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Assessing the Differential Impact of Vacancy on Criminal Violence in the City of St. Louis, MO

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Abstract

This study employs risk terrain modeling to identify the spatial correlates of aggravated assault and homicide in St. Louis, MO. We build upon the empirical literature by (1) replicating recent research examining the role of vacancy in the concentration of criminal violence and (2) examining whether the environmental correlates of violence vary between north and south St. Louis, a boundary that has long divided the city along racial and socioeconomic lines. Our results indicate that vacancy presents a strong, consistent risk for both homicide and aggravated assault and that this pattern emerges most clearly in the northern part of the city which is majority African American and has suffered chronic disinvestment. The concentration of criminal violence in South City is driven primarily by public hubs including housing, transportation, and schools. Our results underscore the importance of vacancy as a driver of the spatial concentration of violent crime and point to potential heterogeneity in risk terrain modeling results when applied to large metropolitan areas. Situational crime prevention strategies would be well served to consider such spatial contingencies as the risk factors driving violent crime are neither uniformly distributed across space nor uniform in their impact on criminal violence.

Keywords

GIS, risk, violence, vacancy, modeling

Empirical research demonstrates that levels of interpersonal violence are not evenly distributed across urban areas. Crime rates vary substantially from neighborhood to neighborhood, even from street to street within the same neighborhood (Weisburd et al., 2012). There is general consensus that

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the spatial concentration of urban violence is intricately linked to the socioeconomic composition of an area and features of the local built environment (see Vogel & Messner, 2019, for a recent review). A growing body of research highlights the ways in which *micro-places*—often conceptualized as street segments or addresses—affect the spatial concentration of crime. A common observation is that approximately 5% of all addresses in a city account for 50% of all crime (Weisburd, 2015). Research in this area often focuses on identifying features of the built environment that either *generate* or *attract* crime (Brantingham & Brantingham, 1993). Indeed, the literature is replete with studies demonstrating the role that bars, parks, and entertainment venues play in crime concentration.

While there has been some recognition that the factors driving the spatial distribution of violence vary from city to city, considerably less attention has focused on the differential impact of these features *within* urban areas. This is an important oversight. After all, elements of the local environment that attract and generate crime are not uniformly distributed across cities. Nor is there a good reason to suspect that their influence on crime will be uniform across places. For instance, a nightclub might provide greater opportunity for interpersonal conflict in a poorly regulated downtown neighborhood than in a highly regulated college neighborhood. Most American cities are characterized by some degree of segregation: Resources, public investment, and local facilities are often disproportionately distributed along racial and socioeconomic lines. It follows that the factors driving interpersonal violence in certain areas of cities differ both in concentration and influence from other areas.

The current study builds upon and moves beyond the empirical literature in two key regards. First, we employ risk terrain models to examine how vacancy, a crime attractor implicated in recent research, contributes to the spatial concentration of homicides and aggravated assaults in the city of St. Louis, MO. In this effort, we answer recent calls to address the dearth of replication studies in the discipline (Pridemore et al., 2018; Savolainen & Van Eseltine, 2018) and further develop the nascent understanding of the relationship between vacancy and crime. Second, we extend prior research by examining whether the influence of vacancy on interpersonal violence varies between North and South St. Louis, long divided along racial and socioeconomic lines. Our results largely confirm the importance of vacancy in the spatial concentration of interpersonal violence in North St. Louis, replicating findings from studies conducted in Akron, OH, and Baton Rouge, LA (Porter et al., 2019; Valasik et al., 2019). The spatial concentration of criminal violence in South City is more strongly linked to points of travel, such as light rail stations and gas stations, and public hubs, such as housing and schools.

Literature Review

Environmental Criminology

Environmental criminology posits that criminal decision making is influenced in large part by environmental context (Bernasco & Luykx, 2003). With theoretical roots dating back to the mid-1850s, the original *application* of environmental criminology came in the form of Park and Burgess's concentric zone theory of urban expansion (1925). Shaw and McKay's (1942) observation that (1) rates of juvenile delinquency clustered in areas characterized by high levels of residential turnover, ethnic heterogeneity, and socioeconomic disadvantage and (2) these trends remained relatively stable over time, provided some of the earliest evidence that characteristics of places, above and beyond the characteristics of the people living within, were consequential for understanding the concentration of crime within cities.

Contemporary explanations for the spatial distribution of urban crime coalesce around three complementary perspectives: routine activity theory, rational choice theory, and crime pattern theory. Routine activity theory (Cohen & Felson, 1979) argues that the key elements of a criminal event are the presence of a motivated offender, a suitable target, and the absence of capable guardianship. Crime is higher in places in which targets abound and guardianship wanes. Rational choice theory assumes that offenders make deliberate decisions to engage in criminal conduct (Cornish & Clarke, 1986). Characteristics of the local environment factor into the cost–benefit analysis and render some places more desirable for criminal conduct than others (see also Bernasco, 2010; Bernsaco & Luykx, 2003; Groff, 2007). Crime pattern theory identifies crime attractors and generators that facilitate the *opportunity* to commit crime. Crime attractors are spaces familiar to potential offenders and thus opportune for criminal acts. A particular street known for sex work is one example. On the other hand, generators are not necessarily known for criminal activity, but rather they provide ease of access to opportunities for criminal action, like a shopping mall or a concert venue. In some cases, these conditions remain constant or occur with discernable regularity, leaving certain places perpetually more vulnerable to crime (Brantingham & Brantingham, 1993).

Vacancy and Crime

Emerging research suggests that vacancy is a particularly salient driver of interpersonal violence (Boessen & Chamberlain, 2017; Porter et al., 2019; Valasik, 2018). However, findings regarding the relationship between crime and vacancy have thus far proven inconclusive (see Wo, 2019; Spelman, 1993). Vacant homes convey a general absence of informal social control. They also provide physical shelter for illegal activity, such as drug sales, to be conducted away from prying eyes. Underground markets are "stateless" social locations that bring together sellers and buyers who have little formal recourse to settle disputes. Those engaged in underground activity are especially attractive targets for theft and robbery. Areas with high levels of vacancy may place upward pressure on criminal conduct by concentrating targets (e.g., those engaged in crime) and limiting guardianship, ultimately contributing to higher rates of interpersonal violence. For instance, Bernasco and Block (2010) highlight the importance of "home like" anchor points (p. 36) referring to vacant buildings or vacant lots where criminally inclined individuals tend to congregate. Consistent with this theme, Porter and colleagues (2019) find that offenders report vacant homes to be "opportunistic because they provide cover, unoccupied spaces, and are easy targets." Similarly, Valasik et al. (2019) report that homicide tends to cluster around vacant properties in Baton Rouge, LA. In a randomized control of Philadelphia neighborhoods, Branas and colleagues (2018) reported significant reductions in crime around vacant properties that had been restored compared to those that remained blighted.

The effect of vacancy on crime is largely unique from other factors of the built environment. Retail establishments typically thought to influence crime, especially those involving cash (Bernasco & Block, 2010), are of higher prevalence in areas of greater economic development. Vacancy, however, is a signal for urban decline. It is suspected that vacancy plays an outsized effect compared to other environmental factors influencing crime (Valasik et al., 2019). Chui and Walsh (2015) found as high as a 19% increase in violent crime rates following a property becoming vacant. In a study of Baton Rouge, Chen and Rafail (2019) found correlations between housing vacancy and both neighborhood-level property crime and violent crime. Importantly, they also found a spatial effect from the rate of vacancy. The rate of housing vacancy in surrounding neighborhoods "increases drug selling and use, property crime, and violence" (Chen & Rafail, 2019, p. 20).

Vacant lots and buildings may also influence crime independently of one another. While a vacant building may afford shelter for illegal activity, a vacant lot offers no such benefit while signaling a similar lack of guardianship. Likewise, it is important to distinguish between vacant lots and buildings for the variation of interventions between them. That is, higher associated risk with vacant buildings suggests demolition would be an effective prevention strategy, while higher associated risk with vacant lots suggests lot remediation tactics. Porter et al. (2019) found a 7% reduction in calls for serious crime following the razing of a vacant building. They argue the building was near a liquor store and car wash known for illicit drug sales and suggest that the vacant building may have afforded the opportunity to consume either of the proximally available substances. Stacy (2017) also observed a reduction in crime of about 8% following the demolition of a vacant building, with the greatest impact within the first 2 months following demolition. Branas et al. (2018) observed a 13% reduction in crime overall and a near 30% reduction in gun violence following vacant lot remediation. Wheeler et al. (2018) also found reductions in crime following the demolition of vacant buildings but found statistically significant results for only a small radius. It seems that vacancy remediation is a potential target for crime reduction, but that a further understanding of the effect of vacancy on crime is necessary.

Risky Places and RTM

Inherent in the notion of attractors and generators is the assumption that the capacity for crime varies from place to place. Kennedy and Caplan's (2012) theory of risky places proposes that *exposure* and *vulnerability* help explain this variation. Specifically, they argue that (1) risk is present everywhere, but the differential impact of spatial factors leads to a gradient of risk across space and time, (2) areas with greater vulnerability are generally where crime occurs, and (3) how risk results in higher levels of crime are dependent on variable degrees of vulnerability and exposure. From this understanding of risky places, one can then effectively analyze "the processes whereby crime emerges, persists, or disappears" (Kennedy & Caplan, 2012, p. 62). Risk terrain modeling (RTM) has emerged as the predominant method for assessing the relationships between environmental risk factors and criminal conduct. Originally proposed by Caplan et al. (2011), RTM has advanced the study of environmental criminology from retrospective analysis, such as hotspot mapping, to predictive modeling. RTM provides an alternative to offender-based predictive models by providing predictive analytics based on environmental risk factors. It is a "systematic plan of action for studying spatial vulnerability to crime" (Caplan & Kennedy, 2016, p. 11).

RTM has not only real-world applications in terms of informing policing strategies and resource allocation but also a novel means for community-based violence prevention activities. There has been a recent development in recognizing violence as a public health issue (Wen & Goodwin, 2016) akin to an infectious disease that spreads among individuals and within communities. As such, there have been calls to better integrate the research methods and findings of criminology and public health (Akers & Lanier, 2009). RTM is a vehicle for collaboration across these two disciplines, as it offers both policing strategy and insights for environmental remediation. Public health agencies have authority over local ordinances (e.g., liquor licensing) but also can collaborate with municipal governments and other groups to spearhead, for example, vacancy abatement efforts. In this sense, RTM provides not only a means of proactively distributing police resources but also a mechanism to intervene in areas before problems manifest. Over the past 10 years, RTM has been applied in a variety of contexts to understand a range of criminal acts such as terrorism (Marchment et al., 2019; Onat, 2019), property crime (Andresen, 2018; Dugato et al., 2018; Lersch, 2017; Moreto et al., 2014), gang violence (Valasik, 2018), drug crime (Escudero & Ramírez, 2018), child abuse (Daley et al., 2016), robbery (Barnum et al., 2017; Caplan et al., 2015, 2017; Connealy & Piza, 2019; Drawve et al., 2016), and both homicide and aggravated assault (Drawve & Barnum, 2018; Gerell, 2018; Giménez-Santana et al., 2018; Kennedy et al., 2016; Thomas & Drawve, 2018; Valasik et al., 2019).

It is important to note that much prior research applies RTM in the context of an entire metropolitan area, implicitly assuming that environmental risk factors are uniform in both distribution and effect. We argue that this assumption may be premature. For instance, Haberman and colleagues found that the effect of public housing, a considerable risk factor for interpersonal violence, on robbery varied significantly across Philadelphia neighborhoods, underscoring potential spatial heterogeneity in the influence of crime attractors within a metropolitan area itself. Similarly, Barnum et al. (2017) report that risk factors for robbery were similar but not identical across three U.S. cities, suggesting that the effects of crime attractors and generators are context-dependent. Connealy (2019) finds similar results in a risk terrain modeling analysis spanning three cities and ultimately suggests "intervention efforts cannot be seamlessly transferred across jurisdictions" (p. 21). Given the well-established observations that both crime and its correlates are differentially distributed within urban areas, it follows that the environmental features that attract and generate crime are neither uniformly distributed nor uniform in their effect within cities. Such spatial contingencies would have important implications for both proactive policing and environmental risk remediation, suggesting that a one-size-fits-all approach would have a limited effect on violence reduction. We interrogate this well-held assumption by examining whether risk varies meaningfully within St. Louis, a city long divided along racial and socioeconomic lines.

Current Study

Spatial Bifurcation of Risk in St. Louis, MO

St. Louis is one of the most racially and economically segregated cities in the country. Even before the great migration of African Americans from the south in the first half of the 20th century, St. Louis was characterized by a high degree of segregated housing. A variety of instruments were used throughout the 20th century to maintain this segregation, including restrictive deed covenants, zoning that inhibited the construction of multifamily units and redlining that restricted the amount of funds available for residential investment (Rothstein, 2017). Attempts at urban renewal further entrenched the issues of segregation by focusing predominantly on commercial developments and neglecting decline in residential neighborhoods (Gordon, 2008). These efforts left much of the city's north side vacant. Vacancy proliferated in regions deemed undesirable for investment, and retail establishments became less prominent as a result.

The combination of these policies has concentrated socioeconomic disadvantage in the city's north side. The dividing line of this disadvantage has been colloquially named the "Delmar Divide" in reference to Delmar Boulevard, a 10-mile-long east–west thoroughfare that splits the city into north and south. The population north of Delmar Blvd. is predominantly African American. The median home value above Delmar Blvd. is US$78,000, which is nearly a quarter of the median value of homes in the area south of Delmar (US$310,000). There are also stark differences in income and educational attainment. Only 5% of residents 25 years or older in the area north of Delmar have a bachelor's degree or higher, compared to 67% south of Delmar (Purnell et al., 2014, p. 29). Perhaps not surprisingly, violent crime is disproportionately concentrated in the north. These differences motivate our decision to examine bifurcated risk profiles for aggravated assault and homicide in the north and south sections of St. Louis.

The goals of the current study are to assess whether vacancy is a risk factor for interpersonal violence in St. Louis and whether the effect of vacancy on violence varies within the city itself. We replicate recent research by incorporating two measures of vacancy—vacant buildings and vacant lots—into our risk terrain models and examine both aggravated assault and homicide across St. Louis. We fit separate risk terrain models for the north and south regions of the city to test whether the risk of crime associated with vacancy is greater in the more disadvantaged north side compared to the south side. In this sense, the analyses serve as both a replication of recent research and a methodological consideration to the application of RTM more generally.

Table 1. Catalogue and Distribution of Environmental Risk Factors.

Environmental Data	Source	Count	North	South
Vacant lot Est.	St. Louis Vacancy Collaborative	18,941	15,370	3,531
Vacant building Est.	St. Louis Vacancy Collaborative	6,398	5,356	1037
Public housing	HUD, NGDA	536	381	1,55
Low income housing tax credits	HUD, NGDA	248	163	85
Parks	St. Louis Open Data Portal	116	43.5	72.5
MetroBus stops	Green City Coalition	3,375	1,460	2,315
MetroLink sations	Green City Coalition	12	1	11
Schools	Green City Coalition	90	36	54
ATMs	Business analyst	664	171	493
Banks and creditu unions	Business analyst	157	24	133
Check cashing establishments	Business analyst	41	10	31
Restaurants	Business analyst	1,445	234	1,211
Hotels/Motels	Business analyst	92	19	73
Convenience stores	Business analyst	218	91	127
Grocery stores	Business analyst	133	47	86
Pawn stores	Business analyst	9	5	4
Laundromats	Business analyst	74	22	52
Gas stations	Business analyst	114	46	68
Liquor stores	Business analyst	28	16	12
Auto mechanics	Business analyst	148	47	101
Recreation centers	Business analyst	76	11	65
Scrap yards	Business analyst	29	15	14

Note. Est. = estimates; HUD = Department of Housing and Urban Development; NGDA = National Geospatial Data Asset.

Data and Methods

Data for this project were culled from a variety of public and subscription services. Our primary dependent variables, locations of homicide and aggravated assault between 2018 and 2019, were obtained from publicly available monthly crime data (City of St. Louis, Missouri Metropolitan Police Department). These data are provided with geographic point locations, and our entire sample had an existing geocode. Estimates for vacant buildings and vacant lots were produced by replicating the St. Louis Vacancy Collaborative's methodology (2018). These estimates were produced in December 2019 by classifying land parcels based on criteria that determine likely vacancy. Such criteria include tax delinquency, the prevalence of city services for boarding abandoned buildings and lot maintenance, and possession by the Land Reutilization Authority, the city's land bank for vacant properties. After determining likely vacancy, it is confirmed from assessor and demolition records whether a building exists on this parcel of land. Of note, vacant lots and vacant buildings are operationalized as polygons in our models in order to account for a wide distribution of parcel area. To better situate the relative risk of vacancy, our models control for an additional 20 risk factors. These were identified by aggregating risk factors shown to have a significant relationship with crime in prior research (Caplan et al., 2011; Drawve & Barnum, 2018; Gerell, 2018; Giménez-Santana, 2018; Kennedy et al., 2016; Valasik et al., 2019; e.g., bus stops, grocery stores, public housing, liquor stores; see Table 1 for complete list of risk factors and corresponding data sources).

The key steps for RTM include (1) gathering and standardizing environmental and crime data, (2) statistically determining spatial risk factors for crime, and (3) illuminating areas most vulnerable for crime. A key strength of RTM is that it can articulate the risk of both selected environmental factors, such as vacancy, and specific places, such as an intersection of multiple risk factors.

We used statistical language R (R Core Team, 2019) for obtaining and cleaning the data. We obtained a license to use Version 1.5 of the RTMDx software (Caplan & Kennedy, 2018). All data were converted to shape files and projected in feet with the NAD1983 Missouri East FIPS 2401 Projection. These data were then uploaded to the RTMDx web application. All models were fit with an aggravating approach, meant to capture factors that increase the likelihood of crime occurring. The standard value, representative of a city block, was set to 300 ft., and place size was set to the application recommendation of ½ of this value, 150 ft. This resulted in a sample size of 82,825 grid squares for the entire city, 34,815 for the northern region and 48,155 for the southern region. We fit a total of six models. The first two models examine the risk for homicide and aggravated assault for the whole of St. Louis City. We then stratified the sample into north and south sections along the aforementioned Delmar Divide and separately estimated the risk terrain models within each area.

For each instance, we allowed the model to deduce whether proximity or density was more significant. Proximity represents the nearest grid square prevalence of certain risk factor. Density represents a weighted measure for the concentration of a certain risk factor, more precisely an area in which the density is two standard deviations above the average density. All variables were given a standard value of three as well as half units increments, meaning that each risk factor would be tested within a range of three grid squares, incrementing by half grid squares each iteration.

Risk terrain modeling works by aggregating geographic data to grid squares, with each square representing either the density or proximity of a risk factor, within a given range of grid squares. This range varies based on block size and standard value, meaning that for each of our variables both density and proximity were tested at 150 ft. increments from 150 ft. to 900 ft. The model is fit iteratively using all the operationalizations of risk factors and different statistical distributions. The model with the best fit as determined by the lowest Bayesian information criterion (BIC) is selected. This entire process is automatically handled by the RTMDx application.

The results of the risk terrain models are the best fit combination of risk factors and operationalizations. For risk factors determined to be significant in the best fit model, operationalization as one of proximity or density, and spatial influence (distance) is reported. The relative risk value (RRV) is also reported as a ratio relative to one, representing the baseline likelihood of a crime occurring in a specific location. For a risk factor operationalized as proximity with a spatial influence of 300 ft. and an RRV of two, this may be interpreted as the risk of crime doubling when within 300 ft. of the risk factor. And for a risk factor operationalized as density, this can be interpreted as a relative increase of risk in regions in which the density of a risk factor is more than two standard deviations above the mean density.

Results

Descriptive Statistics

Table 2 presents the descriptive statistics for the entire city and for north and south St. Louis separately. From 2018 to 2019, there were 403 homicides in the City of St. Louis. These occurred in 343 unique grid squares, or 0.4% of the city. Of these homicides, 285 occurred in 243 unique grid squares, or 0.7% of north St. Louis. In south St. Louis, 118 Homicides occurred in 100 cells or 0.2% of the region.

In this same time frame, there were 7,407 reported aggravated assaults in the City, occurring in 3,775 grid squares, or 4.6% of the city. Of these aggravated assaults, 4,731 were reported in 2,065 unique grid squares, or 5.9% of north St. Louis. In the southern region, 3,128 aggravated assaults occurred in 1,740 unique grid squares or 3.6% of the region.

As evidenced in Table 1, the distribution of environmental factors is also notably different across regions. Despite covering a smaller geographic area, the north side contains an estimated

Table 2. Distribution of Homicide and Aggravated Assault.

	Aggravated Assault			Homicide		
Attribute	City	North	South	City	North	South
Proportion of grid cells with crime	0.046	0.059	0.036	0.004	0.007	0.002
Average *N* per grid cell	0.089	0.136	0.065	0.005	0.008	0.002
Average *N* per grid cell with at least one crime	1.962	2.291	1.178	1.175	1.173	1.180

Note. The total *N* of grid cell in St. Louis is 82,825; 34,815 are in North City, 48,155 in South City. Grid cells along Delmar Blvd are repeated in both the north and south models.

Table 3. Risk Terrain Models Predicting Homicide and Aggravated Assault for City of St. Louis.

Homicide				Aggravated Assault			
Risk factor	Operationalization	Spatial influence	RRV	Risk factor	Operationalization	Spatial influence	RRV
Vacant buildings	Proximity	450	4.6	Convenience stores	Density	150	4.3
Public housing	Proximity	150	4.6	Schools	Density	150	4.0
ATMs	Density	150	4.5	Public housing	Density	300	3.4
Vacant lots	Proximity	900	4.0	Vacant buildings	Proximity	750	2.9
Convenience stores	Density	900	1.7	Restaurants	Density	150	2.3
				Vacant lots	Proximity	900	2.2
				Gas stations	Density	300	1.9
				LIHTC	Density	300	1.7
				Bus stops	Density	300	1.6
				ATMs	Proximity	900	1.5
				Grocery store	Proximity	900	1.3
				Laundromat	Proximity	900	1.2

Note. LIHTC = Low income housing tax credits; RRV = relative risk value.

15,370 vacant lots and 5,356 vacant buildings, compared to 3,531 lots and 1,037 buildings in the region south of Delmar Blvd. Retail establishments are unequally distributed as well, with the south side containing 1,211 restaurants compared to 234 in the north. These findings are consistent with our expectation—both violent crime and the environmental risk factors are differentially distributed across the city.

Risk Terrain Model Results

Entire city. Table 3 presents the results of the risk terrain model fit for the entire city. Vacant buildings (RRV 4.6), public housing (4.6), ATMs (4.5), vacant lots (4.0), and convenience stores (1.7) each emerge as significant correlates of homicide. The spatial influence was smaller for public housing and ATMs than it was for vacant buildings, vacant lots, and convenience stores. The relationship between homicide and both vacancy and public housing is best characterized as one of proximity, whereas for ATMs and convenience stores is that of density. In other words, being within 450 ft. of a vacant building increases the risk of being a victim of homicide by a magnitude of 4.6; whereas for

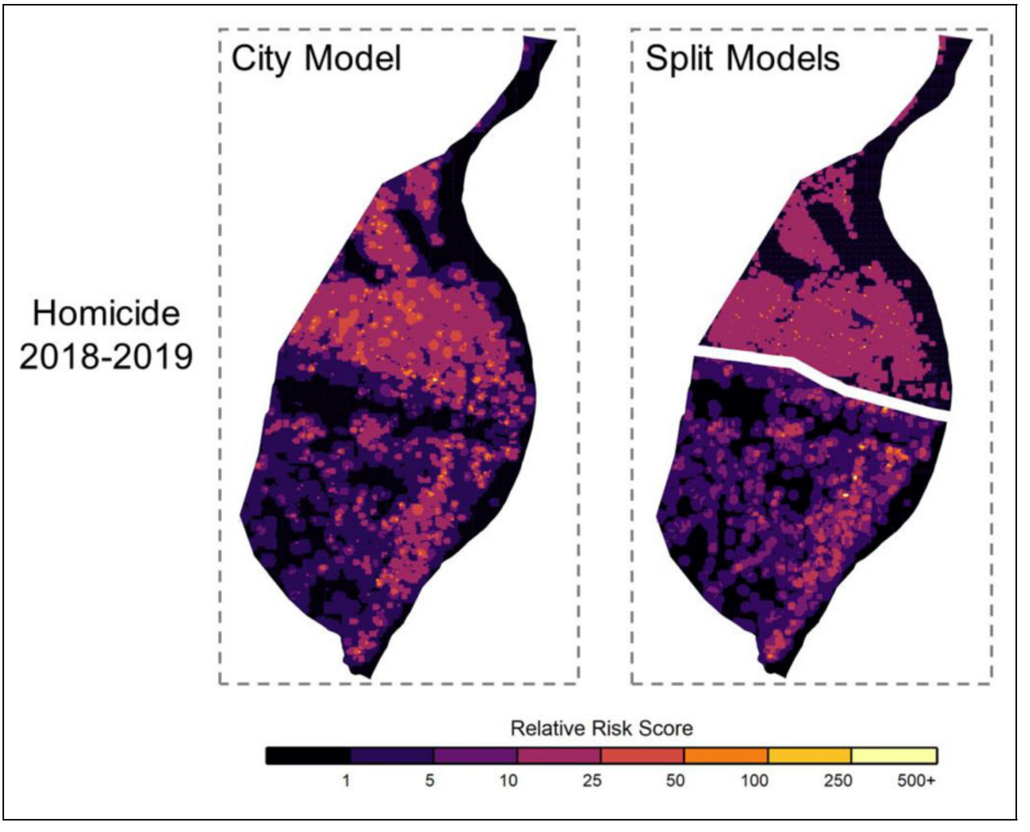

Figure 1. Homicide risk terrain models.

ATMs it was the *concentration* of ATMs that elevated risk, such that being within 150 ft. of an area densely populated with ATMs increased risk for homicide by 4.5. The model for aggravated assault produced 12 statistically significant risk factors. Of note, the riskiest three were gathering places including convenience stores (4.3), schools (4.0), and public housing (3.4). An above-average concentration, or density, of these factors resulted in a higher relative risk. Vacant buildings were also a risk factor, with the risk of being a victim of aggravated assault increasing 2.9 times when within 750 ft. of a vacant building.

Figures 1 and 2 present the resultant model for homicide and aggravated assault fit to the city, north, and south regions, respectively. It is important to note that while the scale is constant, risk is measured relative to the baseline risk of the region. For the northern model, for example, risk is conveyed relative to the north only. Figure 2 is the same in format but represents the models for aggravated assault. In this sense, the risk factors for the northern and southern halves of the city are standardized within region. As demonstrated in this figure, much of the northern half of the city is considered high-risk, while the risk profile in the southern part of the city is better characterized by pockets of risk. These results provide further evidence that the environmental factors driving homicide and aggregated assault vary substantially from one side of the Delmar Divide to the other.

North city. Table 4 presents the results of the model fit on the northern half of the city. Vacant lots emerge as the greatest risk factor for homicide (10.6), followed by restaurants (4.6), ATMs (4.4), and vacant buildings (2.1). The risk of being a victim of homicide increased 10-fold within 450 ft. of a

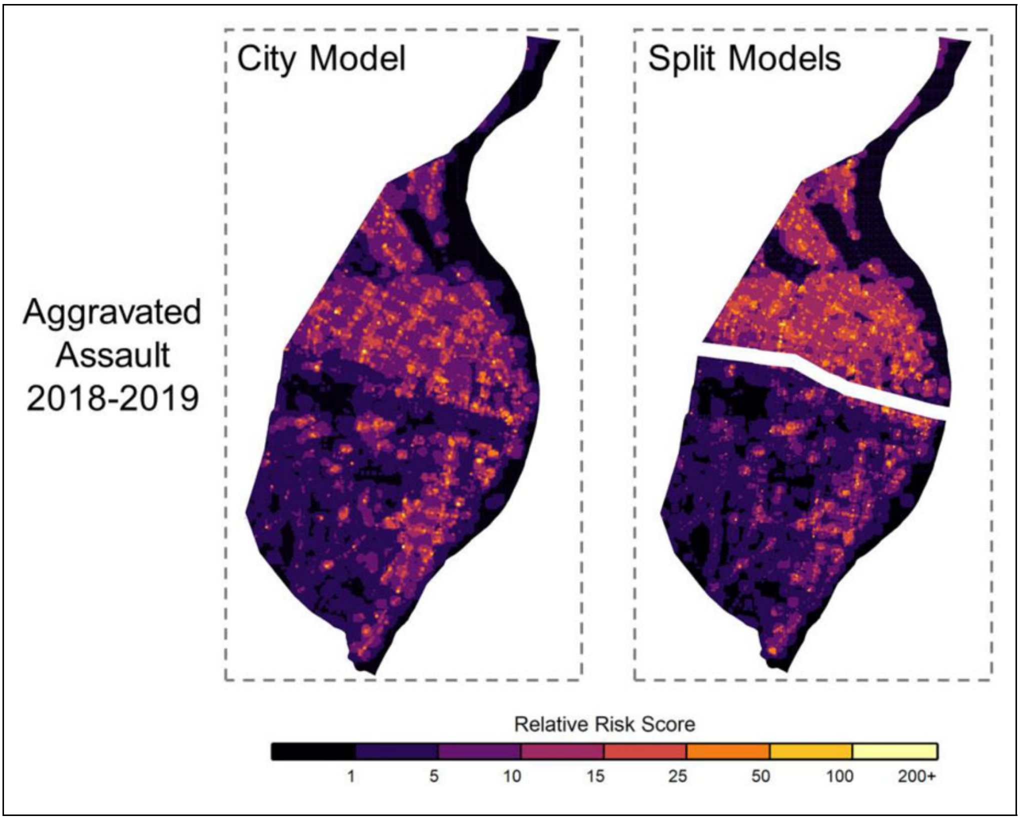

Figure 2. Aggravated assault risk terrain models.

vacant lot. ATMs carried the same relative risk in north city compared to the entire city, while restaurants were significant in north city but not in the entire city. The relative risk of vacant buildings on homicide in north city (2.1) was less than half that of the full city (4.6). Vacant lots also produced the greatest risk (6.0) for aggravated assault in north city, followed by grocery stores (3.3), convenience stores (3.2), and restaurants (2.8). These relationships between aggravated assault and these factors were based on proximity, such that being within 750 ft. of a vacant lot increased likelihood of assault by a factor of six, and being within 150 ft. of a grocery store, convenience store, or restaurant increased risk by a factor of 3.3, 3.2, and 2.8, respectively.

South city. Table 5 presents the results for the southern half of the city. Public housing carried the greatest risk for homicide in South city—being within 300 ft. of public housing increased risk for being a victim of homicide by a factor of 6.7. Other risk factors included vacant buildings (3.1), ATMs (2.8), and vacant lots (2.2). The relationship of homicides to these risk factors is that of closeness or proximity. MetroLink stations carried the greatest risk for aggravated assaults, as a proximity of 150 ft. to a station increased risk by a factor of 8.4. Schools (5.6), gas stations (4.2), and convenience stores (3.8) increased risk, all within a proximity of 150 ft. Vacant lots and restaurants also conveyed risk but to a lesser extent than north city. Public housing on the other hand, conveyed risk to a greater extent in the south (3.0) compared to the north (2.5). Taken as a whole, these results suggest that the risk profiles for homicide and aggravated assault differ in important ways north and south of the Delmar Divide.

Table 4. Risk Terrain Models Predicting Homicide and Aggravated Assault for North St. Louis.

Homicide				Aggravated Assault			
Risk factor	Operationalization	Spatial influence	RRV	Risk factor	Operationalization	Spatial influence	RRV
Vacant lots	Proximity	450	10.6	Vacant lots	Proximity	750	6.0
Restaurants	Proximity	150	4.6	Grocery stores	Proximity	150	3.3
ATMs	Proximity	150	4.4	Convenience stores	Proximity	150	3.2
Vacant buildings	Density	750	2.1	Restaurants	Proximity	150	2.8
				Public housing	Proximity	300	2.5
				Bus stops	Proximity	150	2.2
				Vacant buildings	Proximity	450	2.0
				ATMs	Proximity	300	1.7
				Gas stations	Proximity	600	1.6
				LIHTC	Density	300	1.5
				Laundromats	Proximity	900	1.3

Note. LIHTC = Low income housing tax credits; RRV = relative risk value.

Discussion/Limitations

The current study examined whether vacancy is a risk factor for interpersonal violence in St. Louis and whether the effect of vacancy on violence varies within the city itself. The results of the empirical models largely confirm the importance of vacant properties as drivers of criminal violence reported in other studies (e.g., Boessen & Chamberlain, 2017; Branas et al., 2018; Porter et al., 2019; Valasik et al., 2019). We find that the risk for both homicide and aggravated assaults is highest in proximity of vacant buildings and vacant lots. While the exact mechanisms underlying these relationships remain unclear, we speculate that vacant properties attract illicit behavior, such as drug sales, which drive up the potential for interpersonal violence.

Recognizing that both criminal violence and its environmental correlates are disproportionally distributed across the city, we next examined RTM models separately for north and south St. Louis. The results were striking. As evidenced in the figures, much of the risk profile for the city is carried by north city. Importantly, the relationship between vacancy and violence varies considerably between the regions. Vacant lots carry greater risk for both homicide and aggravated assault in north city. The relative risk score of vacant lots on both homicide and aggravated assault is five times higher in the north than the south. Vacant buildings, on the other hand, express slighter higher risk in the south compared to the north. Recall that these models are standardized within region. Caution must be used in drawing comparisons between subregions, as baseline risk varies between the models. We cannot ascertain whether the overall risk of violence is greater near vacant property in the north than south, but we can establish that vacancy accounts for a greater proportion of risk in the north. This relationship cannot be explained by a greater *concentration* of vacant lots in the north, but by a differential *effect* of vacancy on violence.

This difference in the relationships of vacant buildings and vacant lots in the north and south is an important insight for planning interventions. Given that vacant lots explain a greater proportion of risk in the north, it is likely that lot intervention may offer greater benefit. In contrast, a greater proportion of violent crime was explained by vacant housing in the south, suggesting the effectiveness of demolition efforts over lot remediation.

Table 5. Risk Terrain Models Predicting Homicide and Aggravated Assault for South St. Louis.

Homicide				Aggravated Assault			
Risk factor	Operationalization	Spatial influence	RRV	Risk factor	Operationalization	Spatial influence	RRV
Public housing	Proximity	300	6.7	MetroLink stations	Proximity	150	8.4
Vacant buildings	Proximity	450	3.1	Schools	Proximity	150	5.6
ATMs	Proximity	750	2.8	Gas stations	Proximity	150	4.2
Vacant lots	Proximity	750	2.2	Convenience stores	Proximity	150	3.8
				Public housing	Proximity	450	3.0
				Vacant buildings	Proximity	900	2.4
				Restaurants	Proximity	150	2.0
				ATMs	Proximity	900	1.8
				Bus stops	Density	300	1.7
				LIHTC	Proximity	300	1.6
				Vacant lots	Proximity	600	1.6
				Grocery stores	Proximity	900	1.5
				Auto mechanics	Proximity	900	1.3
				Banks	Proximity	900	1.2

Note. LIHTC = Low income housing tax credits; RRV = relative risk value.

In support of theory that emphasizes microspatial variations, vacancy was not the only risk factor to vary in effect between North and South St. Louis. Many of the tested risk factors were deemed statistically significant. However, in the north especially, this must be reconciled with the spatial distribution of the population. In a largely vacated area, such as in the north, we would expect the density of the population to be congregated in less vacant areas. Meaning, there is likely a greater number of potential victims near areas of higher population density, and points of interest like grocery stores may proxy this density of people. Regardless, the results of the region-specific models point to important nuance in the relative risk of public transportation hubs, public housing, ATMs, and schools between the two regions. Interestingly, not only does the relative risk of these features vary, but so too does their spatial influence. Consider the relationship between a well-known crime attractor, ATMs, and homicide. In north St. Louis, ATMs increase relative risk by a factor of 4.4 compared to a factor of 2.8 in the south. In the north part of the city, the spatial influence of ATMs on homicide is relatively narrow—150 ft. In the south, it is considerably broader—750 ft. For one of the risk factors tested, MetroLink stations—St. Louis's light rail system—there was only one location in the north. The only MetroLink station in North City is mere feet above the Delmar boundary, likely serving to explain why it does not appear in the north model and why it does not play a significant role in the city as a whole. Again, this displays the importance of considering the built environment at a more granular level than citywide. The increased risk of aggravated assault at MetroLink stations has received attention in the St. Louis area recently. An increase in both security measures and personnel has been implemented at these locations. However, our citywide risk terrain model would not have indicated toward this intervention.

While our methodological contributions are modest, our findings have several practical implications. First, the spatial heterogeneity in both the concentration and influence of environmental risk factors suggests that it is problematic to treat metropolitan areas as monolith; fitting risk terrain models to an entire city likely obscures important regional variation. In terms of violence intervention, it seems that efforts to reduce interpersonal violence would take on very different forms in the north and south sides of St. Louis. In the north, remediation efforts like restoring vacant lots should have an appreciable influence on criminal homicide. Violence prevention efforts in the south side of the city would be better served to focus on the criminogenic influence of public hubs like housing and light rail stops. Importantly, the results of the models estimated on the full city placed the relative risk of vacant lots for homicide considerably lower than the deaggregated models, effectively veiling the importance of vacancy for criminal violence in the north part of the city. In general, it seems that risk terrain models are especially strong tools to identify local drivers of criminal violence that can be used to tailor remediation strategies for small-geographic scales. Any prevention efforts that fail to account for such spatial contingencies will be much less effective at addressing violence on the whole.

Our study is not without limitations. Most notably, the results reported here are based on a single city with a well-documented racial and economic dividing line. However, St. Louis is not unique in this regard. Decades of residential segregation are entrenched in the very fabric of most American cities. St. Louis has the Delmar Divide. The Chicago River similarly divides the affluent north side of Chicago from the improvised south side. The infamous 8-mile road has long been a symbol of racial segregation in Detroit. It remains to be seen whether similar spatial variation characterizes the risk profiles of other major cities. We should also note that our analyses were restricted to the political boundary of the City of St Louis, but crime in surrounding counties, including St. Louis County, tends to spill over into the city. In other words, areas just beyond the city boundaries are likely to confer risk into the city. Unfortunately, we were unable to include crime from these other counties due to fragmentation in data collection systems. With nearly 60 separate law enforcement agencies in St. Louis County alone, the fragmentation of crime data makes obtaining complete statistics for the County nearly impossible (The Ferguson Commission, 2015).

Our findings also speak to the importance of transparency and replication in environmental criminology, the topic of this special issue. As public trust in scientific evidence wanes, it has become increasingly important to scrutinize established research findings. This is especially true given contemporary debates around the quality of official data (Karakatsanis, 2020) and the replication crises that have plagued adjacent disciplines in recent years (Warren, 2019). If criminologists hope to keep our seat at the table, we need to be transparent in our methods, data, and analytic decisions (Burt, 2020). We also need to interrogate established findings and assess the generalizability of results generated from single cities with unique histories, politics, and demographics. Regarding transparency, we have made much of our data publicly available here: https://github.com/bransonf/rtm_study. The irony of this statement is not lost on us. We are unable to publicly distribute subscription data nor can we share the software used to produce these models. Both are protected by contract. Such proscriptions and the pay-to-play model of data access are endemic in the field. These issues will need to be addressed as we continue to embrace ideals of open science. In regard to replicability, our analyses demonstrate that vacancy indeed drives criminal violence in St. Louis, similar to how it operates in Akron (Porter et al., 2019), Baton Rouge (Valasik et al., 2019), and Philadelphia (Branas et al., 2018). This lends further credence to the growing body of literature implicating vacancy as a correlate of urban violence. We would strongly encourage researchers to follow suit and make available their data and code and to continue to scrutinize established findings through replicative efforts such as this. As a discipline, we need to be open to replication studies, instead of prioritizing the newest and most novel findings. We also need to be transparent with our data and methods, so that others can interrogate our work and correct the empirical record, as needed.

On the whole, our work further highlights the importance of vacancy for interpersonal violence. Vacant lots and vacant buildings increase the risk of both homicide and aggravated assault. While correlation is established in this study, mechanisms for causality remain a topic for future inquiry. If the nature of vacancy and crime is causal, this relationship may be interrupted by "repairing the appearance of buildings and vacant lots to improve lighting and visibility and increasing police patrols in high-violence areas" (Mercer et al., 2017, p. 21). Such interventions have proved effective in other major cities (e.g., Branas et al., 2019), and our results suggest they could be effective in St. Louis as well. More importantly, our analyses challenge the assumption that environmental risk factors are evenly distributed and equal in effect across the city. Instead, the drivers of homicide and aggravated assault vary considerably between north and south St. Louis. While this is a rather straightforward observation, it calls into question the utility of fitting risk terrain models to an entire metropolitan area. We strongly encourage researchers to attend such spatial contingencies in their own work and to tailor violence remediation strategies accordingly.

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