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Abstract

Purpose – The purpose of this paper is to examine the spatial influence of features of the physical environment on the risk of aggression toward law enforcement.

Design/methodology/approach – The spatial analytic technique, risk terrain modeling was performed on felonious battery data provided by the Chicago Police Department.

Findings – Out of the 991 batteries against law enforcement officers (LEOs) in Chicago, 11 features of the physical environment were identified as presenting a statistically significant spatial risk of battery to LEOs. Calls for service within three blocks of foreclosures and/or within a dense area of problem buildings pose as much as two times greater risk of battery to police officers than what is presented by other significant spatial factors in the model.

Originality/value – An abundance of existing research on aggression toward law enforcement is situated from the perspective of characteristics of the suspect or officer. The research advances the field of violence studies by illustrating the importance of incorporating physical features of the environment into empirical studies of aggression.

Keywords Decision making, Patrol, Intelligence-led policing, Injuries to officers

Paper type Research paper

Introduction

By virtue of emergency situations and criminal investigations, law enforcement officers (LEOs) face a risk of non-accidental injury that far exceeds many other occupations (Bureau of Labor Statistics, 2012; Clarke and Zak, 1999). The 62.9 million annual contacts with the general public (Langton and Durose, 2011) present risk of injury and mortality to LEOs that are five times the national average (Kercher *et al.*, 2013). When compared across all other industries, LEOs tie for the second highest overall incidence rate (11.8 per 100,000 workers) of non-fatal occupational injury and illness cases filed in 2012 (Bureau of Labor Statistics (BLS), 2013). The incidence rate of law enforcement injury was 502 cases per 10,000 full-time workers; nearly five times greater than the national average of 112 per 10,000 full-time workers (BLS, 2013). Injuries from felonious battery[1] result in lost wages due to missed work, stress, disability, and lasting psychological trauma (BLS, 2013; Komarovskaya *et al.*, 2011;

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Liberman *et al.*, 2002). From 2003 to 2012, on average, 50 felonious deaths occurred per year (535 total); such violence to LEOs persists amidst declining numbers of accidental deaths and non-intentional injuries (FBI, 2012).

Despite the obvious dangers, LEOs are committed to deal with criminal behaviors while simultaneously mitigating – as best as possible – the potential for non-accidental injury. In specific compromising situations, individual officers must balance the duty to control crime and the need to attenuate the risk of physical injury. Kennedy and Van Brunschot (2009) surmised that risk provides a metric that offers a probabilistic interpretation to assessments of safety and allows us to suggest that certain things are likely to happen and others can be prevented based on our risk assessments. They defined risk as "a consideration of the probabilities of particular outcomes" (p. 11). Micro places can be evaluated in terms of varying degrees of injury risk relative to certain nearby or far away features of the environment (Caplan, 2011; Cohen *et al.*, 1981). This directs attention from a sole fixation on only the crime type or suspect's characteristics that confront a police officer in response to a call-for-service and permits considerations of qualities of places as well. In this context, the assessment and management of risk becomes a tactically operational imperative and a necessity for public safety practice. Thus, empirical research is necessary to inform policies and practices that provide LEOs with tactical intelligence to attenuate the spatial risk of injury. For example, Ellis *et al.* (1993) found that when prepared through knowledge of the potential harms presented by a call for service, officers were 8.8 percent less likely to sustain an injury than officers who entered into encounters ill-equipped to mitigate risk.

Research has rigorously examined situational, offender, and officer characteristics (e.g. see Bierie *et al.*, 2013; Covington *et al.*, 2014; Peterson and Bailey, 1988; Kent, 2010), yet the influence of specific features of the micro physical environment on the risk of non-accidental injury and death presented to LEOs remains largely absent from empirical inquiry. Existing research has conducted either narrative analysis of felonious deaths or performed correlational studies on the relationships between non-spatial characteristics and felonious assault, often at the macro level (i.e. cities, counties, or states). Fridell *et al.* (2009) found that agency-level factors, including jurisdictional contexts, policies, or practices, might impact the level of violence against police. Their results indicate that police officers may change their behavior based on the situation and/or context. But, no studies to date have explicitly quantified the "environmental backcloth" (Brantingham and Brantingham, 1981) upon which police actions are situated, or the impacts of micro-level spatial influences on the risk of injury to LEOs.

Cohen and Felson's (1979) routine activities theory explains that crime occurrence could be more easily facilitated if there are motivated offenders, suitable targets of victimization, and an absence of capable guardians. So, affecting this "crime triangle" has became the goal of many police agencies; that is, in an effort to be the "present capable guardians." But, a police officer's presence can become the new target of aggression and violence, making the police officer the potential victim. Theorists such as Cohen, Felson, and others (e.g. Cohen *et al.*, 1981; Simon, 1975) have suggested that spatial variations in violence are explained by opportunities to commit offenses at locations that are accessible to the offender, and have gone so far as to write that "the risk of criminal victimization varies dramatically among the circumstances and locations in which people place themselves and their property" (Cohen and Felson, 1979, p. 595). So, in addition to studying who is involved in violence toward police, research should also consider the environmental characteristics of where such incidents occur (Kaminski and Sorensen, 1995; Sherman *et al.*, 1989). The nature of certain places may be perceived by offenders to be opportune locations (Cohen *et al.*, 1981) to behave aggressively toward police. In looking at these locations, we can empirically study the common correlates of these behavior settings.

The way human actors (e.g. motivated offenders or police officers) conceptualize and operate in space is an important consideration for the mapping of risk throughout landscapes. Cartographically modeling these conceptualizations is an important part of what Freundschuh and Egenhofer (1997) describe as "Naïve Geography, a set of theories of how people intuitively or spontaneously conceptualize geographic space and time" (Egenhofer and Mark, 1995). Such modeling can yield more meaningful inferences about criminal behavior and actionable spatial intelligence for use by public safety professionals (Frank, 1993; Mark, 1993). So, spatial risks for battery toward police must be considered not only in terms of the people involved in the events, but also in terms of how the environment forms/informs their behaviors (Freundschuh and Egenhofer, 1997). Examining places rather than people for risk analysis does not remove the importance of the human factor. It simply shifts the focus away from personal characteristics to personal preferences. How individuals select and use the environments that they occupy, and the impact that this has on violent outcomes, becomes the direct focus of the spatial risk perspective. This approach to risk analysis suggests a way of looking at behavioral outcomes as less deterministic and more a function of a dynamic interaction among people that occurs at places. The attributes of places that we seek to identify regarding injury to LEOs are not constant nor necessarily are the interactions set in place over time. However, the ways in which these spatial factors combine can be studied to reveal consistent patterns of interaction, aligned with the views expressed by Brantingham and Brantingham (1981) in their development of crime pattern theory.

In this study, we address gaps in existing research by showing how physical features of a landscape increase the risk of felonious battery to LEOs, in particular, municipal police officers. We contribute to the existing research by providing evidence-based spatial intelligence that LEOs, criminal justice administrations, and urban planners can employ to help mitigate the risk of injury at micro places throughout police jurisdictions. Our research suggests that there are empirically important spatial factors whose presence or absence structures the potential for line-of-duty injury. When spatial risks are neglected or poorly assessed, officers may be at higher risk of serious injury. This study provides information for agencies to incorporate into procedures, training, and best practices for tactical responses catered to the specific physical features of calls-for-service by considering that location, as well as people or crime type, may matter in terms of officers' on-scene safety.

Spatial risk factors

A review of empirical studies, publically available agency safety protocols, in-service training materials, policy reports, research publications, and briefs point to several spatial factors that may generally elevate the likelihood an officer will sustain injury in the process of managing a variety of types of calls for service. This literature suggests that offender and officer characteristics interact with features of the physical environment to structure the level of risk presented to police officers. Locations with high rates of prior violent crimes and/or concentrations of gang members, drug distributors, or illegal drug markets affords suspects with opportunity to elicit assistance from others in evasion or attack (California Commission on Peace Officer Safety Training (POST), 2001; International Association for Chiefs of Police (IACP), 2003; Kaminski *et al.*, 2003; Kaminski and Coleman, 2007; Meyer and Carroll, 2013). Suspects in flight at these areas may have more opportunities to hide or collude with others to obstruct apprehension efforts (IACP, 2003), elevating the risk of physical battery or fatality to police.

Terrain that is not level, tall brush, residential yards, walls, fences, sharp turns, and open areas where it is hard to construct a perimeter all constitute potential spatial risk factors for injury, especially during foot pursuit (Detroit Police Department, 2010; IACP, 2003). Areas with remote or secluded geographic locations and confined spaces are also locations with high risks for battery/assault (California Commission on Peace Officer Safety Training (POST), 2001; IACP, 2003). In cases of ambush, fleeing suspects capitalize on available abandoned vehicles as hiding places. Roadways with limited lighting have been shown to restrict an officer's ability to assess risk and provide spatial opportunities for suspects to initiate violent behavior (National Highway Traffic Safety Administration, 2011).

Some of the most prominent risk factors for felonious battery concern features of the built environment that enable easy barricading of property, as well as evasion from the LEO's line of sight. Meyer and Carroll (2013) found that almost 20 percent of police officer fatalities during domestic disturbance calls involved a barricaded suspect attempting to guard a hostage and obstruct law enforcement entry. Large unlocked buildings or abandoned lots (IACP, 2003; Shane, 2012), or mobile homes or residential structures that are detached or secluded, can enable suspects to evade police attention and facilitate successful ambush (Detroit Police Department, 2010; IACP, 2003; Johnson, 2008).

Spatial features that present risk of felonious battery may be different from features that present risk of death. Kaminski and Sorensen (1995) and Ellis *et al.* (1993) found that injuries sustained by LEOs during domestic disturbance calls were more likely to cluster in multi-unit, attached housing. The findings provided by Kaminski and Sorensen (1995) suggest that small apartment complexes require LEOs to enter enclosed spaces, providing inadequate distance between the officer and the suspect to ensure safety. In 2012, homicides and batteries of LEOs during general disturbance calls occurred predominately at private residences, nightclubs, and bars in circumstances in which officers were attempting to arrest suspects or investigating calls of suspicious activity (Covington *et al.*, 2014; FBI, 2012; International Association for Chiefs of Police (IACP), 2011).

Areas with high concentrations of locations of psychiatric and social service provisions also present potential environmental risk factors for officer injury. This is not because of an inherent potential for violence attributed to the mental health condition itself, but rather the spatial temporal context presented by high concentrations of service provision agencies in charge of distributing a limited supply of essential resources (Cordner, 2006). Cordner (2006) suggests that the agitation imposed by waiting long hours for medications and "drawing straws" to receive essential services, such as shelter services, increases the likelihood of violence. Clinics, group homes, and shelters are all examples of locations with elevated risk of combative, resistant or violent behaviors toward LEOs (Cordner, 2006).

Due to the volatile nature of liquor consumption and crowd density, bars are locations where combative and assaultive behaviors often cluster (Scott and Dedel, 2006; Block and Block, 1995). Studies suggest that violence clusters in close proximity to drinking establishments – in streets, sidewalks, alleys and parking lots – but it is the liquor establishment that is the spatial anchor radiating risk into the immediate surroundings. Other locations pose risks, as well. Banks, poorly lit parking lots and pharmacies are all locations in which LEOs have been killed or assaulted in the line of duty particularly with burglary/larceny calls for service (California Commission on Peace Officer Safety Training (POST), 2001; IACP, 2011).

Summary

Although a broad spectrum of features of a landscape may pose general spatial risks to police officers in the line-of-duty, it is likely that only some of them will be significantly influential to battery against police officers within Chicago. Results of a Nearest Neighbor analysis for spatial randomness suggests that the distribution of battery incidents in 2012 ($n = 991$) are significantly spatially clustered. Though, battery to police officers could become endemic without any evidence of significant spatial clustering of incidents. The question to be answered, then, is: "do battery incidents share common spatial correlates of the landscape upon which they occur?" It is hypothesized that first, particular features of the physical environment constitute significantly higher risk of battery to police officers handling calls-for-service at micro-level places. Further, second, the co-location of one or more risky features at micro-level places will have higher risk of battery to police officers compared to places absent said features. In pragmatic terms, inattention to one or more of these features is presumed to elevate risk to police officers upon arrival on scene to calls for service.

Methods

Setting

Data were collected from the city of Chicago, Illinois. The Chicago Police Department (CPD) is the second largest local law enforcement agency in the USA (behind New York City) with 4.4 sworn officers per 1,000 residents, or about 12,000 sworn officers (Chicago Police Department, 2010). According to CPD officials, "battery" is defined as the intentional causing of serious bodily harm or the attempt to cause serious bodily harm or death. This study focusses on incidents of battery to police officers in Chicago during 2012 but also adds to these data "assaults[2] with a firearm" because of the exceptionally serious nature of threatening a police officer with a firearm, even if the trigger is not pulled or an officer is not struck with a bullet, since there is great potential for serious bodily harm in such situations (Craun *et al.*, 2013). These datasets are merged and analyzed together. For consistency, these incident data will henceforth be referred to as "batteries," a construct referring to battery to police officers or assault with a firearm against police officers.

Analysis

Potential spatial risk factors were identified for empirical testing in this study based on the aforementioned literature review. In addition, practitioner insights also played a role in determining which factors or measures thereof are likely relevant for this particular jurisdiction. This follows the advice of Ratcliffe and McCullagh (1998) who argue that the experience of analysts and practitioners should be considered in order to unravel potentially relevant factors. The knowledge of CPD personnel (when asked in conversation about general factors perceived to be related to battery in Chicago) provided practical experience-based justification for the use of the following factors: laundromats, retail shops, variety stores, recreation centers, grocery stores, gas stations with convenience stores, and problem buildings[3]. Such exercises have been used to identify spatial risk factors in prior research (see, e.g. Kennedy *et al.*, 2011). Laundromats, for instance, were not identified directly by the published literature, but were suggested as a reasonable measure with regard to the Chicago context, as they are often open in the nighttime hours, with limited formal guardianship, and are locations where drugs are distributed. As a consequence of our approach to identifying possible risk factors, our candidate pool, as measured by these datasets, is not only empirically driven but also theoretically and practically meaningful (Ratcliffe and McCullagh, 1998).

Here, construct validity is related to generalizing from these factor concepts to the factor measures. That is, the datasets represent how we translate a potential risk factor construct into an operationalized measure for testing and modeling. We gave this careful consideration and thoughtfully identified datasets and sources that would be reliable and valid.

All 311 service requests for street lights out, 311 service requests for alley lights out, 311 service requests for abandoned vehicles, schools, and parks represented the "limited visibility" hazard type or the landscape-type hazards, such as open areas, that may increase risks to police officers when apprehending fleeing suspects (as discussed above). These data were obtained from Chicago's Data Portal[4]. Gang hotspots were utilized as a proxy for measuring areas where "potential suspects congregate" and were obtained from the CPD. Apartment complexes, foreclosed houses, problem buildings, night clubs, bars, liquor stores, homeless shelters, mental health care providers, substance abuse treatment facilities, recovery homes, recreation centers, pharmacies, parking garages, retail shops, variety stores, banks, laundromats, grocery stores, and gas stations with convenience stores were obtained from the CPD, Chicago's Data Portal, or Infogroup[5]. Reported and investigated incidents of battery to police officers in Chicago during 2012 were obtained from official CPD administrative data at the XY coordinate level.

There are several ways to make sense of the factors that attract or affect the spatial patterns of battery to police officers and, ultimately, create risky places for such incidents. Evaluating the "spatial influences" of features of the landscape on the occurrence of such incidents, and assessing the importance of each feature relative to one another, is a viable method of assessing such risk (Caplan, 2011). Spatial influence refers to the way in which features of a landscape affect behaviors at or around the features themselves (Caplan, 2011). It serves as the measurable link between environmental features and their impacts on people and the ways in which they use space. Spatial influence is, essentially, the articulation of perceptions observed about features. Perceptions may differ among individuals, but collectively, in reference to certain times and settings, patterns emerge and can be operationalized in a geographic information system (GIS). For example, a sidewalk and a bush might be considered benign features of any generic landscape. But, a sidewalk located in an isolated and poorly lit section of a city that is lined on both sides by many tall bushes could be considered a risky area for victimization. Here, the spatial influence of sidewalks might be defined as "[…] being within a certain distance from the sidewalk increases my risk of victimization because motivated offenders presume that people (i.e. suitable targets) are likely to travel on them." The spatial influence of bushes could be defined as "[…] being within a high concentration of tall bushes increases my risk of victimization because it allows many places for motivated offenders to hide," and so forth. In this way, sidewalks could be depicted in a GIS not as finite lines, but as areas accounting for all places within a certain distance of sidewalks. Operationalizing the spatial influences of features of a landscape to GIS maps complements what Freundschuh, Engenhofer, Couclelis, and other geographers advocated for when measuring the theoretical and behavioral links between people and their geographies. Most basically, it maximizes the construct validity of cartographic models and empirical measures used for statistical tests (Golledge and Stimson, 1997). It allows us to consistently evaluate places relative to one another with regard to the types of behaviors we would expect given the influences that certain features have on people located there.

Caplan*et al.* (2011) and Kennedy *et al.* (2011) measured the place-based interaction of several environmental features using a technique called risk terrain modeling (RTM). RTM is an approach to risk analysis whereby separate map layers representing the spatial influence of features of a landscape are created in a GIS. Then all risk map layers are combined to produce a composite "risk terrain" map with values that account for the spatial influences of all features at every place throughout the landscape. Specifically within the context of RTM, modeling refers to the process of attributing qualities of the real world to places throughout a landscape, and combining multiple landscapes together to produce a single composite map where the newly derived value of each place represents the compounded risk of that place. RTM offers a statistically valid way to articulate risky areas for battery at the micro-level according to the spatial influence of many features of the landscape. The 25 aforementioned features of the Chicago landscape that may correlate with battery are analyzed using RTM.

Chicago was modeled as a continuous surface GRID of 426 ft-by-426 ft cells ($N = 36{,}473$), each representing a micro place throughout the city. A total of 426 feet represent approximately one average block length in Chicago, as measured within a GIS. This spatial dimension has practical meaning since the cell size corresponds to the block faces of Chicago's street network and is likely the most realistic unit police can be deployed to at the micro level (Braga and Weisburd, 2010; Groff and Lavigne, 2002; Weisburd *et al.*, 2012, 2009). Empirical research by Taylor and Harrell (1996) suggests that crime-prone places typically comprise just a few street blocks. These qualify as behavior settings that are "regularly occurring, temporally and spatially bounded person-environment units" (Taylor, 1988).

We used the RTMDx Utility, a software application produced by the Rutgers University Center on Public Security (available at: www.rutgerscps.org/software) to perform RTM (Caplan *et al.*, 2013). The testing procedure within the Utility began by using variables of the 25 aforementioned factors (i.e. independent variables) and 2012 battery incidents (i.e. the dependent variable) to build an elastic net penalized regression model assuming a Poisson distribution of events. Penalized regression balances model fit with complexity by pushing variable coefficients toward zero. The optimal amount of coefficient penalization was selected via cross-validation. The model resulting from this step, i.e., the penalized model, would be perfectly valid in-and-of-itself, but the RTMDx Utility finds a more simplified "best model" in subsequent steps via a bidirectional stepwise regression process (Heffner, 2013). It does this starting with a null model with no model factors, and measures the Bayesian Information Criteria (BIC) score for the null model. The BIC score balances how well the model fits the data against the complexity of the model. Then, it adds each model factor to the null model and re-measures the BIC score in order to pinpoint the most parsimonious combination of model factors based upon the data. Every time the BIC score is calculated, the model with the best (lowest) BIC score is selected as the new candidate model (the model to surpass). The Utility repeats the process, adding and removing variables one step at a time, until no factor addition/removal surpassed the previous

BIC score. The Utility repeats this process with two stepwise regression models: one model assumes a Poisson and the other one assumes a negative binomial distribution. At the end, the Utility chooses the best model with the lowest BIC score between Poisson and negative binomial distributions. The Utility also produces a relative risk value (RRV) for comparison of the risk factors. RRVs are produced by rescaling factor coefficients between the minimum and maximum risk values (Heffner, 2013). RRVs can be interpreted as the weights of risk factors. For a more detailed explanation of the RTM process and statistical procedures see the *RTMDx Utility User Manual* (Heffner, 2013).

Results

RTM for batteries against Chicago police officers

In 2012, there were 991 batteries against police officers in Chicago, Illinois. The best RTM was a Negative Binomial model with 11 risk factors and a BIC score of 7,946.9. In order of their RRV, the factors are: foreclosures, problem buildings, bars, schools, gang territories, banks, apartment complexes, liquor stores, 311 service requests for street lights all out, grocery stores, and retail shops. The most meaningful operationalization and spatial influential distances of each risk factor are presented in Table I. The RRV can be easily compared. For instance, a place influenced by "problem buildings" has an expected rate of crime that is nearly twice as high than a place influenced by "311 service requests for street lights all out" (RRVs: 3.00/1.48 = 2.02). Accordingly, all places may pose risk of battery to officers when dealing with a variety of types of calls for service at these locations, but because of the spatial influence of certain features of the landscape, some places are riskier than others. The most important predictor of battery occurrence is proximity to foreclosed properties. Calls for service within three blocks of foreclosures and/or within a dense area of problem buildings pose as much as two-to-three times greater risk of battery to police officers than what is presented by many other significant factors in the model.

Comparing RRV across model factors is useful for prioritizing risky features and for speculating why some features may pose exceptionally high risks compared to others so that mitigation efforts can be implemented appropriately. For instance, foreclosures may be high-risk due to the absence of invested caretakers who would otherwise serve as "eyes and ears" within the area. This void of guardians may serve as cues to certain

Table I. Risk factors, spatial influences, and relative risk values of the risk terrain model for battery to police officers in Chicago, IL

Risk factor	S.I., Op., Coef., R.R.V.
Foreclosures	1,278, P, 1.95, 7.08
Problem buildings	852, D, 1.10, 3.00
Bars	426, D, 0.85, 2.35
Schools	426, D, 0.70, 2.02
Gang territory	1,278, P, 0.63, 1.88
Banks	426, P, 0.61, 1.85
Apartment complexes	426, P, 0.53, 1.70
Liquor stores	852, D, 0.46, 1.59
311 srvc. reqs. for street lights all out	426, D, 0.39, 1.48
Grocery stores	852, D, 0.36, 1.43
Retail shops	1,278, P, 0.28, 1.32
Intercept coefficient	−6.4031

Notes: S.I., Spatial influence (in feet); Op., operationalization (P, proximity; D, density); Coef., coefficient; R.R.V, relative risk value suspects that the prospect for instant freedom from criminal justice authorities is better had with aggression toward police rather than cooperation. If this mechanism through which foreclosed properties pose risks to police were considered legitimate, then mitigation efforts may begin with a new protocol for responses to all calls for service within close proximity to foreclosed properties.

A place where the spatial influence of more than one of the model features in Table I co-locates poses higher risks. This was tested by combining risk map layers of the 11 factors in the model using map algebra (Tomlin, 1994) and ArcGIS for Desktop's Raster Calculator, to produce a risk terrain map. Referring to Table I, the risk terrain map was produced using the following formula:

$$\begin{aligned}&\mathrm{Exp}(-6.4031 + 1.958 \times \text{“Foreclosures”} + 1.1017 \times \text{“Problem Buildings”}\\&+0.85752 \times \text{“Bars”} + 0.7059 \times \text{“Schools”} + 0.63411 \times \text{“Gang Territories”}\\&+0.61638 \times \text{“Banks”} + 0.53103 \times \text{“Apartment Complexes”} + 0.46778 \times\\&\text{“Liquor Stores”} + 0.39284 \times \text{“311 Services Requests Street Lights All Out”}\\&+0.36144 \times \text{“Grocery Stores”} + 0.28092 \times \text{“Retail Shops”})/\mathrm{Exp}(-6.4031)\end{aligned}$$

RRV for each cell in the risk terrain map shown in Figure 1 ranged from 1 for the lowest risk cell to 582.5 for the highest risk cell. A cell with a value of 582.5 has an

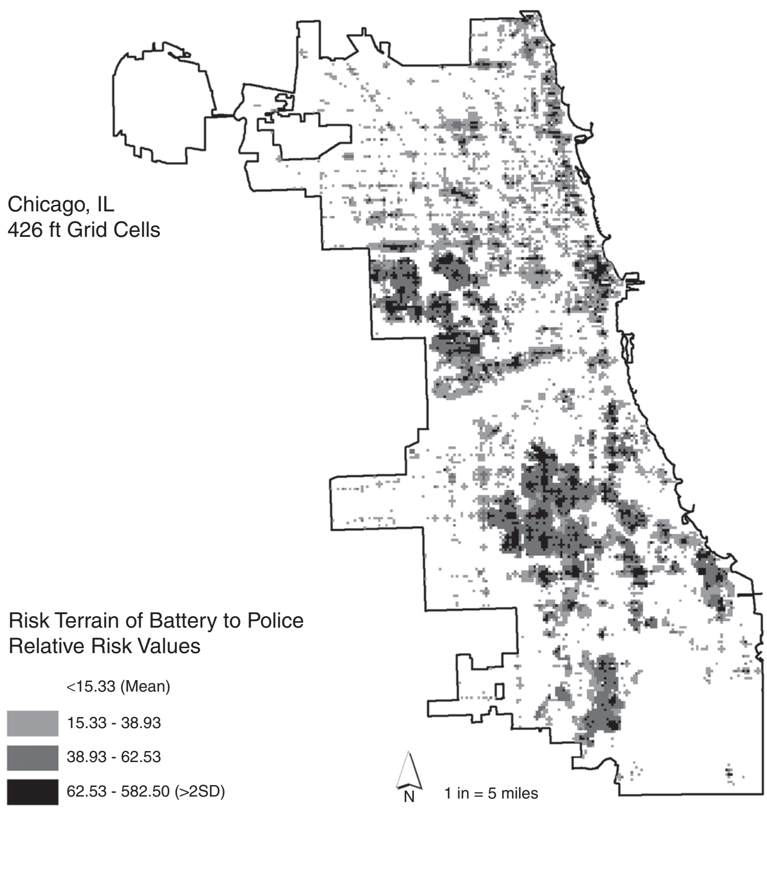

Figure 1. Micro-level risk terrain map for battery to police officers

expected rate of battery that is 582.5 times higher than a cell with a value of 1. The mean risk value is 15.33, with a standard deviation of 23.60. This micro level map shows the highest risk cells symbolized in black (i.e. >2 SD from the mean). These places are where police officers have a 62.53 percent or greater likelihood of experiencing battery compared to police officers managing calls for service at some other locations.

Discussion

This analysis of police officer batteries in Chicago, IL supports the proposition that some places are riskier to police officers than other places in terms of where offending behaviors resulting in battery to police tend to occur. Police who handle calls for service at locations with foreclosures, problem buildings, bars, schools, gang territories, banks, apartment complexes, liquor stores, clusters of 311 service requests for malfunctioning streetlights, grocery stores and/or retail shops are at a greater risk of felonious battery. These specific features of the built environment increase the risk of battery. Places with high RRV are behavior settings that present exceptionally strong likelihoods of battery to police who handle calls for service at these locations.

Albeit, there are many other factors that could be taken into account to assess personal risks to officers responding to calls for service. For instance, additional research is needed to assess the temporal dynamics of battery incidents. Temporal variations in opportunity and ambient populations are important for calculations in evaluating overall risk because the interactions among people and their geographies are deeply fluid in the sense that no feature retains its "social relevancy" permanently (Kinney, 2010, p. 485). For instance, the spatial influence of a bar at 10 p.m. on a Friday is intuitively going to be different than its spatial influence at 10 a.m. on a Tuesday. The situational factors of battery events could also inform risk assessments about future types of calls for service at certain locations (Covington *et al.*, 2014; i.e. uniform or plain-clothes officer, multi-person/car first responders, etc.). Within the scope of this study, it can be said with statistical confidence that battery incidents (i.e. and injuries) occur at places with particular features of the landscape.

Such knowledge could inform tactical decision making for police when responding to calls for service at certain locations. Knowledge of spatial risks can be especially meaningful for resource allocation and tactical responses: Police officers could assess risk of battery given certain features of the landscape even if prior battery incidents have not yet occurred or clustered there. Perceptions may differ among individual offenders as to what locations are most "suitable" to attack police officers, but collectively, a pattern emerged and was operationalized in a RTM. With this knowledge of what locations are most utilized in police officer attacks (based on the spatial factors identified by the RTM), it is possible to anticipate the likelihood of future incident locations prior to their occurrence. RTM is, by all intents-and-purposes, a diagnostic method. But with a diagnosis of the attractors of battery behavior, we can make very precise place-based forecasts (Drawve, 2014). Replication of this study in other jurisdictions could be used to strategically inform responses to calls for service, to allocate resources, or to reform policies and protocols in ways that enhance police officer safety. Micro-level assessments of places (e.g. street blocks) within jurisdictions can be made for tactical purposes on a call-by-call basis, particularly when the call-for-service locations are high-risk as defined by a RTM.

There are a few noteworthy qualifications of this study and several areas of future research that warrant elucidation. It is noted that characteristics of the officer and offender might also influence the risk of battery to police officers (Brandl and Stroshine, 2012; Swedler *et al.*, 2013). Age and on-the-job experience provides LEOs with exposure to techniques and skills in life saving risk management strategies (Kaminski and Sorensen, 1995; Tucker-Gail *et al.*, 2010). Studies have also found that officers are more likely to be killed or battered in first, officer vehicles than assignments to foot patrol, undercover work, second, officer vehicles, special assignments, or while off-duty (Tucker-Gail *et al.*, 2010). We did not have access to these variables in this study. Characteristics of the officer and offender may aggravate or moderate the risks posed by physical features of the landscape and are a worthy area of future research.

We were not able to examine whether specific police officers were more likely to experience physical assault than other officers. A relationship has been found to exist, however, between an officer's history of past battery victimization and future involvement in felonious battery (Tucker-Gail *et al.*, 2010). Officers who have experienced prior victimization are at a greater risk of future battery. Given the results of this current study, future research could investigate whether confounding arises for LEOs who are assigned to certain patrol areas. It is possible that officers' prior history of battery is a product of routine interaction (and greater exposure) with terrain that is higher in risk because of specific features of the physical landscape within the officers' patrol area. Police officers who are repeatedly experiencing battery could stand to benefit from knowledge of the micro-level places within their (macro-level) patrol areas that pose exceptional risks of such events. Or, the average risk value of an officer's patrol area could be used as a control variable in future officer-oriented research on this topic. Average spatial risk at the macro-level may also be considered within the context of racial inequality, politics (Kent, 2010), structural disadvantage (Peterson and Bailey, 1988), and other community level factors (Kaminski *et al.*, 2003) that prior research has linked to violence toward police officers.

We have provided the results of this study to the CPD and they were, in fact, inspired and eager to do a qualitative review of case files to learn about personal and situational factors. Though, their time to completing such a review is uncertain. One CPD analyst (J. Candella, personal communication, July 14, 2014) acknowledged that, without this study, the significant factors identified would not have been considered by CPD for further inquiry into the mechanisms through which they increase risks to police officers' personal safety. So, the CPD saw value in this study's results. This qualitative review and mitigation planning is not unprecedented for Chicago. They are currently involved with a project funded by the National Institute of Justice[6] that seeks to reduce gun violence. "Problem buildings" was identified to be one factor spatially correlated with gun violence. So, the CPD developed strategies to work with other city officials including the Housing Authority to target problem buildings using city ordinances to improve conditions conducive to crime. They are also working with private lenders to address the broader scope of the foreclosure crisis. The intervention is still ongoing and outcome evaluations of the impacts of this risk-based intervention are pending. But from these kinds of responses to spatial intelligence, utilizing environmental factors for anticipating personal risks to police officers could have many pragmatic and actionable benefits. One of these is that it enables intervention activities to focus on places, not just people located at certain places – which could jeopardize public perceptions and community relations. Ultimately, the likelihood of violence during a police officer's encounter with a suspect is mediated through a constellation of risk factors beyond only those that are spatial (Marotta and Caplan, 2013). So there are many more avenues of research needed in this arena.

Conclusion

It was hypothesized that certain features of the physical environment constitute significantly higher risk of battery to police officers handling calls for service at micro places, and that the co-location of certain features at micro places will yield higher risk. It turns out that there are meaningful and statistically significant spatial correlates of battery incident locations that can be used to assess future risks of battery to police officers. The empirical validity of the RTM confirms this for the city of Chicago. Altogether, results suggest that spatial risk assessments can be reliably made within the context of environmental features and not only on the presence of past battery incidents, crime types, or characteristics of suspects.

Giving high regard to place-based risk assessments makes theoretical and intuitive sense: police officers and assailants know they take risks and that these risks increase in certain locations; and police are often deployed to certain geographies to combat crime and manage other real or perceived public safety and security threats (Caplan *et al.*, 2011; Kennedy and Van Brunschot, 2009). This study adds empirical validity to place-based assessments of risks to officers when managing calls for service at certain locations. And, it permits the prioritization of risk presented by different environmental features based on the RRV of each feature in the model, respectively. These place-based risk assessments can have meaningful implications for policies and practices aimed at enhancing officer safety.

Notes

1. Some jurisdictions use the terms "battery" or "assault" interchangeably. Others define "assault" as the threat of bodily harm whereas "battery" is physical contact resulting in harm, serious bodily injury, or death. Much of the literature reviewed here uses these concepts interchangeably to imply any form of violence toward law enforcement with physical contact. For consistency, we henceforth use the term "battery" to connote an act in which an assailant intentionally causes serious bodily harm or death to law enforcement in the line of duty. All battery towards law enforcement are considered "felonious," meaning that they were intentional, aggravated, and illegal in nature as opposed to accidental (e.g. such as harm caused by a trip and fall).
2. Chicago defines "assault" as threats of bodily harm, and can cover a broad range of incidents against police, from resisting arrest without any injury to the police officer to threatening the officer with a weapon (but not using it).
3. Buildings become "problem buildings" when a report is received via either a 311 complaint from a citizen or on view by the police or other city official in regards to the specific location. Reasons for such a report can be due to vacancy, drugs, gangs, etc. According to CPD, a single complaint can label a building a "problem."
4. City of Chicago's Data Portal (https://data.cityofchicago.org).
5. Data on businesses infrastructure were obtained from InfoGroup, a leading commercial provider of business and residential information for reference, research, and marketing purposes (Infogroup, 2010).
6. Award #2012-IJ-CX-0038.

References

Bierie, D.M., Detar, P.L. and Craun, S.W. (2013), "Firearm violence directed at police", *Crime & Delinquency*, available at: http://cad.sagepub.com/content/early/2013/08/21/0011128713498330.abstract.

Block, R.L. and Block, C.R. (1995), "Space, place, and crime: hot-spot areas and hot places of liquor related crime", in Eck, J.E. and Weisburd, D. (Eds), *Crime and Place*, Vol. 4 No. 2, pp. 145-184.

Braga, A.A. and Weisburd, D. (2010), *Policing Problem Places: Crime Hot Spots and Effective Prevention*, Oxford University Press, New York, NY.

Brandl, S.G. and Stroshine, M.S. (2012), "The physical hazards of police work revisited", *Police Quarterly*, Vol. 15 No. 3, pp. 262-282.

Brantingham, P. and Brantingham, P. (1981), *Environmental Criminology*, Sage Publications, Beverly Hills, CA.

Bureau of Labor Statistics (2012), *Highest Incidence Rates of Total Nonfatal Occupational Injury and Illness Cases TABLE SNR01*, United States Department of Labor, Washington, DC, available at: www.bls.gov/iif/oshwc/osh/os/ostb3569.pdf (accessed December 10, 2013).

Bureau of Labor Statistics (BLS) (2013), *Non-Fatal Occupational Injuries and Illnesses Requiring Days Away From Work*, United States Department of Labor, Washington, DC, available at: www.bls.gov/news.release/osh2.nr0.htm (accessed December 10, 2013).

California Commission on Peace Officer Safety Training (POST) (2001), *A Five Year Study of Law Enforcement Officers Killed and Assaulted in the Line of Duty: A 1995-1999 Report*, POST Media Distribution Center, Sacramento, CA, available at: http://lib.post.ca.gov/Publications/55677885.pdf (accessed December 10, 2013).

Caplan, J.M. (2011), "Mapping the spatial influence of crime correlates: a comparison of operationalization schemes and implications for crime analysis and criminal justice practice", *Cityscape*, Vol. 13 No. 3, pp. 57-83.

Caplan, J.M., Kennedy, L.W. and Miller, J. (2011), "Risk terrain modeling: brokering criminological theory and GIS methods for crime forecasting", *Justice Quarterly*, Vol. 28 No. 2, pp. 360-381.

Caplan, J.M., Kennedy, L.W. and Piza, E.L. (2013), "Joint utility of event-dependent and environmental crime analysis techniques for violent crime forecasting", *Crime and Delinquency*, Vol. 59 No. 2, pp. 243-270.

Chicago Police Department (2010), "Annual report", available at: https://portal.chicagopolice.org/portal/page/portal/ClearPath/News/Statistical%20Reports/Annual%20Reports/10AR.pdf (accessed July 16, 2014).

Clarke, C. and Zak, M.J. (1999), "Fatalities to law enforcement officers and firefighters, 1992-97", *Environments*, Vol. 15, pp. 3-8.

Cohen, L., Kluegel, J. and Land, K. (1981), "Social inequality and predatory criminal victimization: an exposition and test of a formal theory", *American Sociological Review*, Vol. 46 No. 5, pp. 505-524.

Cohen, L.E. and Felson, M. (1979), "Social change and crime rate trends: a routine activity approach", *American Sociological Review*, Vol. 44 No. 4, pp. 588-608.

Cordner, G. (2006), *People with Mental Illness*, United States Department of Justice, Office of Community Oriented Policing Services, Washington, DC, available at: http://cops.usdoj.gov/Publications/e04062003.pdf (accessed December 10, 2013).

Covington, M.W., Huff-Corzine, L. and Corzine, J. (2014), "Battered police: risk factors for violence against law enforcement officers", *Violence and Victims*, Vol. 1 No. 29, pp. 34-52.

Craun, S.W., Detar, P.J. and Bierie, D.M. (2013), "Shots fired: firearm discharges during fugitive apprehensions", *Victims & Offenders*, Vol. 8 No. 1, pp. 56-69.

Detroit Police Department (2010), "Foot pursuit protocol", available at: www.detroitmi.gov/Portals/0/docs/police/DPD%20Civil%20Rights/202.7%20Foot%20Pursuit.pdf (accessed December 10, 2013).

Drawve, G. (2014), "A metric comparison of predictive hot spot techniques and RTM", *Justice Quarterly*, pp. 1-29 (in press).

Egenhofer, M. and Mark, D. (1995), "Naive Geography", in Frank, A.U. and Kuhn, W. (Eds), *Spatial Information Theory – A Theoretical Basis for GIS, International Conference COSIT '95, Semmering, Austria: Lecture Notes in Computer Science 988*, Springer-Verlag, New York, NY, pp. 1-15.

Ellis, D., Choi, A. and Blaus, C. (1993), "Injuries to police officers attending domestic disturbances: an empirical study", *Canadian J. Criminology*, Vol. 35, pp. 149-168.

FBI (2012), *Law Enforcement Officers Killed and Assaulted*, United States Department of Justice, Washington, DC, available at: www.fbi.gov/about-us/cjis/ucr/leoka/2011/about-law-enforcement-officers-killed-and-assaulted (accessed December 10, 2014).

Frank, A.U. (1993), "The use of geographical information systems: the user interface is the system", in Medyckyj-Scott, D. and Hearnshaw, H.M. (Eds), *Human Factors in Geographic Information Systems*, Belhaven Press, London, pp. 3-14.

Freundschuh, S. and Egenhofer, M. (1997), "Human conceptions of spaces: implications for geographic information systems", *Transactions in GIS*, Vol. 2 No. 4, pp. 361-375.

Fridell, L., Faggiani, D., Taylor, B., Brito, C.S. and Kubu, B. (2009), "The impact of agency context, policies, and practices on violence against police", *Journal of Criminal Justice*, Vol. 37 No. 6, pp. 542-552.

Golledge, R.G. and Stimson, R.J. (1997), *Spatial Behavior: A Geographic Perspective*, Guildford Press, New York, NY.

Groff, E.R. and Lavigne, N.G. (2002), "Forecasting the future of predictive crime mapping", *Crime Prevention Studies*, Vol. 13, pp. 29-58.

Heffner, J. (2013), "Statistics of the RTMDx utility", in Caplan, J., Kennedy, L. and Piza, E. (Eds), *Risk Terrain Modeling Diagnostics Utility User Manual (Version 1.0)*, Rutgers Center on Public Security, Newark, NJ.

International Association for Chiefs of Police (IACP) (2003), "Foot pursuits: concepts and issues paper, 2003", available at: www.tacp.org/getdoc/b69a2eb9-1ebd-4313-83fd-c5cd688251f1/Foot_Pursuit_Paper (accessed December 10, 2013).

International Association for Chiefs of Police (IACP) (2011), "Law enforcement officers killed by felonious assault", available at: www.theiacp.org/portals/0/pdfs/feloniousreport.pdf (accessed December 10, 2013).

Johnson, R.R. (2008), "Officer firearms assaults at domestic violence calls: a descriptive analysis", *The Police Journal*, Vol. 81 No. 1, pp. 25-45.

Kaminski, R.J., and Coleman, L. (2007), *South Carolina Deaths in Police Custody: Final Report*, South Carolina Department of Public Safety, Office of Justice Programs.

Kaminski, R.J. and Sorensen, D.W. (1995), "A multivariate analysis of individual, situational and environmental factors associated with police assault injuries", *American Journal of Police*, Vol. 14 Nos 3/4, pp. 3-48.

Kaminski, R.J., Jefferis, E. and Gu, J. (2003), "Community correlates of serious assaults on police", *Police Quarterly*, Vol. 6 No. 2, pp. 119-149.

Kennedy, L.W. and Van Brunschot, E. (2009), *The Risk in Crime*, Rowman and Littlefield, Lantham, MD.

Kennedy, L.W., Caplan, J.M. and Piza, E. (2011), "Risk clusters, hotspots, and spatial intelligence: risk terrain modeling as an algorithm for police resource allocation strategies", *Journal of Quantitative Criminology*, Vol. 27 No. 3, pp. 339-362.

Kent, S.L. (2010), "Killings of police in US cities since 1980: an examination of environmental and political explanations", *Homicide Studies*, Vol. 14 No. 1, pp. 3-23.

Kercher, C., Swedler, D.I., Pollack, K.M. and Webster, D.W. (2013), "Homicides of law enforcement officers responding to domestic disturbance calls", *Injury Prevention*, Vol. 19 No. 5, pp. 331-335.

Komarovskaya, I., Maguen, S., McCaslin, S.E., Metzler, T.J., Madan, A., Brown, A.D. and Marmar, C.R. (2011), "The impact of killing and injuring others on mental health symptoms among police officers", *Journal of Psychiatric Research*, Vol. 45 No. 10, pp. 1332-1336.

Langton, M. and Durose, L. (2011), *Police Behavior During Traffic and Street Stops*, United States Department of Justice Office of Justice Programs, Bureau of Justice Statistics, Washington, DC, available at: www.bjs.gov/index.cfm?ty = pbdetail&iid = 4779 (accessed December 10, 2013).

Liberman, A.M., Best, S.R., Metzler, T.J., Fagan, J.A., Weiss, D.S. and Marmar, C.R. (2002), "Routine occupational stress and psychological distress in police", *Policing: An International Journal of Police Strategies & Management*, Vol. 25 No. 2, pp. 421-441.

Mark, D. (1993), "Human spatial cognition", in Medyckyj-Scott, D. and Hearnshaw, H.M. (Eds), *Human Factors in Geographical Information Systems*, Belhaven Press, London, pp. 51-60.

Marotta, P. and Caplan, J.M. (2013), *Felonious Assault and Injury to Law Enforcement: Epidemiology and Spatial Risk Factors*, Rutgers Center on Public Security, Newark, NJ, available at: www.rutgerscps.org/docs/POFeloniousAssault_MarottaCaplan_Dec2013.pdf (accessed December 10, 2013).

Meyer, S. and Carroll, R.H. (2013), "When officers die: understanding deadly domestic violence calls for service", *The Police Chief Magazine*, available at: www.policechiefmagazine.org/magazine/index.cfm?fuseaction = display_arch&article_id = 2378&issue_id = 52011 (accessed December 10, 2013).

National Highway Traffic Safety Administration (2011), *Characteristics of Law Enforcement Officers' Fatalities in Motor Vehicle Crashes, publication 811 411*, National Highway Traffic Safety Administration, Washington, DC, available at: www-nrd.nhtsa.dot.gov/Pubs/811411.pdf (accessed December 10, 2013).

Peterson, R.D. and Bailey, W.C. (1988), "Structural influences on the killing of police: a comparison with general homicides", *Justice Quarterly*, Vol. 5 No. 2, pp. 207-233.

Ratcliffe, J.H. and McCullagh, M.J. (1998), "Identifying repeat victimization with GIS", *British Journal of Criminology*, Vol. 38 No. 4, pp. 651-662.

Scott, M.S. and Dedel, K. (2006), *Assaults in and Around Bars*, United States Department of Justice: Office of Community Oriented Policing (COPS), 2nd ed., available at: www.popcenter.org/problems/assaultsinbars/print/ (accessed December 10, 2013).

Shane, J.M. (2012), *Abandoned Buildings and Lots. Problem-Oriented Guides for Police*, US Department of Justice, Office of Community Oriented Policing Services, Washington, DC, available at: www.popcenter.org/problems/abandoned_buildings_and_lots/ (accessed December 10, 2013).

Sherman, L.W., Gartin, P.R. and Buerger, M.E. (1989), "Hot spots of predatory crime: routine activities and the criminology of place", *Criminology*, Vol. 27 No. 1, pp. 27-56.

Simon, R. (1975), *Women and Crime*, Lexington Books, Lexington, MA.

Swedler, D.I., Kercher, C., Simmons, M.M. and Pollack, K.M. (2013), "Occupational homicide of law enforcement officers in the US, 1996-2010", *Injury Prevention*, available at: http://injuryprevention.bmj.com/content/early/2013/05/30/injuryprev-2013-040799.short

Taylor, R.B. (1988), *Human Territorial Functioning*, University of Cambridge Press, New York, NY.

Taylor, R.B., and Harrell, A. (1996), *Physical Environment and Crime*, US Department of Justice, Office of Justice Programs, National Institute of Justice, pp. 11-12.

Tomlin, C.D. (1994), "Map algebra: one perspective", *Landscape and Urban Planning*, Vol. 30 No. 1, pp. 3-12.

Tucker-Gail, K.A., Selman, D., Kobolt, J.R. and Hill, T. (2010), "Felonious line-of-duty officer deaths (1995-1999): the impact of tenure and age", *International Journal of Police Science & Management*, Vol. 12 No. 1, pp. 119-133.

Weisburd, D., Groff, E. and Yang, S. (2012), *The Criminology of Place: Street Segments and Our Understanding of the Crime Problem*, Oxford University Press, Oxford.

Weisburd, D., Morris, N. and Groff, E. (2009), "Hot spots of juvenile crime: a longitudinal study of arrest incidents at street segments in Seattle, Washington", *Journal of Quantitative Criminology*, Vol. 25 No. 4, pp. 443-467.

Further reading

Edwards, T.D. (1995), "Felonious killings of state police and highway patrol officers: a descriptive and comparative evaluation", *American Journal of Police*, Vol. 14 No. 2, pp. 89-105.

Rabe-Hemp, C.E. and Schuck, A.M. (2007), "Violence against police officers are female officers at greater risk?", *Police Quarterly*, Vol. 10 No. 4, pp. 411-428.

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