

Handbooks of Sociology and Social Research

Marvin D. Krohn
Nicole Hendrix
Gina Penly Hall
Alan J. Lizotte *Editors*

Handbook on Crime and Deviance

Second Edition

Handbooks of Sociology and Social Research

Series Editor

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Handbook on Crime and Deviance

Second Edition

 Springer

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Part I

Methodological Issues in Crime Research by Alan Lizotte

Several methodological issues have come to the foreground in crime and deviance as new and more dynamic data have become available. Traditional data sources continue to be important in addressing issues at the individual, temporal and spatial levels. However, the distinctions between these levels of measurement have become blurred as new nontraditional data have become available. For example, the National Incident-Based Reporting System (NIBRS) provides much more potent data than the traditional Uniform Crime Reports. These data sets provide opportunities for much more dynamic analyses that answer more rigorous and detailed research questions.

As is the case in chapters that follow, we have only addressed a few of the more recent methodological issues. We chose diverse issues that have fundamentally impacted the way data analysis is conducted in our field. To include all of the important issues would easily fill several volumes. The contributors to these chapters are well known for their contributions to the topics covered. They include both newer and more seasoned scholars.

As our view of the context of social interaction becomes keener, Andresen and Hodgekinson give us an ongoing look at place-based data, methods and analysis. They provide evidence supporting analyses of micro-places, like street segments, as part of the bigger picture in criminological research. They summarize the methodological

challenges that face such analyses and provide detailed examinations of additional methods by which questions regarding the strength and stability of the effects of these micro-places can be examined.

Since the 1930s, very little has changed in the way the FBI reports data from the Uniform Crime Reports (UCR). This seriously limited the types of analyses conducted using these data. Recently, the National Incident-Based Reporting System (NIBRS) has and will continue to change all of that. As Lynn Addington demonstrates, NIBRS moves us from a static to a much more dynamic data set allowing much more detailed and sophisticated research questions to be addressed.

As the field becomes more sophisticated in the application of hands-on engaged research, it has become apparent that there are important, diverse and subtle ethical controversies surrounding that work. Janich and Duffee have firsthand experience in dealing with these issues, and they provide a detailed examination of them.

The pathways to our understanding of victimization at K-12 schools and on college and university campuses are divergent. Butler, Kulig, Fisher and Wilcox provide great insight into the historical events that lead to these two research traditions. They show each unique process through the application of the opportunity framework.

Place-Based Data, Methods, and Analysis: Past, Present, and Future

1

Martin A. Andresen and Tarah Hodgkinson

Abstract

Place-based research in criminology considers the micro-place (street segments, for example) as the unit of analysis. Though research considering criminal events, or police calls for service, occurring at the micro-place has a long history, the contemporary “crime and place” literature that considers citywide analyses of criminal events or police calls for service emerged 30 years ago. This research has shown that the micro-place is an important component of understanding the spatial dimension of criminal events, both descriptively and inferentially. In this chapter, we review the crime and place literature, considering place-based data, methods, and forms of analysis. We discuss the significant strides that have been made within the spatial criminology literature using a place-based approach, but conclude that there remains work to be done to move the field forward.

Introduction

Most criminological literature focuses on the offender: why and how they offend. The places criminal events occur, however, consistently show that location matters for understanding crime. The academic examination of “problem places” began with the Chicago School in the early 1900s, but more recently, this focus has begun to shift to include the micro-place, as practitioners and academics acknowledge the role of problem places in understanding crime and its prevention/reduction. Place-based research in criminology considers the micro-place (specific addresses, street segments, street intersections) as the primary unit of analysis when studying criminal events (official incident) and police activity (calls for police service) data.

Micro-level place-based research, as it is currently understood, began with the work of Sherman, Gartin, and Buerger (1989), when they undertook a micro-place analysis of predatory crimes (robbery, rape, and automotive theft) across the entire city of Minneapolis, MN for an entire year. Also referred to as crime and place research (Eck & Weisburd, 1995), the micro-place has proven to be a critical component of understanding the spatial patterns of crime. For example, a small percentage of micro-places account for a significant percentage of crime across many cities: the “typical” reporting is that five percent of micro-places (street segments, street intersections, actual addresses, and so on)

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account for 50% of crime—when individual crime types are considered, this percentage of micro-places can drop to less than one percent (Weisburd, 2015).

The importance of the micro-place to understanding spatial patterns of crime has been shown to be critical by some recent research that has investigated the proportion of the variability in spatial patterns that can be explained at different levels of geography: the micro-level (street segments, for example), the meso-level (larger areas approximately the size of one square kilometre, neighbourhoods or census tracts, for example), and macro-level geographic areas that are larger than neighbourhoods but regions within a city. For example, Steenbeek and Weisburd (2016) investigated the proportion of the variability in spatial crime patterns that could be attributed to the micro-, meso-, and macro-levels of analysis in The Hague, Netherlands. They found that approximately 60–70% of the spatial variability could be attributed to the micro-level, with most of the remaining percentage of the spatial variability attributed to the macro-level; they even go as far as stating that the meso-level of analysis (neighbourhoods) do not add value to understanding spatial patterns of crime. Schnell, Braga, and Piza (2017) found similar results in Chicago, IL, with 55–65% of the spatial variability attributed to the micro-level. In another research study, O'Brien and Winship (2017) found that 95–99% of the spatial variability of crime can be attributed to the street address. These findings indicate that while research comparing cities or neighbourhoods may be important, statistically, the most significant variance occurs from street to street, showing that criminological research needs to take into account these micro-locations. It is also important to note here that such high percentages of spatial variability being accounted for by the micro-place does not mean that larger areal units of analysis are not important for understanding the geography of crime. Rather, this simply shows that place-based analyses should not be ignored if one wishes to understand the spatial dimension of crime.

In this chapter, we outline the empirical consistency of crime concentration, the nature of the data, theoretical implications, methods of

measurement, and methods of analysis most common in place-based criminology. Our goal here is to provide the reader with an understanding of the primary ideas and issues with place-based criminology, concluding with our view on how and where the field can progress in the future.

The Law of Crime Concentration at Places

Sherman et al. (1989) were the first to report a Pareto-type principle for understanding spatial crime concentration at places: three percent of micro places were able to account for 50% of predatory crime in Minneapolis; considering specific crime types, these concentrations are 2.2% for robbery, 2.7% for motor vehicle theft, and 1.2% for rape. This is a considerable level of concentration that is similar to, and consistent with, the study by Wolfgang, Figlio, and Sellin (1972) who found that a small percentage of offenders committed a significant portion of criminal events.

Several years later, Weisburd, Bushway, Lum, and Yang (2004) studied crime concentrations and stability in Seattle, Washington. Similar to Sherman et al. (1989), these researchers found that approximately five percent of street segments accounted for 50% of all calls for police service. Moreover, they found that this high degree of spatial concentration carried over a 14-year time period. In subsequent research, Weisburd, Morris, and Groff (2009), and Weisburd, Groff, and Yang (2012) confirmed these results in other contexts in Seattle, Washington: young offenders over the original 14-year time period and their previous analyses over a 16-year time frame. Braga, Hureau, and Papachristos (2010, 2011) found similar results for shootings and robbery in Boston, Massachusetts; over 29 years, less than 3% of street segments and intersections accounted for 50% of shootings and 8.1% of street segments and intersections accounted for 50% of robberies. In cities of varying sizes across the United States, Weisburd (2015) has found this general pattern of spatial

crime concentrations to be present. And more recently, Haberman, Sorg, and Ratcliffe (2017) confirmed these tendencies at three different temporal scales.

These patterns of spatial concentration have also been found in international contexts. In Canada, Andresen and Malleson (2011) found that approximately five percent of street segments accounted for 50% of crime in Vancouver (1991–2001), and that levels vary by crime type: assault (1.62%), burglary (7.61%), robbery (0.84%), sexual assault (1.12%), theft (2.58%), theft of vehicle (5.97%), and theft from vehicle (2.64%). More recently, Andresen, Curman, and Linning (2017) found that these concentrations increased over time (1991 through to 2006) and Andresen, Linning, and Malleson (2017) found that these spatial concentrations continued to increase (2003 through to 2013) for property crime. Also in Canada, Andresen and Linning (2012) found that for Ottawa in 2006, crime was incredibly concentrated spatially in order to account for 50% of that crime: total burglary (1.67%), total robbery (0.38%), and theft of vehicle (0.99%). Outside of North America, Weisburd and Amram (2014) found that 50% of crime occurred on 4.5% of street segments and all crime could be accounted for by considering 36.8% of street segments in Tel-Aviv-Jaffa, Israel in 2010. And in Campinas, Brazil considering various forms of robbery and theft (commercial, residential, vehicle, street, and public transportation), Melo, Matias, and Andresen (2015) found that 50% of crime is accounted for by 0.1–3.66% of street segments over the years 2010–2013 depending on the crime type.

This high degree of spatial concentration in a variety of international contexts has led Weisburd (2015) to assert a law of crime concentration at places. This law of crime concentration at places states that “for a defined measure of crime at a specific micro-geographic unit, the concentration of crime will fall within a narrow bandwidth of percentages for a defined cumulative proportion of crimes” (Weisburd, 2015, 138). Though this law has been shown to be present in a variety of contexts over space, time, and crime types, the data used for these measurements are

far from perfect, needing consideration for future research.

Data and Its Issues in Place-Based Research

Three primary data issues exist in place-based criminology research: police data and the dark figure of crime, georeferencing/geocoding at the micro-place, and how to account for intersections. Place-based research in criminology primarily relies on police calls-for-service data (police activity) and incident data (Uniform Crime Reports, for example) obtained from various police services. The former represents calls for police service through an emergency service such as 911, requests for police service made by the public directly to a police service, and internal calls for service made by police officers (Sherman et al., 1989), and the latter represent official incident data that are reported to government statistical organizations.

Since the late 1980s, calls for service data has become more available and used more frequently in research. However, because of the sensitivity of criminal event data (or any data concerning any interactions between the public and the police), many police services do not provide address level (micro-place) data for analyses unless there is a pre-existing relationship between the researcher and that police service. Moreover, these calls for service data have been criticized for not appropriately representing criminal events because a call for service does not necessarily mean a crime has actually occurred (Klinger & Bridges, 1997; Sherman et al., 1989). Because of this potential, calls for service data are, at times, referred to as police activity data (Andresen, 2014). Despite these concerns regarding calls for service data, the potential for the inclusion of any unfounded calls would likely be dwarfed by the volume of calls even reported to the police and the importance of catching low level social disorder that often does not translate into official incident data but is still important for understanding what is happening at the street (Black, 1970; Bulwer, 1836; Perreault, 2015; Perreault & Brennan, 2010).

The most significant concern regarding the use of official crime data is that it may not actually be representative of crime patterns; this concern dates back to at least the early 1800s (Bulwer, 1836). The issue is that if a significant portion of criminal events are never reported to the police, those criminal events that do get reported may be biased, potentially leading to improper inferences relating to theoretical testing and, more importantly, subsequent policy implementations. For example, data drawn from the Canadian victimization survey in 2014 indicate that 31% of total criminal victimization was reported to the police, steady at 31% in 2009, down from 34% in 2004, and from 37% in 1999 (Perreault, 2015; Perreault & Brennan, 2010). It should be obvious that with more than two-thirds of criminal event data not even being present in official crime records that the potential for bias in the crime data that we do study is great; this is particularly the case for any investigation of spatial crime patterns, especially for studies considering the micro-place because criminal/police events are so rare for any particular micro-place. The trouble is that we do not have any studies that are able to investigate this potential spatial bias due to the high costs of undertaking a micro-level victimization survey, or even the neighbourhood level survey, for example. The only study we are aware of that considers this issue, and tests it, was undertaken by Ceccato and Lukyte (2011), where they found that the victimization patterns were significantly different from official crime data patterns. This study was for one country and rather coarse spatial units of analysis, but shows the potential for problems with 200 years of spatial criminological research. Regardless, their research is important and points to an issue for which we need to be aware.

Overall, the under-reporting for criminal event data is problematic for place-based, or any spatial, analysis of crime in a manner similar to how offender-based theories often only rely on interviews of offenders in prison, not those who do not get caught. However, in order to address under-reporting, researchers have begun to look

at individual crime types that may have better reporting rates, allowing for more confident analyses—it is assumed that reporting issues within these individual crime types are consistent over time and space. Homicide, for example, is commonly known to have the highest reporting rates because the victims either disappear or are found deceased. Though some homicide victims may be reported as missing persons for some (indefinite) period of time or the cause of death for a person may be mis-identified, homicide-related crime data are considered the most complete (David, 2017; Forst, 2004). The question, then, is how well other crime types are reported to the police? Research in Canada has shown that there is substantial variation across the following individual crime types: sexual assault, robbery, physical assault, residential break and enter (residential burglary), motor vehicle/parts theft, theft of household property, vandalism, and theft of personal property (Perreault, 2015; Perreault & Brennan, 2010). As shown in Table 1.1, property crimes have much greater levels of reporting to the police, especially break and enter and theft related to motor vehicles; this may simply be due to those criminal events often requiring a police report for insurance claims. Despite having higher reporting rates to the police, for the crime types reported in Table 1.1, rarely are the reporting rates greater than 50%, revealing that biases in these data are likely systemic. Though this is less consequence for the actual analyses of criminal event data, the reasons listed for not reporting a crime to the police range from “not important enough” (almost 70%) to “fear of publicity or news coverage” (approximately 5%) (Perreault, 2015; Perreault & Brennan, 2010).

Another georeferencing issue for place-based research is geocoding: the placement of a criminal event on a map (using a dot to represent an address, for example). This is an issue because this process has the potential for error that may impact subsequent analyses. At times, criminal events, or any other location data for that matter, do not have an address or set of geographic coordinates provided. This may be due to a lack

Table 1.1 Percent of self-reported victimizations reported to the police

Crime type	1999	2004	2009	2014
Total victimization	37	34	31	31
Sexual assault	n/a	8	n/a	5
Robbery	46	46	43	45
Physical assault	37	39	34	38
Total violent victimization	31	33	29	28
Break and enter	62	54	54	50
Motor vehicle/parts theft	60	49	50	44
Household property theft	32	29	23	25
Vandalism	34	31	35	37
Total household victimization	44	37	36	36
Theft of personal property	35	31	28	29

Source Perreault and Brennan (2010) and Perreault (2015)

of reporting, unknown locations, or human error in data reporting, for example. If these missing geographic locations are repeatedly occurring in the same places this may be problematic for subsequent analyses to understand spatial crime patterns. However, Ratcliffe (2004) has found that even when data are missing at random, 85% of the data must be geocoded to prevent bias occurring in the spatial patterns of crime. But even when data are geocoded at an acceptable rate, there is still the issue of the availability of micro-level geocoded police data for place-based analyses.

Police data (calls for service or incident) measured at the micro-place level are increasingly becoming available in a variety of different cities and countries (see Weisburd, 2015). In some cases, these data are provided at the street segment level, suitable for place-based analyses, but in other cases data are not provided at such a fine resolution. Of course, we must work with the data that are available to us as researchers, but this limits the reproducibility, and generalizability, of place-based criminological research.

Lastly, an issue that has emerged in place-based criminology research is the inability to properly georeference police calls for service

or incident data to intersections. Depending on the research study, Weisburd (2015) has found that 0–33% of police calls for service data are georeferenced at intersections. These intersections are removed from the analysis in some research (Curman, Andresen, & Brantingham, 2015; Weisburd et al., 2004), but other research has incorporated intersections into the analyses (Andresen, Curman, et al., 2017; Andresen, Linning, et al. 2017; Braga et al., 2010, 2011; Wheeler, Worden, & McLean, 2016) as separate units of analysis. Very few police incidents that are not traffic-related actually occur within an intersection, but if the incident occurred very close to the intersection (a motor vehicle theft, for example, that was parked at the end of a street segment) it often is georeferenced to that point rather than on the street segment itself. The issue is that removing intersection data, especially when it can represent as much as one-third of the police calls for service data, only adds to the “dark figure of crime” issue, but placing police calls for service at an intersection when they did not occur at that intersection imposes some spatial bias. If the number, or percentage, of intersections is low, then either one of these situations will generate very little bias.

Theory Testing in Place-Based Research

Though related to the previous section, another issue with micro-place data that is important to highlight is the lack of correlates with crime measured at the micro-place. These correlates relate to most of the traditional variables used in the spatial criminology literature to test theories, evaluate interventions, or generate criminal justice policy and are simply not available at this scale. The lack of availability may be related to privacy (statistical agencies will not release the data) or the cost of obtaining these measures at the micro-place (most censuses only sample 20% of individuals), but these variables are important to control for in any analyses.

For example, in the cases of social disorganization theory (Sampson & Groves, 1989; Shaw & McKay, 1942, 1969), theoretically informed variables have been measured at the

neighbourhood level; in the case of routine activity theory, theoretically informed variables have been measured at the national level (Cohen & Felson, 1979), the neighbourhood level (Andresen, 2006, 2011), and the individual level (Kennedy & Forde, 1990). Very few theoretically informed variables tend to be available at the micro-geographic level. Rather, these variables tend to be available in various censuses considering areal units such as census tracts and census block groups. The availability of theoretically-informed variables at the micro-place matters and is important for moving place-based research forward in criminology because, as shown in Fig. 1.1, one census tract may include 10 census block groups, and each census block group may include 20 street segments and intersections.

To date, the only two known studies testing theory at the micro-place are Smith, Frazee, and Davison (2000) and Weisburd et al. (2012).

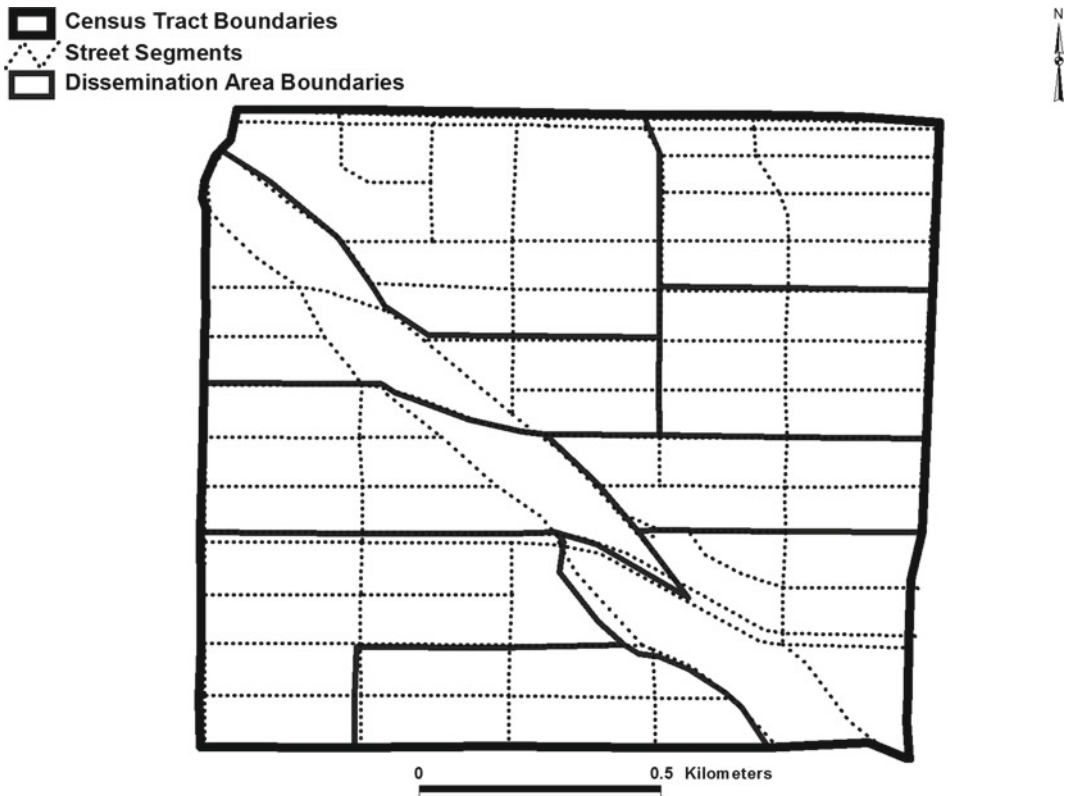


Fig. 1.1 Census tracts, dissemination areas, and street segments. *Source* Andresen and Malleon (2011)

Smith et al. (2000) undertook a citywide study of spatial crime patterns at a micro-spatial unit of analysis, street segments, but also larger areal units of analysis. They used data from a medium-sized southeastern city in the United States, integrating routine activity theory and social disorganization theory in a place-based analysis. They noted that the empirical support in past research for integrating routine activity theory and social disorganization theory has not been strong. However, they note that it was not because routine activity theory and social disorganization theory should not be integrated, rather that the spatial units of analysis have not been appropriate, such as census tracts or census block groups. In their theoretical integration that used the street segment as the spatial unit of analysis, Smith et al. (2000) had far more success, in the context of street robbery. They argued that their success was because of the heterogeneity within neighbourhoods that was averaged out when other researchers had used larger areal units.

Weisburd et al. (2012) conducted the most recent, and comprehensive, place-based investigation of crime. In their book, Weisburd et al. (2012) extended their previous research on crime at places in Seattle, Washington. In addition to investigating trajectories of micro-places over time, they also examined the characteristics of the chronic street segments. Weisburd et al. (2012) analyzed the characteristics of this type of trajectory (time path) from a theoretical perspective. Using logistic regression, they incorporated explanatory variables that represented routine activity theory and social disorganization theory. For routine activity theory, they found the following: the presence of high-risk juveniles (motivated offenders) doubled the probability of high-crime street segments; each additional employee on a street segment (industrial/business land use) increased the probability of a presence of a chronic street segment by eight percent; a public facility (community centre or high school, for example) within 400 m of a street segment increased the probability of a chronic street segment being present by 25%; and street seg-

ments with a greater resident population had a greater probability of being a chronic street segment. Moreover, each additional bus stop increased the probability of a high crime street segment by a factor of two, a street segment on an arterial road was at an increased probability of being a chronic street segment, and the presence of vacant land on a street segment had a very larger impact of a street segment (a one percent increase in the area of vacant land increases the probability of a street segment being chronic by almost 50%).

In the context of social disorganization variables, the results showed that increases in the residential property value were associated with a large magnitude decrease in the probability of a street segment being chronic, and the presence of subsidized housing was associated with a moderate increase in the probability of a street segment being chronic. Weisburd et al. (2012) also found statistically significant effects for the presence of physical disorder, the presence of truant juveniles and, lastly, the presence of residents who are involved in public affairs in that all increase the probability of a street segment being chronic.

This research that is able to incorporate theoretically informed variables in a place-based context has been instructive. However, because of a lack of citywide data that measures these theoretical constructs, there is very little of this research. Though more research is emerging that incorporates more theoretically informed (routine activity theory and social disorganization theory) place-based variables with more traditional variables in the spatial criminology literature (Andresen & Hodgkinson, 2018a), it is often necessary for the place-based variable to be aggregated to larger census-based areal units of analysis such as census tracts and census block groups. The generation, and use, of these more traditional theoretically informed variables at the level of the micro-place are available through the census, but involve confidentiality concerns. As such, in order to move the place-based criminology research agenda forward, this data constraint, and the others named above, need to be addressed.

Measuring Crime at Places

As outlined above, the law of crime concentration at places holds across time, space, and crime types. However, it is important to note that when the spatial units of analysis become increasingly smaller, the spatial concentration of any activity will appear to increase. For example, if there are 1,000 events occurring within 10,000 spatial units, the minimum level of concentration is 5% of spatial units of analysis accounting for 50% of the events; this replicates the Pareto Principle nature of crime concentrations with a (potentially) completely random or uniform distribution of criminal activity.

Although this is a completely hypothetical scenario, this phenomenon has been shown to be present in the crime and place literature. For example, Andresen, Linning, et al. (2017) showed that 100% of property crime in Vancouver, Canada occurred in just over 25% of street segments and intersections; moreover, this level of concentration has been increasing over time: 35–25%, 2003–2013. In the context of specific crime types, 100% of crime can be accounted for considering 5–20% of street segments and intersections. Most often, this is an artefact of crime counts versus the number of spatial units of analysis, but not always. As such, this crime concentration measure should be evaluated critically whenever there are more spatial units of analysis than there are criminal events—see Hipp and Kim (2017) and Levin, Rosenfeld, and Deckard (2017) for other discussions of issues with measuring spatial crime concentrations.

Accounting for this limitation in the crime concentration measure, Andresen and Malleson (2011) not only reported the percentage of criminal events accounted for by 50% of street segments, but also reported the percentage of street segments with any crime and the percentage of street segments with any crime that account for 50% of crime. This allows for the reader to place the standard concentration measure within a context: given how many places crime actually occurs, how concentrated is crime? In the aggregate, this tends to show that

approximately 10–15% of street segments and intersections account for 50% of crime, depending on the year. Though this provision of context is a step forward and, most often, supports the law of crime concentration at places, it still has its limitations.

Bernasco and Steenbeek (2017) standardize the measurement of spatial crime concentrations using a generalized Lorenz curve and Gini coefficient: the Lorenz curve is a function that graphs the cumulative distribution of one variable compared to the cumulative function of another variable (the percentage of crime compared to the percentage of micro-places, for example), and the Gini coefficient is a statistic measuring inequality. The Lorenz curve has a long history (over a century) of being used to measure the magnitude of inequality in the distribution of wealth. As shown in Fig. 1.2, in the graph showing the Lorenz curve there is a line of equality that represents an even distribution; 25% of micro-places account for 25% of crime, 50% of micro-places account for 50% of crime, 75% of micro-places account for 75% of crime, and so on. The Lorenz curve shows the actual distribution: 5% of micro-places account for 50% of crime, for example. As such, the further away the Lorenz curve is from the Line of equality, the greater the degree of inequality present with regard to the distributions of the two variables of interest.

In order to summarize the degree of inequality in one statistic, the Gini coefficient can be calculated as the ratio of the area between the Line of equality and the Lorenz curve (Area A in Fig. 1.2) to the area between the Line of equality and the “Line of perfect inequality” (Areas A and B in Fig. 1.2): $A/(A + B)$. If there is no inequality, the Area A is zero, so the Gini coefficient is equal to zero, but if all crime happens in one place (perfect inequality) Area A is equal to Areas A + B, so the Gini coefficient is equal to unity. This provides a simplistic graph and easily interpreted statistic for comparisons of crime concentrations across different studies. Though instructive, the Lorenz curve and corresponding Gini coefficient have a limitation that can be problematic for such comparisons.

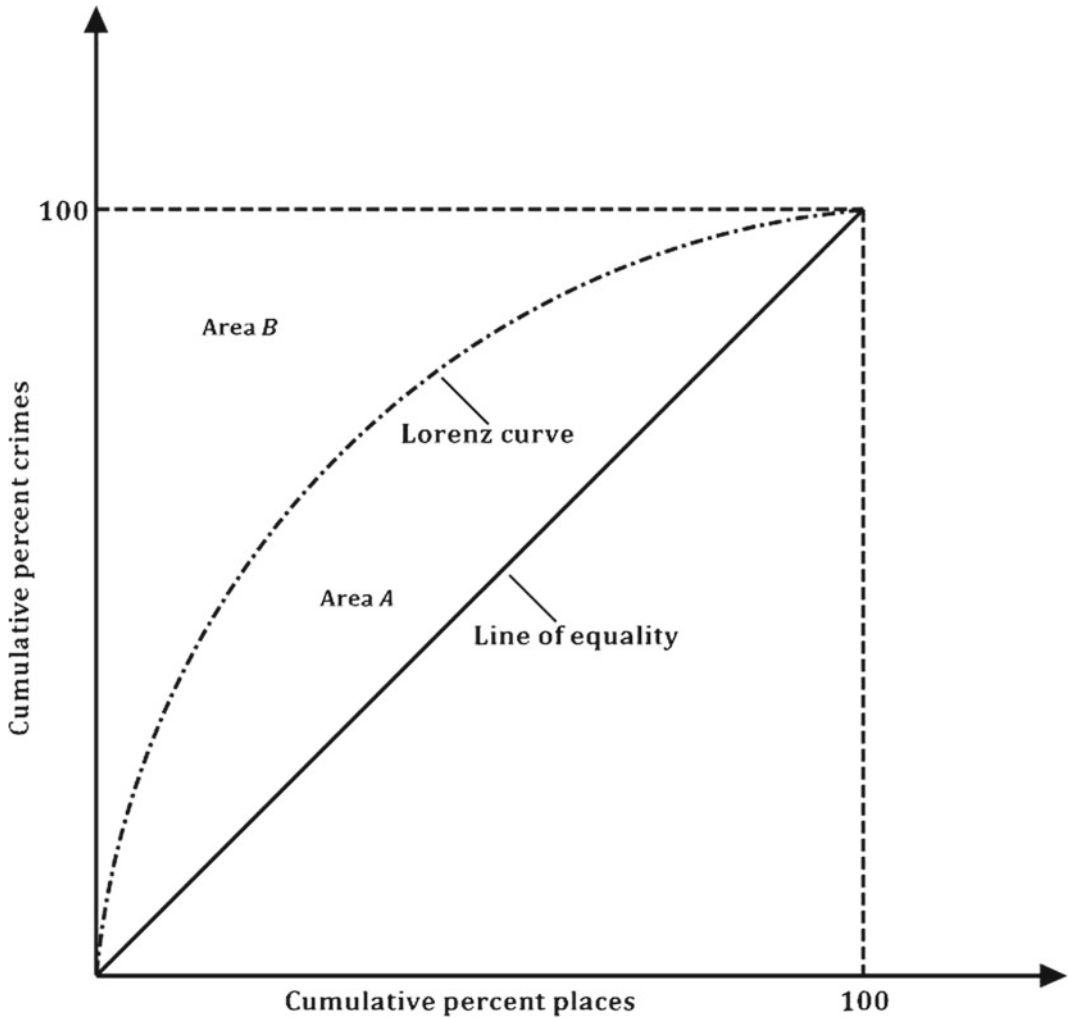


Fig. 1.2 Lorenz curve

In the crime and place literature, the Lorenz curve and the Gini coefficient are limited when there are more micro-places than there are criminal events: 1,000 criminal events and 10,000 street segments, for example. In this situation, the line of equality would not represent what equality would actually be. Even if each criminal event were on a separate street segment, 10% of the street segments would account for all the criminal events and a Gini coefficient close to unity. Visually, Area A would be much larger than it should be. Rather, the actual Line of Equality would be much steeper.

With their generalized Lorenz curve and Gini coefficient, Bernasco and Steenbeek (2017) modified the calculations such that the Line of equality is represented in a manner that accounts for this small number problem. In the crime and place context, if the number of criminal events (or calls for service) is greater than or equal to the number of micro-places their generalized Lorenz curve and Gini coefficient gives the same output as the traditional Lorenz curve and Gini coefficient. Consequently, using the generalized Lorenz curve and Gini coefficient developed by Bernasco and Steenbeek (2017), researchers can

confidently compare concentration rates across all contexts.

Methods of Analysis in Place-Based Research

There are a number of ways to measure spatial crime concentrations, as well as the stability of those spatial crime concentrations over time. This stability is critically important within spatial criminology, more generally, and place-based criminology, specifically. If spatial patterns are not stable over a reasonable length of time, it is not possible to make good predictions regarding the levels of crime, or police activity, at other times or in other places. In other words, if there is no spatial stability in our data, we can only report on historical spatial crime patterns that have no relevance today.

The importance of this spatial stability has been recognized for almost a century, with Shaw, Zorbaugh, McKay, and Cottrell (1929) and Shaw and McKay (1931, 1942, 1969) noting how neighbourhoods maintained their spatial patterns of juvenile delinquency over time, despite the change in ethnic composition of those neighbourhoods. However, it is important to re-assess spatial stability because many North American inner cities have become gentrified as the nature of industry changes (Florida, 2010; Lees, Slater, & Wyly, 2007).

The methods within the place-based criminology literature have primarily consisted of group-based trajectory modeling, growth curve modeling, and a longitudinal spatial point pattern test. In addition, some more traditional statistical methods have been used in the analysis of place-based (crime) data. Each is covered briefly, in turn.

Group-Based Trajectory Modeling and K-Means Clustering

Within investigations of the criminal career debate, Nagin and Land (1993) were the first to use trajectory analysis in criminology.

Commonly referred to as “group-based trajectory modelling” (GBTM), this semi-parametric method was used to identify subgroups of individual offenders who follow a similar pattern of change over time (Andruff, Carraro, Thompson, Gaudreau, & Louvet, 2009; Nagin, 1999, 2005). Effectively, GBTM is a form of cluster analysis that groups individual observations (individuals or places) into groups that have similar time paths. The number of groups identified is identified based on the variance between the different trajectories and is most often measured using the Bayesian Information Criteria (BIC) score. As such, the number of trajectory groups is identified by increasing and decreasing the number of groups in an effort to minimize the BIC. This statistical method has been used in a number of contexts within place-based criminological research (Andresen, Curman, et al., 2017; Curman et al., 2015; Griffiths & Chavez, 2004; Groff, Weisburd, & Yang, 2010; Weisburd et al., 2004, 2009, 2012; Wheeler et al., 2016).

Though instructive, this statistical method has two assumptions that can prove to be problematic. First, GBTM assumes the independence of repeated measures over time for each observation, or unit of analysis. With regard to place-based research, this means that the number of criminal events or calls for police service for a group of streets in one particular trajectory for one year (e.g. 2018) is completely independent of the number of criminal events or calls for police service on those same streets for the following year (e.g. 2019). This assumption is clearly problematic because of the known stability of crime patterns (Weisburd et al., 2004). And second, GBTM does not control for spatial correlation. With regard to criminal events or calls for police service, the respective count for the “300 block of Main Street” is assumed to be independent from the count on its neighbouring street segments, the 200 or 400 block of Main Street. This assumption is problematic because criminal events do not exist on an isotropic plane; rather, criminal events, and calls for police service more generally, cluster close to one another (Andresen, 2014). Regardless, this statistical method has proven to be instructive for

place-based research in criminology. Different places (often street segments) are treated as individuals and grouped together based on similar time paths. This has been used to identify different subgroups of places similar to the subgroups of individual offenders: chronic street segments, discussed further below.

In order to address the two limitations of GBTM, outlined above, k-means clustering has been used to identify these different subgroups (Andresen, Curman, et al., 2017; Curman et al., 2015). As opposed to semi-parametric GBTM, k-means is a non-parametric statistical method that analyzes longitudinal data in order to identify clusters of observations that share similar time paths (Calinski & Harabasz, 1974; Genolini & Falissard, 2010). Though not as common as GBTM, k-means longitudinal clustering has been used in criminology: Huizinga, Esbensen, and Weiher (1991) used k-means to examine the offending trends of 1530 Denver youth over a two-year period (1987–1988), and Mowder, Cummings, and McKinney (2010) used k-means to investigate the resilience of 215 male and female juvenile offenders who were committed to a juvenile facility.

Given that k-means longitudinal clustering is a non-parametric statistic, it does not require data to fit a specific distribution, not being sensitive to the (lack of) autocorrelation and spatial dependence in GBTM. Genolini and Falissard (2010) have noted that when k-means longitudinal clustering is supplemented by GBTM, the researcher is given a thorough picture of longitudinal patterns within a large dataset. Moreover, when the distributional assumptions of GBTM are met, the two methods output comparable results, but when the assumptions are not met, GBTM does not produce the known clusters in the test data whereas k-means longitudinal clustering is able to reproduce those groups. The advantage of using GBTM; however, is that control variables may be introduced. This cannot be done within k-means longitudinal clustering.

Growth Curve Modeling

Another statistical method used in place-based criminological research is growth curve modeling. Growth curve modeling, similar to GBTM, is based on a count-based regression method (negative binomial). This method is multi-level and longitudinal, predicting within unit variation at level 1 and between unit variation at level 2—level 1 intercepts and slopes are the outcomes (Braga et al., 2010, 2011; Gelman, 2005; Singer & Willet, 2003). Similar to GBTM, this statistical method analyzes the overall trend in a data series for each of the spatial units of analysis (street segments and/or intersections), with each spatial unit of analysis having its own slope and intercept such that each spatial unit of analysis can have its own starting level and overall trend.

The advantage of using growth curve modeling instead of GBTM is that rather than estimating trends and subsequently clustering subgroups of trends together such that they “share” a slope coefficient (GBTM), growth curve modeling estimates trend slopes for all spatial units of analysis (see Eggleston, Laub, & Sampson, 2004 and Nagin, 2004 for discussions of the relative merits of these different statistical methods). Regardless, growth curve modeling allows for the trends of individual spatial units of analysis to be estimated such that the researcher may identify the complete nature of the temporal patterning of each spatial unit of analysis for the entire study period through an assessment of individual slope parameters (Braga et al., 2010, 2011; Kubrin & Herting, 2003).

In their analyses of patterns of gun violence and robbery in Boston, MA, Braga et al. (2010, 2011) used a number of control variables in their growth curve models: lagged values of the crime type counts under analysis, street segment length or a variable to differentiate between street segments and street intersections, street type, and a linear trend. This more traditional statistical estimation that includes a set of control variables

has a clear advantage over non-parametric and semi-parametric approaches, but does need to be concerned with any distributional assumptions of the data. Additionally, estimating the trends (stability) for each spatial unit of analysis has a clear advantage because clustering may mask interesting, and critical, variation from street to street.

Longitudinal Spatial Point Pattern Test

Another statistical method that considers change at the level of each spatial unit of analysis is a longitudinal spatial point pattern test. The spatial point pattern test developed by Andresen (2009, 2016) identifies spatial stability through the identification of similar spatial patterns between multiple spatial point pattern datasets. This spatial point pattern test has been used in a variety of contexts: the similarity of spatial patterns across crime types (Andresen, 2009), changing patterns of international trade (Andresen, 2010), the stability of crime patterns (Andresen & Malleson, 2011), the spatial impact of the aggregation of crime types (Andresen & Linning, 2012), the spatial dimension of the seasonality of crime (Andresen & Malleson, 2013a; Linning, 2015), the impact of modifiable areal units on spatial patterns (Andresen & Malleson, 2013b), the role of local analysis in the investigation of crime displacement (Andresen & Malleson, 2014), the comparison of open source crime data and actual police data (Tompson, Johnson, Ashby, Perkins, & Edwards, 2015), the changing spatial patterns of crime with regard to the crime drop (Hodgkinson, Andresen, & Farrell, 2016; Hodgkinson & Andresen, 2019; Pereira, Mota, & Andresen, 2016), the spatial dimension of police proactivity (Wu & Lum, 2017), and the stability of crime concentration at micro-places (Andresen, Linning, et al., 2017; Vandeviver & Steenbeek, 2019).

The details of this test are available in Andresen (2009, 2016), but essentially it involves identifying differences in the spatial patterns of two, or more, spatial data sets at the micro-level, or whatever spatial unit of analysis is employed. Moreover, in addition to the

original version of this spatial point pattern test, Wheeler, Steenbeek, and Andresen (2018) have implemented a Chi-square version and Steenbeek, Vandeviver, Andresen, Malleson, and Wheeler (2018) have produced bootstrap versions of this spatial point pattern test. The output of this test is a global index of similarity, S , that ranges between 0 (no similarity) and 1 (perfect similarity), calculated as follows:

$$S = \frac{\sum_{i=1}^n s_i}{n} \quad (1.1)$$

where s_i is equal 1 if the pattern of two datasets are similar within an individual spatial unit of analysis and 0 otherwise, and n is the number of areas. Simply put, the similarity index measures the percentage of areas (street segments, census tracts, etc.) that share a similar spatial pattern. Though there are no strict guidelines for a value of S to indicate similarity, a rule of thumb has emerged that relates to the rule of thumb in the context of multicollinearity and regression. Specifically, the variance inflation factor (VIF) is used as a diagnostic tool for regression analysis to identify potentially problematic multicollinearity that may lead to issues with inference: most often with a range of 5–10 (O'Brien, 2007). In a bivariate context, this represents a correlation ranging from 0.80 to 0.90, so an S -Index value of 0.80 is often used to identify when two spatial point patterns are similar. In addition to this global index of similarity, the results of this test can be mapped, showing the local level results and the researcher where the two spatial point patterns are different (Andresen, 2009). As such, this statistical method works well in the place-based criminology literature.

The original version of this spatial point pattern test considered pairwise comparisons: two different years of the same crime type or two different crime types, for example. Though instructive, and indicated by Andresen, Linning, et al. (2017), this version of the spatial point pattern test may lead to spurious results when considering changing spatial patterns over time. Even if $S \geq 0.90$ for a number of consecutive pairwise comparisons, if the 10% of non-similar

spatial units of analysis changes with every subsequent pairwise comparison, by the time 10 years have passed spatial similarity will actually be quite low. In order to address this limitation, Andresen, Linning, et al. (2017) extended the original spatial point pattern test making it longitudinal in order to assess the stability of spatial trajectories. In doing so, these researchers also modified the *S*-Index to better represent longitudinal spatial trajectories.

Summary

The place-based criminological research that has investigated the spatial stability of crime patterns has found remarkably consistent results. Weisburd et al. (2004), the first to investigate the stability of spatial crime patterns (calls for police service), found that the vast majority of street segments had stable trajectories over a 14-year time period—this was confirmed in their subsequent work for a 16-year time period (Weisburd et al., 2012). Additionally, these researchers found that the crime drop that occurred in their case study, Seattle, WA, could be accounted for by a small percentage of the street segments, 14% (see also Hodgkinson et al., 2016). As such, the seemingly omnipresence of the international crime drop (Farrell, Tilley, & Tseloni, 2015; Farrell, Tseloni, Mailley, & Tilley, 2011), though present in a large number of contexts, is a rather localized effect. These results have also been confirmed for Seattle, WA in the contexts of juvenile delinquency and the spatial patterns of different street segment trajectories (Groff et al., 2010; Weisburd et al., 2009).

In their analyses of gun violence and robbery in Boston, MA, Braga et al. (2010, 2011) found strong evidence for spatial stability over a 29-year time period. Curman et al. (2015) also found that the vast majority of street segments were stable over a 16-year study period in Vancouver, BC, with Andresen, Curman, et al. (2017) confirming this stability for disaggregated crime types; moreover, in these studies of spatial stability in Vancouver, BC, a relatively small percentage of street segments and intersections

accounted for the crime drop in Vancouver over the study period. In a 14-year study of spatial stability in Albany, NY, Wheeler et al. (2016) found similar results to previous research, particularly those from Vancouver, BC.

In a recent special issue of a journal on place-based criminology, Braga, Andresen, and Lawton (2017), a number of its articles further investigate the stability of spatial crime patterns. Hibdon, Telep, and Groff (2017) extend the research on crime concentrations and spatial stability in Seattle, WA considering drug activity, confirming previous research. Also consistent with previous research, Gill, Wooditch, and Weisburd (2017) reproduced a high degree of spatial stability in a suburban, as opposed to an urban, context. Needless to say, there is a remarkable degree of consistency in place-based criminological research. What we know is most definitely well-established, but now we need to know where to move next in the field to go forward.

Where We Need to Go to Move the Field Forward

The place-based criminological literature has firmly established a number of empirical regularities, some of which may be referred to as stylized facts, or in one case, a law (Weisburd, 2015). However, this area of criminology is still quite young and there is much work to be done. Though there are many ways in which research may proceed in the future, there are a number of pressing issues that should be addressed. Namely, there are still concerns regarding data quality (common in most empirical research), details, specifics, or nuances of the empirical regularities that should be explored, methodological issues, and the role of theoretical development because of its importance to proper policy development.

The primary data quality issue in place-based research is that this research relies on police records management systems for data. These systems are improving and increasingly available for research purposes but, as discussed above, the

dark figure of crime still looms over any research that uses such data. As shown by Ceccato and Lukyte (2011), actual victimization and police data may not be well-aligned. What is needed at this juncture is a set of victimization surveys at the smallest geography possible in multiple cities to confirm or deny the similarity in the spatial patterns of reported and total crime. As noted above, if these spatial patterns are similar enough, previous work in spatial criminology, more generally, and place-based criminology, specifically, regarding patterns remains useful, only the levels of criminal/police activity will be incorrect. However, if it is repeatedly shown that actual crime and reported crime have different spatial patterns, this is problematic for all of spatial criminology, place-based or not, because any relationships found would be spurious.

In a similar way, the details, or nuances, of these empirical regularities needs to be fleshed out. Yes, “crime” and/or “police activity” overall may be spatially concentrated, but the different aspects of crime and police activity may prove to be different. As outlined above, spatial concentrations are greater when measured for specific crime types. Although this is partially due to having fewer data points, these concentrations tend to remain true after controlling for the fewer locations crime may actually occur. It is also important to note that crime only comprises 20–30% of police calls for service, over relatively long periods of time (Wuschke, Andresen, Brantingham, Rattenbury, & Richards, 2018). As such, 70–80% of police activity is ignored when only criminal events are analyzed. For example, Vaughan, Hewitt, Andresen, and Brantingham (2016) found that the spatial patterns of mental health related calls for police service (approximately two percent of calls for police service) are notably different from crime-related calls for police service. Moreover, mental health related calls for police service are more concentrated than crime-related calls for police service.

With regard to statistical methods, traditional statistical methods have their limitations within place-based criminological research. There is not a lot of inferential research (with control variables) simply because of a lack of data, as

discussed above. However, the research that does include more traditional statistical methods tends to be rather sophisticated, spatial, count (Poisson and negative binomial), and discrete choice (logistic) regression models. However, in addition to a lack of theoretically informed variables, because of the extremely rare nature of events at the micro-place, there tends to be very little variation in the counts of criminal events or other police activity: most micro-places have zero events, a few micro-places have a few events, and a very small percentage of micro-places have a large magnitude of events. Though there are statistical methods to deal with low counts of events (count-based and zero-inflated count-based regression models, for example), events at the micro-place are so rare that even using these statistical methods there can be difficulties finding statistical significance for independent variables that have been shown to be critical in previous research (Andresen & Hodgkinson, 2018b). This may be simply because these variables do not matter at the micro-place, but it could be because of a lack of variation in the variables used in the analyses. One way this field may move forward is through the gathering of more theoretically informed variables and, perhaps, considered statistical methods not currently used in criminology such as rare event modelling.

Finally, there is the issue of theoretical development/testing at the micro-place. Do social disorganization theory and routine activity theory (the two most prominent explicitly spatial theories in spatial criminology) still matter when the unit of analysis is the micro-place? As shown by Smith et al. (2000) and Weisburd et al. (2012) routine activity theory and social disorganization theory, respectively, have been shown to be important at the micro-place. In fact, as discussed above, Smith et al. (2000) was able to show that the integration of routine activity theory and social disorganization theory performed best at the micro-place. However, because of a lack of theoretically informed variables and constructs, this work is difficult, if not cumbersome, to undertake. But understanding why there is a high degree of spatial concentration at micro-places

and why those spatial concentrations are stable over time at micro-places is critical for not only understanding the micro-place for theoretical interest, but the proper development of criminal justice policy to make our cities safer places to live, work, and play.

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