Fig. 1 Categorization of CBGs by K-Means based on the prevalence of different types of problematic parcels. See Table 3 for prevalence of each of the five types of problematic parcels in each of the five types of neighborhoods

respectively). The least common grouping (2% of CBGs) had a similar profile, but parcels with gun-related events were largely replaced by a preponderance of violent hubs (2.3% and 3.7% of parcels, respectively). Notably, violent hubs were nearly 20 times more frequent here than in any other type of neighborhood.

The last remaining and fourth-most common neighborhood (5% of CBGs) had a concentration of parcels that generated issues of public denigration (16.6% of parcels) but no other concentration of note. This stands out in two ways. First, no other neighborhood had a concentration of this type of problematic parcel. Second, it appears to set parcels with public denigration (e.g., trash violations, graffiti) geographically apart from those with social disorder, violence, and private neglect (e.g., dilapidation).

We mapped these five categories across the city (see Fig. 1). The CBGs with no concentrations of problematic parcels were generally at the borders of the city in more affluent neighborhoods known to be low in crime and disorder. Moving toward the interior of the city and its majority-minority neighborhoods we see more

Table 4 Relationship between variance in each measure of crime and disorder and distribution of problem properties, include proportion of variance described by the typology of neighborhoods based on their problem properties (left) and the coefficient of variation (CV) across neighborhoods (right) with and without parcels with 5 or more reports of crime or disorder

	R^2 of Nbhd. typology	CV w/all parcels	CV w/o parcels w/< 5 events	Prop. Δ CV
Social disorder	0.10***	1.10	0.98	0.11
Private conflict	0.27***	0.81	0.79	0.02
Violence	0.23***	0.89	0.85	0.04
Guns	0.26***	1.42	1.28	0.10
Private neglect	0.11***	0.68	0.63	0.07
Public denigration	0.49***	1.42	0.97	0.32

$N = 473$ census block groups with 20 or more parcels

***$p < 0.001$

neighborhoods with a greater prevalence and severity of problematic parcels. The CBGs with many parcels with high public denigration were in the downtown portion of the city (northern area along the harbor). These impressions were confirmed by the observation that the neighborhood typologies were associated with racial composition (i.e., proportion of residents White, Black, Latinx, Asian) and median income (i.e., using an ANOVA to explain the variance in these demographic characteristics; R^2s = 0.24–0.31).

How do problem properties relate to neighborhood-level patterns in crime and disorder?

Having observed the distribution of the five types of problematic parcels across neighborhoods, we conclude by examining the extent to which the distribution of problematic parcels aligns with and explains neighborhood-level patterns of crime and disorder. We do this by first examining the extent to which variance in neighborhood-level rates of each form of crime or disorder is explained by the distribution of problematic parcels, as defined by the typology of neighborhoods generated in the previous section. This is done using ANOVA tests (all results in Table 4, left panel). In these regards, the six types of crime and disorder broke out into three sets. First, about a quarter of the variance in private conflict, public violence, and gun-related events were explained by the types of neighborhoods ($R^2 = 0.23$–0.27, p-values < 0.001). Second, the types of neighborhoods were less explanatory for variation in public social disorder and private neglect ($R^2 = 0.10$–0.11, p-value < 0.001). They were most explanatory for public denigration ($R^2 = 0.49$, p-value < 0.001), indicating that properties with much public denigration tended to be in the neighborhoods that had the most public denigration.

To further investigate whether properties with outstanding amounts of crime and disorder are in fact responsible for neighborhood-level variance in crime and disorder, we examine coefficients of variation (CV) with and without these most problematic parcels. We separate out parcels with 5 or more issues because the typology of parcels placed many parcels with as few as 1 instance of disorder or crime in a "problematic" categories; 5 or more issues is the City of Boston's PPTF requirement for an investigation. We calculated CV for each of our six metrics, once for total events in a neighborhood, the second for events occurring at parcels with fewer than five events, effectively isolating the impact of the most problematic parcels on cross-neighborhood variation.[6]

CVs were minimally diminished when limiting to properties with fewer than five instances of crime and disorder (see Table 4 for all results). They dropped by about 1/10th or less for public social disorder, gun-related events, private neglect, and private conflict (prop. Δ CV = 0.02–0.11). The drop was greater for public denigration, though still below half (prop. Δ CV = 0.32). This indicates that the most problematic parcels explain only a small amount of the neighborhood-level variance in crime and disorder, except in the case of public denigration. To confirm that these results were not merely an artifact of the threshold of 5 or more issues, we re-ran the analysis removing parcels with 3 or more issues and 7 or more issues. The results were nearly identical (see Additional file 1: Table S4).

Discussion

The analysis identified five distinct profiles of disorder and crime across the residential parcels in Boston, MA. Notably, four of these five types specialized in a single type of issue—public denigration, private neglect, private conflict, or gun-related events—to the exclusion of others. The one exception was the "violent hubs," which

[6] For this analysis we limit to 473 CBGs with 20 or more parcels to ensure that variation will be meaningful even after removing parcels with many issues.

suffered from all types of issues. When mapped across neighborhoods, these problematic parcels depicted a traditional spectrum from low- to moderate- to high-crime residential neighborhoods. The combinations and prevalences of types of problematic parcels steadily increased along this spectrum; notably, violent hubs were isolated almost entirely to the most troubled neighborhoods. There was also a distinct class of neighborhoods with a large amount of commercial or institutional zoning whose problematic residential parcels primarily specialized in public denigration. Upon further examination, problematic parcels were consistent with the overarching levels and types of crime and disorder in their neighborhoods, but they did not explain them, except in the case of public denigration. This suggests that for all the attention that problematic parcels merit, much of the cross-neighborhood variation we observe is still driven by parcels that have only episodic instances of crime or disorder.

First, the findings contribute to the rich literature that has highlighted the distinction between places that do and do not have problems, including comparisons of quantity of crime and disorder across street segments (Andresen & Malleson, 2011; Braga et al., 2010; Lee et al., 2017; Weisburd, 2015), addresses (Farrell & Pease, 2001; Johnson et al., 2007; O'Brien, 2019; O'Brien & Winship, 2017; Trickett et al., 1992; Tseloni, 2006), and facilities within a class of land use (e.g., motels, bars; Eck et al., 2007). In contrast to this work, we have examined the combinations of crime and disorder that tend to occur at problematic parcels, revealing qualitative differences between them—that is, variation not just in the quantity of crime and disorder at problematic parcels but also in the nature of crime and disorder occurring there.

The profiles of crime and disorder exhibited by problematic parcels tended to specialize in a single type of issue. As such, a parcel suffering from physical disorder did not necessarily also generate social disorder or violence, and vice versa. This was not an inviolable rule, and a close look at Table 2 reveals a crucial nuance. In the four profiles of crime and disorder that captured concentration of a single type of issue, most properties did not experience any other types of issues, though there were certainly those that did. In fact, parcels included in one of these profiles were substantially more likely to experience these other issues than the average parcel. The profiles, therefore, captured concentrations of a single type of issue where other types of issues were possible but were neither likely to reach a high prevalence nor predictable for a given profile. The primary exception to this was violent hubs, which combined all types of issues. Violent hubs were extremely rare (0.2% of parcels), further illustrating how uncommon it was to observe concentrations of multiple types of issues at a single parcel.

The tendency for each problematic parcel to have a concentration of a single type of issue might be understood in terms of routine activities and related theories. Each place is characterized by the people who frequent it; their propensity to be offenders, victims, and guardians; and the activities and contextual factors that influence their likelihood to operate in each of these ways (Brantingham & Brantingham, 1984; Cohen & Felson, 1979). Landlords play a salient role in the latter, even when not physically present, in the decisions they make for managing the property. Our analysis was limited to residential parcels, thereby constraining to the informal, non-commercial activities of residents, property owners, and their visitors. This makes the specialization even more striking as something about the individuals involved or their interpersonal dynamics appears to have made them prone to experiencing one type of issue repeatedly while not necessarily experiencing others. For instance, a property with a neglectful landlord may generate large amounts of physical disorder, but that does not guarantee that the tenants are also disorderly. A family may have internal strife that manifests in domestic dispute calls, but those challenges need not bear upon the upkeep of their property. These simple examples serve to highlight how parcels within a neighborhood vary not only in their levels of crime but can also be problematic in different ways.

Not all residential parcels are equivalent, however. Most simply, they range in quantity of units from single-family homes to large apartment buildings. As the number of units in a building grows there will be more residents and visitors and more varied interactions between them. This has the potential to increase the likelihood that any household therein might specialize in a single issue while also diversifying the types of issues that might occur there. We see this most clearly in apartment buildings. First, they were more likely to have each of the single-issue profiles of crime and disorder. Second, they were ten times more likely to be violent hubs than other parcels. Many of these might in fact contain multiple units specializing in different types of issue. That said, violent hubs were not completely an artifact of multi-unit buildings as they were represented in all categories of residential parcels, including single-family homes. This pointed to a more general lesson that the profiles of crime and disorder identified here were not a mere function of different types of residential parcels.

The distribution of problematic parcels across the city also sheds new light on the complementary roles of places and communities in explaining the distribution of crime across the urban landscape. Whereas the parcels

themselves tended to specialize in a single form of physical disorder, social disorder, or violence, they clustered together spatially to reveal the traditional spectrum from low- to high-crime communities (albeit, setting aside the commercial zoning-heavy neighborhoods that had a density of parcels with many instances of public denigration). In other words, the confluence of problems that we often define as "high-crime communities" arises from the aggregation of many parcels experiencing their own characteristic set of issues.

Importantly, although problematic parcels were consistent with the level and types of crime in their neighborhood, they did not explain them. Properties with 5 or more issues explained only a small amount—1/10th or less—of the proportion of neighborhood-level variation in most of the six measures; the only exception was concentrations of public denigration. Thus, a neighborhood is not just the sum of its problematic parcels. Instead, there is some underlying tendency toward certain patterns of crime and disorder that characterizes the neighborhood and is manifest in parcels that experience only the occasional issues. This stands in contrast to the growing body of work that has found that crime is more concentrated at addresses than streets, and on streets than in neighborhoods (e.g., Boessen & Hipp, 2015; O'Brien, 2019; Schnell et al., 2017; Steenbeek & Weisburd, 2016; Tseloni, 2006). These studies have all used multilevel models to decompose variance across geographic scales, but this can overemphasize variance at more localized scales owing to a heavy representation of units with zero issues.[7] Our approach avoided this pitfall by assessing neighborhood-level variation with and without problematic parcels. As such, the results reveal tangibly how neighborhoods still matter, evincing characteristic levels of various forms of crime and disorder even when setting aside their most prominent parcels.

Last, the findings here hold valuable implications for problem properties policies and interventions.[8] First, when policymakers speak about "problem properties," they are often most concerned with the "violent hubs" we saw here and their ilk, which are both the least common and most problematic places in the city. This perspective is a holdover from the early 1990s, when such policies were designed to eliminate illicit economic activities, like drug dealing and prostitution (LISC, 2015; Way et al., 2013). Modern approaches have since broadened to any location that persistently generates inordinate amounts of crime and disorder, but they still use the same set of strategies originally designed for the most troubled of properties. If, as the results here indicate, there are multiple types of problem properties, each with a characteristic profile of crime and disorder and underlying routine activities, then there will need to be a more nuanced toolbox for interventions. For instance, a parcel with large amounts of physical disorder might require a different form of support and enforcement than one with large amounts of private conflict or violence. Developing and implementing these differentiated strategies is both a challenge and opportunity for enhancing the effectiveness of problem properties policies and programs.

Limitations and further research

There are some limitations that call for further research. First, the analyses conducted here were on a single city and need to be replicated in other locales, especially those of different sizes and urban form (e.g., European cities, cities in the Western United States with lower density). Second, the records used here are reported mainly by constituents, meaning they are potentially an incomplete representation of crime and disorder at places in the city. Neighborhoods differ in their propensity for reporting issues (Klinger & Bridges, 1997; O'Brien et al., 2015), and it would be best to replicate this work with other measures of crime that are not as subject to such tendencies (e.g., crime reports, victimization surveys). That said, a cross-validation of multiple data sets has suggested that patterns of concentration of crime and disorder might be robust to these biases (Hibdon et al., 2017). Third, we have limited our analyses to residential parcels to simplify interpretation. Additional studies will need to be conducted on other types of land use, especially commercial parcels and districts, whose high levels of foot traffic tend to generate distinctive patterns of routine activities.

In sum, it is important not to overgeneralize the precise results of this study—the specific types of parcels and neighborhoods identified—but to concentrate on their overarching story. Problematic parcels differ not only in their quantity of crime but also in the types of issues they experience, which may often feature specialization in a single type of issue. This has important implications for how we understand the routine activities that occur there; the role they play relative to other parcels in the neighborhood; and the way we design interventions to best support them and their communities.

[7] Suppose, as we saw here: (1) > 90% of parcels have no issues; (2) a handful of others have dozens; and, consequently, (3) nearly all streets and tracts, even those with multiple problematic parcels, are composed predominantly of parcels with no issues. In such a situation, the proportion of variance attributed to the parcel level will necessarily be very high relative to streets and tracts. Thus, although there will be statistically significant *amounts* of variance at the higher-order levels, they will account for a modest proportion of the total variance.

[8] Although our analysis was of parcels, we transition back to referring to properties, as this is the standard in intervention strategies.

Supplementary Information

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Additional file 1: Table S1. Average number of events per parcel in 2018 for each of the six measures of violence, physical disorder, and social disorder, broken out by land use type. **Table S2.** Case types composing measures of violence, physical disorder, and social disorder and their frequencies in 2018. **Table S3.** Percentage of parcels falling in each of the six categories of parcel for each type of residential land use. **Table S4.** Coefficient of variation (CV) for neighborhood-level measures of crime and disorder with and without parcels with 5 or more reports of crime or disorder. **Figure S1.** Scree plot for elbow test depicting within-class variance for the optimized result for different levels of *k* in the K-means cluster analysis for types of parcels based on their events of crime and disorder. **Figure S2.** Plot of silhouette values for the distinction between points within and between clusters for the optimized result for different levels of *k* in the K-means cluster analysis for types of parcels based on their events of crime and disorder. **Figure S3.** Plot of Tibshirani's Gap-Statistics for the intra-cluster variation relative to expectations in a hypothetical distribution with no clustering for the optimized result for different levels of *k* in the K-means cluster analysis for types of parcels based on their events of crime and disorder. **Figure S4.** Cluster analysis for parcels grouped along two main dimensions. **Figure S5.** Scree plot for elbow test depicting within-class variance for the optimized result for different levels of *k* in the K-means cluster analysis for types of census block groups based on their problematic parcels. **Figure S6.** Plot of silhouette values for the distinction between points within and between clusters for the optimized result for different levels of *k* in the K-means cluster analysis for types of census block groups based on their problematic parcels. **Figure S7.** Plot of Tibshirani's Gap-Statistics for the intra-cluster variation relative to expectations in a hypothetical distribution with no clustering for the optimized result for different levels of *k* in the K-means cluster analysis for types census block groups based on their problematic parcels.

Author contributions

DTO wrote the paper, oversaw the research, and procured funding. AR edited the paper, led analysis, and contributed to paper conceptualization. FH contributed to analysis and data management, edited the paper, and contributed to paper conceptualization. RT edited the paper and contributed to paper conceptualization.All authors read and approved the final manuscript.

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Declarations

Competing interests

The authors declare that they have no competing interests.

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