The Micro-Geographic and Temporal Patterning of Urban Violence

A grid cell analysis in the cities of Oslo and Bergen

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Abstract

Title: The Micro-Geographic and Temporal Patterning of Urban Violence: A Grid Cell Analysis in the Cities of Oslo and Bergen

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This study examines the micro-spatial and temporal patterns of violent crime in Oslo and Bergen. The observation that the majority of crime within a city tends to cluster in a small number of micro-places (e.g. street segments or small grid-cells) has sparked the field of 'criminology of place,' which concerns itself with the study of micro-geographical distributions of crime and related characteristics. Research has recently paid overt attention to the spatial-temporal patterns of crime, determinants of crime concentrations, and the recent proposal of a 'law of crime concentration' applicable across cities and stable over time. Engagement with this area of research appears promising in regard to advancing strategies of crime prevention, and is especially lacking in a Norwegian context. Therefore, the main research objectives of this study are to examine spatial-temporal patterns and concentrations of violent crime in the cities of Oslo and Bergen, attempt to explain these concentrations, and lastly, test the law of crime concentration in a Norwegian context. Police incident data on violent crime, geocoded to grid-cells of 100m by 100m, as well as data regarding physical attributes inherent to these grid-cells were employed in pursuing the research objectives. Crime maps were produced to visually examine the spatial-temporal patterns and concentrations of violence, and models of multiple linear regression were run to better understand the effect of environmental factors in explaining these concentrations. Finally, a grid-cell analysis was conducted to assess the validity of the law of crime concentration in a Norwegian context. Findings confirm that violent crime concentrates at the grid-cell level, albeit not strongly enough to allocate full support for a law of crime concentration. Further, findings suggest that the temporal fluctuations within hot spots largely reflect the underlying function inherent to each location. Environmental factors (public transit stations, major roads,

residential areas and commercial areas) contributed significantly in explaining these concentrations of violent crime. However, the impact of grid-cell characteristics were seen to vary by urban setting.

In sum, it is evident that analysis of micro-spatial and temporal patterns of violence as well as the effect of environmental factors in explaining its micro-spatial concentrations aids in facilitating a deeper understanding of the phenomenon. These findings present an essential step in the development towards common knowledge of crime at micro-places, as well as advancing place-based policing strategies. Future studies should examine the spatial-temporal patterns of other crime types, further contribute to the question of generalizability of the law of crime concentration, and employ an integrated theoretical approach considering also the effect of social disorganization factors on the micro-spatial concentrations of violent crime in order to continue to deepen our understanding of crime at place.

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1. INTRODUCTION

Studies of crime, therein violent crime have long been concerned with unravelling its broader patterns, largely disregarding micro-spatial and temporal characteristics. By examining crime patterns on the larger community or neighborhood scale, one risks overlooking smaller patterns that thrive within these units. Recognizing this, in 1989, Sherman, Gartin and Buerger coined the term 'criminology of place', to describe a growing area of criminological research that explores crime patterns at micro-geographic locations (e.g. street segments and small grid-cells). Thereafter, there has been a spark in studies illustrating the way crime tends to concentrate at micro-geographic units as well as a newfound interest in attempting to theoretically explain these concentrations. Research in the field is especially extensive in the U.S. (Braga et al., 2010; Braga and Clarke, 2014; Felson et al., 2013; Groff, 2014; LaFree et al., 2012; Ratcliffe and Rengert, 2008; Tita and Radil, 2011; Weisburd et al., 2012), but also prominent in some European countries (Bernasco, 2010; Bernasco and Steenbeek, 2017; Bruinsma et al., 2013; Ceccato, 2009; Ceccato and Oberwittler, 2008; Dugato, 2014; Johnson et al., 2007; Steenbeek et al., 2012; Van Wilsem, 2009; Van Nes and López, 2010).

Today, scholars vigorously emphasize the need for continued engagement with the criminology of place, especially its temporal components, as such pursuits are argued to have profound implications for strategies of crime prevention (Haberman, Sorg and Ratcliffe, 2017). Recognizing the potential advantages related to gaining knowledge of the dynamics of crime at the micro-geographic level, the present study aims to examine the micro-spatial and temporal patterns of violence in two Norwegian cities; Oslo and Bergen. Contemporary research within the field focuses on, inter alia, assessing the effect of particular environmental factors in explaining spatial concentrations of crime. 'Crime mapping' is currently argued to be *the* most powerful tool when it comes to visually depicting geographic crime trends of large volumes, also on the micro-geographic level (Ratcliffe, 2009).

Perhaps the most prominent aspect within contemporary criminology of place is the recent audacious proposal of a 'law of crime concentration' (Weisburd, 2015), which argues that the proportion of micro-places (e.g. 6% of street segments in a city) that account for a percentage of the cumulative proportion of crime (for instance 50% of all crime) will only vary slightly across time and across cities. Weisburd (2015) has, based on a very geographically-limited study sample, claimed this law to be a "general proposition of universal validity, analogous to physical laws observed in the natural sciences" (p. 151).

Thus, a proliferation of studies testing the law across a magnitude of different contexts is certainly necessary in order to assess its true generalizability.

Research Objectives

Generally, research on the micro-geographic patterns of violence is notably lacking in Norway. This substantial lack of research exploring micro-geographic patterns of violent crime, especially so in Norway, motivated the formulation of the following research objectives:

Objective 1: Through crime mapping, visually explore micro-spatial and temporal patterns of violent crime in Oslo and Bergen.
Objective 2: Test the effect of environmental factors in explaining micro-spatial concentrations of violent crime in Oslo and Bergen.
Objective 3: Assess the validity of the law of crime concentration in Oslo and Bergen.

Based on environmental theories of crime and through employing a quantitative analytical approach – this paper aims to illustrate how variables related to *where* and *when* violence occurs are valuable in examining the patterning of violence at the micro-geographic level in the cities of Oslo and Bergen, Norway. The study utilizes police incident data of violent crime geocoded to grid-cells of 100m by 100m as well as data regarding environmental factors present in these grid-cells, retrieved from entur.org and OpenStreetMap[1]. A small-scale, *micro-spatial* approach, in conjunction with temporal information facilitates detailed knowledge regarding the relatively precise spatial distribution of violence, information of which is becoming progressively more salient for both law enforcement and city planners. In-depth knowledge regarding the spatial-temporal distribution of violence in Oslo and Bergen can offer valuable information for crime prevention purposes. Identification of 'hot spots'[2] and corresponding temporal fluctuations can potentially better the cost-effectiveness of the hot spot policing strategy. In a similar mentation, identification of hot spots of violence and its determinants can enable more effective city planning with respect to 'designing the environment' to reduce particular locations' criminogenic factors and susceptibility to crime.

[1] Shapefiles were accessed through https://www.geofabrik.de/en/data/shapefiles.html
[2] A *hotspot* will in this study refer to places displaying high concentrations of crime relative to the general distribution of crime across the city.

This is especially relevant as police departments in both Oslo and Bergen strive to 'police effectively using minimal resources' (Christensen, Lægreid & Rykkja, 2017). In sum, this paper aims not only to unravel characteristics of contemporary spatial-temporal patterns of violence in the respective cities, but also to illustrate the value of gaining greater knowledge of this trend both in regard to future research and crime prevention efforts**.**

Thesis Composition

This study is structured to comprise chapters presenting relevant theory, background and prior research, methodology, results and a discussion. Chapter 2 will present the particular theories embedded in environmental criminology that are applied in this study. Chapter 3 will provide background context regarding the practice of crime mapping - as well as an overview of relevant literature within the criminology of place. The latter focuses on the relationship between environmental factors and violent crime at micro-places, and studies testing the law of crime concentration. Thereafter, Chapter 4 presents the data and methodologies utilized, as well as the analytical plan employed in pursuing the aforementioned research objectives.

Results are thereafter presented in separate chapters for each research objective. The first of three result-chapters concerns the first research objective; examining micro-spatial and temporal patterns of violence in Oslo and Bergen through crime mapping. These spatial-temporal patterns are explored on the citywide scale, for sub-areas of the cities and for smaller hot-spot areas. The following chapter explores the second research objective; the effect of environmental factors on micro-spatial concentrations of violence. Models of multiple linear regression are estimated for both cities in order to facilitate a comparison of the observed effects between the two cities. Lastly, the final result-chapter pursues the final research objective; assessing the validity of the law of crime concentration, both in Oslo and Bergen. This law is also assessed across three theoretically relevant temporal scales; seasons of the year, days of the week and hours of the day.

Upon presenting the research findings, a discussion of them is engaged in Chapter 6. Here, important policy implications of the research findings are identified. In addition, several avenues for future research are suggested. Main findings and lessons learned throughout pursuing the research objectives are then summarized in Chapter 7.

2. THEORETICAL FRAMEWORK

It is widely recognized that in order to conduct fruitful analysis of spatial crime patterns, therein crime mapping, examination of crime concentration levels and the relationship between physical attributes in the environment and crime, as are the objectives of this paper - it is crucial to gain an understanding of relevant criminological theories (Eck, Chainey, Cameron, Leitner & Wilson, 2005). Indeed, Eck et al. (2005) emphasize that research has found the most accurate and informational spatial analyses of crime to be those that are produced in guidance with theories of crime. In the case of crime mapping for instance, it is argued that employing relevant theories of crime can significantly aid in the interpretation of the resulting maps (Eck, 1998). Overall, it is deemed crucial to develop an understanding of how relevant theories of crime may account for spatial crime patterns. It is to this we now turn.

Environmental Criminology

Several such theories attempting to explain the spatial aspect of crime trends exist. However, different theories explain *'different types of crime phenomena that occur at different geographic levels'* (Eck et al., 2005, p. 3). That is, some theories assist in explaining crime trends at the micro-geographic level whereas other theoretical perspectives assist in explaining crime trends that occur at larger geographical levels, such as the neighborhood or community level (Eck et al., 2005). These may involve social disorganization theory and related ecological theories, routine activity theory and crime pattern theory, to name a few. The present study will, due to being concerned with the micro-geographic units inherent to the *criminology of place*, seeking to examine patterns of violent crime at a small-scale level– apply theories situated within the broader branch of environmental criminology (hereafter 'EC'). Ratcliffe (2009) articulates three prerequisites for exploring such small-scale spatial crime patterns. These involve a) access to spatial crime data, b) a statistical tool suited for the task, and c) an understanding of *environmental criminological theory.* An overview of relevant literature within the criminology of place will be introduced in the following chapter.

In short, environmental criminology forms a family of theories which all take an interest in crime events and the immediate physical circumstances in which they take place (Wortley & Mazorelle, 2008). In addition, according to Ratcliffe (2006), environmental criminology has in recent years been dominated by theories concerned with the spatial

patterns of offenders, and it is argued that these theories place much emphasis on the *micro-geographic* interactions between offender and target. These theories typically attempt to explain the convergence of offenders and victims at certain places and times – ultimately resulting in crime events. In short, it is suggested that crime will concentrate at certain places and at certain times based on 'people's movement patterns' within a city (Haberman, Sorg & Ratcliffe, 2017).

Such theories of environmental criminology as mentioned above are routinely applied in studies examining micro-geographic crime patterns, due to their ability to explain crime at the micro-geographic level (Rosser, Davies, Bowers, Johnson & Cheng, 2017). Theories situated within other branches of criminology, such as social disorganization theory, have been utilized where crime patterns are examined on much larger scales – like that of communities or neighborhoods (Eck et al., 2005). However, these studies typically view crime as the result of unfavorable ecological factors in the larger community of which lead to high rates of unemployment, high-school drop-outs and single-parent homes, for instance. Conversely, due to the current projects' micro-geographic approach and interest predominantly in the spatial and circumstantial aspects related to incidents of violence, *routine activity theory* and the related theories of *crime pattern* and *temporal constraint*, all situated within environmental criminology, will comprise the theoretical framework of the present study. These theories and their relation to the current research project will be discussed below.

Routine Activity Theory

Routine activity theory (RAT), introduced by Cohen and Felson (1979) forms part of the aforementioned criminological theories routinely applied in studies examining micro-spatial patterns of violent crime (see Favarin, 2018; Haberman, Sorg & Ratcliffe, 2017, Nelson, Bromley & Thomas, 2001; Rosser et al., 2017). This theory suggests that 'direct contact predatory crimes', that is, crimes which involve direct contact between offender and target (person or property) - occur as a result of human interaction (Rosser et al., 2017). Examples of such crimes include robbery and violence (Rosser et al., 2017). Crime types that fall outside this category of 'direct contact predatory crimes' are typically crimes like identity fraud and various forms of cybercrime – as engaging in such crimes does not require direct contact between offender and target (Rosser et al., 2017).

This human interaction Cohen and Felson refer to is thought to emerge through the everyday activities engaged in by both offenders and victims (Rosser et al., 2017). It is argued that peoples' everyday routine activities to great extents determine what type of activity they will be engaging in throughout the course of a day and across the days of the week. According to Horton and Reynolds (1971), most people routinely spend time at work during daytime on weekdays, then spend time at home or engaged in leisure activities during evening hours. Further, a vast amount of people spend considerably more time away from the home during weekends while engaged in leisure activities. These everyday activities typically make up the routine activities engaged in by the average citizen, as suggested by routine activity theory. Put in the context of a typical city, this generally means that peoples' everyday routines often lead to a concentration of people in some places at certain times of the day, and an absence of people at other places and times (Rosser et al., 2017).

According to RAT, a crime event occurs upon the fulfillment of three conditions; the co-occurrence of a *motivated offender*, a *target* of which the offender is capable of victimizing, and finally, the absence of *capable guardians* who could potentially deter criminal activity (Cohen & Felson, 1979). According to Cohen and Felson (1979), a *motivated offender* is considered to be a person who possesses both criminal inclinations and the ability to act on those inclinations. Capable guardians are thought to be people or other elements in the environment (such as CCTV cameras or security systems) that may deter the criminally inclined individual from engaging in unlawful behavior. Central to the routine activity theory is the notion that the *lack of* any of the aforementioned conditions can prevent such crimes requiring offender-target contact from occurring. Importantly, according to RAT, it is the various routine activities as exemplified above that determine the likelihood of such offender-target-guardian convergences in space and time.

To illustrate, in light of RAT, burglaries are to be expected when motivated offenders encounter situations which supply them with ideal targets to burglarize (unsecured or poorly secured homes), while the presence of potential guardians is considered low (target is sufficiently hidden from on-lookers or during hours when the home is expected to be vacant). A home located at a cul-de-sac for instance, will in light of RAT, be less likely to form part of such a convergence due to the increased likelihood of guardians being present (in this case neighbors). Similarly, a potential offender will be less likely to encounter a situation in which all the above requirements are fulfilled if he only frequents areas in which the structure of the neighborhood encourages neighborhood surveillance or during hours when homes are usually

occupied.

With regard to RAT and the occurrence of *violent* crime, violence is to be expected when motivated offenders encounter situations that supply them with ideal people they may subject to violence. It seems reasonable to expect that such crime accelerates in crowded, dispute-prone environments. Violent crime is often theorized to flourish in situations involving night-life entertainment and the consumption of alcohol (Favarin, 2018). Such night-life venues typically provide *motivated offenders* (bar-goers, oftentimes intoxicated and thus violence-prone) and *suitable targets* (fellow bar-goers in a crowded, dispute-prone environment). With regard to the last condition of RAT, lack of *capable guardians*, it seems plausible to suggest that motivated offenders engage in violence at times when it is assumed (by the offender) that this will go unnoticed by bouncers, police or CCTV.

Likewise, it seems sensible to suggest that violent offending may fester at or near public transport stations. As with night-life venues, such environments often promote a crowding of people, creating a dispute-prone environment. In light of the routine activity theory, a criminally inclined individual present at a public transport station may encounter a suitable victim (fellow public transport user amidst the crowd). If capable guardians known to the potential offender are absent, such as surveillance cameras overlooking stations, security guards or police - violence may occur. Overall, this provides an illustration of how, in light of routine activity theory, violent crime may ensue.

Crime Pattern Theory

As discussed above, routine activity theory assists in explaining *under what circumstances* crime may ensue, that is – upon a convergence between a motivated offender, suitable target and the absence of a potential guardian. It is further specified that the likelihood of such convergences is affected by peoples' engagement in everyday routine activities. However, RAT's ability to comment on *where* crime may occur is argued to be weaker (Rosser et al., 2017). Attempting to overcome this shortcoming of the routine activity theory, Brantingham and Brantingham (1993) introduced 'crime pattern theory' (CPT). CPT draws on the concepts of routine activity theory and may serve to complement RAT regarding this question of *where*, ultimately further assisting in explaining spatial crime patterns. As Rosser et al. (2017) emphasize, offenders, victims and potential guardians are all subject to constraints that affect their routine activities (and subsequently also their respective locations), an element of which crime pattern theory takes into account.

CPT views the city as consisting of *nodes* (the specific places that people travel to and from) and *pathways* (specific streets or public transportation routes utilized to get from one node to another (Rosser et al., 2017)). Importantly, it is argued that these nodes are formed by peoples' respective routine activities as defined in the discussion of routine activity theory above (Rosser et al., 2017). In sum, CPT takes into consideration people's patterns of movement (nodes and pathways) *and* engagement in routine activities upon claiming that in conjunction, these two factors form a person's 'awareness space' (Haberman, Sorg & Ratcliffe, 2017). It is argued that these aforementioned pathways connect with the various nodes existent in a person's life, ultimately creating a perimeter - here referred to as the person's 'awareness space'. Simply put, 'awareness space' refers to the physical areas in which an individual is familiar (Brantingham & Brantingham, 1993). As mentioned above, this familiarity develops as a result of routines engaged in and the nodes and pathways utilized when engaging in these routine activities. In other words, areas of familiarity will reflect a person's routine activities and related patterns of movement. Greatest familiarity is said to develop in locations a person frequents relatively often, places in close proximity to those specific locations, and throughout the various pathways that lead from one (relatively heavily-visited) location to another.

Of great importance in relation to violent crime then, are these various areas of familiarity. As mentioned above, Horton & Reynolds (1971) argue that to a large degree, most people's activity spaces comprise locations in which they live, work, go to school, engage in leisure activities, and importantly – streets and public transportation routes utilized in travelling to and from these locations. In other words, most people's awareness spaces consist of the perimeter created by their locations of home, work, school, leisure - and the travel routes between these places. According to crime pattern theory, crime is argued to occur when the awareness space of an offender and a victim overlap (Brantingham and Brantingham, 1993).

Considering potential offenders, it is argued that this awareness space provides criminally-inclined individuals with knowledge regarding the opportunities for engaging in unlawful behavior in the various locations of which they are familiar - which may lead to offending in such an area (Haberman, Sorg & Ratcliffe, 2017). Locations that are selected for offending will oftentimes differ from the locations that facilitate criminal activity most effectively. In other words, there are likely a number of locations that are 'more suited' for criminal activity than locations in which crime actually occurs. As is central to crime pattern

theory, an offender cannot choose to offend in areas he is *unaware* of (Brantingham & Brantingham, 1993).

In addition to the aforementioned importance of potential offenders' 'awareness spaces', prior awareness of the location is thought to decrease the degree of uncertainty regarding the possible costs and benefits involved in offending there (Haberman, Sorg & Ratcliffe, 2017), which - according to rational choice theory (Cornish & Clarke, 1986), many offenders make assessments of prior to engaging in criminal activity. Consequently, crime pattern theory predicts not only that offenders will commit crime at, or in close proximity to locations of which they are most familiar, that is – the most heavily frequented nodes and pathways. In addition, drawing on the rational choice perspective, it seems reasonable to anticipate that locations in which offenders are sufficiently familiar *and* that top an offender's list of 'places where benefits of offending are maximized and risks minimized', are selected for offending.

Further, and of specific interest to the present study, crime pattern theory suggests that offending will *concentrate* at, and in close proximity to the specific nodes and pathways that are frequented by the *largest number of people* (Haberman, Sorg & Ratcliffe, 2017). This is argued to be due to the fact that these specific nodes and pathways are the ones that produce the greatest convergence of RAT's three conditions; motivated offenders, suitable targets and an absence of potential guardians, simply as a greater number of people increases the likelihood of at least two of them being either a motivated offender or a suitable victim. Thus, in light of Horton and Reynold's (1971) statement regarding which locations comprise 'most peoples' activity spaces', it seems reasonable to expect offending to concentrate in close proximity to major public transport stations and in the city centre where workplaces cluster, for instance.

Temporal Constraint Theory

In addition to the abovementioned *areas* in which, based on human activity, it is theorized that offending occurs - it is emphasized that human activity also varies over time, ultimately affecting *when* these areas are more likely to be victimized (Chapin, 1974; Cohen & Felson, 1979; Hawley; 1950). Every individual's routine activities are argued to be constrained by social and biological factors (Ratcliffe, 2006). That is, the majority of people sleep during nighttime and until early morning hours. Further, during daytime from Monday through to Friday, the majority of people are situated at their respective workplaces or schools (Haberman, Sorg & Ratcliffe, 2017). In the timeframe before and after work-hours, people spend time in transit (Haberman & Ratcliffe, 2015). Thereafter, most people engage in leisure activities during evening hours, either at home or away from the home (Haberman, Sorg & Ratcliffe, 2017). Finally, upon termination of the workweek on Friday evening and until Sunday evening, people experience more time available for engagement in recreational activities – and thus might spend more time away from the home (Haberman, Sorg & Ratcliffe, 2017). The abovementioned fluctuations in routine activities are argued to influence the *times* in which convergences of Cohen and Felson's three basic elements of RAT are the greatest – and consequently, at what times of the day and week spatial concentrations of crime are strongest.

In addition, people's routine activity patterns are also theorized to differ throughout the course of a year (Haberman, Sorg and Ratcliffe, 2017). It is argued that the majority of people will spend more time outdoors (and away from the home) during spring, summer and fall as opposed to winter months when weather conditions may become unpleasant to many. Further, it is stressed that as seasons change, typically from winter to spring and summer months, students are released from school-commitments, certain sport seasons commence, and many travel for vacation (Haberman, Sorg and Ratcliffe, 2017). The main point to derive from the aforementioned fluctuations in routine activities is that, similarly to hourly and weekly fluctuations, also seasonal changes are thought to impact where people tend to be situated. For instance, tourist attractions may be deserted during winter months, yet crowded with people during summer months. Based on the observations discussed above, crime opportunities (in light of RAT and crime pattern theory) are not theorized to be stable across hour of the day, day of week or season of the year (Felson and Eckert, 2016; Ratcliffe, 2006). This because "as the relevant actors – victims, offenders, guardians and place managers –

adjust their relative densities over time and around specific places, the opportunities for crime shift and coagulate" (Ratcliffe, 2010, p 15.).

In order to further address this temporal aspect of spatial offending patterns, Ratcliffe (2006) introduced a theory of 'temporal constraint', building on concepts from routine activity theory and crime pattern theory. Simply put, the theory suggests that various temporal constraints existent in offenders' daily lives influence their spatial-temporal patterns of offending. Examples of such temporal constraints include the requirement to present for work or school, leisure activities, social gatherings and the like (Ratcliffe, 2006).

Further, through recognizing that much offending (therein violent offending) is opportunistic in nature - the theory suggests many crime opportunities are identified through *non-crime journeys* (Ratcliffe, 2006). That is, the decision to engage in criminal activity at a certain place is considered to be weighed upon encountering a suitable opportunity to do so, like that suggested by routine activity theory – whilst conducting a commute that initially was *not* engaged in for the purpose of criminal activity (Ratcliffe, 2006). Recognizing this opportunistic nature of much crime is a key point of the temporal constraint theory. This acknowledgement enables one to argue that the various temporal constraints present in an offender's daily life explain their lack of exploration of paths (as defined in crime pattern theory) other than the 'least-distance' one (Ratcliffe, 2006).

Least-distance paths are here thought to be the routes leading from A to B in which take the least amount of time (Ratcliffe, 2006). Building on evidence (obtained through offender interviews) suggesting most offenders who conduct these arguably opportunistic offences do not anticipate to encounter a crime opportunity along their non-crime journey – temporal constraint theory argues that additional time is *not* set aside for 'criminal activities' in their commute from A to B. In other words, such crime is seldom planned. Therefore, most offenders solely reserve sufficient time to arrive at their destination just before such arrival is required. Thus, the least-distance path is the one most usually travelled, as 'available travel time' does not allow for much deviation from this particular path (Valente, 2019).

It is argued, based on the fact that much crime is opportunistic in nature, such 'non-crime journeys' (journeys lacking premeditated criminal intent) seem to dominate the daily routines of potential offenders, and, due at least in part to temporal constraints, least-distance paths are argued to be those most travelled. Based on these establishments then, it is argued that temporal constraints assist in explaining the likely locations for offending. It is further hypothesized that these same temporal constraints explain unfamiliarity in areas that

transcend that of an offender's direct least-distance path, and consequently, the *absence* of offending in these areas. In other words, temporal constraints assist in explaining the recurring engagement in certain routes as well as the lack of exploration of paths *outside* of those routes. This will be discussed in further detail below.

Ratcliffe (2006) provides an example to illustrate the key concepts of temporal constraint theory, portraying how time can be considered a constraint in regard to offender movement patterns and subsequent offending. Consider a youth capable of an act of graffiti, traveling from home to school. As mentioned earlier, it is recognized that most people estimate their travel time based on the notion of reaching their destination close to the required arrival time - in this case, school start at 09:00. The shortest travel-path in this particular case takes 33 minutes, rendering the latest feasible departure time 08.27. In this case, 7 minutes have been set aside as a 'reserve budget', to account for unexpected issues. An act of graffiti is thought to take 5 minutes to complete.

Ratcliffe (2006) argues that the immediate path of the youth, that is, the exact path of the shortest-journey alternative, is at greatest risk of experiencing crime. The reason for this being the fact that this specific path is the path in which the offender has the *most available time* to loiter (and consequently discover an opportunity for crime and commit an offence), before having to resume the commute in order to avoid arriving late. As deviation from this path of the shortest-journey increases, less time is disposable for criminal activity (Ratcliffe, 2006). Were the offender to stray off the original route to encounter a crime opportunity on an adjacent street in which traveling there took an additional 5 minutes, this leaves the offender a mere 2 minutes to commit the actual crime. Thus, the longer an offender may afford to stay at a certain point on the path, the greater the risk of that location experiencing a crime is theorized to be – as the temporal constraint (school start time) is at its minimum here.

Ratcliffe argues that there are two elements in this example case of which place temporal constraints on the youth. First, the temporal constraint related to committing the offence itself (5 minutes deducted from the 7-minute reserve budget) leaves little time for exploration of crime opportunities transcending that of the most direct path to school. Likewise, the temporal constraint of the school's starting time functions as an inhibitor to deviation far from the original path, assuming the offender wishes to arrive on time to avoid adverse consequences (in line with the arguments of rational choice theory). As illustrated here, opportunities for crime, and thus the likelihood of an act of crime taking place, are thought to be smaller in locations that deviate from the least-distance path as opposed to

locations situated *on* the least-distance path. In sum, for this example case, both temporal constraints inherent to the commission of the offence itself *and* school start together place significant constraint on the opportunity for crime for the particular offender traveling this particular path.

Environmental Criminological Theory and Crime at Place

Put in the context of crime at place, such temporal constraints imposed on offenders as illustrated above directly relate to 'target risk' (Ratcliffe, 2006). In other words, temporal constraints affect the likelihood of a certain location (micro-place in the context of the present study) experiencing a crime event. Utilizing the example above regarding a youth traveling to school, the theory argues that as time approaches 09:00, the locations of which are at greatest risk of experiencing crime are those situated in close proximity to the school (Ratcliffe, 2006). Locations in immediate vicinity of the youth's home are simply not available for crime at 08:50, as the youth is not in possession of sufficient amount of time to both commit the crime *and* undertake the 33-minute journey to school without arriving late. Conversely, at around 08.27 (anticipated departure time from home), locations near the youth's home are at greater risk of victimization, as the youth will (again due to the temporal constraint imposed by the school) at this point be at the very beginning of his journey. In sum, this illustrates how the risk of a micro-place experiencing a crime event is largely dependent on offenders' temporal constraints and, in turn, their travel patterns.

As mentioned earlier, much of violent crime is theorized to flourish in the context of night-life entertainment and public transportation, as these situations facilitate concentrations of people – consequently increasing the convergences of RAT's three conditions for criminal activity. Based on this, it seems reasonable to anticipate that also violent crime in Oslo and Bergen will be likely to occur in close proximity to public transport stations and venues of night-life entertainment. Moreover, in light of temporal constraint theory, it seems plausible to suggest that violence is especially likely in situations where both temporal constraints related to public transport departure times *and* night-life venues' closing times are active simultaneously. When night-life venues close, patrons are required to leave the premises. In addition, upon having to leave the premises, most patrons start planning their commute home. For a large number of people, this commute involves public transport.

Seen from the perspective of temporal constraint theory, and again, assuming (as evidence suggests) people wish to arrive approximately just in time for departure, the same 'risk to place' dynamic can be suggested here as in the youth example case above. That is, the temporal constraint of tram, subway or bus departure times limits a potential offender's available time for loitering outside of the least-distance path. Many night-life venues in Oslo and Bergen close between 02:00 and 03:00. This temporal constraint of night-life venues' closing times, in combination with public transport departure times, renders the immediate vicinity of night-life zones in greatest risk of victimization at approximately 03:00. As time passes, the locations at greatest risk of victimization shifts from entertainment areas and onto the least-distance paths patrons are employing to get from A to B. As mentioned above, a significant amount of people utilize public transport at the end of a night out. Thus, in this time period, the least distance path from the leisure-zones to public transport stations and taxi stands are at greatest risk of experiencing violent crime. As more time passes, the locations considered to be at greatest risk of experiencing violence are those in immediate vicinity of transit stations and taxi stands, since people are now expected to have reached these. It seems reasonable to suggest that the risk of victimization for locations in close proximity to night-life venues peak from approximately 02:00 to 03:00, and locations in close proximity to public transport stations experience increased risk between approximately 03:00 and 04:00.

In addition, assuming that, as argued by Ratcliffe (2006), most people set aside a reserve time budget for unforeseen problems, offenders may arrive at their destination with time to spare. In the context of temporal constraints, this 'time to spare' translates to 'time available for offending'. That is, the temporal constraint is at this point in time less intense, and the individual may unhinderedly engage in loitering at this location. In other words, due to an 'early arrival' at the public transport station, it seems reasonable to suggest the risk of an offence occurring increases here. On the contrary, violence along the path from a bar to the public transport station would be considered less likely as the available time would usually not allow for such a deviation in original travel plans without eating into the reserve time budget. However, violence that *does occur* along the path from A to B is likely to take place on the most direct, least-distance path - as the temporal constraints (departure times) do not allow for much deviation from this path.

The scenario described above is especially relevant to the present study due to the fact that night-life venues' closing times are related to great numbers of people leaving said venues simultaneously. From the viewpoint of routine activity theory as discussed above, this

leads to an increase in victim-offender convergences, providing opportunities for crime. However, such a high-flow of people travelling from A to B is also seen to occur earlier in the night. Night-life venues report a rapid increase in traffic between 23:00 and 00:00. In other words, one can expect the same type of risk pattern for this earlier time period**.** That is, locations in close proximity to public transport stations between approximately 22:30 and 23:30 seem to be at increased risk of experiencing offending. Likewise, locations in immediate vicinity of night-life venues seem to be at increased risk of offending between approximately 23:30 and 00:30. Ultimately, least-distance paths between transport stations and night-life venues are at somewhat increased risk for the duration of time it is hypothesized that 'many people' are travelling this route, which in this case is thought to be between 23:00 and 00:30. Based on the same mentation, it also seems plausible to expect violence to concentrate at or near public transport stations during typical rush hours in the morning when people conduct their commute to work, as well as upon termination of the workday when people head home.

Based on the above discussion of the theories of routine activity, crime pattern and temporal constraint, it is expected that concentrations of violent crime in both Oslo and Bergen emerge:

1. *Where* a magnitude of individual offenders' awareness spaces overlap,

2. *Where*, in accordance with routine activity theory, potential offenders, targets and capable guardians converge in a fashion that facilitates violent offending, and

3. At times *when* the temporal constraints of individual offenders overlap.

Recognizing Limitations of Environmental Theories of Crime

The emergence of environmental criminology has illuminated the benefits of employing practical solutions in combatting crime (e.g. hot spot policing), rather than examining 'root causes' of crime as seen in more mainstream, traditional criminological theory - therein strain and control theory. However, the rejection of valuable elements of such traditional criminological theories has its costs. It is argued that environmental criminology 'undertheorizes' offenders (Cullen & Kulig, 2018). As seen in the overview of several environmental theories above, only sparse attention is given to offenders beyond that *just before* and *during* the crime event. Cohen and Felson's (1979) concept of 'motivated offender' entails no explanation of how the offender becomes criminally motivated. Rather, attention is devoted to examining how offenders exercise choice when traveling to places in which crime can potentially occur (Cullen & Kulig, 2018). When motivation *does* appear to enwrap the attention of EC, it appears to either be viewed as part of human nature or as a result of rational assessment of situational (crime inducing) circumstances (e.g. offender burglarizes *unsecured* home).

Cullen and Kulig (2018) suggest that researchers employing environmental criminology when studying offenders may benefit from incorporating perspectives of developmental criminology. Such an approach may allow one to shed light on at what age youth typically come to recognize opportunities for crime, and how they, throughout adolescence, develop their views on what constitutes an 'attractive target'. In the same mentation, it seems plausible to suggest that one can assess the influence of family, peers and area of residency on the youth's perspective of crime opportunity and target attractiveness. In the case of the present study, such theoretical developments could shed additional light on the reasons behind concentrations of violence at particular places in Oslo and Bergen, transcending those solely of offender-target convergences in space and time. Indeed, the aforementioned approach could assist in commenting on the ways in which social factors (previously ignored by EC) influence the development of key elements within environmental criminology (motivated offenders and suitable targets, for example).

EC scholars have also been criticized for their use of the term 'informal social control', which in short encompasses all forms of non-state operated actions that are thought to prevent criminal activity (Cullen & Kulig, 2018). This involves the crime-deterring effect the presence of 'guardians' in the routine activity approach are theorized to have. Studies attempting to measure the extent to which guardians are able to limit crime typically entail

questioning respondents' willingness to intervene in hypothetical situations of crime. Culling and Kulig (2018) emphasize that scholars within environmental criminology rarely question whether responses to such questionnaires which indicate willingness to intervene actually reflect what would happen had the scenario occurred, or whether such responses merely reflect what most people view as the 'socially desirable' response. It is suggested that willingness to intervene upon encountering a crime event may vary based on several factors, including the presence of surveillance cameras, personally confronting offenders or the use of force, to mention some (Cullen & Kulig, 2018). Surely, environmental criminology could benefit from an assessment of the *actual* effect of informal social control on opportunities within crime events.

Environmental theories of crime have also been criticized for its adverse effects stemming from the implementation of 'capable guardians' to deter crime, especially in relation to the policing of hot spots (Weisburd & Braga, 2006). It is thought that the increased police presence in identified hot spots may foster mistrust in law enforcement by citizens. Rosenbaum (2006) argues that hot spot policing may easily transform into 'zero tolerance policing' as this is a tactic police typically find easy to adopt. Consequently, this can cause a wedge between police and the community, as the latter is, through more aggressive forms of law enforcement, becoming targets rather than partners.

Lastly, the perspective of environmental criminology has been criticized for neglecting to take into account the larger context in which crime occurs, (for an exception see Wilcox, Gialopsos & Land, 2013). Accounting for such 'larger contexts' in which crime occurs involves devoting attention to the effect of inequality on crime, for instance (Cullen & Kulig, 2018). Important to note, an attempt at incorporating such a focus has been observed in the EC field recently.

In conclusion, it should be recognized that by devoting more attention to offenders - perhaps through an integration of divergent theoretical perspectives, and by testing the effect of 'informal social control' on opportunities for crime– one may facilitate an enrichment of environmental criminology and our understanding of crime events. In addition, more attention should be paid to the potential adverse effects in practicing elements of these theories in practice.

3. CRIMINOLOGY OF PLACE – PREVIOUS RESEARCH AND RELEVANCE

This chapter will provide an overview of three main focus points within contemporary 'criminology of place', therein crime-mapping, the influence of environmental factors on violent crime and the 'law of crime concentration', respectively - and their relation to the current research project. In concluding this section, an overview of the current project's research objectives will be provided.

Criminologists agree that criminal activity is not evenly distributed throughout a city (Weisburd & Amram, 2014). Indeed, a vast amount of research has shown that crime tends to concentrate, and has shown to do so at various different scales, ranging from larger communities to individual addresses (Rosser et al., 2017). Scholars began taking interest in studying crime at 'micro-geographic units' in the 1980's, and this area of study has since been termed the 'criminology of place' (Sherman, Gartin & Buerger, 1989). As was mentioned in a preceding chapter, crime at such micro-geographic units, typically that of small grid-cells, is of special interest to the present study.

Compared to other areas of criminological research, only sparse attention has been devoted to the criminology of place (Weisburd, 2015). Undoubtedly, criminology has long been concerned with larger units of analysis such as communities, and attempting to unravel why certain types of people break the law- in which criminology of place takes no interest (ibid.). Studying the criminology of place pushes criminologists to examine why crime concentrates in certain places - which shifts the focus away from traditional points of criminological concern such as the *person committing the crime* and onto the *physical place* in which the offence is committed. Weisburd (2015) suggests that criminologists should change their 'unit of analysis' and devote more attention to crime trends at micro-geographic units.

Focusing on the journal '*Criminology',* due to it being the highest impact journal in the field of criminology, Weisburd (2015) examined the units of analysis utilized in empirical studies between 1990 and 2014. It was concluded that there has in recent years been observed an increasing trend in studies examining crime at the micro-geographic level. However, in comparison to other units of analysis, studies focusing on micro-places and the criminology of place have played only a very minor role in criminological research overall. It was found that 66% of all studies were person-focused, compared to a mere 4.3% of studies concerned with

micro-geographic units of analysis. Thus, scholars emphasize the need for engagement with the criminology of place (Weisburd, 2015).

Examples of studies from the meager criminology of place literature include Bowers (2014) study of bar thefts in London, which found that 20% of all venues accounted for 80% of all bar thefts. In addition, Sherman, Gartin and Buerger (1989), examining calls for service in Minneapolis, U.S., found that 50% of all calls came from 3.3% of addresses or intersections in the city. Similarly, Braga, Hureau and Papachristos (2011) found that 1% of street-segments in Boston, U.S., were responsible for 50% of robberies. Further, Andresen and Malleson (2011) reported that only 5% of street-segments in Vancouver, Canada, generated 50% of all vehicle theft. Overall, these studies serve as examples of how crime has been found to be highly concentrated at places - also across cities, types of crime and for various units of analysis.

Important to note from the abovementioned research is that, in short, it has been established that a few high-crime locations in a city will often account for a disproportionate amount of criminal activity whereas other areas will be devoid of criminal activity altogether (Weisburd & Amram, 2014). This is arguably the most important empirical finding within the criminology of place, and ultimately a central factor in the current research project.

Crime Mapping

The abovementioned finding that crime tends to concentrate geographically has proved beneficial to visually portray on maps, that is, 'crime mapping' (Eck, Chainey, Cameron, Leitner and Wilson, 2005). Crime mapping will in this context refer to the act of combining geographical data and police incident data in order to subsequently display this information on maps. Such digital crime mapping was introduced in the 1970's upon advances in computer technology (Ratcliffe, 2009). However, crime mapping attempts at this time were hindered by limitations in both technology and available data (Maltz, Gordon & Friedman, 1991). Crime mappers experienced difficulties in converting addresses to individual points on a map – of which is a fundamental step in crime mapping (Bichler & Balchak, 2007). Further, many criminal justice agencies simply were not adequately equipped to register spatial information in such a format that later allowed this data to be utilized for crime mapping purposes (Ratcliffe & McCullagh, 1998). Important to note, these limitations have experienced a significant decrease in recent years, resulting in the practice of crime mapping becoming widely adopted among many police departments – especially in the U.S. (Weisburd

& Lum, 2005).

Today, crime mapping is frequently utilized by law enforcement agencies in order to visualize and analyze patterns of crime (Ratcliffe, 2009). Moreover, several countries make their maps of crime patterns available to the public in an attempt to inform their respective citizens of crime patterns in the areas they frequent (Ratcliffe, 2009). Well-designed crime maps are able to, through symbols, convey powerful messages to its readers (Eck et al., 2005), and it is argued that crime mapping is *the* most powerful tool when it comes to visually depicting geographic crime trends of large volumes (Ratcliffe, 2009). For instance, and especially relevant to the present study, Patten, Mckenlden-Coner and Cox (2009) utilized crime mapping to analyze *micro geographic* patterns of robbery in Roanoke, Virginia, U.S. The overarching research aim was to determine whether the city exhibited clear hot spots of robbery incidents. Various areas in the city were indeed found to be 'hot spots' of robbery, and the authors were able to confirm a presence of robbery-clustering in the city. Upon obtaining these results, the authors formulated suggestions for police efforts in these high-crime places.

Similarly, Block and Block (1995), also on the micro-geographic level, examined the co-occurrence of hot spots of crime and liquor establishments. Findings suggested that clustering of liquor establishments and clustering of crime were not strongly related. Rather, crime was found to concentrate in close proximity to public transport stations (ibid.). As mentioned above, not only has crime mapping shown to be a powerful tool in informing citizens about crime trends, it has, and can yield valuable information both for researchers and other entities concerned with crime (Ratcliffe, 2009). In fact, mapping hot spots of crime has proven to be a useful tool in regard to crime prevention efforts. It is to this we now turn.

Crime Mapping and Related Policing Strategies

Such areas as mentioned above, locations in which crime tends to concentrate, present natural targets for crime prevention – as it is in these locations prevention efforts are likely to have the greatest effect (Rosser et al., 2017). The strategy of 'hot spots policing' has developed as a result of the finding that the majority of crime tends to concentrate in a disproportionate amount of places (Braga, Papachristos & Hureau, 2014; Braga & Weisburd, 2010). This policing approach centers around focusing police resources in places identified as experiencing notably high crime rates (Braga, Papachristos & Hureau, 2014), as opposed to solely dispersing resources according to predetermined police beats, for instance (Goldstein,

1990). Such places may range from individual houses, certain stores, subway stations and street segments to larger geographical areas (Rosser et al., 2017).

Police have reported finding maps portraying hot spots of crime useful when engaging in hot spot policing (Rosser et al., 2017). In addition, Braga, Papachristos and Hureau's (2014) extensive systematic review of the effectiveness of hot spot policing supports the conclusion that hot spot policing strategies generate ample crime control benefits. Effectiveness of the policing strategy was found to be greatest when in combination with problem-oriented policing, which involves more than simply increasing police presence at hot spot locations. That is, problem-oriented policing involves addressing the underlying conditions present at hot spots that seemingly lead to recurring crime problems – oftentimes requiring police to consider non-traditional approaches in combatting crime (Weisburd & Eck, 2004). Indeed, in Braga, Papachristos and Hureau's (2014) systematic review, crime prevention benefits were found to be greatest where methods of 'situational crime prevention' were employed. That is, where intervention also involved *altering physical characteristics* of hot spot locations in order to reduce target attractiveness and increase the difficulty or risk of performing crime (Clarke, 1980; Knutsson and Søvik, 2005). Rosenbaum (2006) stresses that despite the promising results of hot spots policing, much is yet to be learned. Current knowledge is argued to be too general and thus research regarding how the hot spot policing strategy affects different *types* of crime is needed.

Crime Displacement?

This aforementioned finding of the effectiveness related to hot spot policing has challenged the conclusion of David Bayley in 1994, namely that 'police do not prevent crime' (Bayley, 1994). Whereas other policing strategies at that time were found to be ineffective in preventing crime, the emergence of hot spots policing suggests differently (Sherman & Weisburd, 1995). However, a number of scholars have expressed concern regarding 'crime displacement' in relation to hot spots policing (Weisburd et al., 2006). That is, crime simply moving 'around the corner' to an area in which police efforts have not been targeted – and thus neither truly preventing crime nor falsifying Bayley's statement. Several studies have suggested that crime tends to move to new locations in which criminal activities may ensue, to a larger degree, undistracted by specifically tailored police efforts (Bowers & Johnson, 2003). However, according to Weisburd et al. (2006), a magnitude of these studies exhibit significant methodological issues of which it is argued limits their ability to adequately

comment on the issue of crime displacement.

Weisburd et al. (2006) attempt to overcome said methodological issues in their study of displacement of drug and prostitution crimes in New Jersey, U.S. This study aimed to assess the degree to which hot spot policing efforts produced 'immediate spatial displacement' of crime. Findings indicated that, for these crime types at least, crime did not seem to relocate to neighboring, untargeted areas. Rather, it was suggested that the hot spot policing efforts stimulated a 'diffusion of crime control benefits'. That is, as opposed to crime flourishing in neighboring, untargeted areas, the observed benefits of hot spots policing were seen to transcend that of the targeted areas. Put differently, crime prevention benefits have shown to penetrate beyond the selected hot spots, thus enlarging the positive outcomes of prevention efforts rather than 'pushing criminal activity around the corner'. Overall, the study lends support to the notion that the most likely outcome of such police efforts is a diffusion of crime control benefits to nearby locations. This conclusion has later been supported in other studies (Bowers, Johnson, Guerette, Summers & Poynton, 2011; Braga, Papachristos & Hureau, 2014). This illustrates how crime mapping may produce valuable information in regard to truly tackling contemporary crime problems, that is – elimination of the crime problem rather than relocation.

Although a multitude of studies strongly suggest hot spot policing initiatives are effective in preventing crime, research evaluating hot spot policing strategies in Copenhagen, Denmark has suggested that such policing efforts may also result in an *increase* in violence committed against police officers performing these duties of crime prevention (Jørgensen, 2010). Jørgensen (2010) argues that one shall recognize that implementing such policing efforts may, despite facilitating a reduction in overall crime, accompany an increase in police-targeted violence - emphasizing the potential adverse effects of hot spot policing. In addition, contrary to the overall aim of hot spots policing, namely that of 'policing utilizing minimal resources', Jørgensen (2010) conducted an evaluation of hot spot policing initiatives in Copenhagen from a cost-benefit perspective – and interestingly, concluded that benefits did not outweigh costs. This evaluation involved hot spot policing efforts initiated in the city of Copenhagen in 2007, after experiencing significant crime problems related to night-life fueled violence and disorder. Police resources were put in place at certain locations and during certain times were violence had shown to concentrate. That is, several hot spots in the inner-city of Copenhagen between 23:00 and 07:00 during Friday and Saturday.

The additional costs emanating from increased police presence were measured against the reduction in expenses related to court cases dealing with violent crimes, and it was concluded that the benefits, in this case, did not outweigh the costs from a strict economic point of view (Jørgensen, 2010). Although recognized as an effective method in reducing crime in instances where other crime prevention methods have little effect, hot spot policing was in this case deemed an 'expensive form of crime prevention'. It is speculated that similar crime control benefits may be observed upon utilizing fewer police resources than was employed in this study, consequently lowering the cost related to increased police presence – a notion the author suggests is an objective for future research. Nevertheless, although hot spot policing has largely shown to be a promising crime prevention strategy, this evaluation serves to illustrate possible unwanted effects associated with the initiative of which research should consider in further developing the strategy.

As was stated in the introduction of this paper, the *first research objective* concerns the 'exploration of spatial-temporal patterns and concentrations of violence in Oslo and Bergen'. This research objective is formed based on the above discussion. Due to the aforementioned benefits related to visually depicting crime patterns on maps, the current research project will aim to produce and explore maps of violent crime in Oslo and Bergen. In addition, temporal factors will be of particular interest – of which will be further discussed below.

Why Map Violent Crime?

Not all types of crime are suitable for mapping, and, according to Eck et al. (2005), establishing whether a category of crime can be meaningfully plotted onto a map involves examining the unique attributes of the type of crime in question. Eck et al. (2015) highlight robberies of taxi drivers as one such category of crime that is 'unmappable'. It is argued that these crimes are likely to be distributed across a city fairly dispersedly and thus not exhibiting any meaningful concentrations - as any hot spots that would occur are likely due to chance. This is argued to be due to the fact that features likely to influence taxi-robberies include the driver's age, presence of security cameras inside the vehicle and the specific taxi company it represents. A common denominator of all these elements is the fact that they cannot be meaningfully depicted on maps. That is, they are not physical characteristics of which geographical maps may portray. This is the reason any geographic concentration resulting from plotting such robbery data onto a map would be considered to exist due to chance. It is

argued that there are no known 'non-vehicle related' physical characteristics that attract taxi-robberies (Eck et al., 2005). Other crime types of which it is argued identification of geographical location is strenuous includes tax evasion and internet fraud (Ratcliffe, 2004).

Contrary to taxi-robberies, tax-evasions and internet fraud, concentrations of violent crime *can* be meaningfully portrayed on maps. A number of studies have confirmed that several location-based physical features are related to, and assist in explaining the presence of crime, therein violent crime (Favarin, 2018). Examples of such features include licensed premises and public transport stations (Abbey, 2011; Brady & Li, 2013; Ceccato & Uittenbogaard, 2013; Conrow, Aldstadt & Mendoza, 2015; Favarin, 2018; Gerell & Kronkvist, 2016; Groff & McCord, 2011; Murray & Roncek, 2008; Weisburd et al., 2012). Consequently, geographic locations in which violent crime concentrates, and in turn, maps portraying those concentrations, do not represent random distributions. In other words, since violent crime has shown to flourish in locations that exhibit, inter alia, the above **'***location-based* crime attractors', mapping violent crime provides more meaningful information than mapping a crime type of which its suggested crime attractors are *not* location-based, or alternatively, not of 'mappable' nature. This illustrates how mapping violent crime is a suitable approach when seeking to unravel fruitful information regarding its spatial patterns. Moreover, as acknowledged above, the identification of such geographic patterns may inform potential police initiatives attempting to combat this specific crime problem.

However, with any such 'mappable' crime, it is important to recognize the potential issues related to the reliability of geographical police data (Mazeika & Summerton, 2017). It is widely recognized that police data suffers from numerous limitations (Gerell, 2018), for instance it not encompassing the dark figure of crime (Gibson & Kim, 2008). However, the extent to which the geographical reliability of police data constitutes a problem in analysis of 'crime at place' is relatively unknown. Therefore, Gerell (2018) attempted to assess the extent of this issue through examining incidents of vehicle-arson in Sweden. The author was able to quantify the inaccuracy of police-geocoding of this particular crime type through a comparison of police records with an alternative, more reliable recording system - namely that of rescue services. Results suggested that police records exhibited a median error of 83 meters, a finding of which the author argues presents a potential pitfall for researchers (and police themselves) who utilize these data in analysis of crime at place. The main point to derive from the above study is the importance of recognizing these inaccuracies in conducting analysis of crime at place.

Type of Crime Mapping

Eck et al. (2005) emphasize that research has found the most accurate and informational crime maps are those that adjust mapping strategies specifically according to the research objectives in question. Scholars highly suggest that the way in which hot spots are displayed on maps should be consistent with the type of crime in question and the possible police action to be implemented in light of potential findings. Production of crime maps that do not fulfill the aforementioned suggestions often result in less meaningful maps (Eck et al., 2005). For instance, a map portraying hot spot *addresses* whereas researchers seek to unravel hot spot neighborhoods would be uninformative. Conversely, suppose a map depicts large shaded areas, like that of neighborhoods or the size-equivalent of one. Meanwhile, the actual hot spots of interest are individual addresses. In this case, the map would be imprecise. Such a large shaded area (given that it lacks a color gradient or the like indicating degree of concentration) would imply that the hot spot(s) may be situated *anywhere* within the shaded area. In the context of hot spot policing, that would translate to an allocation of resources equally throughout that area. Needless to say, this would be a significant waste of resources – ultimately contradicting the overall aim of 'policing using minimal resources'. This demonstrates the possible consequences of non-optimal production of hot spot maps.

Based on the abovementioned points to consider upon mapping hot spots of crime, the current research project will first, in order to provide an overview of general patterns of violent crime in Oslo and Bergen, create crime maps portraying citywide trends. Subsequently, in line with the discussion above, and in an attempt to unravel more specific crime concentrations throughout various parts of each city - separate crime maps will be produced presenting crime concentrations in subsets of both cities. Further, grid-cells will be equipped with color-gradients to indicate the density of crime in each cell. This will produce more detailed and informative hot spot maps, on a much smaller-scale level as opposed to the initial maps of each city in its entirety. Such small scaled, informative maps will, in addition to being in line with the essence of the criminology of place, be significantly more fruitful in regard to informing police initiatives and other entities concerned with combatting crime.

Spatial-Temporal Clustering

Although spatial information is of paramount importance in mapping hot spots of crime, it is argued that the use of temporal information in this setting can further advance our understanding of crime patterns (Nelson, Bromley & Thomas, 2001). However, research on spatial-temporal trends is, according to Ratcliffe (2009) the most under-researched area within contemporary criminology of place. Further, Ratcliffe (2009) emphasizes that valuable information in regard to crime prevention efforts can result from analyzing spatial-temporal crime trends - stressing the need for research to address this temporal aspect of crime clustering.

The fact that crime trends fluctuate over time is not a new observation. Surveys of crime for instance, have found that violent crime tends to concentrate on Friday and Saturday nights between 22.00 and 03.00 (Nelson, Bromley & Thomas, 2001; Shepherd, 1990). The British Crime Survey found about 50% of violent crime to take place between 18.00 on Fridays and 06.00 on Mondays (Mayhew, Maung & Mirrlees-Black, 1993). Further, analyzing violent crime trends through the use of police records, Nelson, Bromley and Thomas (2001) found that 42% of all violent crime occurred between 23:00 and 05:00. A noticeably smaller portion, 29%, took place between 09:00 and 17:00. Overall, this suggests that violent crime tends to peak during night-time. In addition, it was found that 27% of violent crime occurred on Saturdays, whereas Friday and Sunday experienced 15.4% and 15.2%, respectively. In total, 57% of all violent crime took place during Friday, Saturday and Sunday – suggesting that violent crime tends to temporally cluster not only during late-night hours, but also during weekends. A common denominator for the abovementioned studies is that the concept of place is entirely ignored. Put differently, these studies examine temporal crime patterns on a citywide-scale as opposed to smaller spatial units.

Recently, some scholars have conducted similar analyses in a *spatial-temporal* context (Conrow, Aldstadt & Mendoza, 2015). Conrow, Aldstadt and Mendoza examined hot spots of violent crime in close proximity to bars in Buffalo, New York, U.S. Violent crime in these hot spots was shown to peak at midnight, and experienced a decrease from midnight until 05:00, with the exception of an increase at about 02:30. The remaining hours of the day experienced far less crime. This finding has also been reflected in other studies (Bromley & Nelson, 2002; Brower & Carroll, 2007; Rand, Sabol, Sinclair & Snyder, 2010). Further, also Rosser et al. (2017) argue, based on their analysis of property crime in a U.K city, that even in the most crime-ridden places, crime trends will, due to their dynamic nature, fluctuate throughout the

course of a day, the week, and so on. Hence, deciding to allocate increased police resources to these places *permanently* until said hot spots cease to exist may not be the most efficient solution.

In addition, Haberman, Sorg and Ratcliffe (2017) found in their study of street robberies in Philadelphia, U.S., that some places experienced consistent patterns of crime, that is, crime occurred quite evenly throughout the day and throughout the week - whereas other places experienced crime only during specific times of the day and week. In other words, temporal trends may vary from hot spot to hot spot – and may not conform to the citywide temporal trend. Two neighboring hot spots may exhibit vastly different temporal trends despite their close proximity to one another. Haberman, Sorg and Ratcliffe suggested that more attention should be paid to the interaction of space and time in understanding concentrations of crime. Importantly, Rosser et al. (2017) argue that although it has been established that crime prevention measures specifically tailored to geographic hot spots of crime are deemed effective in preventing crime, adding a temporal component to the equation may yield even more informative results, potentially further increasing the effectiveness of crime prevention efforts.

Interestingly, and adding to the importance of including a temporal component in researching spatial crime patterns - research has indicated that spatial-temporal trends are less stable than their sole spatial-trend counterpart (Rosser et al., 2017). This further emphasizes the need for police resources to not only be specifically tailored to address certain geographic hot spots, but also to tailor the allocated resources according to times in which crime has shown to peak in these hot spot areas. That is, pay regard to temporal fluctuations in crime density *within* identified hot spot areas. This way, the cost-effectiveness of crime prevention efforts can be maximized even further compared to instances in which only the geographic information of hot spots are taken into account (Nelson, Bromley & Thomas, 2001). This is a concern of great importance as resources available to utilize for crime prevention purposes are limited.

In addition to the observed hourly and weekly fluctuations of both violent crime and crime in general as shown above, research by Field (1992) suggests that violent crime trends also fluctuate seasonally. It was argued that violent crime tends to display an increase during summer months. This finding has also been supported in other studies (Schinasi & Hamra, 2017), specifying that May through to September oftentimes prove to be the most crime-ridden months. Analogous results have been reported by Andresen and Malleson (2013), who

observed seasonal changes in the spatial distribution of crime in Vancouver, Canada.

It is further argued that when seasons change, this encompasses times in which aggregate routine activities change throughout the year. For instance, the fall typically involves a time when schools and universities commence after summer break, causing a magnitude of students to return to these locations. Winters in Oslo and Bergen usually involve low temperatures, causing people to spend more time indoors. As spring time commences, temperatures gradually become more pleasant, and people typically return to spending more time outdoors. As the temperature further increases during summer in both Oslo and Bergen, many spend more time outdoors and partake in festivals and other public events. Tourism also increases during these months. It is thought that these changes in routine activities usually occurring during each season impacts levels of violent crime. During summer months for instance, it is hypothesized that the number of people visiting the city centre for recreational activities and night life increases, thus facilitating violent crime. In recognizing the apparent value of spatial-temporal analysis, the current study will aim to accompany crime maps with an examination of corresponding spatial-temporal trends of violent crime in Oslo and Bergen. These examinations will, given the literature discussed above, concern three different temporal scales – season, day of week and hour of day.

The Relationship between Environment and Violent Crime

It seems reasonable to suspect that the now established fact that rates of violent crime tend to fluctuate *over time within* hot spot areas - is related to the specific features of each location. As mentioned above, violent crime, as opposed to for instance taxi-robberies – can be meaningfully depicted on maps due to the very nature of this crime type. That is, certain elements in the physical environment have shown to influence the presence of violent crime – resulting in non-random spatial trends. Nelson, Bromley and Thomas (2001) suggest the observed temporal fluctuations in crime rates reflect the varying *functions* of each location.

To exemplify, the above authors observed in their study of violent crime in Worcester, England, that one identified hot spot (identified as an important night-leisure zone) experienced a high number of violent crime incidents from Friday through to Sunday, compared to the remainder of the week. Conversely, another area (identified as a major retail location) experienced a high number of violent crime during Saturday, however violence did not continue past midnight (as is typical for night-life fueled violence). In fact, 48% of violent crime occurred between 09:00 and 17:00. Only 25 % of violent crime occurred during late

night or early morning hours. This finding suggested that violence in this area was predominantly daytime or shopping related. On the contrary, violent crime in the former area was seen to largely relate to night-life activities due to crime incidents continuing (and peaking) past midnight both on Friday and Saturday (62% of violent crime was recorded between 23:00 and 05:00). Analogous results have been reported by Brower and Carroll (2007) in their study of multiple crime types in Madison, Wisconsin, U.S. Further analysis by Nelson, Bromley and Thomas (2001) also suggested that certain places functioned as typical shopping locations during the day, then transforming into leisure zones during weekends and at night, whereas other locations exhibited one main function and crime patterns varied accordingly. Overall, it was argued, in line with other scholars, that analysis of temporal information (in combination with spatial information) enabled one to, in this case, identify a distinction between daytime related violence and violence assumingly related to night-time leisure activity. In other words, it is argued that the specific *function* of each location influences the way in which crime rates fluctuate throughout the day and week. This highly suggests that *features in the environment* influence the presence of violent crime.

Closely related to the notion that night-life venues attract violent crime is the observation of Nelson, Bromley and Thomas (2001), namely that a majority of violent crime incidents involve alcohol consumption. The 1995 British Crime Survey (Mirrlees-Black, Mayhew & Percy, 1996) suggested that in approximately 50% of violent crime cases covered by the survey, the offender was shown to be under the influence of alcohol at the time of the offence. In addition, extant literature continuously suggests a strong link between the use of the city centre for leisure activities and violent crime (Mirrlees-Black, Budd, Partridge & Mayhew, 1998; Shepherd, 1994). Shepherd (1994) found, in his analysis of the spatial distribution of violent crime in a U.K. city that most alcohol related violent crime occurred in or in close proximity to bars and adjacent public transport stations. This finding corresponds with the notion of Levi (1997), namely that the vast majority of violent crime incidents (excluding domestic violence) occur in situations where people become physically clustered upon leaving drinking venues – consequently becoming involved in disputes.

Further, Nelson, Bromley and Thomas (2001) found in their analysis of violent crime distributions in two English cities that 52% of all violent crime incidents occurred in streets. Another 18% of violent crime was accounted for by night-life venue locations. Contrary to a number of other studies, it was found that little violent crime occurred at bus stops. However, regardless of whether the incident was situated inside a night-life venue or on nearby streets,

the study found that the presence of night-life entertainment venues was associated with an increase in violent crime - a finding the authors emphasize is widely recognized. This indicates that a significant portion of the aforementioned 52% of violent crime incidents occurring in streets may have occurred in streets in close proximity to such venues – suggesting that violence ensued upon travelling to and from said venues.

More recent research also emphasize the aforementioned points made by Nelson, Bromley and Thomas (2001) and others regarding environmental factors seen to influence the presence of violent crime. Some of the most prominent features in the environment shown to be related to violent crime include public transport stations (Block & Block, 1995; Favarin, 2018; Gerell & Kronkvist, 2016; Groff & McCord, 2011; Sousa, Pitombo, Rocha, Salgueiro & Delgado, 2017) and night-life venues (Abbey, 2011; Brady & Li, 2013; Ceccato & Oberwittler, 2008; Conrow, Aldstadt & Mendoza, 2015; Favarin, 2018 Gerell & Kronkvist, 2016; Murray & Roncek, 2008).

Favarin (2018) also examined the effect of areas primarily defined as 'residential' and 'retail' areas on violent crime, ultimately linking areas with a high density of retail shops to an increase in violence. Overall, a magnitude of research suggests the aforementioned physical attributes of the environment are 'criminogenic' in relation to violent crime. In other words, places that, due to their characteristics are likely to attract violent crime. In light of the routine activity perspective, the presence of a public transport station is thought to increase the possibility of reaching a target in that area, and in turn, increase crime. Likewise, venues that are licensed to sell alcohol to their patrons such as bars, night clubs and restaurants – function as crime attractors for suitable targets, especially during evening and late-night hours.

The aforementioned literature serves to display the extent to which there has been suggested a link between physical features in the environment and violent crime, in a number of cities across different countries. As for many of the points made throughout this paper, such a link may be informative for crime prevention efforts. However, research assessing the effect of such environmental features in explaining crime concentrations at the *micro-place* level is scarce. Rosenbaum (2006) argues that data analysis within the hot spot policing strategy typically does not examine the environmental context of identified hot spots (as opposed to problem-oriented policing). However, knowledge of the physical characteristics inherent to the hot spot in question is crucial in order to understand which factors contribute to and sustain hot spots of violence (Hardyns, Snaphaan & Pauwels, 2018). The real problems

are typically hidden *behind* the reported incidents of violence. Thus, the *second research objective* of the present study is formed based on the above discussion; "Testing the effect of environmental factors in explaining concentrations of violent crime". Attributes of the environment are incorporated in the analysis to supplement police incident data. Following the lead of Favarin (2018) and others, these attributes involve public transport stations, major roads, commercial areas and residential areas. Although it would have been preferable to examine the relationship also between the presence of night-life venues and violent crime, the present study is not in possession of suitable data for conducting such analysis. In conclusion, these physical attributes are included in analysis in order to facilitate a deeper understanding of the dynamics of violence at micro-places. As stated by Rosenbaum (2006), without 'digging deeper', police responses to identified hot spots will remain superficial and result in short-term impacts, at best.

The Law of Crime Concentration

The third and final focus point of the current project is that of the 'law of crime concentration'. The findings discussed above regarding the tendency of crime to cluster geographically has prompted American criminologist David Weisburd to, based on recent analysis of crime concentrations in eight jurisdictions, propose the 'law of crime concentration' - arguably the first law within the 'criminology of place' (Favarin, 2018). This proposed law 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 crime'* (Weisburd, 2015, p. 1).

Put differently, the law states that the amount of micro places (e.g. 6% of street segments in a city) that account for a percentage of the cumulative proportion of crime (for example 50% of all crime) will only vary slightly across time and across cities. In other words, if Weisburd's proposed law of crime concentration at place is accurate, the following should be a reality; if 6% of street segments in Oslo account for 50% of all violent crime (in Oslo), similar numbers should be reflected in Bergen and other cities. This forms the foundation of the present study's *final research objective;* to assess the validity of the law of crime concentration in the cities of Oslo and Bergen.

In Weisburd's (2015) initial attempt at defining the bandwidth of the law he found that 50% of crime concentration was accounted for by 2.1 – 6 % of street segments, implying a bandwidth of approximately 4 %. In the case of 25% concentration it varied from .4 to 1.6 %, implying a bandwidth of less than 1.5%. This initial study functioned as the first cross-city comparison of crime concentration using the same geographical unit (street segment), the same type of crime data (police incident data) and a general measure of crime. Upon the proposal of this law of crime concentration in 2015, several studies have been conducted to examine its validity. It is to these we now turn.

Gill, Wooditch and Weisburd (2017) tested the law of crime concentration in a suburban setting, namely Brooklyn Park, U.S., over a 14-year period. Findings suggest strong support for the law. Only 2% of street segments accounted for 50% of all crime, whereas 0.4% of street segments accounted for 25% of all crime. In addition, these trends were highly stable over time. The authors concluded that resulting place-based crime prevention efforts can be as effective in non-urban settings as they are regarded to be in urban settings.

According to Weisburd (2015), several studies have been conducted examining concentration trends also solely for *one* specific type of crime (e.g. violent crime). However, drawing conclusions from these has proved difficult due to low base rates in micro-geographic areas (ibid.). Interestingly, recent studies that have overcome this issue have found that also individual crime types exhibit high levels of concentration similar to their aggregated counterparts (Weisburd, 2015). For instance, Schnell, Braga and Piza (2017) conducted a study examining violent crime trends in Chicago, U.S. between 2001 and 2014, utilizing multiple units of analysis (from street segments to larger communal areas). Results indicated strong overall support for the law of crime concentration at places, stating that between 5% and 7% of street segments accounted for 50% of all violent crime. Further, Hibdon, Telep and Groff (2017) tested the law in Seattle, U.S over a 5-year period, focusing on drug activity and utilizing calls-for-service and emergency medical services data to do so. Both the calls-for-service data and emergency medical service data showed crime concentrations in line with the claims of Weisburd's proposed law. Indeed, 50% of all drug-use related inquiries were accounted for by less than 2% of street segments. Additional American studies that have expressed support for the proposed law include Levin, Rosenfeld and Deckard's (2016) study in St. Loius U.S and Hipp and Kim's (2017) study of 42 cities in California, U.S, to name some.

Overall, studies reviewed so far have offered strong support for a law of crime concentration. However, the abovementioned studies were all undertaken in U.S cities. Although much less extensive, also recent non-American studies have been conducted to test the validity of the law of crime concentration. Andresen, Curman and Linning (2017) conducted a longitudinal study of street segments and intersections in Vancouver, Canada. The authors also disaggregated their data (in line with several U.S studies mentioned above), and, interestingly, it was found that crime exhibited 'high concentration levels' regardless of crime type - however, specific concentration levels varied across crime types. For the category of assault, 50% of all incidents were accounted for by 1.62% of street segments, whereas for burglary, 7.61% of street segments accounted for 50% of all burglary. This portrays a relatively large difference in concentration levels, prompting the authors to suggest that specificity is crucial in further developing the law of crime concentration. As mentioned, several of the aforementioned studies also analyzed clustering of specific crime types as opposed to a general measure of crime, however only one crime type was included in these studies – rendering a within-city comparison of clustering trends *between* crime types unfeasible. In other words, Andresen, Curman and Linning (2017) provide one of the first studies testing the law of crime concentration including analyses of concentration levels for *multiple* crime types in a non-U.S. city – ultimately enabling them to comment on the extent to which concentration levels of different crime types may vary within the same city. This enables the authors to offer some clarification as to whether concentration trends of specific crime types vary simply due to the fact that different cities may exhibit different concentration trends or whether such variation exists *within* the same city – suggesting the cause of variation is the specific crime type itself.

Also European studies are beginning to address the validity of the law. Despite findings from extant European studies implicitly lending support to the law of crime concentration (Van Wilsem, 2009), these were not designed to 'test the law in a European context' (Favarin, 2018). The recent studies on crime concentration trends in The Hague (Steenbeek & Weisburd, 2016), Milan, Italy (Favarin, 2018) and Belgium (Hardyns, Snaphaan & Pauwels, 2018; Vandeviver & Steenbeek, 2017) form part of the European studies that 'directly and strictly' aim to test the law of crime concentration.

Favarin (2018) tested the law of crime concentration in Milan, being the only study to test the law in Italy. The study utilized crime incident data over a seven-year period to analyze crime concentrations at the street-segment level. The author investigated both burglaries and robberies. As with the study of Andresen, Curman and Linning (2017) in Vancouver, Canada mentioned above, this allowed for an assessment of the degree to which different crime types in the same city exhibit differing concentration trends. Favarin (2018) found that on average, 4.0 % of street segments accounted for 50% of all burglaries, whereas 1.6 % of street segments accounted for 50% of all robberies. Interestingly, the category of robbery was found to experience a higher degree of concentration compared to that of burglary. This further amplifies the abovementioned notion that the law of crime concentration should be assessed utilizing specific measures of crime, as it is speculated that concentration levels may vary across crime types. Ultimately, Favarin emphasizes the fact that results obtained from this study cannot be directly compared with previous studies that analyze a general measure of crime, and are better suited to be compared with other studies that have analyzed concentrations for the same crime types.

Favarin concludes that the observed crime concentrations for burglary and robbery in Milan are not only consistent with that of other cities' analyses of concentration for other specific crime types (e.g. Bernasco & Steenbeek, 2017; Braga, Hureau & Papachristos, 2011), concentrations in Milan showed to be even denser than that of previous studies. Again, this emphasizes the notion that the law of crime concentration may vary across crime types. Several other studies assessing the law of crime concentration have also observed differing concentration trends for different types of crime (Bernasco & Steenbeek, 2017; Braga, Papachristos & Hureau, 2010; Braga, Hureau & Papachristos, 2011; Hibdon, Telep & Groff., 2017; Hipp and Kim, 2017). Weisburd (2015) has proposed a bandwidth for an *aggregated measure* of crime, that is, analysis including all crime types. Thus, Favarin (2018) suggests it remains a task for future research to determine whether this specific bandwidth also applies to specific types of crime, or whether individual crime types call for unique bandwidths.

Of specific interest to the present study is the suggested reasoning for the observed higher concentration trends in Milan compared to previous studies investigating concentrations for specific crime types. The author suggested this be due to the nature of the type of crimes in question. Research not concerned with the law of crime concentration has shown that violent crime (as included in Favarin's study) tends to exhibit higher levels of concentration compared to their non-violent counterparts like that of property crime (Lee,

Eck, SooHyun & Martinez, 2017) – an observation of which Lee et al. (2017) suggest stems from a higher concentration of targets or a smaller number of offences. Based on these findings, it seems reasonable to expect a high concentration of violent crime in Oslo and Bergen. Moreover, it further strengthens the need to assess the extent to which the law of crime concentration is unanimous across all categories of crime.

In addition to the above, also studies in Rotterdam, Netherlands (Van Wilsem, 2009), Tel Aviv-Yafo, Israel (Weisburd & Amram, 2014), The Hague, Netherlands (Steenbeek & Weisburd, 2016), Florianopolis, Brazil (Valente, 2019) and Belgium (Hardyns, Snaphaan & Pauwels, 2018) found concentrations in line with the proposed law – adding to the studies supporting the law in non-American contexts.

As illustrated above, a constant growth of research has found support for the proposed law of crime concentration. This proliferation of studies reflect an interest in the law and the criminology of place in general – suggesting that the value of engaging, somewhat, in a deviation from traditional criminology is becoming more recognized. However, Weisburd (2015) emphasizes the fact that despite the existence of strong evidence in favor of the law, studies have mostly been conducted in cities he refers to as comprising a 'convenience sample', and the vast majority being U.S. cities. Consequently, Weisburd, alongside other scholars who have assessed the law (Levin, Rosenfeld & Deckard, 2017; Favarin, 2018) question whether the proposed law is truly generalizable. It is argued that the law must be assessed across 'diverse social settings'. Commenting on the generalizability of the law, Hardyns, Snaphaan and Pauwels (2018) state that "as social laws are supposed to have a general nature and thus applicable in different contexts, every additional test informs us of the robustness of the relationship" (p. 1). In addition, every study testing the law may be viewed as a potential falsifier of the law (Hardyns, Snaphaan & Pauwels, 2018). Further, Favarin (2018) emphasizes the especially lacking information on the law of crime concentration in Europe, and ultimately – the need for testing in this area. Therefore, the current research project aims to introduce such a 'new social setting', namely that of two major Norwegian cities – ultimately contributing to the currently lacking research on the law in Europe, more specifically Scandinavia, and the overall question of generalizability.

In addition to the aforementioned issues regarding the generalizability of the law, Weisburd (2015) has identified issues related to studies testing the law for disaggregated crime types. Despite the growing literature examining the law of crime concentration for specific crime types, it is emphasized that studies of crime concentration for specific crime

types *across cities* is limited (ibid.). It is argued that many existing studies make it difficult to draw strong conclusions regarding similarities in crime concentration across cities due to strong variation in types of data, types of crime and units of analysis utilized. As seen in much of the literature reviewed above, crime types have been manifold, and units of analysis have ranged from individual addresses to larger regions. In addition, types of data utilized in the various studies have ranged from police incident data to calls for service and medical services data. It must be recognized that characteristics inherent to these various types of crime, units of analysis and data may influence the resulting concentrations observed, and comparisons of studies in which these factors differ may not be particularly fruitful. Thus, the present study will focus on one type of crime (violent crime), one type of data (police incident data) and one unit of analysis (grid-cells) consistently *for both cities* in order to allow for a meaningful comparison of their respective concentration trends.

As for locating studies of which are comparable to the present study, this has proved difficult. The number of studies testing the law utilizing grid-cells as the unit of analysis is relatively limited. However, the recent study in Belgium (Hardyns, Snaphaan & Pauwels, 2018) utilized grid cells of 200m by 200m and found support for the law of crime concentration for specific crime types, including violent crime. The study also utilized police incident data. These factors combined render this study one in which results are highly comparable to those to be yielded in the current study.

Another significant aspect of the law in which it seems reasonable to suggest studies shall address is that of its stability over time. Some studies have tested Weisburds' (2015) claim that crime concentrations stay within the established bandwidths over time, despite 'strong volatility' in crime incidents. That is, concentrations staying within these bandwidths regardless of total number of incidents varying significantly from year to year. Valente (2019) for instance, examining robbery crimes, found support for this claim in his analysis of the law in a Brazilian city across a 7-year period. Similar conclusions were reached by Hardyns, Snaphaan and Pauwels (2018) in their study of two major Belgian cities. In light of this, the present study will test the law also separately for each year from 2015 up until 2018 in order to assess its stability over time in a Norwegian context. Based on prior findings, it seems reasonable to expect to find that concentration trends are relatively stable over time.

The studies mentioned above assessing whether crime concentrations stay within the established bandwidths over time test an aspect of the law previously claimed by Weisburd (2015). Conversely, Haberman, Sorg and Ratcliffe (2017) assess whether the law holds across

various temporal scales *not* considered by Weisburd, but in which the authors argue are important to explore in regards to future research and crime prevention policy - therein especially hot spot policing. These temporal scales include season, days of the week and hours of the day. As empirical research reviewed above suggested, crime concentrations may fluctuate by hour of day, day of week and season. Based on this, it was deemed crucial also to assess the validity of the law across these temporal scales. The authors found, in their study of robbery in Philadelphia, U.S., that the law of crime concentration held across all temporal scales analyzed. The present study will, based on the above, consider multiple temporal scales in assessing the validity of the law in Oslo and Bergen.

Overall, studies discussed thus far all seem to offer considerable support for the law of crime concentration. However, as mentioned above, scholars in the field, along with Weisburd himself question the true generalizability of the law, and stress the importance of assessing its validity across different contexts and for different crime types (Favarin, 2018; Weisburd, 2015). Having the question of generalizability in mind, Lee et al. (2017) conducted a meta-analysis reviewing studies (both U.S. and non-U.S.) examining concentrations of crime on the micro-geographic level between 1970 and 2015, aiming to assess whether the concentration levels reported in these studies align with those specified by the law in 2015. Interestingly, the authors concluded that results could not fully support the law of crime concentration. Rather, support was allocated to a modified version along the lines of *'a relatively small proportion of all places contain most crime'* (Lee et al., 2017, p. 15). The authors were adamant in clarifying that this modified version of the law would not guarantee a certain percentage of micro-places to account for a certain percentage of all crime – seeing as the studies which were reviewed did not *all* observe such a trend. Perhaps this study revealed variations in crime concentrations which exceeded that of what Weisburd's law commends due to a wide inclusion of different contexts, geographic units and various crime types. Nevertheless, this meta-analysis served to suggest that upon examining a vast amount of studies on crime concentration at the micro-geographic level (much like striving to establish generalizability), results were not *as clearly* in favour of the law. This indication of disparity in study-results should only further motivate contemporary research to contribute to the question of generalizability, as is the objective of this study.

Recent studies have also highlighted the fact that Weisburd and other developers of the law have failed to specify clear criteria for corroboration and falsification of the law, therein whether one should examine all micro-places, regardless of crime experience

(prevalence), or solely micro-places which have experienced at least one incident (frequency) (Boivin & De Melo, 2019; Hardyns, Snaphaans & Pauwels, 2018; Lee et al., 2017). In light of this, the present study will measure crime concentration levels based on both prevalence and frequency to assess the degree to which concentrations vary based on the procedure applied.

The Present Study

The above section has provided an overview of extant literature that has aimed to examine spatial patterns (and related aspects) of crime, therein violent crime. Overall, this sets the context for the current research project, which in short, aims to examine the spatial and temporal patterns of violent crime in two major Norwegian cities. To conclude, the current project presents three main research objectives, as follows:

Objective 1: Through crime mapping, visually depict spatial patterns of violent crime in Oslo and Bergen – both on the larger 'citywide' scale and for smaller subsets of the respective cities (in order to unravel smaller-scale trends). In addition, temporal components will be considered.

Objective 2: Examine, through the use of regression analysis, the effect of environmental factors in explaining concentrations of violent crime in Oslo and Bergen.

Objective 3: Assess the validity of Weisburd's (2015) proposed 'law of crime concentration' in Oslo and Bergen. The law will be assessed using two different calculation methods as well as across different theoretically relevant temporal scales.

Based on the above discussion of environmental criminological theory and extant literature within the criminology of place, several hypothesizes have been formulated to accompany the aforementioned research objectives: (1) Violent crimes in Oslo and Bergen concentrate across space and over time. (2) These concentrations vary notably across seasons, days of the week and the hours of the day. (3) The presence of transit stations, major roads, residential and commercial land use significantly affect the concentration of violence at micro-places. (4) The law of crime concentration will hold for violent crime in Oslo and Bergen.

4. DATA AND METHODOLOGY

The following section provides an overview of the data and methodologies employed to achieve the aforementioned research objectives. In addition, ethical considerations are discussed. Finally, an analytical plan is articulated concerning each individual objective.

Study Sites

The present study examines spatial-temporal patterns of violent crime in Oslo and Bergen, Norway. According to Norway Statistics (NS), Oslo and Bergen represent the two largest cities in Norway, with population counts of 683,947 and 281,858, respectively (NS, 2019a; NS, 2019b). In Oslo, 19% of the population are aged between 30-39 years old, rendering them the most prominent age group in the city, closely followed by the age group spanning 20-29 years (17.4% (NS, 2019a)). Reversely for Bergen, the younger group (years 20-29) comprise the population's most prominent age group (16.5%), closely followed by the 30-39 group (14.8% (NS, 2019b)). In sum, these two groups make up a considerable size of the overall population for both cities (36.6% and 33.6% for Oslo and Bergen, respectively).

As opposed to Oslo, the city of Bergen is characterized by multiple, far-stretched areas comprising forestation and mountains. In light of this, Bergen can be considered to display a 'discontinuous urban setting' (Valente, 2019). In addition, the city centre is more geographically spread out in Oslo as opposed to Bergen. Consequently, bars, pubs and shopping centers are more clustered in Bergen, a characteristic it seems reasonable to suggest may significantly influence rates of violence. In sum, it is important to note that there are substantial geographical differences between the two cities.

Data

Violent Crime

The data utilized for analysis consists of police incident data on violent crime for Oslo and Bergen, spanning from 2015 to 2018. It comprises reports of violence to the police that have not yet been investigated. This data is extracted from the police register STRASAK and accessed through the National Criminal Investigation Service in Norway. It forms part of a larger dataset intended for other research purposes, and a subset including only incidents of

violent crime within the city borders of Oslo and Bergen was allocated to the present study. The data covers incidents of violent crime from October 1st 2015 through June 1st of 2018, due to changes in penal legislation prior to October of 2015 (Stene, 2017). Consequently, also registration practices in police registers shifted. Thus, including data from before that point in time would introduce issues relating to differing definitions of what constitutes 'violent crime'. Violent crime in the present study involves assault (with or without the use of weapons) ranging from mild to severe (severe causing substantial injury), threats of violence, murder, attempted murder, and conspiracy to murder. Violence committed against service-workers, including police officers, is also included in the data. The data covers *only* violent crime reported in public space. In other words, cases of domestic violence are not reflected in the data. The definitions of violent crime in Oslo and Bergen are identical, which facilitates a fruitful comparison of results.

It should be noted that the present dataset only covers incidents that are recorded as *crimes.* In other words, incidents classified as disturbing public order - not qualifying as crimes, are excluded. Such incidents typically involve less serious forms of violence (Nelson, Bromley & Thomas, 2001). In light of this, the resulting analysis of this paper should be viewed as representing more serious forms of violence.

Unlike the vast majority of data utilized for criminological research, the present data is devoid of all personal information such as gender, age and place of residence (for both offenders and victims). However, alongside incidents of violent crime, the dataset includes information regarding date, time (hour of day) and place of occurrence. In total, the data comprises 14,529 incidents of violent crime available for analysis. Of these, 11,118 were reported in Oslo and the remaining 3,411 were reported in Bergen.

Violent crime is chosen as the crime type for analysis both for theoretical and practical reasons. First, reports of violent crime was a readily available sub-sample of the overarching project. In addition, it appears valuable to compare crime patterns across two cities that exhibit drastically different rates of reported incidents. Further, as was seen in previous chapters presenting extant literature and theories of environmental criminology, there exists theoretical grounds and empirical support to expect that rates of violent crime will vary alongside variations in people's routine activities (Bromley & Nelson, 2002; Haberman & Ratcliffe, 2015). Indeed, the predatory nature of violent crime (as defined in this study) requires motivated offenders to encounter suitable targets in *public areas*. Importantly, the presence of people in public areas is largely determined by variations in

aggregate routine activity patterns (Felson & Eckert, 2016). In addition, issues related to the recording of dates and times of crime incidents is not as great of a concern for violent crime as it is for many other crime types. This is because violent crime requires the victims' presence, and they are thus oftentimes also able to report the time of the event relatively accurately. A range of other crime types do not rely on the presence of victims for crime to form (e.g. burglary), resulting in much greater difficulty in accurately recording the time of the act (Ratcliffe, 2000), and ultimately, raising questions regarding the reliability of the data. This issue will be revisited in the discussion.

Physical Attributes

A second dataset comprising information regarding the presence of theoretically relevant physical attributes in the environment is merged with the original dataset, intended to utilize in the regression analysis. Here, all grid-cells in the city are included – also those with zero-counts of violence. Information regarding physical attributes was originally gathered from OpenStreetMap[3] and entur.org. Attributes of which are included in the analysis involve public transport stations (of bus, train, subway and tram), major roads, commercial and residential areas. Commercial areas are defined as areas in which land use is primarily for commercial activities (e.g. shops, restaurants, shopping malls). On the contrary, residential areas are defined as areas in which the primary land use is housing citizens.

Unit of Analysis

Law enforcement in Oslo and Bergen have geocoded all violent incidents at the address-level using exact locations. However, in discussions between my supervisor and the Norwegian Centre for Research Data, data was aggregated to grid-cells of 100m by 100m. As was shown in a prior chapter, the street segment appears to be the preferred unit of analysis within the literature of crime at place. However, it is argued that also small grid cells capture 'behavior settings', similar to that of street segments, in that they compose small areas in which crime may occur as consequence of temptations, provocations, cues and deterrence levels (Bernasco, Bruinsma, Pauwels & Weerman, 2013). Geocoding of data in this instance refers to assigning longitude and latitude references to each grid (Burgess, 2011). Police incident data includes only grid-cells in which criminal activity *has* been recorded by police.

[3] Shapefiles were accessed through https://www.geofabrik.de/en/data/shapefiles.html

Consequently, grid-cells in which no criminal activity has been recorded between October 1st of 2015 and June 1st of 2018 are not reflected here. However, in pursuing research objective 2 and 3, *all* grid-cells in the respective cities are included – also those with zero-counts of violence. These cells were retrieved from OpenStreetMap.

In total, the cities of Oslo and Bergen consist of 16,248 and 10,365 grid-cells, respectively. Likewise, the police data comprises 3,743 such grid-cells. Of these, 2,856 are located in Oslo and the remaining 887 cells are located in Bergen. In other words, 2,856 and 887 grid cells in Oslo and Bergen respectively, have experienced violent crime during the study period. In other words, the vast majority of grid-cells in both cities experience no violence at all (13,392 in Oslo and 9,478 in Bergen). For the city of Oslo, the number of violent crimes recorded per grid-cell range from 0 to 228, averaging 0.68 incidents per cell (Table 1). For Bergen, the number of violent crimes recorded per cell range from 0 to 138, the average number of incidents per grid-cell being 0.31. The terms grid-cell and micro-place will be used interchangeably throughout the remainder of this paper.

As stated earlier, analysis of crime data using larger geographical units can conceal variations in crime inherent to the micro-level, as was the reason for employing small grid cells rather than larger units. Weisburd (2015), in formulation of the law of crime concentration, did not specify one operationalization of micro-place to be preferred over another, but is seems reasonable to assume he prefers the street segment, as he utilized this in his following analysis. However, importantly, Vandeviver and Steenbeek (2017) emphasize that major European cities lack the gridiron plan as is seen in major U.S. cities. In short, a city with a gridiron plan exists of streets that run at 90° angles to each other, forming grids. As a consequence, street segments in many European cities vary significantly in length (as opposed to those in the U.S). It seems sensible to presume that longer street segments likely attract more crime than shorter ones. Thus, it is argued that employing grid cells as the definition of micro-place is better suited for studies assessing the law in major European cities (Hardyns, Snaphaans & Pauwels, 2018), as such an operationalization of micro-place provides units of consistently equal size, similar to what street-segments in the U.S provide.

Ethical Considerations

It is apparent that ethical considerations are allocated greater attention in qualitative research as opposed to quantitative research (Jones, 2000). That is not to say ethical considerations are not of importance also in quantitative studies.

The dataset at hand has been collected as part of police reporting routines, and assumingly, questions of anonymity and confidentiality of offenders and victims have been rightfully upheld during the data-collection phase, in line with research-ethical guidelines. However, additional precautions have been implemented to further secure anonymity and confidentiality. First, all violence that occurs in private housing is dropped as including these would involve disclosing criminal records of the individuals residing at the premises. In addition, in discussions with the Norwegian Centre for Research Data (NSD), it was agreed to, as opposed to original aims, employ data geocoded to grids-cells of 100m by 100m instead of street-segments. This was established as the most appropriate approach due to an otherwise possibility to identify actors involved at the scene of the crime. Indeed, it was established that distributing such sensitive information could challenge the attainment of anonymity and confidentiality. This consideration rendered the project's desired unit of analysis non-feasible, and an alteration of research aims was inevitable. This can be frustrating in terms of having to discard original research aims, but nevertheless provided valuable first-hand experience regarding the role of ethics in formulation of research objectives.

In addition to the elements mentioned above, a third initiative was introduced to ensure that anonymity and confidentiality of the data was upheld. Physical access to the data was gained only through the use of Services for Sensitive Data (TSD). TSD functioned as a remote desktop in which the dataset was localized and where all data-handling and analysis was conducted.

In addition to the aforementioned precautions taken prior to the commencement of any analytical procedures, there exists several ethical considerations related to the conducting and reporting of quantitative research which should not be overlooked. Jones (2000, p. 151) emphasizes that scholars conducting quantitative research should (1) "not exaggerate the accuracy or explanatory power of their data", (2) "alert potential users of their data to the limits of their reliability and applicability", (3) "present their findings and interpretations honestly and objectively" and (4) "be prepared to document inaccuracies in the data, steps taken to correct or refine the data, statistical procedures applied to the data and the assumptions required for their application."

Following the lead of Jones (2000), I have strived to follow the below points in order to assure that results presented in this paper are reliable and valid:

1. Data-handling and analysis will not be manipulated to fit personal views or otherwise wrongfully convey the data at hand. Where changes in the data are made, this is clearly stated, reasons for doing so are articulated and potential effects on research outcomes are recognized.

2. I remain skeptical of the ability of numbers to accurately answer social science related questions. No statistical model can claim to explain real word phenomenon with perfect accuracy, and interpretations of results should reflect this.

Analytical Plan

The various research objectives presented above are approached using quantitative methods. R 3.4.4 (R Core Team, 2018), a statistical program suited for conducting spatial analysis is employed to handle and analyze data.

Objective 1: Mapping violent crime in Oslo and Bergen, Norway

In order to produce crime maps of Oslo and Bergen, R is used as Geographic Information System (GIS). Here, one of the main packages for GIS operations, 'sp' is employed (Bivand, Pebesma & Gomez-Rubio, 2013). Maps of Oslo and Bergen are retrieved from OpenStreetMap and Kartverket[4], and used as backdrops for all crime maps produced. For Oslo, city borders specified by the Norwegian Bureau of Statistics are adopted. The city-borders of Bergen were defined differently. As opposed to Oslo, the city of Bergen is characterized by multiple, far-stretched areas comprising forestation and mountains. In light of this, Bergen can be considered to display a 'discontinuous urban setting' (Valente, 2019). These areas in Bergen mostly exhibit little or no criminal activity, and it was therefore rendered reasonable to exclude these areas from analysis. Thus, in the context of the present study, the 'city of Bergen' attains a definition of a more restricted geographical area within Bergen municipality. That is, largely unpopulated areas comprising mostly forestation and

[4] Accessed through Geonorge.no

mountains are excluded. Bergen's discontinuous urban setting and the specific borders applied will be examined in greater detail in the analysis.

Having established the perimeters of the backdrops, aesthetics are added: city borders, city-district borders, train lines, roads and major roads. These attributes are also retrieved from OpenStreetMap and Kartverket. Crime data is then plotted onto this backdrop in the form of grid-cells. Each individual grid-cell is equipped with a color gradient scale intended to show levels of density (crime rate).

Such crime maps are then produced for each city. First, crime maps are produced for the cities in their entirety, followed by multiple maps visualizing violence in sub-areas of each city. It was argued earlier that routine activities shift across multiple temporal scales. Therefore, subsequent analysis is conducted to comment on corresponding seasonal, weekly and hourly fluctuations in violence. Four seasonal periods are examined, namely summer, fall, spring, and winter. Here, summer spans June through August. Fall begins on the first day of September and ends on the last day of November. Next, spring includes the days between March 1st and the end of May. Finally, winter spans from December through February. This operationalization of seasons aligns with those utilized in prior studies examining seasonal variations in crime patterns (Andresen & Malleson, 2013; Linning, 2015), and encompass times in which routine activities change throughout the year, as argued in an earlier chapter.

Patterns of violent crime are also examined by day of week. Following the lead of Haberman, Sorg and Ratcliffe (2017), the week is divided into bifurcated weekday (Monday through Thursday) and weekend periods (Friday through Sunday). As with the operationalization of seasons above, also this division of the week is thought to capture within-week variations in routine activity patterns. Lastly, within-day fluctuations in crime patterns are examined across a 24-hour span.

Objective 2: Testing the effect of environmental factors in explaining crime concentrations

In order to further examine the effects of environmental factors in explaining crime concentrations in Oslo and Bergen, models of multiple linear regression are estimated. Here, the police incident data was joined with *all* grid cells in the cities (16,248 and 10,365 for Oslo and Bergen respectively). In other words, also grid cells with zero-counts of violence are included.

Dependent variable. The dependent variable is the average number of violent crime incidents reported in each grid-cell from October 1st 2015 through June 1st 2018 (Table 1). Models are estimated separately for each city.

Table 1. Descriptive statistics of the dependent variable.

Variable	City	Total grid-cells	Mean	SD	Min.	Max.
Violence	Oslo	16,248	0.68	4.55	0	228
Violence	Bergen	10,365	0.31	2.97	0	138

Source: Author's elaboration of data of The National Criminal Investigation Service.

Explanatory variables. All explanatory variables included in the model are derived from environmental theories of crime as shown in an earlier chapter (Table 2). That is, the explanatory variables include physical attributes in the environment of which it is hypothesized influence the way in which clustering of people may form to facilitate convergences of *motivated offenders, suitable targets* and absence of *capable guardians*.

The models include as physical attributes: major roads, public transport stations (of bus, tram, subway and train), residential areas and commercial areas. It should be noted that additional variables (for example of night-life venues) would be desirable to include in the models, but were unavailable to the present study. The included variables are expressed as dummy variables, indicating either the presence or absence of the physical attribute. The presence of major roads, public transport stations and commercial land use is thought to facilitate an increased 'passing through' of people, and it is expected that violence increases in grid-cells where these physical attributes are present. On the contrary, residential areas are thought to discourage such clustering of people as their predominant function is housing people. In addition, residential areas are thought to involve areas in which capable guardians flourish (local residents who care about their neighborhood). Therefore, residential areas are not thought to increase the occurrence of violent crime. Rather, it is expected that grid-cells situated in residential areas are linked to fewer incidents of violence.

In order to further extrapolate the aforementioned physical attributes employed as explanatory variables, additional variables are included for each attribute which express how many of the *adjacent* grid-cells exhibit the physical attribute in question. Values range from 0 to 8, where a cell can have a maximum of eight adjacent cells.

Assumptions of Multiple Linear Regression

In pursuing *research objective 2*, assumptions of linear regression were assessed in order to ensure that validity of results are upheld. According to Altman (1980), faulty analysis of data is the best known inappropriate use of statistical methods in quantitative research. Usually, such inappropriate use stems from the fact that the data being analyzed fails to comply with the underlying assumptions of the statistical method. Paying regard to these underlying assumptions forms part of the ethical considerations discussed above. Ethical consequences related to the inappropriate use of such statistical methods involve exaggerating the accuracy or explanatory power of the data as well as the risk of presenting erroneous results. Therefore, prior to performing multiple linear regression, several tests were run to ensure the validity of results. First, a correlation matrix was produced to ensure the data did not exhibit issues of multicollinearity. Multicollinearity exists when the independent variables are highly correlated with one another. In such cases, standard errors reported are typically very large, and one might conclude there is no association by mistake. The presence of such multicollinearity can also make it troublesome to distinguish from which independent variable an effect observed in the dependent variable stems from (Acock, 2012). Correlations close to 1 is thought to increase the risk of multicollinearity, and scholars usually prefer correlations to be at 0.75 or lower. Correlations reported as 0.90 or higher are regarded to constitute severe problems in interpreting subsequent regression models (Linneman, 2010). Present data were not seen to exhibit such issues of multicollinearity.

To ensure validity of results, it is also useful to ensure that the variance of error terms are similar across the values of the independent variables (Jones, 2000). Multiple linear regression models assume that residuals are evenly spread along the regression line. In cases where residuals are *not* normally spread along the regression line, this is suggestive of heteroscedasticity of variance (Linneman, 2010). Heteroscedasticity (meaning non-constant variance) can be assessed using multiple tests. When the homoscedasticity of variance assumption is violated, the resulting standard errors of the regression model will be inconsistent. Typically, the standard errors reported are too small. Importantly, the challenges heteroscedasticity introduce can be overcome by conducting regression models with robust standard errors (Hayes & Cai, 2007). Heteroscedasticity-consistent standard errors are typically employed to allow for the fitting of models that exhibit heteroscedastic residuals, as they do not assume homoscedasticity (Hayes & Cai, 2007). Since the data exhibited signs of

heteroscedasticity, the present study presents the regression model with robust standard errors as implemented in the R-procedure.

Table 2. Summary of environmental factors utilized in each regression model.

Variable	***Definition***	***Function***	***Type of variable***
Transit Stations	Dummy variable (1= grid-cell encompassing at least one public transport station)	Accessibility	Explanatory
Major roads	Dummy variable (1= grid-cell encompassing at least one major road)	Accessibility	Explanatory
Residential area	Dummy variable (1= grid-cells situated within residential areas)	Target/Guardian	Explanatory
Commercial area	Dummy variable (1= grid-cells situated within commercial areas)	Target/Guardian	Explanatory
	Adjacent-cells		
Transit Stations AC	Number of adjacent cells that have transit stations	Accessibility	Explanatory
Major roads AC	Number of adjacent cells that have major roads	Accessibility	Explanatory
Residential area AC	Number of adjacent cells located in a residential area	Target/Guardian	Explanatory
Commercial area AC	Number of adjacent cells located in a commercial area	Target/Guardian	Explanatory

Source: Author's elaboration
[a] AC indicates 'adjacent cells'

Objective 3: Assessing the validity of the law of crime concentration in Oslo and Bergen

First, concentrations of violent crime in Oslo and Bergen are examined at the aggregate level. In other words, crime concentrations are computed based on all recorded violence between October of 2015 and June of 2018. Next, crime concentrations are examined for each individual year, enabling an assessment of 'concentration stability' over time. Thereafter, concentration levels are examined for each specified theoretically relevant temporal scale (season, day of week and within-day). Seasonal and within-day periods are operationalized in the same manner as in *objective 1*. Following the lead of Haberman, Sorg and Ratcliffe (2017), within-day concentrations are examined across four arbitrary six-hour periods. These periods are as follows: (1a) morning (06:00 to 11:59), (1b) daytime (12:00 to 17:59), (1c) evening (18:00 to 23:59), and (1d) night (00:00 to 05:59). As emphasized by Haberman, Sorg and Ratcliffe (2017), this operationalization of within-day periods provides the benefit of equal exposure lengths.

In order to assess the extent to which violent crime concentrates in Oslo and Bergen, descriptive statistics for each period's distribution of violent crime are first computed. Thereafter, replications of Weisburd's (2015) cumulative percentages of micro-places experiencing 25% and 50% of violence are created. First, the number of grid-cells experiencing 25% of violence is calculated. This number of grid-cells is then divided by the total number of grid-cells in order to reveal the percentage of total grid-cells that accounted for 25% of violence. The same process is repeated in order to calculate the percentage of grid-cells that account for 50% of violence. The abovementioned calculation method reflects the procedure employed for replicating Weisburd's percentages of micro places experiencing 25% and 50% of violence *across the entire study period.* For all other periods (individual years, seasons, days of the week and hours of the day) the same method is applied, with the exception of exchanging total number of grid-cells to now reflect total number of grid-cells *within the period examined*. For prevalence measures, calculations are based on data including also grid-cells with zero-counts of violence. For frequency measures, calculations are based solely on crime-ridden cells.

5. RESULTS

This chapter presents the results acquired from analysis. For the purpose of clarity, results are presented in accordance with the study's research objectives. Chapter 6 will discuss the presented research findings in further detail.

Objective 1: Mapping Violent Crime in Oslo and Bergen:

City of Oslo

In the following section, spatial-temporal trends of violent crime will be explored, both on the citywide scale and in four city subsets. Hot spots are selected as they emerge to facilitate further examination of temporal patterns *within* these high-crime areas. Such an examination is thought to inform the extent of within-hotspot variations in temporal patterns. Figure 1 presents the spatial distribution of violent crime within the city borders of Oslo. The city has been further divided into city districts. The map backdrop displays railways, illustrated through the use of light blue lines, and major roads represented by gray lines. Grid-cells in which at least one violent crime has occurred within the study period appear on the map. All other grid-cells in which no violent crime was recorded within the study period are excluded from the map altogether (here represented by the absence of color coded grid-cells on the map). In grid-cells that *did* experience violent crime, a color gradient scale has been employed to display the density of crime within each cell. This scale cycles from red to yellow, in which yellow represents a high density of crime.

Concentrations of violent crime are clearly present in Oslo. As anticipated based on prior research, the map portrays strong concentrations in the inner city (here defined as comprising the city districts of Sentrum, Gamle Oslo and Grunerløkka). Generally, the presence of violent crime becomes more disperse as one diverts away from the city centre. Compared to surrounding areas, the inner city exhibits both greater numbers of grid-cells experiencing a very small number of crimes (cells of red color), *and* account for the most crime ridden cells in the city (yellow cells). Only three grid-cells experienced more than 200 incidents throughout the study period, all of which were situated within the city centre. Apart from the mere three grid-cells experiencing more than 200 incidents of violence during the study period, only four grid-cells experienced between 100 and 200 incidents. Based on the

highly unequal distribution of red and yellow grid-cells, red being the color assumed by the majority of cells, it is apparent that for most places in which violence has been recorded, such events are rare. Simply put, only very few places experience an especially high crime rate. This is further confirmed in Figure 2, which illustrates that the vast majority of grid cells experienced only between 1 and 5 incidents of violent crime in the time period studied.

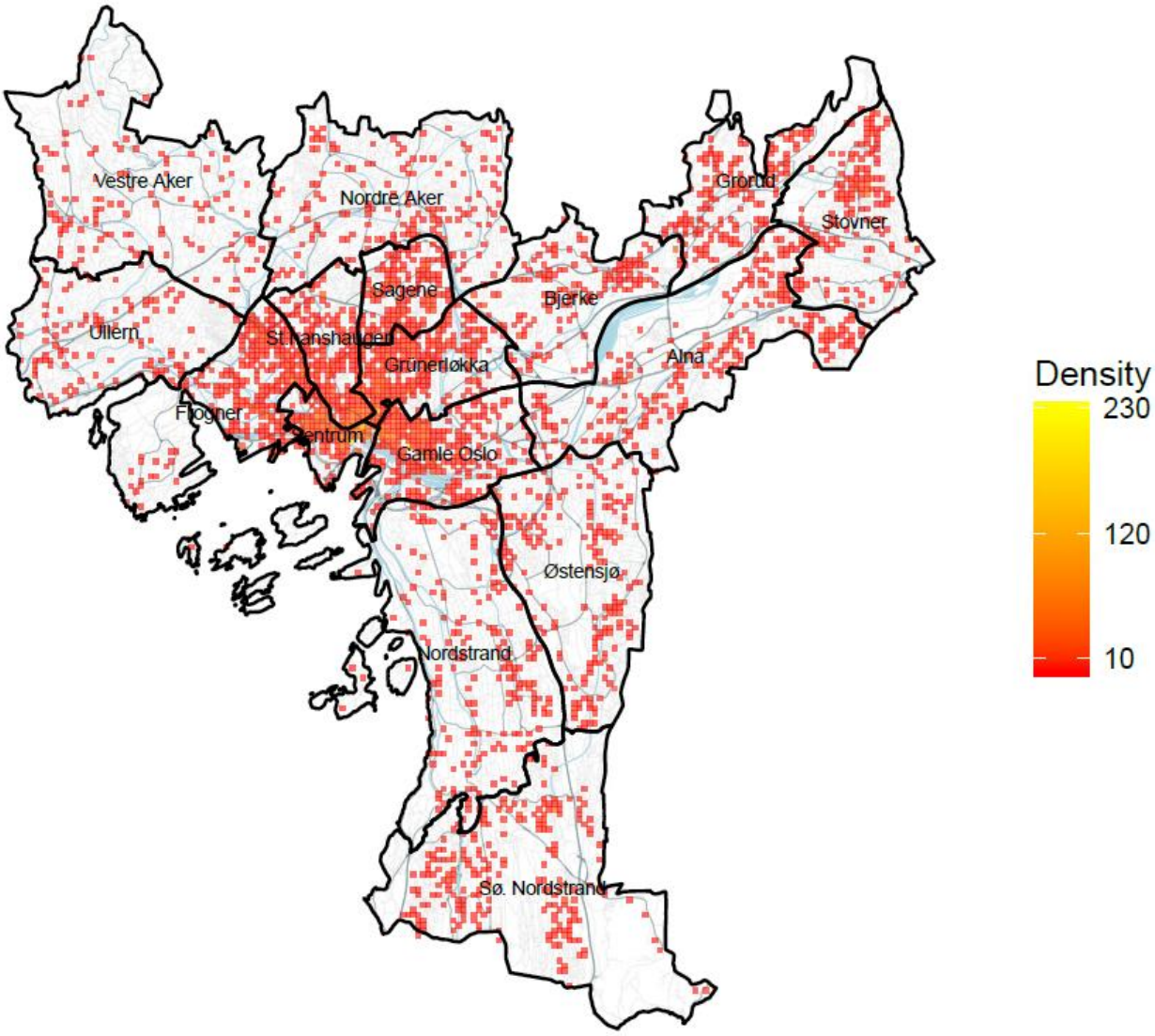


Figure 1. Map of violent crime in the city of Oslo.

Regarding temporal patterns, a significant amount of violence (48%) occurred between the hours of 23:00 and 05:00 (hereafter referred to as 'nighttime' (Figure 3)). A noticeably smaller portion, 28%, occurred between 09:00 and 17:00 (hereafter referred to as 'daytime'). This finding aligns well with that of other European studies examining temporal patterns of violence (Mayhew, Muang & Mirrlees-Black, 1993; Nelson, Bromley & Thomas, 2001).

Further, Sunday is consistently reported as the most crime-ridden day of the week, in which violence is found to peak between 02:00 and 04:00. Peak times during Saturdays and Sundays exhibit only slight variations across seasons, peak times ranging from 02:00 to 03:00. To clarify, violence reported at 02:00-03:00 Saturday morning arguably reflects that of patrons who engaged in night-life activities the evening prior (Friday). Similarly, peaks in violence during early Sunday hours reflect the actions of night-life patrons who commenced their night out the prior Saturday evening. Overall, rates of violence appear lower during summer months, however this variation is likely attributable to an underrepresentation of summer months in the data[5]. In sum, violence does not seem to vary significantly across seasons.

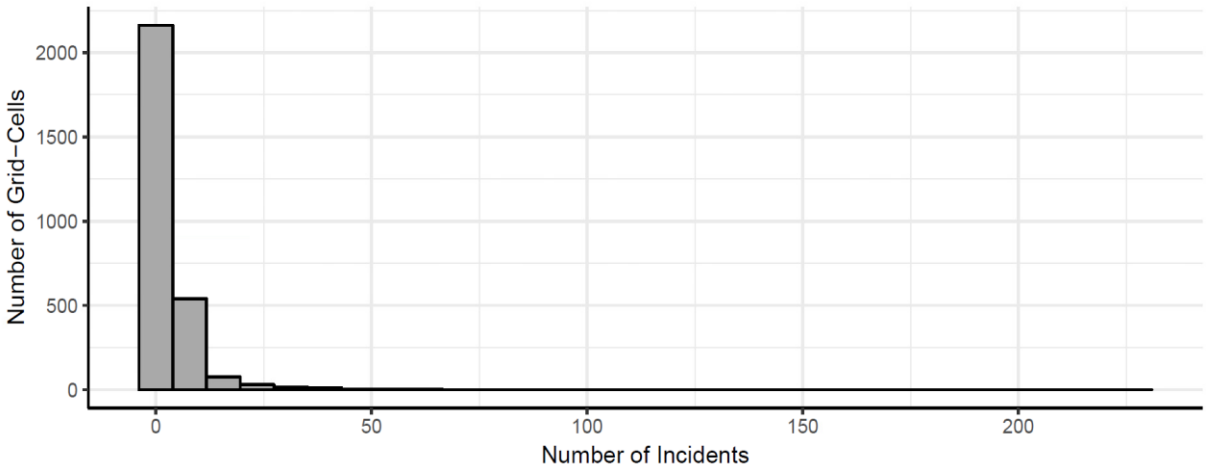


Figure 2. Histogram confirming a skewed spatial distribution of violence.

As mentioned above, Saturday and Sunday represent the two most heavily affected days in terms of exposure to violent crime, experiencing 17.4 and 17.9% respectively. Each day during the workweek[6] experience similar, lower rates of crime. Here, percentages range from 11.9% (Monday) to 13% (Thursday). In line with prior research on the weekly distribution of violent crime, violence in Oslo was shown to concentrate during the weekend (here defined as Friday, Saturday and Sunday). Of all incidents, a slight majority (50.4 %) occurred during the weekend period. However, contrary to much prior research, Saturdays and Sundays in Oslo experienced very similar rates of violence (17.4 and 17.9% respectively). Prior research typically report higher crime rates on Sundays, indicating that night-life related violence is at its most prevalent in the morning hours following a night out the prior Saturday evening. However, in Oslo, no single day is identified as significantly superior in terms of crime.

[5] As the dataset spans registered violence from October 1st 2015 to June 1st 2018, several summer months are not included in year 2015 and 2018, ultimately causing an underrepresentation of summer months in the data.
[6] The 'workweek' reflects the days spanning from Monday through Thursday.

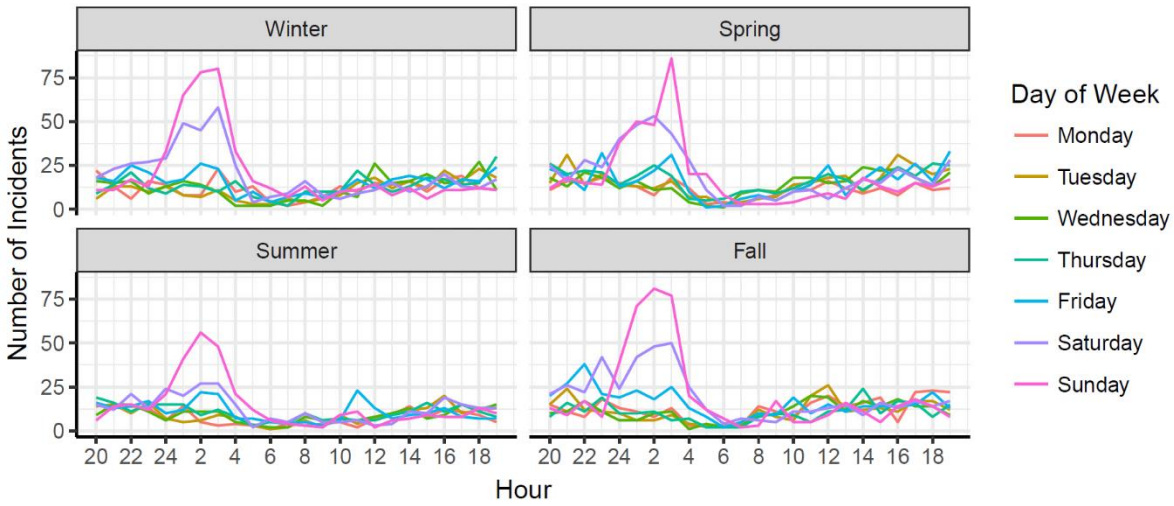


Figure 3. Citywide temporal fluctuations in violent crime.

As mentioned, crime during Saturdays and Sundays appear to peak between 02:00 and 03:00. Following 03:00, the city experiences a rapid decrease in events of violence, reaching its minimum between approximately 06:00 and 07:00. These findings also somewhat differ from other research examining fluctuations in violence across hours of the day. Studies have reported seeing a peak at approximately midnight, followed by a steady decrease until 05:00, with the exception of an increase at approximately 02:30 (Conrow, Aldstadt & Mendoza, 2015, Rand et al., 2010). In Oslo, generally the peak appears to occur between approximately 02:00 and 03:00, followed by a steady decrease until 06:00, without a significant increase between the two. In fact, such a 'spike-decrease-spike' trend was only observed on Saturdays during winter and summer. Generally, violence peaks (although to a lesser extent) at approximately 08:00, 12:00 and 17:00 before forming a steady increase spanning from approximately 19:00 through 24:00. In other words, in line with expectations based on environmental theories of crime, violence in Oslo appears to peak simultaneously with bar and night-club closing times (approximately 02:00-03:00), rush hours (08:00 and 17:00) and during typical lunch hour (12:00). As has been argued in prior research, this skewed distribution in favor of weekend and nighttime concentrations typically suggests that the majority of violent crime in Oslo is night-life related.

Within-city Exploration of Spatial-temporal Patterns

The following section explores spatial-temporal trends in violent crime across four subsets of Oslo, allowing for an exploration of within-city variations in crime patterns (i.e. unaffected by citywide trends). Subsets include the city centre, the west, east and south side. It is important to note that since subset maps portray spatial patterns *within* certain sections of the city, *unaffected* by citywide trends – color gradient scales will reflect this.

Also when examined in isolation, unaffected by citywide trends, violent crime in the city centre form clear concentrations of violence (Figure 4) – confirming the presence of within-city concentrations. As illustrated above, the city centre (here defined as comprising the city districts of Sentrum, St.Hanshaugen, Nordre Aker, Sagene, Grunerløkka and Gamle Oslo) represents the subset in which violence is most prevalent - accounting for 62% of all reported violence during the study period. The prevalence of incidents in Gamle Oslo, Grunerløkka and St. Hanshaugen appears to increase as proximity to Sentrum increases. In other words, areas within the aforementioned city districts that directly neighbor to Sentrum experience the highest crime density. Nordre Aker differs from other districts in terms of prevalence and clustering. Here, violence does not appear to exhibit any clear spatial concentrations. Rather, crime appears to occur fairly evenly (yet dispersedly) throughout the district. This makes sense, given that this district functions primarily as a residential area, largely lacking bars, pubs and restaurants causing a concentration of people (ultimately not causing great convergences of offender-target convergences)[7].

Temporal fluctuations in the city centre align well with citywide trends (Figure 5), arguably because the city centre most heavily influences citywide trends (due to the vast majority of crime festering here). Overall, 40% of violence took place between 23:00 and 05:00, and 31% between 09:00 and 17:00. This is indicative of a tendency for violence to be largely, but not exclusively, night-life related.

[7] All identification of area characteristics (for larger subset-areas as well as smaller hot spots) were identified through a visual examination of the area in question using Google Maps.

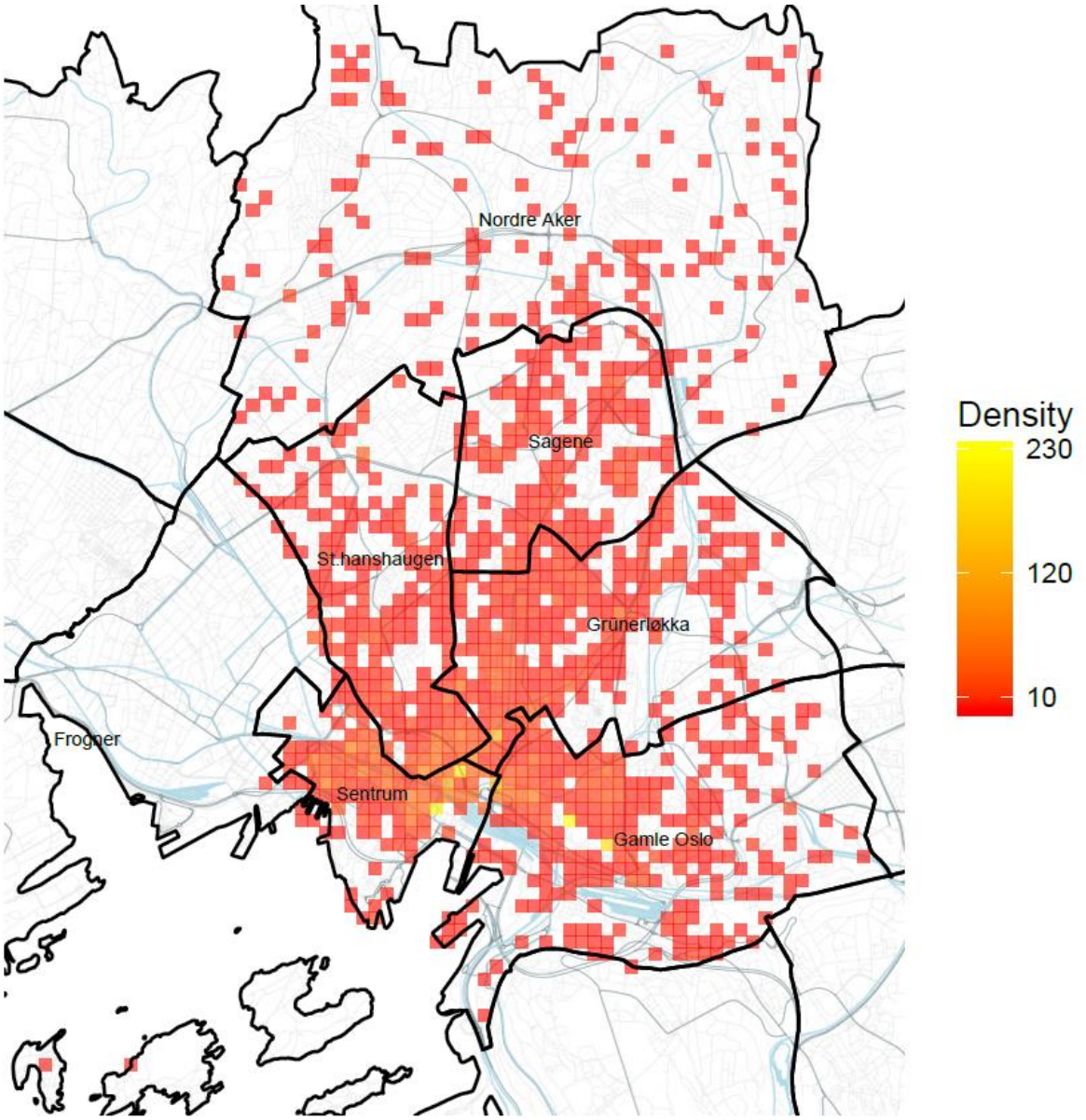


Figure 4. Map of violent crime in the city centre.

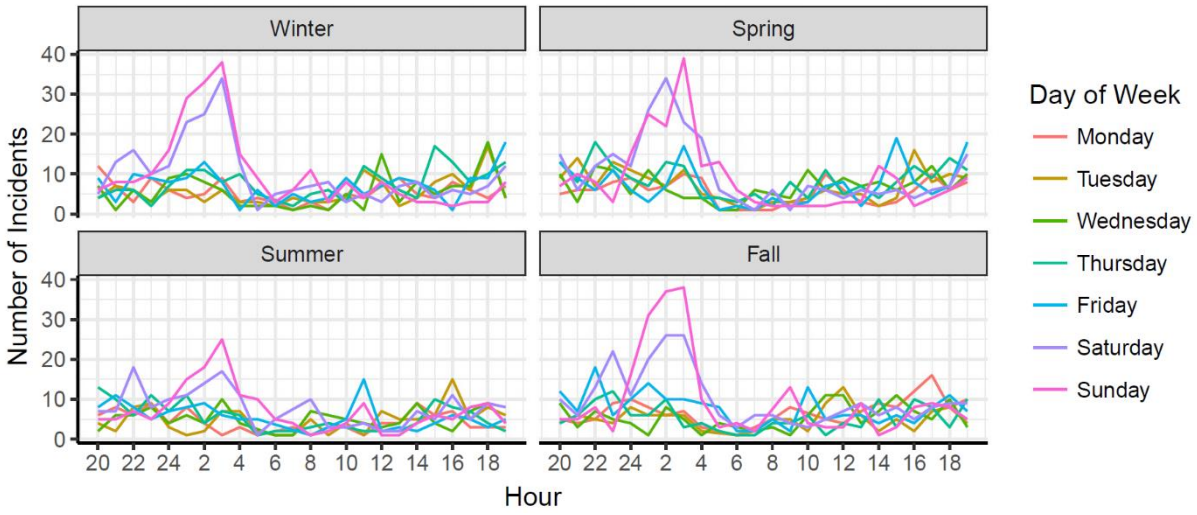


Figure 5. Temporal fluctuations in the city centre.

An especially dense micro-place is situated in close proximity to Oslo Central Station. Here, crime rates appear to be relatively high throughout the year, week and day. This particular grid-cell is characterized by consistently high crime rates interrupted by *especially* high rates during certain times. 43% and 29% of violence occurred during nighttime and daytime, respectively. As violence is more apparent during nighttime, it seems plausible to suggest that a notable amount of incidents reported here were fueled by citizens engaged in night-life activity. During the weekend, the greatest peak occurs at 22:00, followed by less extensive peaks at 01:00 and 06:00. This trend fails to confirm both to citywide trends and other studies examining temporal trends of night-life related violence, as these have reported peaks to occur at 00:00 or later (Nelson, Bromley & Thomas, 2001). During the workweek, violence peaks at 17:00. This may be attributable to the major function of this micro-place: transit. The time period between approximately 16:00 and 17:00 typically represent rush hour times where people cluster in public transport stations as part of their commute home from work. The fact that the micro-place accounts for a relatively high crime rate regardless of time seems plausible to attribute to the fact that the cell is located in close proximity to the most busy public transport conjunction in the city. Hence, a magnitude of people will frequent this area at any given time causing offender-target convergences. However, due to shifts in aggregate routine activities as discussed in an earlier chapter, certain times of the day and week facilitate an *even greater* clustering of people – ultimately resulting in peaks of violent crime.

Another high-density grid cell (n=200) harbors Oslo City shopping mall. Nearby locations include Byporten Shopping and Oslo Central Station. Again, based on environmental criminological theory and previous research, it seems plausible to suspect that

this location exhibits, to a greater extent, day-time related violence. However, 56% and 26% of violence occurred during nighttime and daytime, respectively. These findings present an even more skewed within-day distribution of violence compared to that of the aforementioned hot spot. Further supporting the notion that this hot spot exhibits predominantly night-life related violence is the finding that, during weekends, violence peaks significantly at 03:00. Other sub-peaks occur at 17:00 (workweek) and 16:00 (weekend), arguably reflecting general daytime or rush hour-related violence. As the present hot spot encompasses a shopping mall of high traffic, *and* is situated in immediate vicinity of a magnitude of public transport stations (of tram, bus, subway and train), it is highly likely that daytime related violence *is* prevalent here. Temporal fluctuations throughout the day reflect those typically seen in commercial, shopping zones (Nelson, Bromley and Thomas, 2001). However, the many public transport platforms in immediate vicinity to the hot spot also make up one of the closest 'major' public transport hubs for a magnitude of nearby night-life venues, perhaps explaining the prevalence of nighttime violence, especially at 03:00. Similar to what has been seen in prior studies on violent crime in cities (Nelson, Bromley & Thomas, 2001), this particular hot spot appears to transform its function to 'night-life and transit' during late night and early morning hours – and the sheer magnitude of violence that occurs in this timeframe overshadows that of daytime related violence, rendering the hot spot predominantly night-life fueled when assessed in its entirety. Important to note from the above is that a *within-hotspot* variation in crime levels is confirmed, and this is thought to be related to its multiple *functions.*

Figure 6 presents a map of violent crime in the west of Oslo. Here, the city district of Frogner accounts for the vast majority (72%) of crime. Vestre Aker and Ullern experience only 15.5 and 12.5%, respectively. As with violence in the city centre examined above, crime appears denser near the borders to Sentrum and Grunerløkka. The city districts of Vestre Aker and Ullern experience violent events that are both fewer and further between. As with Nordre Aker, this makes sense given that these districts are primarily residential in character. The majority of events that did occur here however, seem to be situated in close proximity to major roads. This supports the speculation that major roads facilitate a greater 'passing through' of people, producing offender-target convergences, perhaps as major roads often accompanies transit stations. Seasonal distributions exhibit greater variations compared to both the citywide and city centre trends in that crime appears to be more prevalent in winter (Figure 7). Also the west side of the city seems to experience predominantly weekend and

night-life related violence.

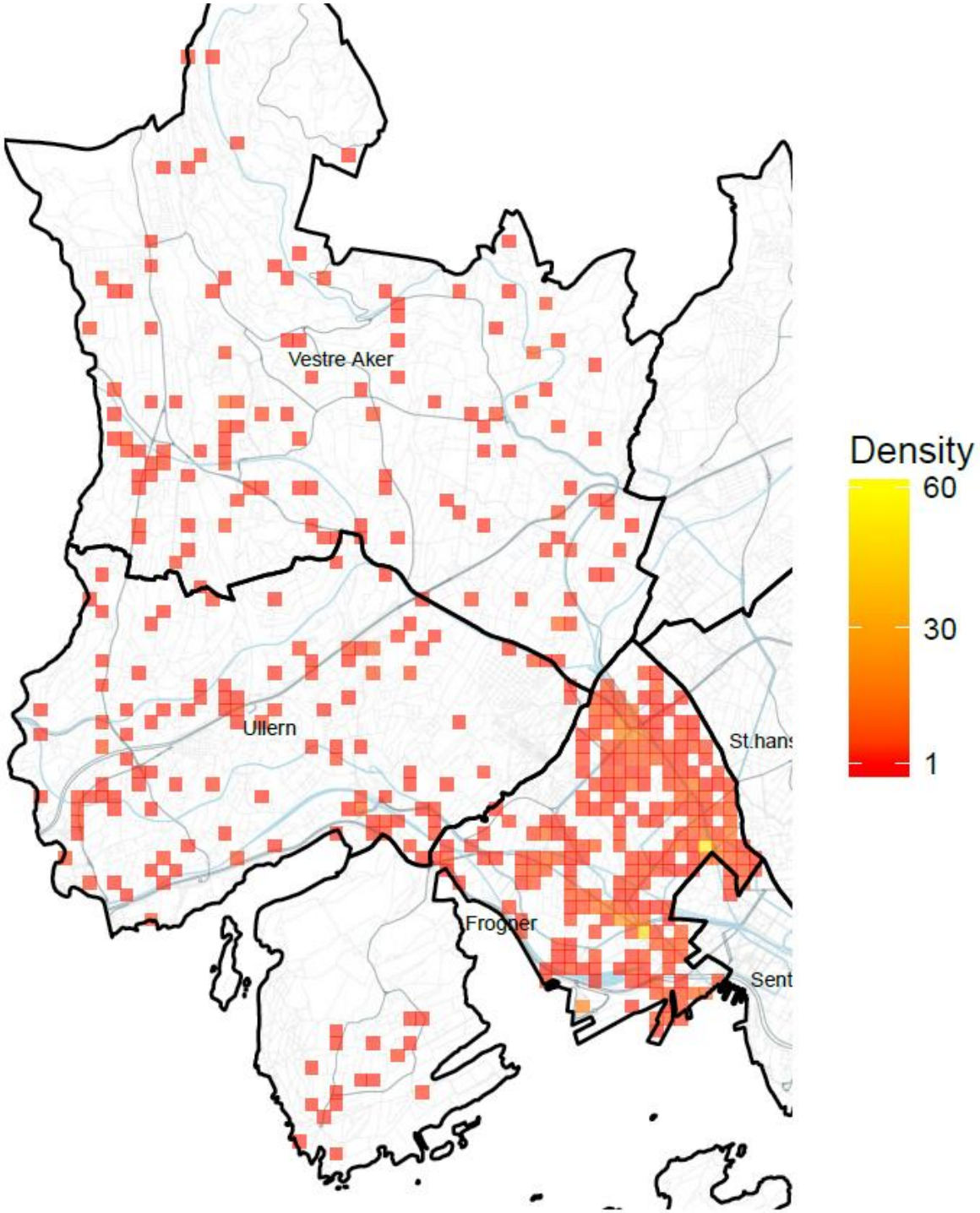


Figure 6. Map of violent crime in Oslo West.

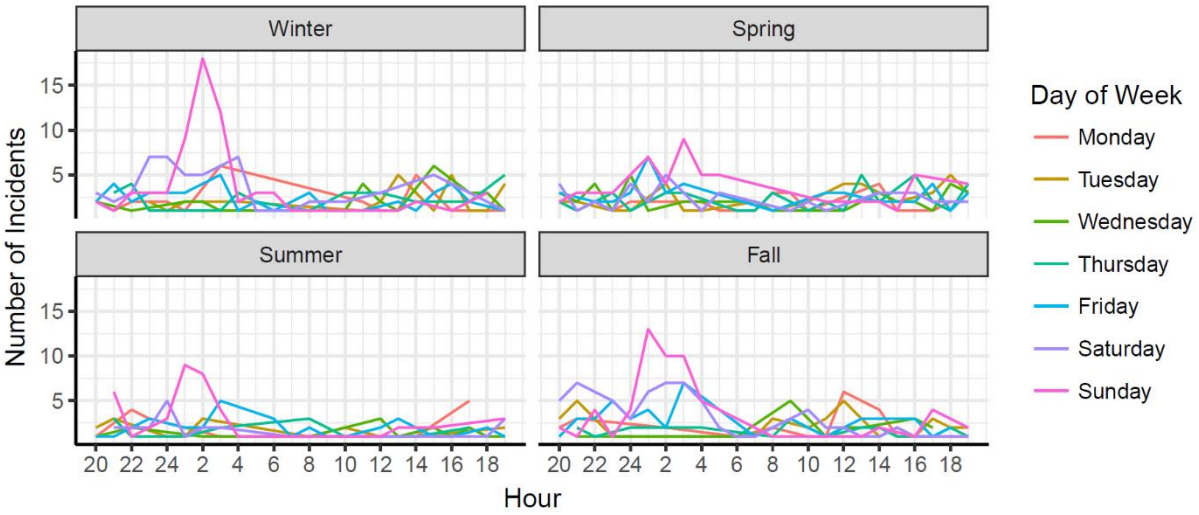
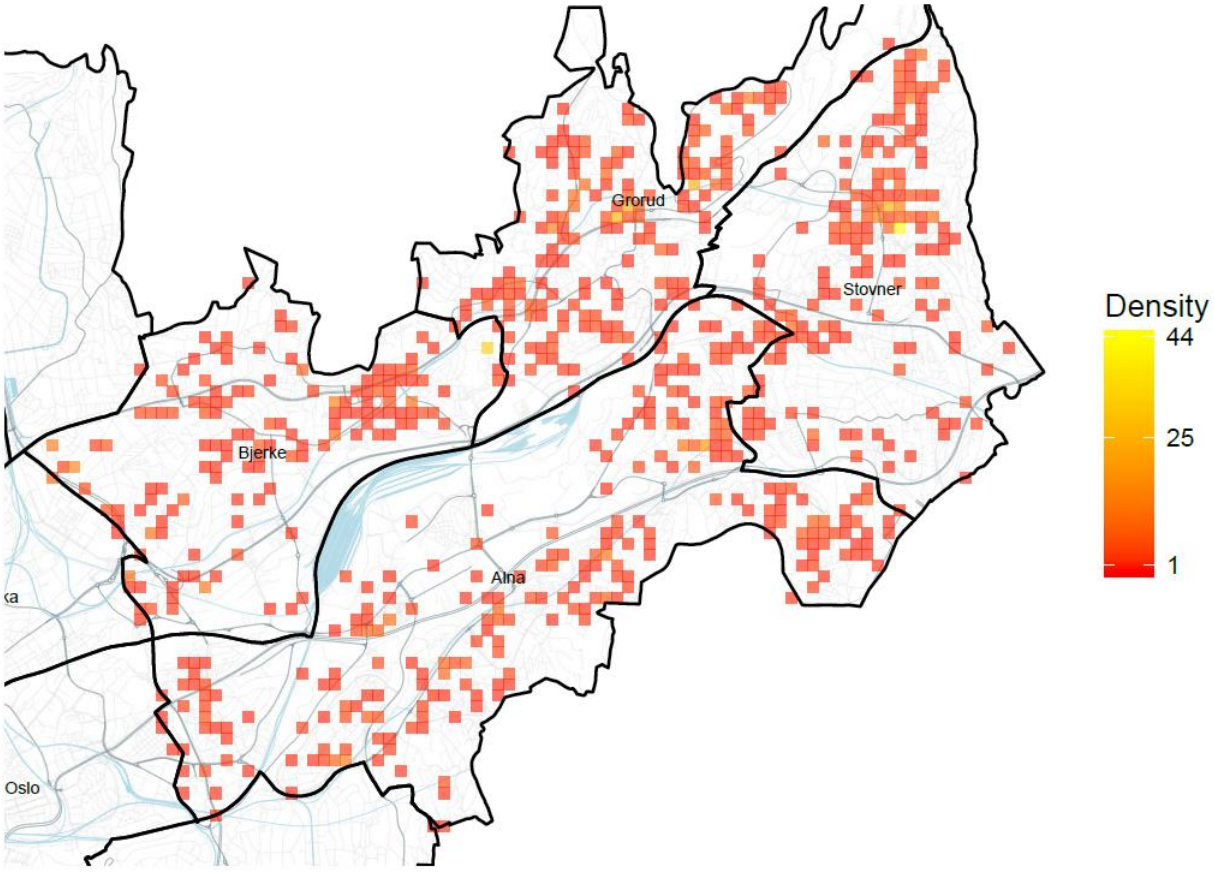


Figure 7. Temporal fluctuations in Oslo West.

An especially high-density micro-place (n=48) encompasses 'Nox' (a night club), and is located across the road from bus and tram stops, as well in close proximity to the subway station of Nationaltheatret. Based on these characteristics, it seems plausible to anticipate that violence at this micro-place is predominantly related to night-life. This speculation is supported in finding that the vast majority (83%) of violence occurred during the weekend. Further, an even stronger clustering (88% of violence) is found in the time period between 23:00 and 05:00, and peak at 02:00. Evidently, this hot spot appears to exhibit *one* primary function: night-life entertainment, and concentrations form accordingly.

Clear concentrations of crime can also be seen in all four districts comprising the eastside of Oslo (Figure 8). The most prominent concentrations unfold in Stovner, experiencing both larger clusters of violence *and* grid-cells especially high in crime densities within these clusters. Alna accounts for the largest portion of violence (32%), but this is likely due to its large size. Despite housing the most violence, such events are more disperse here as opposed to neighboring districts. However, Alna appears to exhibit concentrations of violence in certain areas bordering to Grorud and Stovner. Further, the northern part of Stovner appears to be the most violence-affected region, and Bjerke exhibits a clear concentration of violence situated near the border to Grorud. Temporal patterns are vastly different from those reported both on the citywide scale and for prior city-subsets (Figure 9). Most notably, Sunday (which typically represents violence stemming from Saturday night extending into Sunday) is no longer the most crime-ridden day, nor does crime cluster during weekends - as was seen on the city-wide scale, and of which has been reported in a magnitude of studies examining violent crime patterns across the course of the week (Nelson, Bromley & Thomas, 2001;

Shepherd, 1990). Violence appears to be more evenly dispersed throughout the week and throughout the day compared to other city subsets and the city as a whole. Also, violence during evening and night-time peaks significantly earlier (between 21:00 and 24:00). This is indicative of violence in this area (as opposed to the city centre and the city as a whole) *not* being predominantly night-life related. Indeed, 40% of violence occurred between 23:00 and 05:00 whereas 34% of incidents occurred between 09:00 and 17:00. Further small-scale investigation is warranted to assess whether this trends festers throughout the subset.



F**igure 8.** Map of violent crime on the eastside of Oslo.

The most crime ridden micro-place (n=44) unfolds in Stovner. This cell houses Stovner shopping mall, which is located in close proximity to the subway station as well as several bus stops. As the micro-place harbors the largest retail venue within the district, it seems plausible to speculate that crime will not fester past midnight as has been observed for areas exhibiting opportunities for night-life activities. Surely, workweek and weekend periods experienced 82 and 18% of crime, respectively. This significantly skewed weekly distribution in favor of the former is highly suggestive of non-night life fueled violence. In addition, the majority of incidents (60%) transpired in the time period between 09:00 and 17:00, further

supporting this suggestion. During the workweek, crime was found to peak to equal extents at both 00:00 and 14:00, the former not attributable to engagement in neither shopping nor other daytime leisure activities in the area. An alternative explanation may be the close proximity to public transport stations, rendering the area high in 'passing through' traffic. Alternatively, it may function as a meeting place for youth – and violence observed stems from such meetups, for instance. These are speculations of which require further examination in future research. In sum, temporal patterns of violence in this particular hot spot deviates from that of the larger city-subset, and appears to predominantly reflect the primary functions of the area: retail and transit.

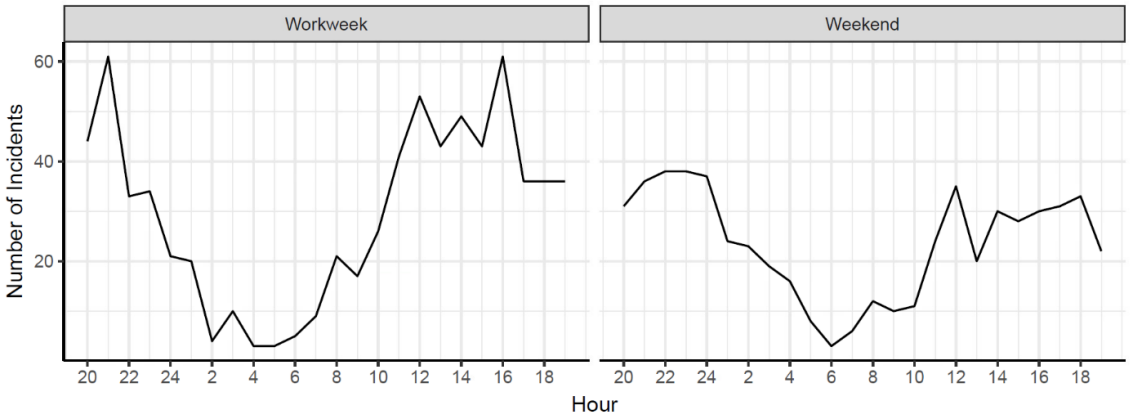


Figure 9. Temporal fluctuations within the eastside of Oslo.

In Grorud, two high-density micro-places are located at Grorud Mall and in its immediate vicinity, totaling 49 incidents of violence. Of these, a majority (57%) occurred during the workweek and during daytime (67%), allocating support for another daytime-dominant hot spot. In regard to within-day fluctuations, violence appears to peak at 21:00 both during the workweek and during weekends. Only during the former does crime also peak at 19:00. Only peaks at 21:00 and 19:00 during the workweek may reflect violence spurring from traffic related to the shopping mall, as the center is in operation in this time period. Peaks at 21:00 during the weekend however, may perhaps be explained by the shopping center functioning as a 'after hours' meeting place as is typical for youth. Overall, this hot spot appears to be better aligned with subset-specific temporal trends.

Within-city concentrations are confirmed also in the south of Oslo (Figure 10). This part of the city accounted solely for 5% of all violent crime in Oslo during the study period. Of these 5%, Nordstrand, Søndre Nordstrand and Østensjø accounted for 31, 37 and 32%, respectively. In comparison to other city-subsets examined above, violence appears to fester more dispersedly. Also here, this makes sense given that its primary function is housing residents. As for weekly trends in violent crime, no apparent concentration is observed during the weekend as was confirmed on the citywide scale (Figure 11). The majority (57%) of violence occurred during the workweek. The hourly distribution deviates considerably from that of citywide trends, as well as several other city subsets (city centre and west side). Violence during the workweek is at its most prevalent at approximately 14:00 and 18:00, these two times experiencing similar rates of violence. During the weekend, crime peaks (although to a lesser extent) at 00:00. The greater spikes in violent crime at 14:00 and 18:00 suggests that violence in this area is not predominantly night-life related.

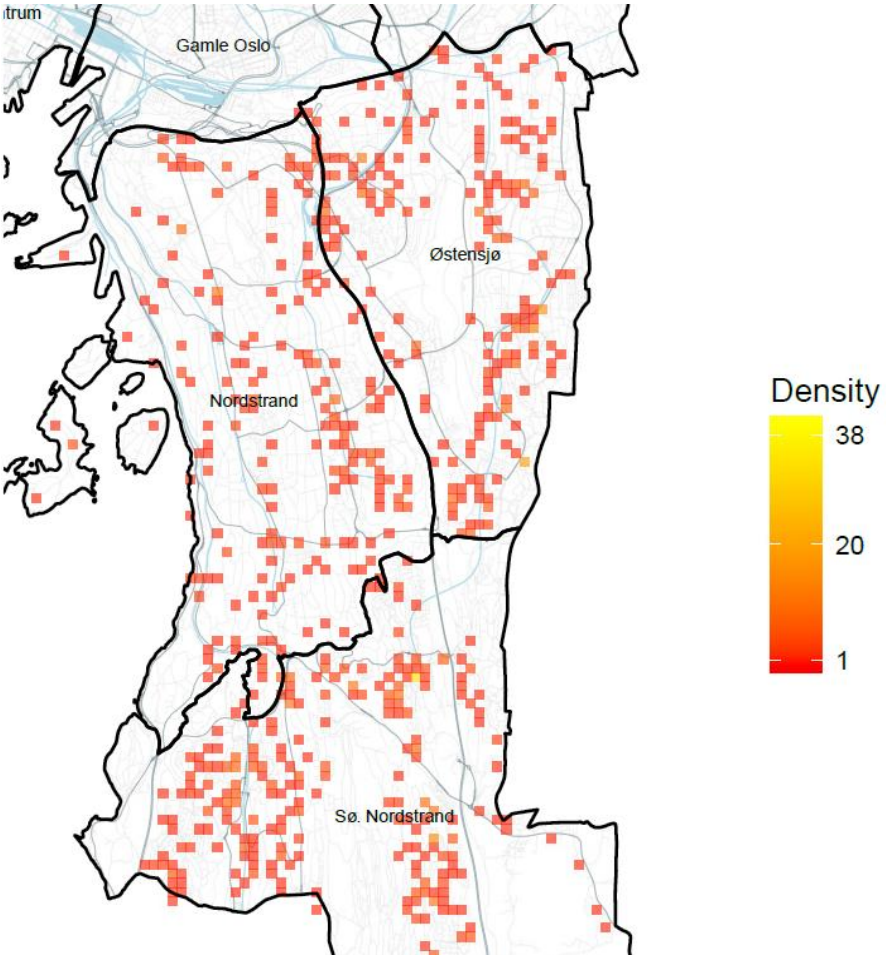


Figure 10. Map of violent crime in Oslo South.

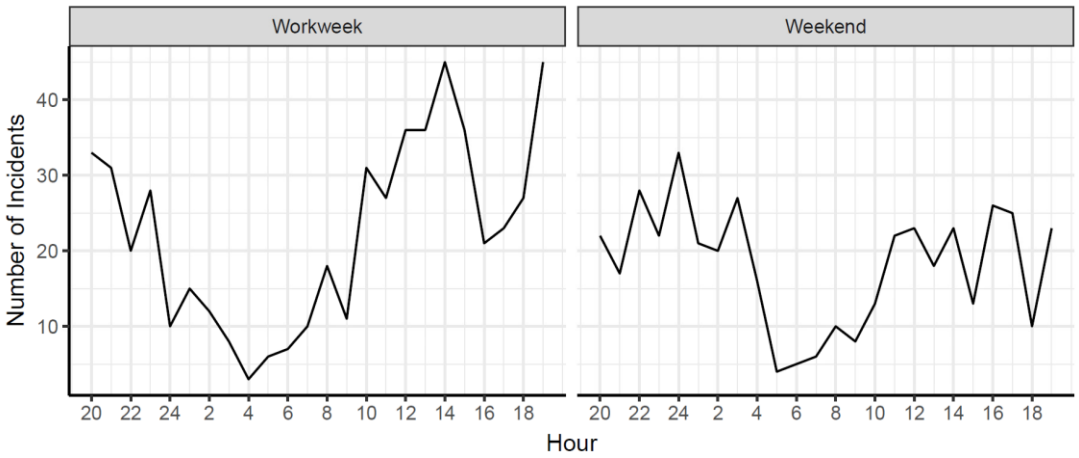


Figure 11. Temporal fluctuations in violence within the south of Oslo.

A cluster of grid-cells is situated on the eastern side of Østensjø, totaling 54 registered incidents. The hot spot appears to encompass Bøler shopping center, a subway station and five bus stops. As discussed earlier, such characteristics are thought to facilitate offender-target convergences during daytime. The hot spot does indeed unfold as being primarily daytime or transit related. The vast majority of incidents (73%) occurred during the workweek, and 60% occurred during daytime. This area represents yet another hotspot in which temporal trends do not align with those of the larger city-subset trends, and of which its temporal fluctuations seem to largely relate to its main functions: retail and transit. Importantly, nor does it align with other identified hot spots within the *same* city subset.

Table 3 provides an overview of the dissimilar characteristics of the specific hot-spot locations that were identified above, as well as corresponding temporal characteristics inherent to each hot spot. Overall, it is apparent that the temporal patterns vary significantly across hot spots, arguably due to the varying underlying functions of each location.

Table 3. Characteristics of identified hot-spots in Oslo.

Hot Spot	Workweek %	Weekend %	Primary Function	Peak Workweek	Peak Weekend
Oslo Central Station	54	46	Transit	17:00, 21:00	22:00
Oslo City Mall	49	51	Retail/Transit	03:00, 17:00	03:00
Nox Night Club	17	83	Night-Life	01:00	02:00
Stovner Mall	82	18	Retail	00:00, 14:00	00:00
Grorud Mall	57	43	Retail	21:00,19:00	21:00
Bøler Mall/Station	73	27	Retail/Transit	14:00	14:00

Source: Authors elaboration.

In sum, the above exploration of spatial-temporal distributions of violence in Oslo has facilitated four main revelations. (1) Violence is predominantly night-life related. (2) Within-city patterns recurrently deviate from city-wide patterns, as do individual hot spots in relation to corresponding city-subset specific trends. (3) Temporal patterns of hot spots largely reflect the underlying functions inherent to the location in question. (4) Such functions may transform across temporal scales. These findings will be discussed in further detail in a later chapter.

City of Bergen

Spatial-temporal patterns of violence will now be explored across the city of Bergen. Exploration of a second Norwegian city allows for fruitful comparison, and contributes to the question of whether the aforementioned revelations are of city-specific or general nature. As for Oslo, violence will be examined on the citywide scale, as well as for three city-subsets. Several hot spots will be selected as they emerge in order to allow for further examination of temporal patterns *within* these high-crime areas.

As earlier mentioned, only a subset of Bergen municipality is included to optimize subsequent crime maps. Here, Bergen city comprises the city districts of Bergenhus, Laksevåg, Årstad, Fyllingsdalen, Ytrebygda and the western part of Fana. The city districts of Åsane and Arna have been excluded, as these areas exhibit mostly mountains and forestation. Apart from this alteration of city borders, maps are produced in the same manner for both Oslo and Bergen. In other words, the map backdrop displays railways and major roads, illustrated through the use of light blue lines and gray lines, respectively. Grid-cells in which at least one violent crime has occurred within the study period appear on the map. All other grid-cells in which no violent crime was recorded within the study period are excluded from the map altogether (here represented by the *absence* of color coded grid-cells on the map). In grid-cells that *did* experience violent crime, a color gradient scale has been employed to display the density of crime within each cell, yellow cells representing micro-places of high crime rates.

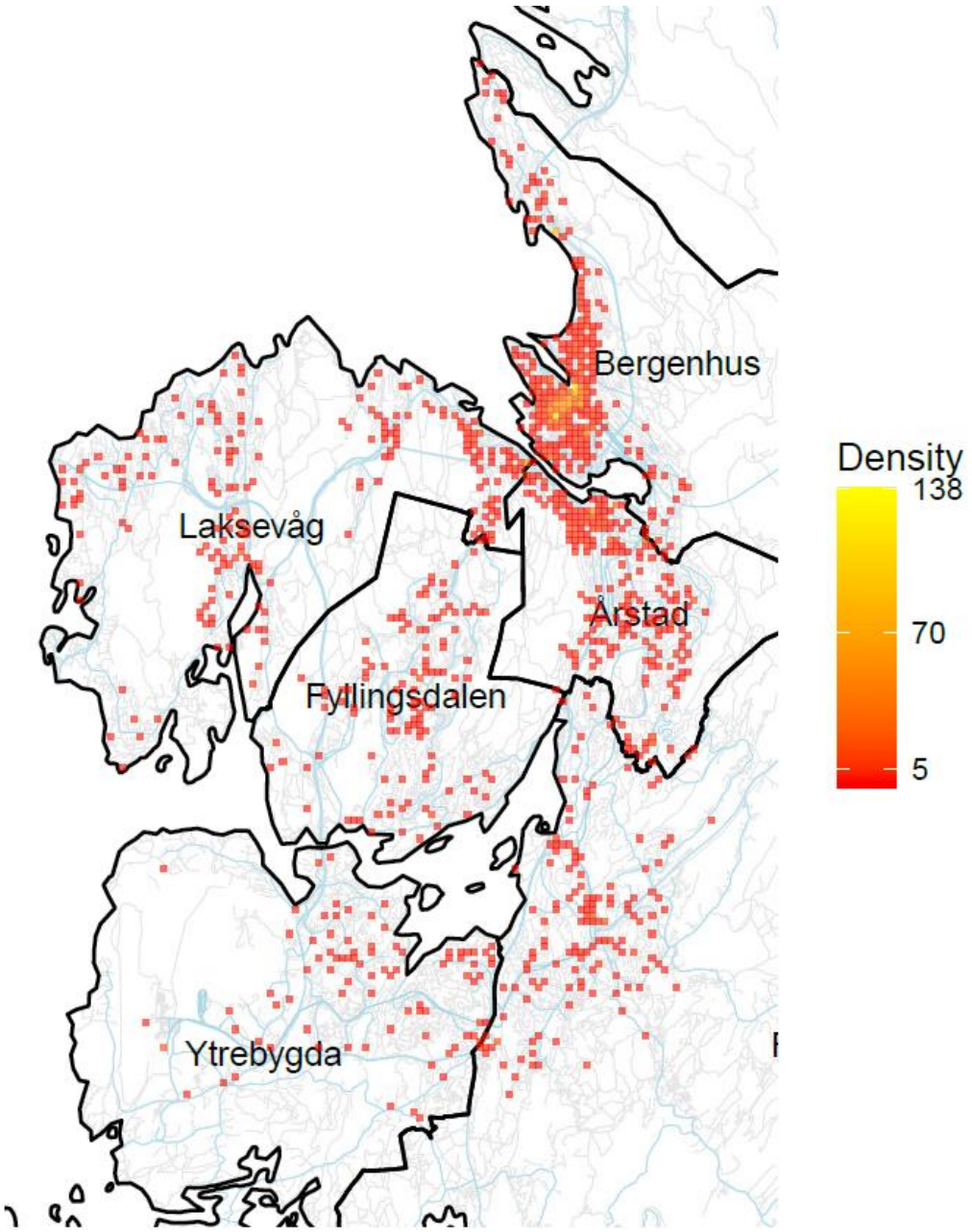


Figure 12. Map of violent crime in Bergen.

Concentrations of violence are confirmed to be present also in the city of Bergen (Figure 12). As opposed to Oslo, Bergen is characterized by multiple areas of forestation and mountain regions leading to a complete absence of recorded violence in several areas. This characteristic is important to note upon interpretation of subsequent crime maps. As anticipated based on both environmental criminological theory and prior research - the map portrays strong concentrations in the inner city (here defined predominantly as Bergenhus.) Compared to surrounding areas, the inner city exhibits both a greater number of grid-cells experiencing a small number of crimes (grid cells of red color), *and* account for the most

crime ridden grid-cells in the city (yellow cells). Of all crime-ridden grid-cells in the city (n= 887)[8], only three grid cells experienced more than 80 incidents of violent crime in the study period - all of which were situated within the city centre.

As was observed in Oslo, concentrations of violence is greatest in the city centre, followed by areas located in immediate vicinity of the city centre (here seen as areas in Årstad and Laksevåg that border to Bergenhus). Generally, the presence of violent crime becomes more disperse as one diverts away from the city centre, both in terms of presence of crime and its density. As is seen in Figure 12, no single grid-cell of yellow color (i.e. high density) is situated outside of the city centre and its immediate vicinity (Årstad). This fundamental axiom of the criminology of place, namely that a *few* micro-places in a city contain a disproportionate amount of crime, is further confirmed in Figure 13. Like Oslo, the vast majority experienced only between one and five incidents throughout the study period. Undoubtedly, this forms, as expected, a significantly skewed spatial distribution of violence. Thus far, patterns of violence appear to align well with established expectations based on theory and prior international studies concerning the spatial distribution of violence.

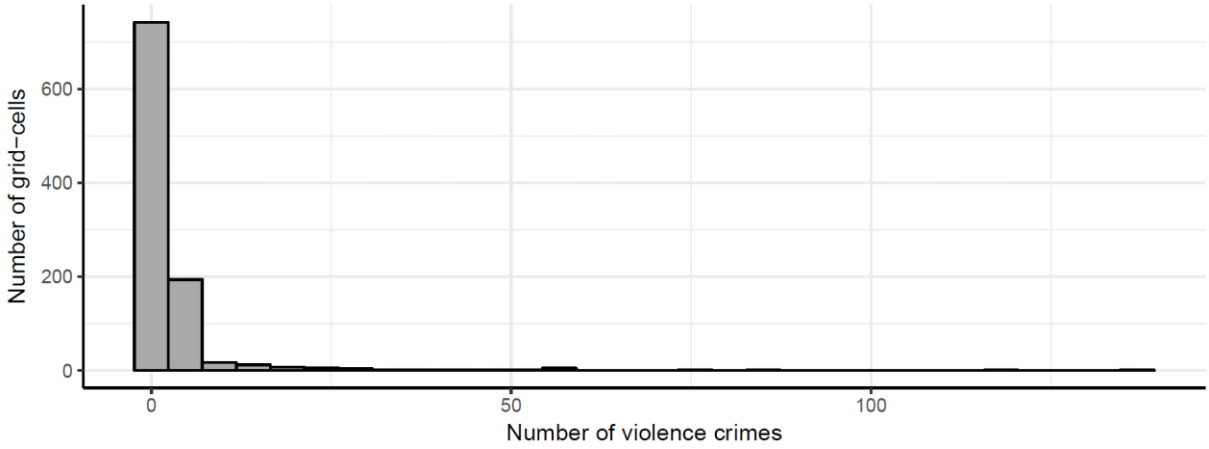


Figure 13. Histogram confirming a skewed spatial distribution of violence.

[8] The term 'all grid-cells' is here used to describe all grid-cells in which *at least one* incident of violence has been registered, excluding all cells in which no violence is registered (i.e. the vast majority).

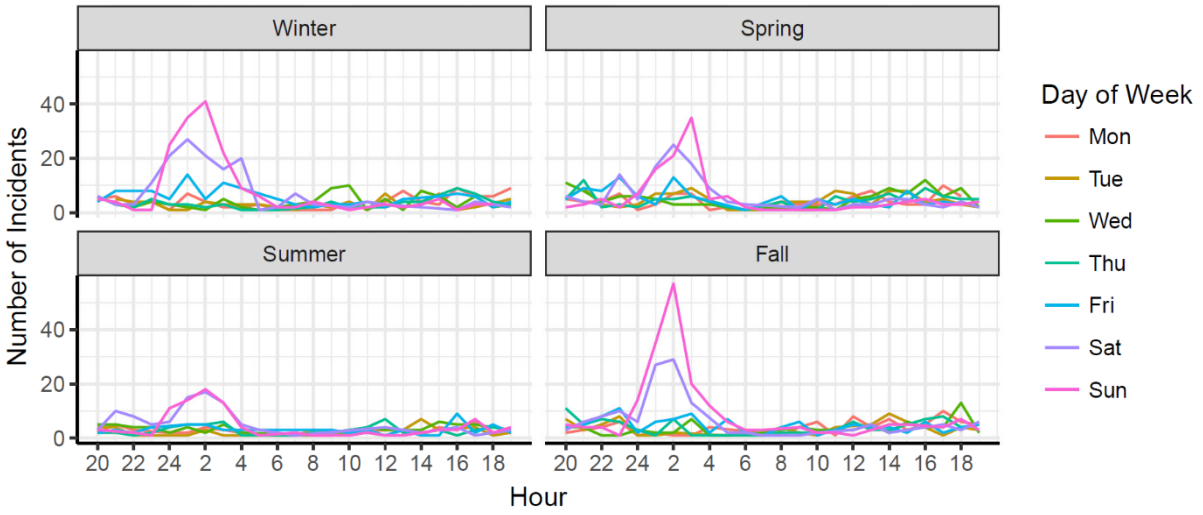


Figure 14. Temporal fluctuations in violent crime across the city of Bergen.

With regard to citywide temporal patterns of violence in Bergen, patterns observed appear similar to those reported in Oslo. That is, a slight majority (53%) of violence in Bergen occurred during the weekend (Friday, Saturday and Sunday), whereas the remaining 47% occurred during the workweek. Crime rates appear lower during summer time (Figure 14), however this variation is, akin to that of Oslo, likely attributable to an underrepresentation of summer months in the data.

Sunday is consistently reported as the most crime-ridden day of the week, in which violence is found to peak primarily at 02:00. Contrary to expectations, seasonal variations in violence are minor. The significant spike in violence during Saturdays between 01:00 and 02:00 and Sundays from 02:00 to 03:00 strongly indicates that a vast amount of violence in Bergen (on a citywide scale) is night-life related. Also here, violence reported at 01:00-02:00 Saturday morning arguably reflects that of patrons who engaged in night-life activities the evening prior (Friday). Similarly, peaks in violence during early Sunday hours reflect the actions of night-life patrons who commenced their night out the prior Saturday evening. Overall, 42% of all violence in the study period occurred between 23:00 and 05:00. A noticeably smaller portion of crime, 20%, occurred in the time period between 09:00 and 17:00. This is indicative of night-life related violence being the greatest contributor to overall rates of violence in the city. In addition, the slight trend of violence to concentrate in later morning-hours during Sundays is perhaps suggestive of Bergen citizens tending to end their nights out earlier on Friday nights compared to Saturday nights. Similar to Oslo, this aforementioned temporal distribution of violence presents a distinction between night-life related violence and other violence, in which the former appears to dominate. In sum,

violence is found to concentrate during the weekend (Friday, Saturday and Sunday), and during late night hours (between 23:00 and 05:00).

Apart from night-life related violence identifying as the leading form of violence in Bergen, violence also appears to experience (although to a lesser degree) a steady increase from approximately 12:00 through 18:00, regardless of weekday or season. This time period between 12:00 and 18:00 arguably reflects a time when the city becomes more active. Recall that Horton and Reynolds (1971) argued based on aggregate routine activities that people may be out for lunch, shopping or conducting work-commutes in this timeframe. Thus, it seems plausible to suggest an increase in violence during this time period can be attributed to typical shifts in routine activities causing a clustering of people in certain public areas. The aforementioned spatial-temporal patterns of violence reflect that of a general, citywide trend. The essential question regarding within-city variations remain. It is to this we now turn.

Within-city Spatial-temporal Distributions of Violent Crime

The city districts of Bergenhus and Årstad represent the most populous part of the city, of which account for 58% of all reported violence in the city – rendering it the most crime ridden subset. A crime map of Bergenhus and Årstad portrays concentrations of violence in the inner city, alongside concentrations of night-life venues in the city centre (Figure 15). Temporal fluctuations align well with that of citywide trends (Figure 16), arguably due to Bergenhus and Årstad being the districts of which most heavily determine the citywide trends (due to their disproportionally high crime rate). However, a notably larger proportion of incidents occurred within the nighttime period (66%) as opposed to citywide trends (42%), which suggests that violence in Bergenhus and Årstad is significantly more fueled by night-life entertainment.

As mentioned above, Bergenhus houses the greatest quantity of high-density micro-places, clustered alongside concentrations of numerous night-life venues, rendering a closer examination warranted. The most crime ridden grid-cell (n=138) is located in the heart of this cluster, along the major road of 'Håkonsgaten'[9]. Venues in close proximity include 'Det Akademiste Kvarter' (a student house providing concerts and other events), several restaurants, 'Naboen Pub and Restaurant' as well as hotels. Interestingly, 83% of violence was found to occur during the weekend. Moreover, 89% of violence occurred between 23:00

[9] All identification of area characteristics (for larger subset-areas as well as smaller hot spots) were identified through a visual examination of the area in question using Google Maps.

and 05:00, and was shown to peak as early as 01:00. Since this micro-place is located along the first major road south of a number of night-life venues, it seems reasonable to anticipate that patrons have either utilized this road through public transportation in arriving or departing from the location - subsequently becoming involved in disputes. Nevertheless, violence at this hot spot (hereafter referred to as 'Håkonsgate') appears almost exclusively night-life fueled.

The second most crime ridden grid-cell (n=120) houses 'Zachariasbryggen', a popular night-life zone located at the harbor. The place is known for its magnitude of night-life venues, including restaurants, bars and nightclubs. It is apparent that this micro-place attracts a large number of people, ultimately rendering it one of the most crime ridden micro-places in Bergen. As for the aforementioned hot spot in Håkonsgate, also violence at Zachariasbryggen appears to be almost exclusively night-life related. A vast majority of all violence occurred during the weekend (85%), and 93% of violence occurred between 23:00 and 05:00, reaching its peak at 02:00. In sum, both hot spots appear to exhibit patterns of violence that greatly reflect the major function inherent to each location: night-life entertainment.

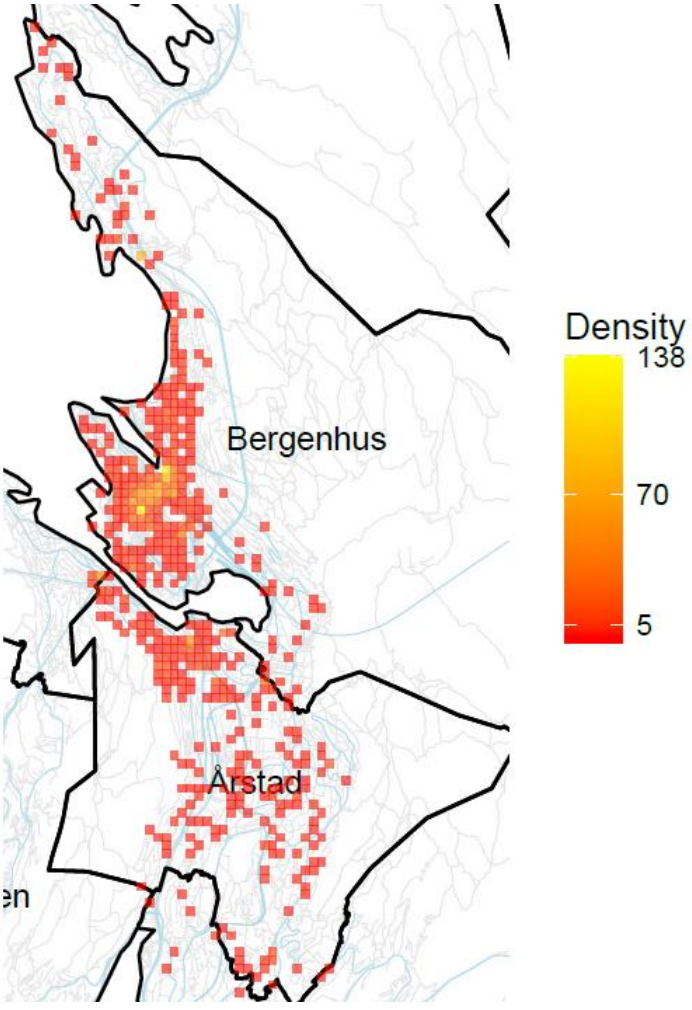


Figure 15. Map of violent crime in Bergenhus and Årstad.

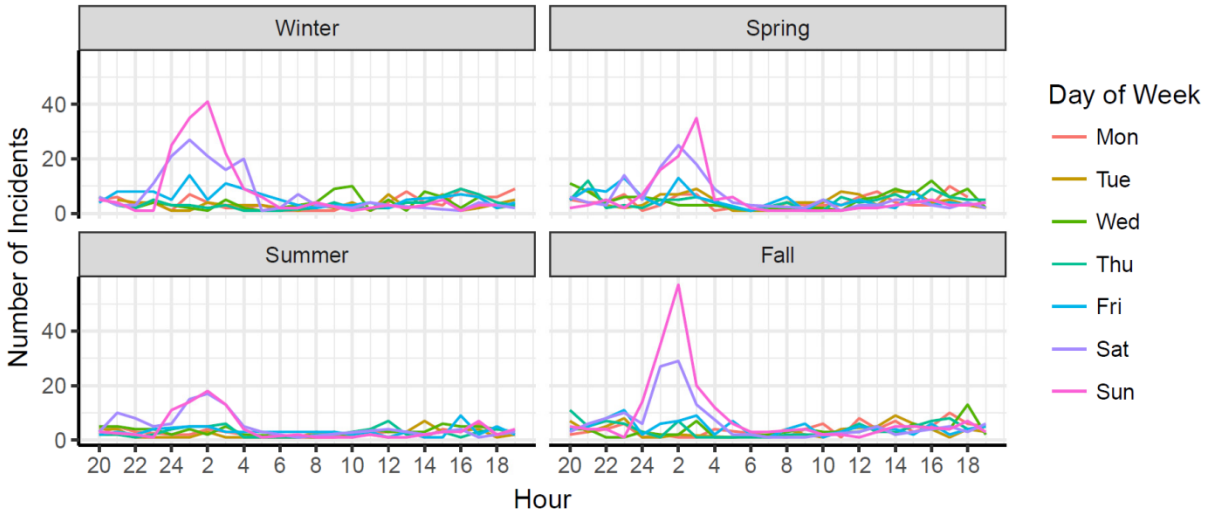


Figure 16. Temporal fluctuations of violence within Bergenhus and Årstad.

Another high-density grid cell is situated in the northern part of Bergenhus (Figure 15). This micro-place is located in close proximity to the event venue 'Torvsalen'. Torvsalen is advertised as suitable for office-parties, weddings, concerts, confirmations and anniversaries, to name some. True for the aforementioned events is the likely clustering of people and potential involvement of alcohol. Arguably, this explains the isolated occurrence of high-density violence in this particular grid-cell. Indeed, this micro-place experienced 71% of reported violence between 18:00 and 06:00. However, incidents were not clustered during weekends. This reflects, perhaps, the opportunity to book the venue also on weekdays. Many night-life venues simply are not open during the workweek, rendering a festering of violence at these locations unfeasible at this time of the week. This may offer an explanation as to why crime is not as greatly clustered during the weekend at this specific location.

The east and west side of Årstad comprise large areas of forestation, hence the absence of registered incidents. As mentioned earlier, the border between Bergenhus and Årstad is characterized by relatively intense clusters of violence, especially so in the area of 'Kronstad'. Upon closer examination of the area, it unfolds as a typical extension of the city centre – comprising restaurants, cafes, student housing, hotels, major roads and the city light rail, with the exception of night-clubs and bars. Based on these characteristics, it seems plausible to suggest that violence in this area is *not* predominantly night-life related. Indeed, 46% of violence occurred during the weekend, which is indicative of a hot spot in which violence is not exclusively night-life related. Interestingly then, a considerable proportion of incidents (41%) were registered in the typical night-life period between 23:00 and 05:00. Further, the hot spot experienced a significant spike in violence during weekends at 04:00. This spike

occurs noticeably later in Kronstad as opposed to in the inner city where night-life venues concentrate. Thus, it seems plausible to speculate that patrons (originally stemming from night-life venues in the city centre) have engaged in violence upon arriving at their end destinations after a night out. As the area appears to function largely as a residential and daytime retail area, it seems sensible to suggest that most late-light weekend related violence stems from patrons visiting venues in the inner city who have, due to travel time, not arrived at this destination before approximately 04:00 – either by use of taxi or night bus[10]. In addition, violence during weekdays appears to cluster between 14:00 and 18:00. An increase in this time period is also seen to occur during the weekend. Based on the above observations, it seems reasonable to suggest that this hot spot area reflects violence that is *both* night-life and daytime related, rather than predominantly night-life related.

Although it seems plausible to suggest that violence at this hot spot stems from patrons who arrived at their end destination upon having engaged in night-life activities the evening prior - it seems reasonable to suspect that violence may also be related to other factors (e.g. socioeconomic factors). This because not *all* transit station accompany hot spots of violence. An examination of socioeconomic factors revealed that a larger proportion of residents in this hot spot aged between 18 and 64 received social assistance during the reference year compared to areas transcending the hot spot (ResSegr, 2018). Further, the share of persons aged 25-64 who were employed was lower in this hot spot compared to surrounding areas (ResSegr, 2018). These characteristics indicate, at least in this particular hot spot, that both situational factors (transit station, student housing) *and* socioeconomic factors (rates of employment and use of social assistance) appear to present themselves alongside higher rates of violent crime. In light of this, it seems plausible to suggest that analysis of crime at place may benefit from including also socioeconomic variables, rather than solely situation-based variables. This suggestion will be discussed in further detail in chapter 6.

A distinctive amount of violence in Laksevåg and Fyllingsdalen is characterized by being few and far between (Figure 17). Temporally, crime in this city-subset differs from citywide trends in that crime occurs relatively evenly across the workweek and weekend (51% and 49% respectively (Figure 18)). Moreover, only 31% of violence occurred at night between 23:00 and 05:00. An isolated high-density grid cell (n=58) is located at the border between Laksevåg and Bergenhus. This cell appears to encompass ‘Strax Huset’, an

[10] An examination of departure times at https://moovitapp.com/ confirmed that public transportation departures from the city centre arrive at Kronstad at approximately 04:00 during weekends.

intoxication protection service. It seems reasonable to suspect that such a facility attracts a vast number of addicted, dispute-prone people, much like night-life venues do. Although such facilities were not included in the earlier established 'expected crime attractors' they operate much in the same manner (in regard to offender-target convergences). Indeed, the disproportionate amount of violence at this location is not random. The micro-place differs form night-life venues in temporal patterns, however. Only 17% of violence occurred between 23:00 and 05:00 (as opposed to 89% and 93% reported for the same temporal period in night-life zones examined above). No significant fluctuations are seen in crime rates across the week or season. It seems reasonable to suspect that visitors here utilize the service at all times, as their addictions and resulting behaviors fester throughout all hours of the day. These findings largely support the notion that violence at place varies according to the function of the hot spot in question.

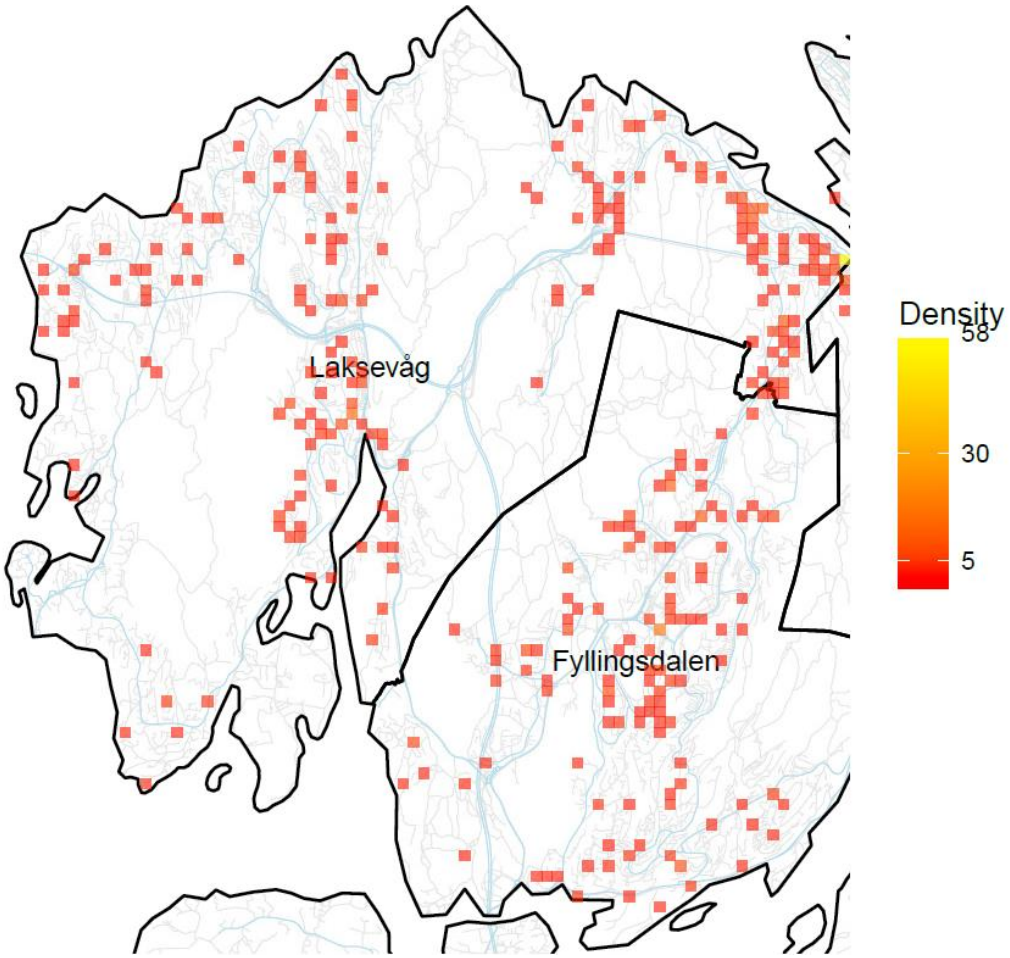


Figure 17. Map of violent crime in Laksevåg and Fyllingsdalen.

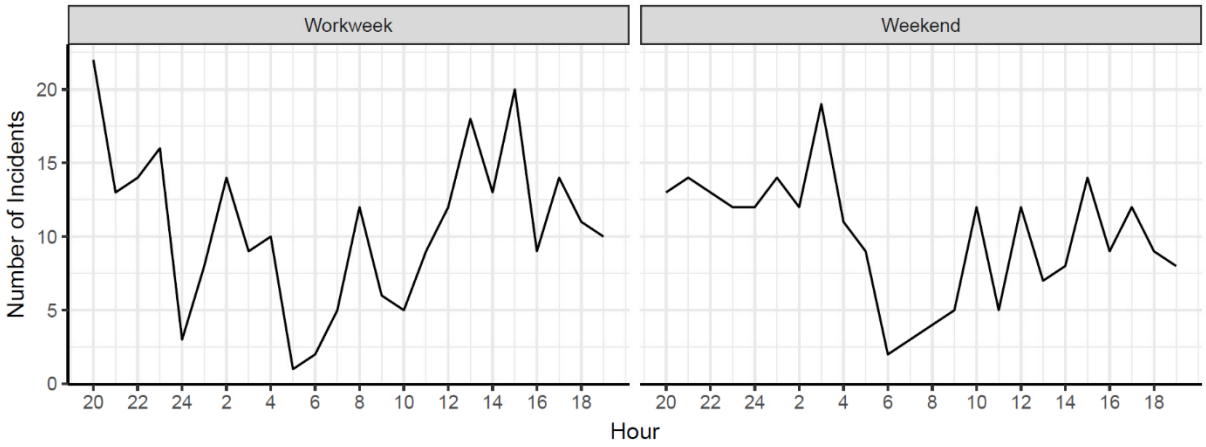


Figure 18. Temporal fluctuations in violence across Laksevåg and Fyllingsdalen.

Violence also appears to concentrate in the center of Laksevåg. This area houses a major shopping center: 'Vestkanten Storsenter', and a few restaurants and bars - characteristics of which cease upon exiting the area. A clear majority of crime occurs during the workweek (61%), and was shown to peak at 14:00 and 21:00. During the weekend, although incidents registered were much fewer, violence appears to cluster mostly between 22:00 and 02:00, and again at 16:00. In other words, also this hot spot appears to facilitate both night-life *and* daytime related crime. In addition, temporal trends differ slightly from that of the general city-subset in which it is located.

Lastly, Ytrebygda and Fana present as the districts accounting for the least amount of violent crime (8% of all violence in Bergen). This makes sense given that these districts are predominantly residential in nature. Where land is not covered in forestation or by mountain regions, violence appears to occur relatively evenly throughout this city-subset (Figure 19). Temporally, violence in this city-subset clusters during the workweek (Figure 20). During the workweek, crime is seen to peak at 14:00 and 18:00, whereas peaks are observed at 23:00 and 03:00 during weekends.

In Fana, the most crime ridden-micro place is located on the west side. This area lies in close proximity to the relatively popular shopping center 'AMFI Nesttun'. Adjacent micro-places house restaurants and other retail shops, banks and the like. Pubs, bars and nightclubs are absent. These characteristics cease as one diverts away from the area. Based on prior findings throughout this chapter, it seems reasonable to suspect that violence occurring in this area is predominantly daytime related and thus does not continue (or peak) past midnight as has been seen to be the case in areas exhibiting a magnitude of night-life venues. One could suggest that the place functions as a within-city district 'center', with the exception of

providing for night-life entertainment. That is, when one excludes the significant concentrations of such retail opportunities in the city centre and examines this district in isolation (i.e. unaffected by city-wide trends), leisure and shopping opportunities concentrate here – as does violence. Temporal trends confirmed this suggestion. Violence was shown to be equally divided across the workweek (50%) and the weekend (50%). Further, violence during the former was found to peak between 12:00 and 16:00, and violence during the weekend peaked as early as 11:00. In other words, violence in this area does not exhibit temporal patterns that align with typical night-life violence. As seen in earlier hot spots, and as suggested in prior research, night-life related violence is characterized by a peak *after* midnight. Nor does it align with the within-city subset patterns in which it is situated. In sum, this supports the aforementioned notion that spatial-temporal patterns vary also within city-subsets.

Yet another high-density crime cell in Fana is located near the border to Ytrebydga, and is situated in close proximity to six micro-places experiencing lower rates of violence. The former micro-place covers the premises of 'Lagunen Storsenter', a popular shopping centre in the district. Surrounding micro-places cover additional shops and two schools. In other words, as for multiple other hot spots examined, also this hot spot exhibits a shopping zone facilitating concentrations of people. The vast majority of violence occurred during the workweek (64%). Of crime that took place within the workweek, most occurred in the time period between 13:00 and 18:00, reaching a peak at 17:00. This time period corresponds with business hours of retail establishments in the area. Much the same pattern is observed during the weekend. In sum, violence in this hot spot appears to exhibit very similar temporal patterns across the week, and to reflect predominantly daytime related violence. Thus, it does not correspond to citywide nor subset-specific trends. Importantly, it exhibits different temporal patterns than other hot spots *within the same city subset.*

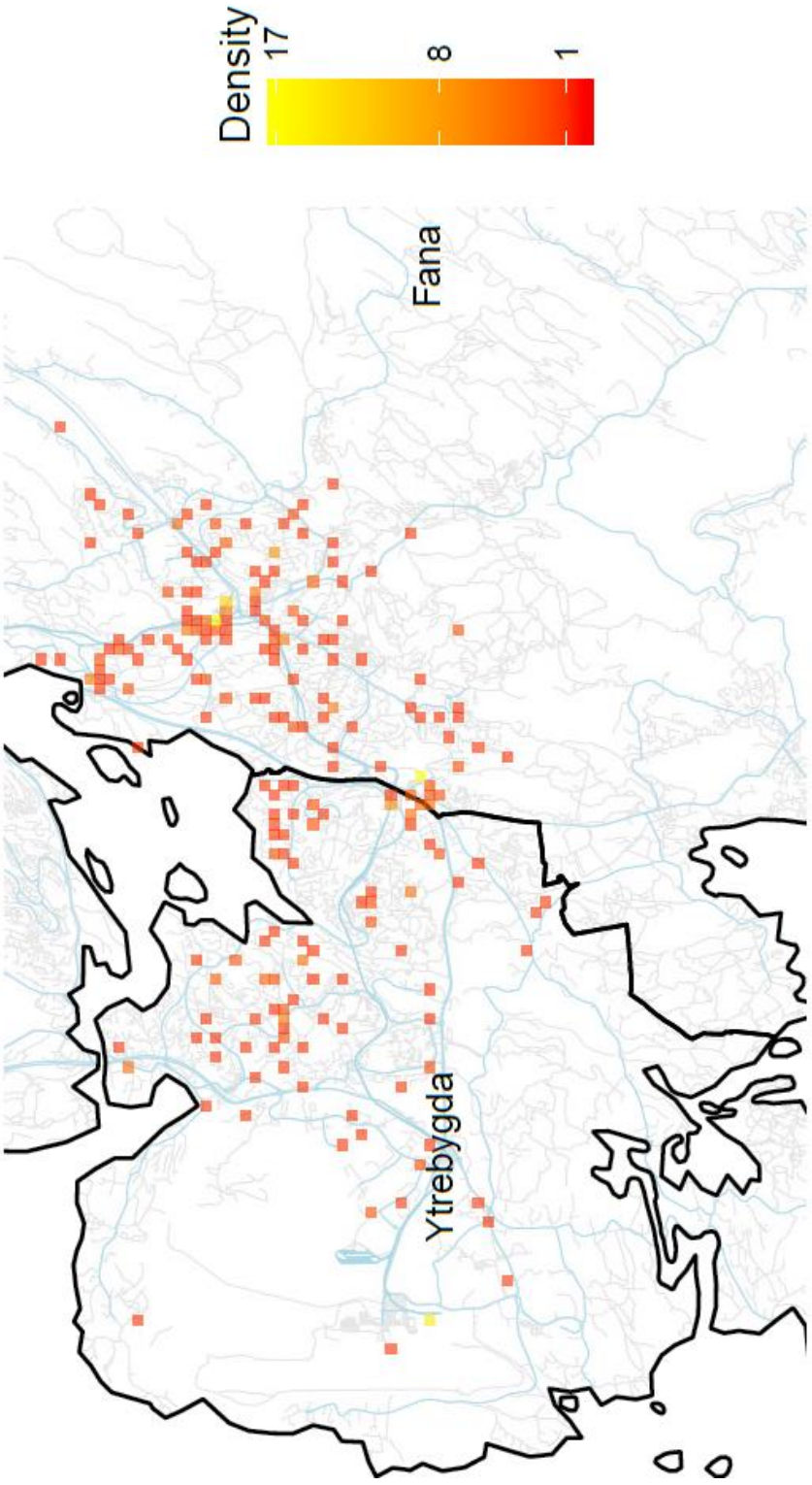


Figure 19. Map of violent crime in Ytrebygda and Fana.

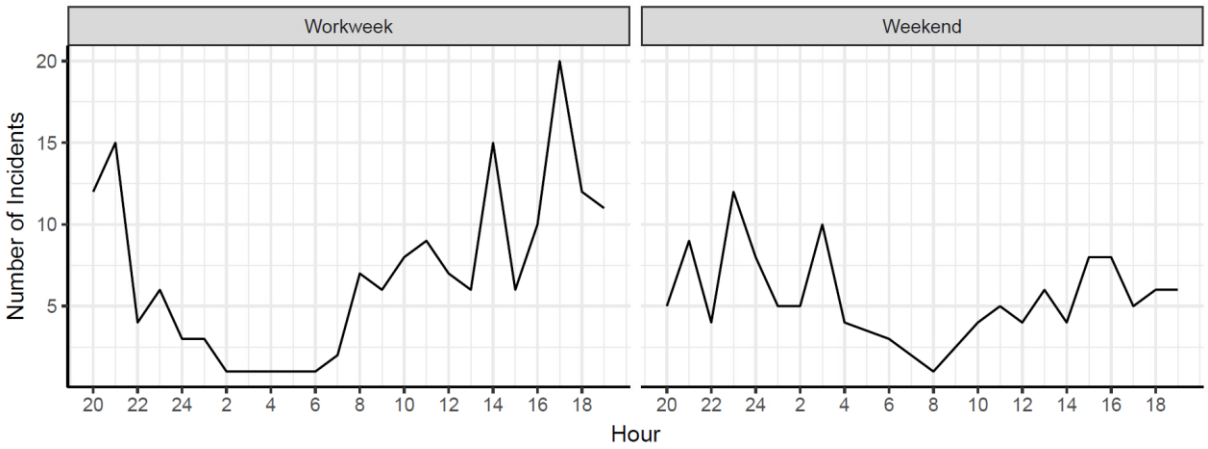


Figure 20. Temporal fluctuations across Ytrebygda and Fana.

Table 4 provides an overview of the various hot-spot locations that were identified through crime mapping in Bergen, as well as corresponding temporal patterns inherent to each hot-spot. Overall, as with Oslo, it is apparent that the temporal patterns vary significantly across hot spots, arguably due to the varying underlying functions of each location (e.g. night-life entertainment or retail). In addition, hot spots were also found to exhibit significantly differing temporal patterns despite being situated within the same city-subset – emphasizing the importance of employing the micro-place as the unit of analysis in examining spatial temporal patterns of violence.

Table 4. Characteristics of identified hot-spots in Bergen.

Hot Spot	Workweek %	Weekend %	Primary Function	Peak Workweek	Peak Weekend
Zachariasbryggen	13	87	Night-Life	01:00-03:00	02:00
Strax Huset	51	49	Service	11:00-13:00	13:00
Torvsalen	57	43	Leisure	10:00-14:00	09:00
Lagunen	64	36	Retail	17:00	16:00
Nesttun	50	50	Retail/Leisure	12:00-16:00	11:00
Håkonsgate	16	84	Night-Life	01:00	01:00
Vestkanten Storsenter	61	39	Retail	16:00, 21:00	00:00, 18:00
Kronstad	46	54	Residential/Leisure	18:00	04:00

Source: Authors elaboration.

Overall, pursuing *research objective 1* facilitated four main revelations in Oslo which were then confirmed to be present also in Bergen – indicating that these characteristics are of a general nature. In short, violence in Oslo and Bergen appears to be predominantly night-life related, albeit often peaking earlier than initially expected. Further, this night-life related violence appears to be most rampant in the inner city centres. Other forms of violence is found to dominate in areas that transcend that of the inner city, arguably due to underlying functions being vastly different. Perhaps most importantly, a hot spots' identified primary function may transform across temporal scales as 'dormant' functions become active (i.e. night-life venues are only temporally inactive during certain times of the day and week). These findings will be further discussed in Chapter 6. Overall, present findings only further motivated the following research objective regarding the effect of environmental factors (which typically reflect the *functions* of places) in explaining the concentrations of violent crime in Oslo and Bergen.

Objective 2*:* Testing the Effect of Environmental Factors in Explaining Concentrations of Violent Crime

In order to further assess the effects of environmental factors in explaining clusters of violent crime in Oslo and Bergen – models of multiple linear regression are estimated. Results are presented separately for Oslo and Bergen. Here, the outcome variable is the count of violent incidents between 2015 and 2018 summarised for each grid-cell. The models present unstandardized coefficients (B). Standard errors are shown in parenthesis.

As multiple regression concerns multiple independent variables, it is essential to assess whether a specific independent variable contributes significantly to the model *after* effects of other variables are accounted for. The resulting model for Oslo indicates that environmental factors play an intrinsic role in explaining concentrations of violence at the grid-cell level. However, environmental factors in *adjacent cells* appear to better explain violence than environmental factors inherent to the original cell, as the former presents statistically significant coefficients (Table 5). Note that the effect in the original grid-cells is interpreted as when nearby areas are accounted for. 'AC' variables pick up characteristics of the slightly broader geographical area. Models without 'AC' variables were run to confirm that features inherent to the original cell have significant effects on violence when AC variables are

excluded[11]. Important to note from this is the fact that the non-significant coefficients seen in the presented regression models *do not* mean that attributes of original grid-cells are unimportant.

For the statistically significant coefficients seen in Table 5 and 6, levels of significance vary. It should be noted that these significance levels (p-values) primarily inform that the observed relationships are not attributable to chance. Variables with higher p-values (here variable 'Commercial Area AC') do not 'explain less' than variables that are attributed lower p-values. In sum, all variables in the model reporting having a significant effect on violent crime (p-values of 0.05 or less) are interpreted as having real effects on the prevalence of violent crime – not attributable to chance. Examining the model for Oslo, these variables include (1) transit stations in original cell, (2) transit stations in adjacent cells, (3) commercial area in adjacent cells and (4) residential area in adjacent cells.

Grid-cells in which transit stations are present are, as expected, positively associated with violent crime. The unstandardized regression coefficients (B) for transit suggest that in grid-cells where transit stations are present but absent in adjacent cells – this is related to an increase in the average number of violent incidents by 0.713. In addition, the average number of incidents in a grid-cell further increase by 0.483 with every single increase in adjacent cells that house transit stations. In other words, violence is suggested to increase in grid-cells where transit stations are present, and to *further* increase if the aforementioned grid-cell neighbors to grid-cells that *also* house transit stations. This makes sense, given that clusters of transit stations likely produce greater offender-target convergences than isolated transit stations do.

Contrary to initial expectations, the coefficients for major roads suggest that the average number of violent incidents in a grid-cell decreases by -0.045 incidents if major roads are present, but interestingly, increase by 0.034 with every single increase of adjacent cells that exhibit major roads. Simply put, violence appears to cluster in grid-cells where the broader area surrounding that grid cell *also* harbors major roads. This makes sense, given that violence, especially public violence, is typically conducted in areas accessible by foot. In grid-cells in which few or no adjacent cells exhibit major roads, this may be indicative of the larger area lacking major roads other than the one present in the original cell. Such areas characterised solely by a single major road oftentimes reflect more natural land areas mostly utilised for passing through using vehicles, thus largely prohibiting or limiting offender-target convergences that may facilitate violence. Alternatively, the presence of major roads may also

[11] These models are available in the appendix (Tables 9 and 10).

be indicative of less attractive areas. Attractive areas of residency are usually more sheltered from major roads and the traffic and noise that accompanies them. Hence, given the increase of violence with every additional adjacent grid-cell that harbors major roads, one may speculate that violence is more prevalent in areas that are generally less sought after in terms of housing. However, neither variable concerning the presence of major roads appears to have statistically significant effects on violent crime in Oslo, implying that the effects observed may be due to chance.

Tables 5 & 6. Results from the linear regression model for Oslo (Table 5) and Bergen (Table 6). Outcome variable is the count of violent incidents 2015-2018 summarized for each grid-cell. Standard errors in parenthesis.

Table 5

	Violent Crime
	B
Transit Stations	0.713***
	(0.224)
Major Roads	-0.045
	(0.127)
Commercial Area	-0.309
	(0.383)
Residential Area	0.128
	(0.092)
Transit Stations AC	0.483***
	(0.073)
Major Roads AC	0.034
	(0.024)
Commercial Area AC	0.178**
	(0.070)
Residential Area AC	-0.066***
	(0.020)
Constant	0.463***
	(0.085)

Note: *p**p***p<0.01
Adjusted R^2: 0.01578
[a] AC indicates 'adjacent cells'

Table 6

	Violent Crime
	B
Transit Stations	0.481*
	(0.263)
Major Roads	-0.037
	(0.100)
Commercial Area	0.079
	(0.334)
Residential Area	-0.002
	(0.049)
Transit Stations AC	0.211**
	(0.100)
Major Roads AC	0.171***
	(0.059)
Commercial Area AC	0.245***
	(0.088)
Residential Area AC	0.044***
	(0.013)
Constant	-0.109***
	(0.027)

Note: *p**p***p<0.01
Adjusted R^2: 0.02613
[a] AC indicates 'adjacent cells'

Further, contrary to expectations, grid-cells located in commercial areas are seen to be negatively (though not significantly) correlated with violent crime if adjacent cells are *not* commercial in character. The commercial area coefficients suggest that the average number of violent incidents in a grid cell decreases by -0.309 if located in a commercial area, yet *increases* (significantly) by 0.178 incidents with every single increase in adjacent cells that are located in commercial areas. In other words, it appears as though where land use is commercial in character, *and* it stretches across multiple grid cells – this is associated with a significant increase in violence compared to instances where grid-cells are situated in commercial areas, and it does *not* transcend to adjacent cells. This makes sense, given that clusters of commercial areas are thought to facilitate more offender-target convergences that may result in violence. Such clusters of commercial areas are typically situated in the city centre or at shopping centers in the suburbs.

In a similar fashion, the effect of residential land use is only significant when it is also present in adjacent cells. Grid cells located in residential areas that are *not* adjacent to other 'residential grid cells' are, contrary to what was hypothesized - associated with an increase in violence. The residential area coefficients suggest that the average number of violent incidents in a grid cell increases by 0.128 if it is located in a residential area, and decreases by -0.066 with every single increase in adjacent cells located in residential areas. This means that for a 'residential grid-cell' in which all adjacent cells are also situated in residential areas, the average number of violent incidents decreases by -0.4 Thus, it appears that larger residential areas are negatively correlated with violence. This makes sense, given that grid cells that are located in residential areas but that lack them in adjacent cells may instead neighbor to commercial areas, causing more thoroughfare (i.e. crowding of people), ultimately facilitating violent encounters. However, in cases where grid-cells in residential areas are surrounded by grid cells that are *also* located in residential areas, no 'adjacent commercial area' is available to facilitate thoroughfare. This indicates that *larger* residential areas experience less violence. It also seems reasonable to suspect this is related to the lack of or less frequent public transport stations in residential areas (i.e. less crowding of people). In sum, the more residential in character an area is, the fewer crime inducing offender-target convergences are facilitated, and incidents of violent crime appear to remain low.

Also the resulting model for violence in Bergen indicates that environmental factors play an integral role in explaining concentrations of violence at the grid-cell level (Table 6). As was seen in Oslo, statistically significant effects are seen mostly for environmental factors in *adjacent cells* rather than in original cells. In fact, *all* coefficients for adjacent cells are statistically significant whereas environmental factors in original cells present only one statistically significant coefficient – that of transit stations. However, as noted above, a regression model estimated *without* 'AC' variables yielded statistically significant coefficients for attributes inherent to the original cell also in Bergen – illustrating their relevance in explaining concentrations of violence[12]. Across the models for Oslo and Bergen, transit stations is the only factor that consistently reports having significant effects on the concentration of violence *and* having the same effect on violence (i.e., a positive relationship) both in the original cell and in adjacent cells. The effect of several other variables appear to have notably different effects between the two cities, as will be discussed below.

The coefficients for transit in Bergen suggest that in grid-cells where transit stations are present, but absent in adjacent cells – this is related to an increase in average number of violent incidents by 0.481. As mentioned, of all the variables concerning environmental factors in original cells, transit is the only factor to report a statistically significant effect on concentrations of violence. Further, similar to Oslo, the average number of violent crimes *increases* by 0.211 with every single increase of adjacent cells that exhibit transit stations. In other words, violence is suggested to increase in grid-cells where transit stations are present, and to further increase if the aforementioned grid-cell neighbors to grid-cells that *also* house transit stations.

Further, as was seen in Oslo, the coefficients for major roads suggest that the average number of violent crimes in a grid-cell decreases by -0.37 if major roads are present, although this effect is not statistically significant. Violence is seen to *increase* by 0.171 with every increase in adjacent cells that exhibit major roads. As opposed to Oslo, this effect *is* statistically significant. In other words, the same variable has differing effects on concentration levels across the two cities. This observation may be related to the differences in urban settings between the two cities. As suggested above, grid-cells exhibiting major roads but that lack them in adjacent cells often take place in conjunction with the earlier

[12] See Table 10 in the appendix.

discussed areas of forestation, mountain regions and otherwise natural land areas. In many areas, such 'natural land areas' are typically only interrupted by a single road utilized almost exclusively to pass through the area. Such areas differ from typical urban settings, and do not produce especially great target-offender convergences that may facilitate violence. Importantly, such areas are much more prevalent in Bergen than in Oslo. As these natural-land areas are less frequent in Oslo, clusters of major roads are more prevalent here. Thus, it seems plausible to suspect that the less common clusters of major roads in Bergen attract more thoroughfare to *fewer locations* – ultimately yielding a statistically significant effect on the concentration of violence in these specific, less common areas. This may offer an explanation as to why these same variables have differing effects on concentration levels in the two cities.

In line with initial expectations, grid-cells located in commercial areas are positively correlated with violent crime. The commercial area coefficients indicate that the average number of violent incidents in a grid cell increases by 0.079 if it is located within a commercial area, and further increases by 0.245 incidents with every adjacent cell that is also located within a commercial area. Only the latter has a significant effect on the presence of violent crime. This finding coincides with initial expectations in which commercial areas where thought to facilitate greater numbers of offender-target convergences, ultimately facilitating violence. As was mentioned above, it seems plausible to suggest that clusters of grid-cells characterized by commercial land use facilitates more thoroughfare than commercial land use that is largely surrounded only by residential areas, simply as the former harbors more restaurants, shops, public transit and other factors that attract a large number of people. Also, as was established in pursuing *research objective 1,* the majority of violence in both cities appears to be night-life related. Commercial areas and night-life venues tend to coincide in the city centres, and stretch across multiple 100m by 100m grid-cells. These elements may contribute in explaining the tendency of violence to significantly increase in commercial areas that *transcend multiple grid-cells.*

Lastly, as *opposed* to initial expectations, the coefficients for residential land use indicate that the average number of violent crimes in a grid-cell decreases by -0.002 if it is located in a residential area, but *increases* by 0.044 with every adjacent cell that is located in a residential area. This effect is opposite that of Oslo, in which residential land use in adjacent cells was, as expected, associated with a decrease in violence. In Bergen, violence appears to be *more* prevalent in areas where residential land use is stretched across multiple grid-cells. It seems

reasonable to speculate that this trend may be related to the urban structure of Bergen in which there are several smaller clusters of residential areas that exhibit smaller 'local centers'. Consequently, these local centers are all situated in proximity to residential areas[13]. Likewise, a number of residential areas are situated in proximity to the city centre. These associations should be addressed in future research. In sum, similar to major roads, residential areas appear to have differing effects across the two cities – suggesting that effects of environmental factors do not remain stable across cities of diverging urban settings.

The coefficient of multiple determination (R^2) indicates the percentage of the variance in the dependent variable (violence) that the independent variables explain. In the models for Oslo and Bergen the R^2 is 0.016 and 0.026 respectively, indicating that the independent variables together explain 1.6% and 2.6% of the variation in violence in Oslo and Bergen. These are low R^2 values and the models are thereby not particularly well suited for making predictions of violence. Such low R^2 values indicates that a wide array of factors (beyond those examined in this study) affect concentrations of violence. These findings will be further discussed in Chapter 6.

Objective 3: Assessing the Validity of the Law of Crime Concentration

As Weisburd (2015) himself has failed to allude to what constitutes 'non-conformity' to his proposed law, non-conformity to the law will here be defined as any percentage that exceeds those bandwidth percentages initially specified. Recall that these bandwidths are as follows: 50% of crime concentration is accounted for by 2.1-6% of micro-places in a city. Likewise, 25% of crime concentration is accounted for by .4 to 1.6 of micro-places.

Figure 21 presents the percentages of grid cells in which 25% and 50% of violence occurred in both cities across the entire study period, as well as for each year. Both measures based on calculations including only cells with registered violence (frequency) and all grid cells regardless of the presence of violence (prevalence) are included, as earlier discussed in the literature review. The individual bars indicate the percentage of grid cells that account for the respective percentages of violence. Thus, lower bars (i.e., lower percentages) indicate *stronger* concentrations. Concentrations of violent crime are confirmed to be present at the grid-cell level in both Oslo and Bergen, and appear to be relatively stable across years (with the exception of fragmentary years). Overall, Bergen has exhibited higher concentrations

[13] Clusters of residential areas were identified using Google Maps.

levels over the years compared to that of Oslo. This difference in concentration levels may be due to a smaller number of facilitators of violent crime (e.g. venues of night-life entertainment) in Bergen compared to Oslo, which are more widespread in the latter. Alternatively, concentration levels may also be affected by Bergen's discontinuous urban setting accentuating spatial concentrations, as discussed earlier.

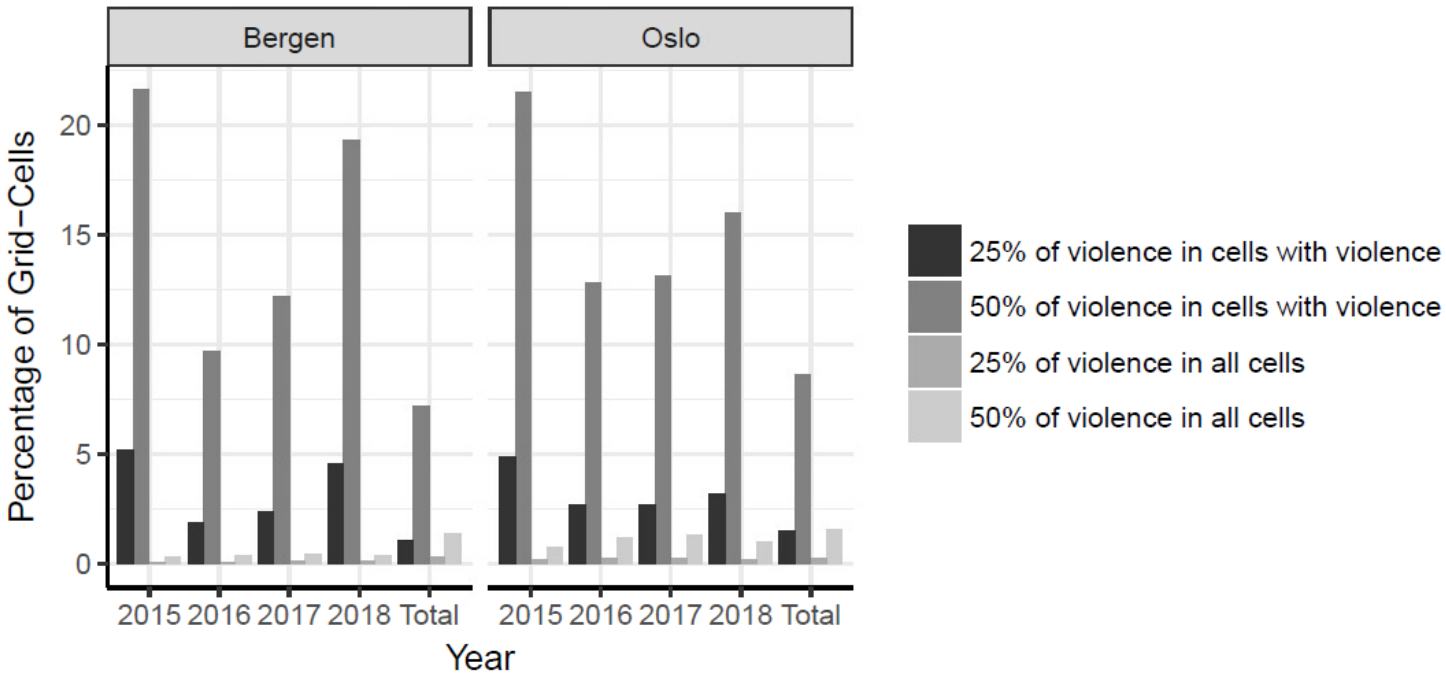


Figure 21. Spatial concentrations of violent crime in Bergen and Oslo.

With respect to frequency measures, concentration levels are as follows: upon aggregating all violence that occurred between 2015 and 2018, 1.5% and 8.6% of grid-cells in Oslo accounted for 25% and 50 % of violent crime in the city, respectively. Likewise, 1.1% and 6.3% of grid-cells in Bergen accounted for 25% and 50% of violence. These findings somewhat support previous results in Italy (Favarin, 2018) and Belgium (Hardyns, Snaphaan & Pauwels, 2018). Some concentration levels also surpass those established by Weisburd (2015). The percentages of grid-cells found to account for 25% of all violence concur with Weisburd's establishments both in Oslo and Bergen. However, both cities exhibit higher percentages of grid-cells accounting for 50% of violence (i.e. weaker concentrations) than earlier suggested by Weisburd (2015). That is, 6.3% and 8.6% of grid-cells in Bergen and Oslo respectively, in comparison to Weisburd's (2015) suggested range spanning from 2.1 - 6%. In other words, for an aggregated measure (based on calculations of prevalence), the law does not hold for 50% concentration in either city. For each individual year, concentration levels are consistently considerably higher than pre-established percentages both for 25 and

50% of violence; thus the law appears to fail for such a disaggregated measure.

As opposed to concentration levels calculated based only on grid-cells that have experienced violence during the study period, figure 21 also shows that results are vastly different when calculation is contingent on including all cells in the respective cities. Here, aggregate measures of concentration levels *surpass* Weisburd's specifications both for Oslo and Bergen. In Oslo, 25% of violence was found to have occurred in only 0.3% of micro-places, whereas 50% of violence was accounted for by 1.6% of micro-places. Likewise, in Bergen, percentages reported were 0.3% and 1.4% for 25 and 50% concentration, respectively. The finding that concentration levels are stronger when calculated based on *all* grid-cells in the city is not surprising. Rather, it is a consequence of employing higher numbers as denominators in calculation (caused by including grid-cells without registered violence). In other words, the higher the number employed as the denominator, the smaller the resulting concentration levels. In sum, this disparity in results illustrate that the employed calculation method has a significant effect on concentration levels reported.

Interestingly, the variation in concentration levels based on frequency and prevalence measures is larger in Bergen than in Oslo. In Bergen, the concentration levels dropped by 22% (for 50% of violence) when examined based on all grid-cells rather than only crime-ridden cells. For Oslo, concentration levels dropped by 18%. In other words, the impact of including grid-cells without registered violence has a greater effect in Bergen than in Oslo. Put differently, there appears to be a greater number of grid-cells in Bergen without registered violence than in Oslo. A possible explanation for this may be the differing urban settings between the two cities in which Bergen displays more forestation and mountain areas – thus locations (and grid-cells) in which violent offending is highly unlikely due to a lack of thoroughfare. Both the implications of these calculation methods and the differing concentration levels as well as their suggested relation to urban structure will be discussed in more detail in Chapter 6.

Although prevalence measures yield significantly stronger concentration levels overall, prevalence measures also appear to accompany, contrary to frequency measures, higher percentages (i.e. weaker concentrations) when assessing the study period in its entirety as opposed to each individual year. This finding is in line with that of other scholars who have assessed the law based on measures of prevalence (Favarin, 2018; Levin, Rosenfeld & Deckard, 2016). Favarin (2018) argued, upon observing weaker concentrations in aggregate analysis that this trend was due to the fact that it is not always the same micro-places that

experience crime across the years. In other words, there is a lack of stability in the places that account for crime. This notion is also supported by Levin, Rosenfeld and Deckard (2016). It is important to note then, that frequency measures display the *opposite* trend, namely *lower* percentages (stronger concentrations) when aggregating crime incidents across years as opposed to examining concentrations for each individual year.

Assessing the Law of Crime Concentrations across Different Temporal Periods

Having demonstrated the effect of calculation method applied on concentration levels, the following results will present concentration levels across three temporal periods calculated based only on grid-cells that have experienced violence (frequency). Here, the cumulative percentages of grid cells in Oslo and Bergen accounting for 25 and 50% of violent crime by hour of the day, day of the week and season of the year were compared to the pre-established bandwidths by Weisburd (2015). For both cities, the percentages specified in the law were *not* upheld in an examination of the concentration of violence across multiple temporal periods (Tables 7 and 8). The percentages of grid-cells accounting for 25% of violent crime throughout the day ranged from lowest at nighttime to highest during morning hours. The same pattern is seen for 50% of violence. In other words, spatial concentrations of violence appear to be greatest during late-night hours, both in Oslo and Bergen. Interestingly, concentration levels matched Weisburd's (2015) percentages only for the nighttime period. Put differently, the vast majority of percentages reported largely exceed those proposed by Weisburd. The weakest concentration was found in Bergen during morning hours, in which 50% of violence was accounted for by a staggering 21.5% of grid-cells.

With regard to weekday and weekend periods in Oslo, 2.43% and 11.65% of grid-cells experienced 25% and 50% of violence during weekdays. For weekends, almost identical percentages were reported; 2.03% and 11.16%, respectively. In other words, the spatial concentration of violence in Oslo does not appear to be stronger during the weekend. As with concentrations of violence across the week, violence appears to exhibit relatively stable levels of concentrations also across seasons. Veritably, the only temporal period exhibiting striking fluctuations in crime concentration levels is the within-day period. On the contrary, crime concentration levels in Bergen were shown to fluctuate considerably more. For instance, concentration levels were almost reduced by half between the weekday and weekend period, percentages shifting from 2.05% to 1.29% and from 11.06% to 6.06% for 25% and 50% of all violence, respectively (Table 8). Concentrations also fluctuate more across seasons. Common for both cities is the fact that the most striking fluctuations occur during the within-day

period. However, regardless of these notable differences in concentration levels across the two cities, in sum, only *very few* periods (i.e. weekend and nighttime in Bergen) reported concentration levels in line with those specified by Weisburd (2015). Recall that for 50% of all crime in a given study period, Weisburd's (2015) upper limit of micro-places accounting for this proportion of crime was set to 6%. Likewise, for 25% of crime, the upper limit of micro-places accounting for this proportion of crime was set to 1.6%. In other words, as seen above, none of the temporal periods examined (within-day, day of week and season of the year) fully conformed to these pre-established percentages. The specific temporal period experiencing the most potent spatial concentrations of violence was the within-day period classified as 'nighttime'. However, even despite exhibiting the strongest spatial concentrations, only nighttime concentration levels in Bergen aligned with the law. In Oslo, 50% of violence occurred in 9.94% of grid cells, and 25% of violence occurred in 1.90% of grid-cells - both transcending the upper-limit earlier reported by Weisburd, and *largely* so for 50% of violence.

Table 7. Spatial concentration of violence in Oslo, measured by temporal periods.

	Percentage of grid-cells experiencing… [a]	
	25% of period's violence	50% of period's violence
Within-day		
Morning	4.26	20.31
Daytime	3.77	17.38
Evening	2.82	15.58
Night	1.90	9.94
Days		
Weekdays	2.43	11.65
Weekend	2.03	11.16
Seasons		
Winter	3.48	15.69
Spring	3.01	14.60
Summer	3.16	15.13
Fall	3.70	15.72
Total	1.61	8.85

[a] Percentages of grid-cells experiencing 25 and 50% of violence was computed within each temporal period.

Table 8. Spatial concentration of violence in Bergen, measured by temporal periods.

	Percentage of grid-cells experiencing… [a]	
	25% of period's violence	50% of period's violence
Within-day		
Morning	4.87	21.46
Daytime	4.37	18.07
Evening	3.96	17.72
Night	0.92	5.16
Days		
Weekdays	2.05	11.06
Weekend	1.29	6.06
Seasons		
Winter	2.24	10.47
Spring	3.12	13.83
Summer	3.74	14.96
Fall	2.89	13.15
Total	1.10	6.31

[a] Percentages of grid-cells experiencing 25 and 50% of violence was computed within each temporal period.

Contrary to the present study, Haberman, Sorg and Ratcliffe (2017) reported seeing lower percentages (stronger concentrations) when assessing the law across the three aforementioned temporal periods in Philadelphia, U.S, than those earlier reported by Weisburd (2015). The bandwidth percentages of micro-places experiencing 50% of all crime during the within-day periods ranged from 0.29 to 0.95. In the present study, equivalent time period bandwidths ranged from 0.92 to 4.87 (implying a bandwidth of 3.95% - more than four times the size of that reported by Haberman, Sorg and Ratcliffe (2017)). This finding of lower bandwidth percentages was in their study attributed to the percentages being calculated based on a lower number of micro-places. Recall that in calculating concentrations percentages for the various temporal scales (as opposed to the entire study period), the 'total number of grid-cells' employed as the denominator in calculating the percentages of grid-cells accounting for 25% and 50% of violence here reflects total number of grid-cells *within the period examined* – ultimately constituting lower numbers. Haberman, Sorg and Ratcliffe (2017) suggest that such calculation using 'lower numbers' yielded stronger concentrations, and that given this finding – data volume may influence resulting bandwidth percentages. However, it appears in the current study that calculating concentration percentages based on lower counts did *not* result

in lower bandwidth percentages. Thus, it seems plausible to suggest that, in this case, fewer micro-places does not equal lower percentages and that perhaps data volume is not a reliable predictor of bandwidth percentages. In sum, results indicate that the law of crime concentrations holds only for 25% of violence in both cities, and only when analyzing aggregate numbers. It does *not* hold across different temporal scales. These findings will be discussed in further detail in the following chapter.

6. DISCUSSION

This chapter provides a discussion of the research findings as well as avenues for future research and implications for crime policy. For the purpose of clarity, the discussion of findings is presented in accordance with the study's research objectives.

Objective 1: Mapping Violent Crime in Oslo and Bergen

Violence conducted in public areas is often attributed predominantly to night-life activities (Nelson, Bromley & Thomas, 2001). The present study argues this to be true for inner-city violence only. Violence in Oslo and Bergen was, on the citywide scale, shown to be predominantly night-life related because the citywide trends are most heavily determined by city-center trends (due to their disproportionally high crime rate) – and these were dominated by night-life related violence. However, an exploration of violence in areas transcending the city centres revealed violence to be substantially *non*-nightlife related. The inspection of several high-crime micro places outside of the city centre revealed many to be active predominantly during daytime. Findings also support suggestions of prior research in that violence appears to cluster near night-life venues (Abbey, 2011; Brady & Li, 2013; Gerell and Kronkvist, 2016; Murray and Roncekm, 2008; Conrow, Aldstadt and Mendoza; Favarin, 2018) and transit stations (Salguerio & Dulgado, 2017; Favarin, 2018) because they imply a concentration of people (and offender-target convergences).

Also based on prior research and environmental criminological theory, this study hypothesized that violent crime would peak significantly during summer months as aggregate routine activities shift and produce concentrations of people outdoors. However, violence in Oslo and Bergen does not appear to fluctuate substantially across seasons. Similar to its spatial counterpart, also temporal variations in crime patterns appear to be most significant on the small-scale level (i.e. across the week and across hours of the day). This finding is relevant in regard to crime prevention efforts, which will be discussed in a later section.

Evidence strongly suggests that exploring micro-spatial and temporal patterns of violence can yield valuable insights into the patterns of violence that are otherwise obscured using larger spatial scales. As was expected based on prior literature, results illustrated that the temporal patterns of high-crime areas in Oslo and Bergen may vary greatly from one hot spot to another. More specifically, results indicate that these fluctuations largely reflect the underlying function of the location in question. The detail available in the dataset revealed

that in the inner cities of both Oslo and Bergen, primary clusters of violence occur during nighttime in typical night-life zones, and *secondary* clusters are found during the day in typical high-traffic areas. In other words, violence is found to cluster most significantly during nighttime in typical night-life zones, followed by clusters to a lesser extent during the day in typical commercial, high-traffic areas. Some locations appeared to exhibit multiple functions, and violence festered across temporal scales accordingly. Put differently, some places experienced relatively stable patterns of crime throughout the course of a day, week and season, whereas other areas experienced significant spikes in violence only during certain times. These findings corroborate those of Nelson, Bromley and Thomas (2001) in their study of inner city violence in the U.K.

Despite hot spots differing in the degree of temporal fluctuation, even the most crime-ridden locations experienced notable temporal fluctuations. As mentioned in an earlier chapter, this is a finding that scholars are beginning to highlight the importance of allocating more attention to (Haberman, Sorg & Ratcliffe, 2017). Present findings illustrate that analysis of temporal information *in conjunction* with spatial information can enable one to identify a distinction between day-time related violence and violence assumingly related to night-life.

As was mentioned earlier, violence in Oslo and Bergen was found to be predominantly night-life fueled in the inner city centres. Recall from an earlier chapter discussing environmental theories of crime, that the city centres in both Oslo and Bergen were expected to experience night-life related violence due to the magnitude of night-life venues clustered here. It was argued that the presence of night-life venues would attract great amounts of people to the city centre and that these concentrations of people would ultimately facilitate great amounts of offender-target convergences, causing violence. Results support this notion. Further, based on the same mentality, violence was expected to flourish in areas presenting opportunities shopping or leisure activities (i.e. places facilitating great concentrations of people). Results revealed such a tendency to be present, but largely overshadowed by night-life related violence in hot spots where functions of night-life *and* retail or daytime leisure coincide.

In addition to the above expected crime concentrations based on offender-target convergences, violence was, based on the same mentation, also expected to cluster at or near major public transport stations. Additionally, based on temporal constraint theory – violence was expected to concentrate at times when temporal constraints were active. Findings allocated only mixed support for this. First, in line with initial expectations, between

approximately 07:00 and 08:00, correlating with the time when citizens leave for work, violence increases in the city centres especially; where workplaces are more densely concentrated. Second, also in line with initial expectations, violence increases between approximately 16:00 and 17:00, when the aforementioned citizens commence their journey home from work. These times of the day represent times when motivated offenders (individuals who possess criminal inclinations and the ability to act on these inclinations) and suitable targets (e.g. people traveling to work) converge in time and space near major public transit stations.

It was also expected that crime would peak at times when both temporal constraints related to night-life venue closing times *and* public transport departure times were active simultaneously. More specifically, it was theorized that crime would concentrate in close proximity to night-life venues during closing times (here, between approximately 02:30 and 03:00), and at public transport stations as time continued to pass. This study found crime patterns that support the general mentality of this application of temporal constraint theory, but for an *earlier* time period than anticipated. That is, identified hot spots that were situated at or in immediate vicinity to night-life venues typically experienced a peak in violence between 01:00 and 02:00, whereas nearby public transport stations experienced crime at approximately 03:00. In other words, the general idea of temporal constraints causing crime to cluster in the immediate vicinity to night-life venues *first*, then concentrating at or near public transport stations *later* as temporal constraints shift, was supported.

The tendency of these concentrations to fester earlier than expected (i.e. earlier than most venue closing times) indicates that perhaps the greatest offender-target convergences do *not* occur during venue closing times. Instead, it appears as though the vast majority of patrons leave the premises *before* doing so is mandatory (perhaps in order to catch the last bus). If one is to accept that most patrons leave the premises before doing so is mandatory, the temporal constraint earlier attributed to night-life venues' closing times is no longer valid and thus not of value in explaining concentrations of violent crime. When patrons themselves decide to leave prior to closing times, this action itself cannot be attributed to venue closing times. Thus, the temporal constraint of night-life venue closing times does not appear to explain the observed concentration of violence in close proximity to these venues between 01:00 and 02:00. Alternatively, the clusters seen at night-life venues between 01:00 and 02:00 may stem from patrons leaving to catch the last bus home. The hypothesized temporal constraints related to public transport departure times thus appear to remain valid. The

number of departures are fewer during nighttime, rendering planning and reaching public transport in due time to still be of reasonable concern, regardless of whether patrons leave their respective venues at 01:00 or 03:00. Thus, because a vast majority of patrons are (in light of current findings) thought to leave night-life venues between approximately 01:00 and 02:00, a clustering at nearby transport stations at approximately 03:00 is, in light of temporal constraint theory - to be expected. In addition, several places of public transit stations coincide with taxi stands. Thus, late night clusters of violence seen in these places may well be reflecting violence stemming also from taxi queues. Future studies in other cities should further examine the suggested (lack of) temporal constraints related to night-life venue closing times as well as public transport or taxi departure queues on the clustering of violent crime in order to corroborate these findings.

As the present study examined crime maps of Oslo and Bergen at one point in time (using aggregate measures of violent crime spanning from late 2015 to mid-2018), the study was not able to comment on the degree to which the identified hot spots and their corresponding temporal trends remain stable over time. However, assessing the stability levels of identified high-crime areas is fruitful in regard to crime prevention efforts. Thus, in order to examine the degree to which these high-crime areas remain stable over time, further longitudinal analysis of the spatial concentrations of violence in Oslo and Bergen is warranted – and should be addressed in future research. Scholars should also examine the micro-spatial and temporal patterns of other crime types. As was noted earlier in this paper, both spatial and spatial-temporal patterns are thought to vary for different crime types – and crime prevention methods, therein hot spot policing, may benefit from tailoring prevention methods to the specific crime type in question. Implications for crime policy will be revisited in more detail below. In the interim, results of *research objective 2* will be discussed.

Objective 2: Testing the Effect of Environmental Factors in Explaining Concentrations of Violent Crime

This research objective represented an attempt at analyzing the effects of particular environmental factors in explaining concentrations of violent crime on the micro-geographic level in Oslo and Bergen. Results indicate that such environmental factors (here major roads, public transit stations, residential and commercial land use) play an integral role in explaining these crime concentrations. Generally, commercial areas (typically including the presence of retail shops and licensed premises) and transit stations are seen to be related to an increase in violent crime in both cities. This somewhat corroborates the finding of Favarin (2018) in her study of, inter alia, violent crime at the street-segment level in Milan, Italy. Interestingly, certain environmental factors were found to impact concentration levels differently across the two cities, especially so for that of major roads and residential areas. Results indicate that for violent crime at least, the *same* variables drawn from environmental criminology may affect crime concentrations differently depending on the context. More specifically, study results indicate that they operate differently in continuous and discontinuous urban settings (Oslo and Bergen, respectively). In order to gain a better understanding of how these variables may have differing effects depending on the contexts in which they operate, future research should examine the effect of these environmental factors on the micro-spatial concentrations of violence in cities of diverging urban settings. In addition, it seems reasonable to suggest that additional environmental factors that were not available for analysis in this study, but that are evidenced to be closely related to violent crime (e.g. bars, pubs, night clubs and restaurants), would contribute significantly in explaining the observed concentrations. In light of this, future analysis of the clustering of violence at micro-places should aim to also incorporate such 'crime-type specific factors'.

As stated throughout this study, research on spatial-temporal crime patterns is notably lacking. The present study's mapping of the spatial distributions of violent crime and related temporal patterns presents an attempt to address the lack of research in this area, and valuable insights have been made. However, the earlier finding regarding the tendency of violent crime to exhibit different temporal patterns in different locations strongly suggests, as Bromley, Nelson and Thomas (2001) and Favarin (2018) have argued, that features in the environment not only influence the spatial patterns of crime, but also their spatial-*temporal* patterns. As

emphasized by other scholars in the field (Haberman, Sorg & Ratcliffe, 2017; Nelson, Bromley & Thomas, 2001; Ratcliffe, 2006) – since research on spatial-temporal crime patterns is so vastly under-researched, it is especially important to formulate research questions that incorporate spatial-temporal factors. The present study examined the effect of various environmental factors on the *spatial* concentrations of violence. However, in order to further advance our understanding of spatial-temporal crime patterns, one may extend examinations to also assess the effect of such environmental features on the spatial-*temporal* patterns of crime. In other words, the field could benefit from formulating research questions that ultimately examine which independent variables affect the spatial concentrations of crime *across different temporal periods*. Such analysis would allow for the spatial-temporal theorizations derived from environmental criminology as discussed throughout this paper to be supported empirically. To illustrate, one could for instance empirically assess whether the clustering of retail-shops (theorized to attract large numbers of people, thus facilitating offender-target convergences) is limited mainly to certain within-day or across-week periods. If temporal factors are as important in explaining crime concentrations as scholars are beginning to suggest, this should also be supported empirically. Thus, the independent variables assessed in this study should in future research be utilized to examine *which* independent variables influence the clustering of violence across *different temporal scales.*

Recall from an earlier chapter that crime concentrations examined on larger geographical scales (like neighborhoods and communities) are oftentimes explained utilizing theories of social disorganization (Shaw & McKay, 1969). Recently, scholars have begun suggesting that these theoretical perspectives may also explain crime on the micro-geographic level (see Groff, 2015 and Weisburd, Hinkle, Famega & Ready, 2012). Ultimately, recent studies within the criminology of place literature have attempted to combine environmental theories and social disorganization theories in explaining crime at micro-geographic locations (Dugato, 2014; Favarin, 2018; Weisburd & Amram, 2014). In light of such an integrated theoretical approach, crime at micro-places can be thought to be influenced both by physical features of the place (e.g. prevalence of targets and guardians) *and* by contextual factors of the particular place in question (e.g. level of collective efficacy and socioeconomic characteristics (Braga & Clarke, 2014; Favarin, 2018; Weisburd et al., 2012)). In light of this, future studies of violence at micro-places should also seek to employ integrated theory in attempting to enrich our understanding of its determinants. In addition, if spatial-temporal crime patterns are deemed valuable to gain an understanding of, which the present study among others

strongly suggests, then this integration of theoretical perspectives should also consider temporal factors. Social disorganization factors, akin to environmental factors, should be elaborated to also delineate how they operate across different temporal scales. In sum, future research on the determinants of clustering of violence at micro-places should aim to: (1) Examine the effect of environmental factors on the micro-spatial concentration of violence in cities of diverging urban settings. (2) Incorporate more crime-type specific environmental factors in analysis (e.g. licensed premises). (3) Apply an integrated theoretical approach, and (4) delineate how both environmental factors and social disorganization factors operate across different temporal scales.

Objective 3: Testing the law of crime concentration in Oslo and Bergen

The present study assessed the validity of the law of crime concentration (Weisburd, 2015). In doing so, six contributions were made. (1) The law was assessed in two major Norwegian cities. (2) The law was assessed utilizing the same types of data and unit of analysis (police incident data and grid-cells) in both cities. (3) The validity of the law was assessed utilizing a disaggregated measure of crime: violent crime. (4) The study employed an unconventional operationalization of micro-place (grid-cell). (5) The law was assessed across three different temporal scales, of which, as far as is known to the author – has only been done once in the literature to date, and (6) the study employed two different calculation methods.

As Weisburd (2015) and other developers of the law have neglected to specify clear criteria for corroboration and falsification of the law, therein whether concentration levels should be calculated based on all grid-cells in a city (prevalence) or only grid-cells that have experienced at least one crime (frequency) - this study measured crime concentration levels for both. As noted in the presentation of results, the stronger concentration levels observed in measuring concentrations based on prevalence is thought to be a result of employing higher numbers as denominators. In other words, the higher the number employed as the denominator, the smaller (i.e. stronger) the resulting concentration levels. It is important to note that when utilizing *all* grid cells (i.e. also those with zero-counts of violence), this means that grid-cells encompassing, inter alia, thick forestation, mountains and small lakes, are taken into account in calculating concentration levels. However, these areas typically reflect places in which violent crime rarely or never occur. This is an issue one encounters in utilizing grid cells as the unit of analysis of micro-place. In employing street-segments, such ‘inaccessible

areas' are avoided as street-segments are contingent on precisely that – streets facilitating access. Thus, measuring crime concentrations based on prevalence (whilst also employing grid-cells as the unit of analysis), means that one includes a number of places in which it is highly unlikely that violence has occurred – considerably increasing the number of zero-counts which in turn causes a spike in concentration levels.

As for the larger variation in concentration levels seen in Bergen depending on measure of prevalence or frequency, this is likely connected to its urban setting. As stated throughout this paper, the urban setting inherent to the municipality of Bergen deviates significantly from that of Oslo in that multiple, far-stretched areas are covered in forestation, mountains or otherwise natural-land areas. In other words, there are more grid-cells here that do not experience crime, compared to that of Oslo. Acknowledging this, many of these natural-land areas were discarded from analysis in an attempt to exclude areas of little or no population. This alteration only affects the prevalence method of measurement (as only this method includes such zero-count cells that were discarded). Thus, results should be interpreted keeping in mind that much of the natural-land areas with zero-counts of violence (potentially causing a spike in concentration levels) have already been excluded prior to analysis. Put differently, one could expect even greater concentrations of violence for a prevalence measure if this was based on an unaltered version of the borders in Bergen.

Even despite these alterations of borders, natural land areas are still much more prevalent in Bergen than in Oslo. Consequently, concentration levels may appear stronger when including these areas in calculation of the spatial concentration of crime. Put differently, it seems plausible to suspect that such a discontinuous urban structure as Bergen exhibits may accentuate crime concentration levels due to the inclusion of numerous grid-cells in which violent crime practically does not occur. It therefore seems reasonable to argue that a measurement based only on crime-ridden cells (frequency) yields the most informative and useful results when assessing the law using grid-cells as the unit of analysis, especially in regard to crime prevention efforts and in order to facilitate meaningful comparison of concentration levels across cities of diverging urban settings. In conclusion, employing grid-cells as the unit of analysis whilst also measuring concentrations based on prevalence may result in overstating concentration levels, especially so in cities where such natural-land areas are more common (e.g. Bergen). Therefore, this paper argues that in employing grid-cells as the unit of analysis, frequency measures are the most appropriate. Hence, the remainder of the discussion will focus solely on results presented based on frequency measures.

Having established frequency measures as the most appropriate form of measurement in this study, it is important to note that both versions of measurement have their weaknesses and thus neither method is perfectly accurate. Prevalence measures typically include *too many* grid-cells (i.e. places where crime practically does not occur), whereas frequency measures typically include *too few* grid-cells (e.g. excluding those were violence may have occurred).

The Law of Crime Concentration: Applicable across All Cities?

Weisburd, in his initial study of eight cities (seven U.S cities and one non-U.S city), stated the following about the potential proposal of a law of crime concentration: "If we find strong consistency across such a diverse group of cities, then it is reasonable to draw an inference regarding the *general application* of a law of crime concentration at place" (Weisburd, 2015 p. 139). Although the cities comprising his research sample did exhibit vastly different characteristics (e.g. population size, crime rates, social characteristics), it seems unreasonable to argue that inferences can be drawn regarding a general application of the law based on a study in which seven out of eight sample cities were located within *one* country: the U.S. The geographical differences between the sample cities were anything but vast when discussed in the context of making inferences regarding a general application of the law. Nevertheless, upon presenting his study results, Weisburd (2015) expresses the following:

> I have focused on a first law of the criminology of place - the law of crime concentration at places. I have presented new evidence showing that the law applies with startling consistency both across cities and within cities across time. The data suggest that the law of crime concentration is a "general proposition of universal validity" (Sutherland, 1947:23), analogous to physical laws observed in the natural sciences. (p. 151).

In addition, scholars have recently stated that "the law of crime concentration at place has become a criminological axiom and the foundation for one of the strongest evidence-based policing strategies to date" (Carter, Mohler & Ray, 2019, p. 1). Undoubtedly, these are bold statements, and such claims of general validity necessitate replication studies across a magnitude of different settings (Hardyns, Snaphaan & Pauwels, 2018). The present study, by extending the law to a new country, represents an important step towards expanding our knowledge regarding the generalizability of the law.

This study does not allocate full support for the law of crime concentration. As was shown, only the percentages of grid-cells experiencing 25% of all violence aligned with the bandwidth percentages previously established by Weisburd (2015). This was the case for both cities. It is observed however, that the bandwidth percentages observed in the current study appear to align *better* with those reported by Weisburd for very populous cities, both for 25% and 50% of violence. Weisburd defined populous cities as those comprised of 300,000 or more inhabitants (Weisburd, 2015). Recall that Oslo and Bergen reflect populations of 681,071 and 281,190, respectively. Thus, Oslo and (almost) Bergen classify as 'large' cities according to Weisburd. Weisburd's more populous cities in which concentration numbers have been reported include Cincinnati, U.S. and New York, U.S, of which (in 2015) exhibited populations of approximately 300,000 and 8,000,000, respectively. Here, 25% of crime was found to concentrate at 1.6% of street segments, whereas 50% of crime was found to occur in 6% of street segments. Less populous cities (in which stronger concentrations were found) included Ventura, U.S and Redlands, C.A, both counting less than 110,000 inhabitants. In the latter, the percentages of street segments accounting for 25% and 50% were reported as 0.4% and 2.1%. Recall that 1.5% of grid-cells in Oslo accounted for 25% of violence, whereas 8.6% of grid-cells accounted for 50% of violence. It is clear then, that concentration levels reported do align *better* (but not perfectly) with those reported by Weisburd for larger cities, supporting the notion that more populous cities experience slightly weaker concentrations. Overall, adopting a strict 'as defined by Weisburd in 2015' definition of the law's bandwidth percentages, - concentration levels for 25% of all violence align well, and concentration levels for 50% of all violence slightly exceed it.

Approximately one year after the proposal of the law, Weisburd et al. (2016) 'concretized' the law by adjusting the upper-limits of the respective bandwidths. According to the revised version of the law in 2016, 50% of crime occurs at approximately 4% of micro-places, whereas 25% of crime occurs at approximately 1.5% of micro-places. Comparing present results with these new thresholds renders Oslo's percentage of micro-places accounting for 50% of violence (8%), *double* that established by Weisburd et al. (2016). Bergen's percentage of micro-places accounting for 50% of violence exceeds it by 2.3%. These results indicate even greater non-compliance with the law.

In addition to the discontinuous urban setting potentially accentuating the degree of spatial concentration of violence in Bergen, it seems plausible to suggest that the stronger concentration levels observed are also somewhat related to the spatial distribution of *crime attractors*. As was established in pursuing *research objective 1*, the majority of violence both in Oslo and Bergen appears to be night-life related. It seems reasonable to suggest that concentration levels were seen to be stronger in Bergen as opposed to Oslo due to a stronger concentration of crime attractors (night-life venues) in the former city. Indeed, venues of night-life entertainment are much more (geographically) widespread in Oslo[14]. This also appears to explain why concentration levels are strongest for the within-day period of 'nighttime' (i.e. when these crime attractors are active). Thus, it seems reasonable to suggest the cities' significant differences in the clustering of crime attractors may partly explain also their differences in concentration levels of *reported violence.*

As discussed throughout this paper, night-life venues are thought to attract violent crime; hence the value of discussing them in relation to concentration levels of violence. However, crime attractors differ across crime types. Burglary, for instance, would likely not cluster near night-life venues as crime attractors for burglary involve poorly secured homes or areas of low neighborhood surveillance, for example (Favarin, 2018). In other words, because different crime attractors (for different crime types) are differently distributed within a city, such differing crime attractors would likely also facilitate different levels of crime concentrations for the crime types that they attract. To illustrate, if one were to examine concentration levels of burglary in Bergen, these may not concentrate as strongly as violence – because its related crime attractors are not as significantly concentrated as night-life venues in Bergen are. This illustrates how, due to differing crime attractors and their varying degrees of presence in different cities - different crime types may exhibit differing levels of concentration.

The aforementioned observations are valuable for two reasons. First, it is implied that crime concentration levels may vary across cities. Since evidence from Oslo and Bergen suggest cities can exhibit different patterns of crime attractors, and this is thought to influence subsequent crime concentration levels - it seems unlikely that Weisburd's law will be applicable across *all* cities. Second, it suggests that concentration levels may differ according to crime type examined and thus perhaps individual crime types should be attributed unique bandwidth percentages that fit the particular crime type in question. Scholars should test the

[14] The concentrations of night-life venues in each city were manually examined using www.google.com/maps

law in different cities and for different crime types in order to better understand the extent of these variations and if falsification or refinement of the law is truly warranted.

As with the general assessment of the law discussed above, it was also found to fail for all three temporal scales examined. This finding deviates significantly from that of Haberman, Sorg and Ratcliffe (2017) who were the first to examine, and allocate support for the law across these temporal scales. Contrary to Haberman, Sorg and Ratcliffe (2017), the findings of the present study contradict the suggestion that 'lower data volume equals lower concentration percentages' as was noted in the presentation of results. In the present study, lower data volume resulted in *greater* concentration percentages - perhaps indicating that data volume is *not* a valid predictor of bandwidth percentages. Despite present findings not being able to allocate support for a law of crime concentration neither for a general application nor across different temporal scales, results did demonstrate that the spatial concentration levels of violent crime vary significantly across within-day periods, night-time being the specific within-day period of greatest spatial concentration. This was the case for both cities. Further, it was recognized that degree of concentration varied much more across temporal scales in Bergen than in Oslo, suggesting that concentration levels across temporal scales are not consistent across cities. These findings only further strengthens the aforementioned suggestion that time should be considered a vital factor to take into account upon researching the criminology of place.

Lack of Criteria for Corroboration and Falsification of the Law

Chalfin, Kaplan and Cuellar (2019, p. 5) stated that "the law of crime concentration holds, to a reasonable degree, in every city in which crime concentration has been studied". Thus, presenting the current results marks the present study as one of the first to have assessed the law and not fully allocate support for such a law of crime concentration. Two possible reasons explaining this have been identified. First, crime concentrations are inherently weaker in Oslo and Bergen. Second, the reporting practices of other studies assessing the validity of the law are oftentimes characterized by ambiguity. Indeed, concerning the latter, several studies (Andresen, Curman and Linning, 2017; Favarin, 2018: Hardyns, Snaphaans & Pauwels, 2018; Schnell, Braga and Piza, 2017), have reported finding concentration levels that (similar to the present study) exceed those earlier established by Weisburd (2015). However, despite observing higher concentration percentages (i.e. weaker concentrations) than those defined by

the law, studies oftentimes allocate support for the law regardless. For instance, Favarin (2018), assessing the law in Milan, Italy, allocated support for the law despite reporting 50% of burglary to occur at 8.2% of street segments (exceeding the newly concretized bandwidth percentages by more than 4%). In fact, Favarin confidently stated that "*despite their differences, cities around the world share the same crime concentration"* (Favarin, 2018 p. 702). Interestingly, the percentages reported in Favarin's study are strikingly similar to those of the present study, yet the former allocated full support for the law.

It seems reasonable to suspect that the aforementioned ambiguity stems, at least in part, from the fact that Weisburd (2015) and other developers of the law have failed to specify the criteria both for corroboration and falsification of the law. As stated by Hardyns, Snaphaans & Pauwels (2018), without explicitly stating such criteria, no precise testing is possible. In the absence of such criteria, scholars roam much more freely in their interpretation of results. One might argue that it is reasonable to allocate support for the law when the reported percentages exceed the law only by a mere 4%. However, when the very principle of the law is the fact that "bandwidth percentages are *very* narrow" (Weisburd, 2015 p. 143), and that only a "*very small* percentage of micro-places account for a disproportionate amount of crime" (Weisburd, 2015, p. 143), how much deviation from pre-established bandwidth percentages can be accepted before the law loses its stateliness? In a similar vein of thought, if studies continuously report concentrations that exceed these bandwidth percentages, is the law really suitable for a 'general application' as Weisburd (2015) proclaims? It seems plausible to expect that if specific criteria for corroboration and falsification of the law is made readily available, more studies will emerge which are not as clearly in favor of the law.

Considering both the non-supportive findings of the present study and the aforementioned issue of prior studies allocating support for the law despite finding crime concentrations that exceed those established by Weisburd - it appears as though the law does not accurately reflect crime trends in *every city,* and should thus either be falsified or refined. If the latter, this may involve establishing bandwidth percentages that are more inclusive. However, in the hypothesized situation where the law is refined to now exhibit wider bandwidths, ultimately allowing for weaker concentrations – how much would the implications of such a proposed law differ from what we already know? The fact that a 'relatively small proportion' of all places contain most crime is by no means new information in the field of criminology. Research has shown that crime tends to concentrate in micro

places for *decades* (Johnson, 2010; Sherman, 1989; Weisburd, 2012). How novel of a discovery is the law of crime concentration then? These are considerations future studies assessing the validity of the law should concern themselves with. Future research should also strive to establish clear criteria for testing in order to better determine whether results are consistent with the law. In sum, this study advocates for a modified version of the law in which no particular bandwidth percentages are guaranteed, along the lines of *only a small proportion of all micro-places in a city contain the majority of crime.*

Implications for Crime Policy

As mentioned in the introduction of this paper, both police districts in Oslo and Bergen face challenges regarding the use of resources for combatting crime. That is, departments strive to operate as effectively as possible with the lowest possible costs of doing so – particularly through a reduced number of police officers on duty. Findings from the present study have revealed patterns of violence in Bergen and Oslo which can inform crime prevention strategies in the search for optimizing cost-effectiveness in policing. First, evidence has confirmed that violent crime in Oslo and Bergen occurs at very few micro-places overall. Although the law of crime concentration was not fully supported in terms of results not consistently falling within the pre-established bandwidth percentages, it is still recognized that violent crime in both cities concentrates in a small number of micro-places, and the degree of this concentration appears to remain fairly stable across years. The crime maps presented an initial attempt at establishing knowledge regarding precisely where these high-density micro-places are located. In sum, findings support the saying that "police do not need to put a cop on every corner" in combatting violent crime in Oslo and Bergen. Rather, employing strategies of hot spot policing to these few micro-places that account for a disproportionate amount of violence appears to offer greater crime-control benefits, both in regard to crime control itself and related costs. Indeed, studies have suggested that police may spend as little as 15 minutes at identified hot spots every 2 hours in order to reduce crime (Koper, 1995; Telep, Mitchell & Weisburd, 2014).

Although studies have suggested that police may efficiently police hot spots by being present for 15 minutes every 2 hours, the findings of this study indicate that police may tailor their efforts to operate even more cost-efficiently. As discussed above, despite the law of crime concentration not holding across multiple temporal scales, important spatial-temporal observations of violent crime concentrations have been reported of which should further

interest the proponents of hot spot policing. The finding that violence concentrates in much fewer micro-places during nighttime can inform law enforcement of which areas to focus police resources to when nighttime arrives. Likewise, in Bergen, since micro-places accounting for 50% of violence is almost halved during weekends – it seems plausible to suggest that police may tailor resources more efficiently to predominantly target these specific areas at this particular time rather than targeting also the micro-places that are predominantly affected by violence solely during the workweek, for instance. Since, similar to that of spatial patterns, also temporal variations appear to be most significant on the smaller scales (across-week and within-day periods), it seems reasonable to suggest that police should focus their attention to variations within these smaller temporal scales. In other words, police may consider tailoring their resources according to times of the week and day in which violence has shown to concentrate.

In addition, present findings suggest that law enforcement may benefit even further by taking into account the temporal fluctuations *within each identified hot spot*. The finding that temporal patterns vary greatly within each identified hot spot, and across hot spots in relatively close proximity to one another supports the notion that police may be able to refine strategies of hot spot policing - to utilize their resources more efficiently by accounting for the temporal patterns *within* individual hot spots. This way, law enforcement in Oslo and Bergen may not only limit their crime prevention efforts to certain micro-geographic hot spots in the city, prevention efforts in these locations may also be specifically tailored to times where crime has shown to peak within each particular hot spot – minimizing cost whilst maximizing benefit. It should be noted that police departments both in Oslo and Bergen likely already harbor some experience-based knowledge regarding the presence of hot-spots in the respective cities and attempt to allocate their resources accordingly. Thus, findings of the present study should be viewed as a potential supplement to further deepen this understanding.

Scholars have recently argued that police engaged in the strategy of hot spot policing should do more than solely be present or practice activities of law enforcement in identified high-crime areas (Braga, Papachristos & Hureau, 2014; Haberman, Groff, Ratcliffe & Sorg, 2016; Rosenbaum, 2006; Telep & Weisburd, 2012; Sorg, Haberman, Ratcliffe & Groff, 2013). As was mentioned in an earlier chapter, such ‘superficial’ police responses usually only lead to short-term crime control benefits (Rosenbaum, 2006). Arguably, the simple observation that crime concentrates in certain locations does not justify concentrating

(limited) police resources to these areas unless police come equipped with a well-founded plan as to how to combat the problem at hand. Incorporating temporal components to the strategy so as to adjust strategies of 'being present' to reflect temporal patterns inherent to individual hot spots represents a vital point of departure. Indeed, recognizing the importance of time in the make-up of various hot spots introduces an additional theoretical approach to understanding and addressing hot spots of violence.

In addition to providing valuable information in terms of efficiently targeting scarce police resources to specific locations during particular times, results from this study may also inform initiatives of situational crime prevention. The identified areas of high crime-density and their corresponding temporal trends reflect places and times in which an alteration of physical characteristics may be especially beneficial. That is, hot spot interventions that are both tailored to particular times *and* used in combination with situational crime prevention methods may yield promising results. Such physical alterations could for instance involve the rearrangement of or introduction of que systems at premises of nightlife, transit and retail that discourages overcrowding of people. Generally, such measures of situational crime prevention tend to be popular due to their relatively low cost (yet notable effectiveness) compared to other initiatives (e.g. employing security guards or further increasing police presence). Alternatively, installments of CCTV cameras can be tailored to key hot spot locations, and most carefully monitored during especially problematic times. Although research has shown that the presence of CCTV cameras typically have weak deterrent effects (Gerell, 2016; Marklund & Holmberg, 2015; Welsh & Farrington, 2008), the installment of such cameras in problematic micro-places may aid police investigations in terms of gathering evidence (Squires, 2017). In sum, such pursuits are more likely to eliminate the crime problem on a long-term basis. Ultimately, reallocation of police resources to these locations would be unnecessary - as crime problems are now unlikely to resuscitate as a result of 'deterrence effects of random police presence wearing off '.

Recognizing Limitations of the Present Study

As for the limitations of this study, the reliability of data presents multiple points of concern. First, police incident data is oftentimes questioned due to it not taking into account the dark figure of crime (Valente, 2019). That is, crimes that are not reported to or recorded by police. This is of especial concern in regard to violent crime, as this category of crime is linked to high rates of underreporting (Levi, 1997). In other words, this dark figure of crime could hide a vital proportion of actual violence in Oslo and Bergen. The incorporation of additional data (e.g. hospital emergency-department data or calls for service data) would be of benefit in further analysis in order to more accurately capture the spatial-temporal trends in violence.

A second limitation concerns the level of accuracy of geocoded crime events. It is recognized that crime incidents in which police are aware of the full address, namely street number, street name and postcode – the incident can be geocoded very precisely (Burgess, 2011). Nevertheless, as earlier stated in the literature review, Gerell (2017) in his study of vehicle arson in Sweden found that geocoded incidents by police exhibited a median error of 83 meters - a greater error compared to other entities that practice geocoding, arguably due to police data being based on addresses (thus focusing primarily on buildings). In other words, errors in police incident data was seen to largely reflect the difference between the location at which crime is committed and the specific addresses these crimes are ascribed to. It was argued that such errors are also likely to be found for other types of crime committed in *public areas* – such as the violent crimes examined in the present study.

Many areas like that of car parks or open squares oftentimes lack postcodes entirely, and incidents reported here may be geocoded to an alternative, nearby address instead (Burgess, 2011). This may appear as an insignificant problem as this study is not concerned with unique addresses (as the original dataset was aggregated to grid cells of 100m by 100m). However, in the case that an officer follows the practice of geocoding an unknown address to the middle of the street in question – this may push the incident from its original grid-cell to an adjacent cell, ultimately making it appear as though certain places harbor more or less crime than they actually do. Depending on the magnitude of incidents and how frequently this occurs, such practices can cause a misrepresentation of actual crime trends. As stated by Gerell (2017, p. 5), “even fairly modest errors in the geographical information used to identify such locations may have an impact”. In order to facilitate more precise explorations of crime patterns, law enforcement should strive to obtain geocoding practices that increase their accuracy. Gerell (2017) also emphasized that such errors in police data are of cogent concern

in instances where this data is analyzed to inform subsequent police strategies (typically hot spot policing), as such errors could, at worst, potentially cause an allocation of police resources to the *wrong* locations.

Also in tackling this issue may the incorporation of the aforementioned hospital emergency data be fruitful. According to Boyle, Snelling, White, Ariel and Ashelford (2013), in Cardiff, Wales, emergency-room staff collect spatial information from assault victims and share this information with police in an attempt to combat violent crime. Gerell (2017) argues that such hospital sources of data on violent crime deserves further attention in an attempt to better the accuracy of police incident data for this particular crime type. Having acknowledged this, it should be noted that police in both Oslo and Bergen do utilize experience-based information of hot spots in their attempt to police effectively. Thus, it seems plausible to argue that in cases where analysis based on inaccurate data renders police allocation to the wrong hot spots, police may utilize their experience-based knowledge in an attempt to steer prevention efforts in the right directions.

Of the variables in the dataset, the temporal component arguably provides the most reliable incident-related information. This is due to the fact that police records routinely note the date and time of incidents, and there is less ambiguity related to the recording of time than spatial information (Nelson, Bromley & Thomas, 2001). A police officer assigning a wrongful location to a crime event is more likely to occur than a police officer recording the wrong *day* of the occurrence. In addition, recorded dates and times of the crime occurrences are of higher accuracy for violent crime compared to that of many other crime types, as the victim is present during the act - often able to register, in the very least, an approximate timing of the offence (Haberman, Sorg & Ratcliffe, 2017). Having noted these limitations and their potential adverse effects on research outcomes, police incident data was, despite its deficiencies among the most reliable sources of data for this project. Many studies of violent crime are based solely on victimization survey data or hospital emergency department data, which are often less reliable (Nelson, Bromley & Thomas, 2001).

7. CONCLUSION

This study, focusing on the cities of Oslo and Bergen, has responded to a call for more rigorous assessment of crime concentrations at the micro-place level in Europe - placing overt attention to the interaction of space *and* time in understanding concentrations of crime. In doing so, the paper has illustrated the valuable insights that can be derived from engaging in an exploration of spatial-temporal patterns of violence at the micro-geographic level, as opposed to larger-scale analysis. First, violent crime was mapped on the 100m by 100m grid-level, confirming that violence is unequally distributed across space and time. Violence in the inner cities was characterized by *primary clusters* during typical night-life hours and *secondary clusters* during daytime. Areas transcending that of the inner city were typically characterized by a lack of night-life related violence. The temporal patterns within identified hot spot areas were found to be largely related to the underlying functions of the hot spot locations in question, and importantly, it was suggested that these functions may transform across temporal scales. Thus, temporal patterns varied significantly across city-subsets, within city-subsets and within small geographic hot spots. It is apparent that even in the most crime-ridden places, temporal patterns will, due to their inherently dynamic nature fluctuate throughout the course of the day, week and season. In addition, night-life related violence was found to peak earlier than initially expected based on a discussion of temporal constraint theory, and consequently, night-life venue closing times were argued to pose weak temporal constraints on patrons.

This study also contributed to extant literature in assessing the effect of environmental factors derived from environmental criminological theory in explaining the crime concentrations that were observed in Oslo and Bergen. It was found that the presence of major roads, transit stations, commercial land use and residential significantly contribute in explaining the clustering of violence at the grid-cell level. This was the case for both cities. However, these environmental factors were seen to affect violence differently across the two cities, arguably due at least in part to the differing urban settings between the cities. It is argued that future studies should assess these environmental factors on the micro-spatial patterning of violence across different urban settings in order to facilitate a deeper understanding of the ways in which the same variables may operate differently for the *same* crime type across *different urban settings*. Further, it is essential to recognize that the prevalence of violence in both cities appears to be a result of a wide interplay of factors, and

cannot be attributed to any single causal factor. In light of this, the present study suggests future research should incorporate also theories of social disorganization in attempting to explain micro-geographic clustering of violence - and also delineate the way in which elements of such an integrated theoretical approach operate across different temporal scales. Such pursuits may yield more in-depth knowledge regarding the dynamics of crime at place, of which it has been argued is highly important in striving to establish more effective policing strategies. As several scholars stress, addressing hot spots of crime (therein violent crime) without detailed knowledge regarding the factors that contribute to and sustain the hot spots in question will likely only yield short-term crime control benefits. Consequently, increased police resources will likely have to be reallocated to the same hot spots as they continue to reemerge. Undoubtedly, this is a costly form of crime prevention police departments should strive to lessen.

Finally, this study tested aspects of the law of crime concentration recently posed by Weisburd (2015). In comparing findings to prior research, two conclusions stand out. First, crime concentrations appear to be stronger in Bergen, conceivably in part due to its discontinuous urban setting, thus corroborating the conclusion reached by (Valente, 2019) in his analysis of robbery and homicide concentrations in Florianópolis, Brazil – namely that a discontinuous urban setting may accentuate crime concentrations. Second, the law of crime concentration did not hold in either city, neither for a general measure nor across the three temporal scales assessed, thus contributing to the question of the law's true generalizability. Future studies should dwell more on the issue relating to the lack of specific criteria for corroboration and falsification of the law (therein the issue of frequency versus prevalence measures) in order to be able to truly assess its validity.

Despite the present study not allocating support for a law of crime concentration, it is essential to recognize the valuable information that an assessment of crime concentration levels at micro places can yield. For instance, analyses suggest that crime prevention efforts may focus on a small number of problematic micro-places where the majority of all violent crime is committed. Further, the sizeable variations in concentration levels observed between Oslo and Bergen, especially across the three temporal periods examined highlights the merit of implementing hot spot policing strategies that are specifically tailored to address *certain hot spots* during *certain times.*

Overall, in light of the present findings signaling the micro-place as a valuable unit of analysis of violence in urban areas, especially in regard to identification of problem areas and the following implementation of crime prevention strategies - it is highly suggested that also future research should adopt a micro-analytical approach in order to facilitate a more profound understanding of the micro-dynamics of violent crime. A myriad of research questions regarding the micro-spatial and temporal patterns of crime remain and deserve investigation. For instance, additional research is needed that deepens our theoretical understanding of why violent crime concentrates in micro-geographic locations during specific times of the day, week and year. Further, given the general lack of research on micro-spatial and temporal patterns of crime, researchers should aim to study these patterns also for other crime types and in other cities, and also here aim to formulate research objectives that more deeply consider *time*.

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REFERENCE LIST

Abbey, A. (2011). Alcohol's role in sexual violence perpetration: Theoretical explanations, existing evidence and future directions. *Drug and Alcohol Review,* 30(*5*), 481-489. doi: 10.1111/j.1465-3362.2011.00296.x

Acock, A. C. (2012). *A gentle introduction to stata.* Texas: Stata Press.

Altman, D. G. (1980). Statistics and Ethics in Medical Research: Misuse of Statistics is Unethical. *British Medical Journal*, 281 (*6249*), 1182-1184. doi: 10.1136/bmj.281.6249.1182

Andresen, M., Curman, A., & Linning, S. (2017). The Trajectories of Crime at Places: Understanding the Patterns of Disaggregated Crime Types. *Journal of Quantitative Criminology,* 33(*3*), 427-449. doi: 10.1007/s10940-016-9301-1

Andresen, M.A., & Malleson, N. (2011). Testing the stability of crime patterns: implications for theory and policy. *Journal of Research in Crime and Delinquency,* 48(1), 58-82. doi: 10.1177/0022427810384136

Andresen, M.A., & Malleson, N. (2013). Crime seasonality and its variations across space. *Applied Geography*, 43(*11*), 25-35. doi:10.1016/j-apgeog.2013.06.007

Bayley, D.H. (1994). Future for the police. *European Journal of Crime, Criminal Law and Criminal Justice*, 5(*4*), 427-430.

Bernasco, W. (2010). Modeling micro-level crime location choice: Application of the discrete choice framework to crime at places. *Journal of Quantitative Criminology*, 26(*1*), 113 –138. doi: 10.1007/s10940-009-9086-6

Bernasco, W., Bruinsma, G. J. N., Pauwels, L. J. R., & Weerman, F. M. (2013). Adolescent delinquency and diversity in behavior settings. *Australian & New Zealand Journal of Criminology*, 46(*3*), 357–378. doi: 10.1177/0004865813490949

Bernasco, W. & Steenbeek, W. (2017). More places than crimes: Implications for evaluating the law of crime concentration at place. *Journal of Quantitative Criminology*, 33(*3*), 451–467. doi: 10.1007/s10940-016-9324-7

Bichler, G., & Balchak, S. (2007). Address matching bias: ignorance is not bliss. *Policing: An international journal of police strategy and management,* 30(1), 32-60. doi: 10.1108/13639510710725613

Bivand, R.S., Pebesma, E., Gomez-Rubio, Virgilio (2013). *Applied spatial data analysis with R*, Second edition. Springer, NY. http://www.asdar-book.org/

Block, R.L., & Block, C.R. (1995). Space, place, and crime: Hot spot areas and hot places of liquor-related crime. *Crime Prevention Studies,* 4*, 145-183.*

Boivin, R., & De Melo, S.N. (2019). The Concentrations of Crime at Place in Montreal and Toronto. *Canadian Journal of Criminology and Criminal Justice,* 61(*2*), 46-65.

Boyle, A., Snelling, K., White, L., Ariel, B., & Ashelford, L. (2013). External validation of the Cardiff model of information sharing to reduce community violence: Natural experiment. *Emergency Medical Journal,* 30(*12*), 1020-1023. doi: 10.1136/emermed-2012-201898

Bowers, K. (2014). Risky facilities: crime radiators or crime absorbers? A comparison of internal and external levels of theft. *Journal of Quantitative Criminology,* 30(*3*), 389 -414. doi: 10.1007/s10940-013-9208-z

Bowers, K., & Johnson, S. (2003). *The Role of Publicity in Crime Prevention: Findings from Reducing Burglary Initiative.* Home Office Research Study NO. 272. London: Home Office

Bowers, K. J., Johnson, S.D., Guerette, R.T., Summers, L., Poynton, S. (2011). Spatial displacement and diffusion of benefits among geographically focused policing initiatives: a meta-analytical review. *Journal of Experimental Criminology,* 7(*4*), 347-374. doi: 10.1007/s11292-011-9134-8.

Brady, J. E., & Li, G. (2013). Prevalence of alcohol and other drugs in fatally injured drivers. *Addiction,* 108(*1*), 104-114. doi: 10.1111/j.1360-0443.2012.03993.x

Braga, A. A., & Clarke, R.V. (2014). Explaining high-risk concentrations of crime in the city: Social disorganization, crime opportunities, and important next steps. *Journal of Research in Crime and Delinquency,* 51(*4*), 480–498. doi: 10.1177/0022427814521217

Braga, A.A., Hureau, D.M, & Papachristos A.V. (2011). The relevance of micro places to citywide robbery trends: a longitudinal analysis of robbery incidents at street corners and block faces in Boston. *Journal of Research in Crime and Delinquency,* 48(*1*), 7 -32. doi: 10.1177/0022427810384137

Braga, A.A., Papachristos A.V., & Hureau, D.M. (2014). The effects of hot spots policing on crime: an updated systematic review and meta-analysis. *Justice Quarterly,* 31(*4*), 633 -663. doi: 10.1080/07418825.2012.673632

Braga, A.A., Papachristos, A.V., & Hureau, D.M. (2010). The concentration and stability of gun violence at micro-places in Boston, 1980-2008. *Journal of Quantitative Criminology,* 26(*1*), 33-53. doi: 10.1007/s10940-009-9082-x

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

Brantingham, P.L., & Brantingham, P.J. (1993). Environment, Routine and Situation: Toward a Pattern Theory of Crime. In Clarke, R.V. and Felson, M. (Eds.) *Routine Activity and Rational Choice: Advances in Criminological Theory (*pp. 259-294). New Brunswick, NJ: Transaction Publications.

Bromley, R.D.F., & Nelson, A.L. (2002). Alcohol-related crime and disorder across urban space and time: evidence from a British city. *Geoforum* 33(*2*), 239-667.

Brower, A.M., & Carroll, L. (2007). Spatial and temporal aspects of alcohol-related crime in a college town. *Journal of American Collective Health*, 55(*5*), 267-275. doi: 10.3200/JACH.55.5.267-276

Bruinsma, G. J. N., Pauwels, L. J. R., Weerman, F. M., & Bernasco, W. (2013). Social disorganization, social capital, collective efficacy and the spatial distribution of crime and offenders: An empirical test of six neighborhood models for a Dutch city. *British Journal of Criminology*, 53(*5*), 942–963. doi: 10.1093/bjc/azt030

Burgess, M. (2011). *Understanding crime hotspot maps* (Report no. 60). Retrieved from: https://www.bocsar.nsw.gov.au/Documents/BB/bb60.pdf

Carter, J.G., Mohler, G., & Ray, B., White, C., (Ed.) & Weisburd, D. (Ed.) (2019). Spatial Concentration of Opioid Overdose Deaths in Indianapolis: An Application of the Law of Crime Concentration at Place to a Public Health Epidemic. *Journal of Contemporary Criminal Justice*, 35(*2*), 161-185. doi: 10.1177/1043986218803527

Ceccato, V. (2009). Crime in a city in transition: The case of Tallinn, Estonia. *Urban Studies*, 46(*8*), 1611–1638. doi: 10.1177/0042098009105501

Ceccato, V., & Oberwittler, D. (2008). Comparing spatial patterns of robbery: Evidence from a Western and an Eastern European city. *Cities*, 25(*4*), 185–196. doi: 10.1016/j.cities.2008.04.002

Chalfin, A., Kaplan, J., & Cuellar, M. (2019). Re-Examining the Law of Crime Concentration: Between and Within-City Evidence (July 19th, 2019). Retrieved from: https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3423065

Chapin, F.S. (1974). Human activity patterns in the city; things people do in time and space. New York: Wiley.

Christensen, T., Lægreid, P., & Rykkja, L. (2017). Reforming the Norwegian police between structure and culture: Community police or emergency police. *Public Policy and Administration,* 33(*3*), 241-259.

Clarke, R. V. G. (1980). Situational crime prevention: Theory and practice. *British Journal of Criminology*, 20(*1*), 136–147.

Clarke, R.V., & Cornish, D.B. (1985). Modeling offender's decisions: a framework for research and policy. *Crime and Justice,* 6, 147-185.

Cohen, L.E., & Felson, M. (1979). Social change and crime rate trends: a routine activity approach. *American Sociology Review*, 44(*4*), 588-608.

Conrow, L., Aldstadt, J., & Mendoza, N.S. (2015). A spatio-temporal analysis of on-premises alcohol outlets and violent crime in Buffalo, NY. *Applied Geography,* 58, 198-205. doi: 10.1016/.japgeog.2015.02.006

Cornish, D., & Clarke, R. (1986). *The reasoning criminal: Rational choice perspectives on offending*. New York: Springer-Verlag.

Cullen, F. T., & Kulig, T. C. (2018). Evaluating theories of environmental criminology: Strengths and weaknesses. In *The Oxford Handbook of Environmental Criminology* (pp. 160-174). Oxford University Press.

Dugato, M. (2013). Assessing the validity of risk terrain modeling in a European city: Preventing robberies in Milan. *Crime Mapping* 5, 63-89.

Eck, J. E. (1998). What do those dots mean? Mapping theories with data. *Crime Mapping and Crime Prevention,* 8, 379-406.

Eck, J.E., Chainey, S., Cameron, J.G., Leitner, M., & Wilson, R.E. (2005). *Mapping crime: understanding hot spots (Special Report).* National Institute of Justice, Washington D.C.

Favarin, S. (2018). This must be the place (to commit a crime). Testing the law of crime concentration in Milan, Italy. *European Journal of Criminology*, 15(*6*), 702-729. doi: 10.1177/1477370818757700

Felson, M., Eckert, M.A. (2016). *Crime and everyday life.* Thousand Oaks: SAGE Publications.

Felson, R.B., Savolainen J., Berg M. T., & Ellonen, N. (2013). Does spending time in public settings contribute to the adolescent risk of violent victimization? *Journal of Quantitative Criminology* 29, 273–293. doi: 10.1007/s10940-012-9179-5

Field, S. (1992). The effect of temperature on crime. *British Journal of Criminology,* 32(3), 340-351.

Gerell, M. (2016). Hot spot policing with actively monitored CCTV cameras: Does it reduce assaults in public places? *International Criminal Justice Review,* 26(*2*), 187-201. doi: 10.1177/1057567716639098

Gerell, M. (2017). Smallest is better? The spatial distribution of arson and the modifiable areal unit problem. *Journal of Quantitative Criminology*, 33, 293–318.

Gerell, M. (2018). Quantifying the Geographical (un)reliability of Police Data. *Nordisk Politiforskning,* 4(*2*) 157-171.

Gerell, M., & Kronkvist, K. (2016). Violent crime, collective efficacy and city-centre effects in Malmo. *British Journal of Criminology,* 57*(5), 1185-1207.* doi: 10.1093/bjc/azw074

Gibson, J., & Kim, B. (2008). The effect of reporting errors on the cross-country relationship between inequality and crime. *Journal of Development Economics,* 87(*2*), 247-254. doi: 10.1016/j.jdeveco.2007.12.001

Gill, C., Wooditch, A., & Weisburd, D. (2017). Testing the "law of crime concentration at place" in a suburban setting: Implications for research and practice. *Journal of Quantitative Criminology,* 33(*3*), 519–545. doi: 10.1007/s10940-016-9304-y

Goldstein, H. (1990). *Excellence in problem-oriented policing*. McGraw-Hill: New York

Groff, E.R. (2014). Quantifying the exposure of street segments to drinking places nearby. *Journal of Quantitative Criminology,* 30(*3*), 527–548. doi: 10.1007/s10940-013-9213-2

Groff, E.R. (2015). Informal Social Control and Crime Events. *Journal of Contemporary Criminal Justice*, 31(*1*), 90-106. doi: 10.1177/1043986214552619

Groff, E.R., & McCord, E.S. (2011). The role of neighborhood parks as crime generators. *Security Journal*, 25(*1*), 1–24. doi: 10.1057/sj.2011.1

Haberman, C.P., Groff, E.R., Ratcliffe, J.H., & Sorg, E.T. (2016). Satisfaction with police in violent crime hot spots: using community surveys as a guide for selecting hot spots policing tactics. *Crime Delinquency,* 62(4), 525,557. doi: 10.1177/0011128713516840

Haberman, C.P., Ratcliffe, J.H. (2015). Testing for temporally differentiated relationships among potentially criminogenic places and census block street robbery counts. *Criminology* 53(3), 457-483. doi: 10.1111/1745-9125.12076

Haberman, C.P., Sorg, E.T., & Ratcliffe, J.H. (2017). Assessing the validity of the law of crime concentration across different temporal scales. *Journal of Quantitative Criminology,* 33(*3*). doi: 10.1007/s10940-016-9327-4.

Hardyns, W., Snaphaan, T., & Pauwels, L.R. (2018). Crime concentrations and micro-places: An empirical test of the "law of crime concentration at places" in Belgium. *Australian & New Zealand Journal of Criminology,* 1-21. doi: 10.1177/0004865818807243

Hayes, A.F., & Cai, L. (2007). Using heteroscedasticity-consistent standard errors in OLS regression: An introduction and software implementation. *Behavior Research Methods,* 39(*4*), 709-722. doi: 10.3758/BF03192961

Hawley, A.H. (1950). Human ecology: a theory of community structure. New York: The Ronald Press Company.

Hibdon, J., Telep, C., & Groff, E. (2017). The Concentration and Stability of Drug Activity in Seattle, Washington Using Police and Emergency Medical Services Data. *Journal of Quantitative Criminology,* 33(*3*), 497-517. doi: 10.1007/s10940-016-9302-0.

Hipp, J., & Kim, Y. (2017). Measuring Crime Concentration Across Cities of Varying Sizes: Complications Based on the Spatial and Temporal Scale Employed. *Journal of Quantitative Criminology,* 33(*3*), 633-633. doi: 10.1007/s10940-017-9349-6

Horton, F.E., & Reynolds, D.R. (1971). Effects of urban spatial structure on individual behavior. *Economic Geography,* 47(*1*), 36-48. doi: 10.2307/143224

Johnson S.D. (2010). A brief history of the analysis of crime concentration. *European Journal of Applied Mathematics*, 21(*4-5*), 349–370. doi: 10.1017/S0956792510000082

Johnson, S.D., Bernasco, W., Bowers, K.J., Elffers, H., Ratcliffe, J., Rengert, G., & Townsley, M. (2007). Space–time patterns of risk: A cross national assessment of residential burglary victimization. *Journal of Quantitative Criminology,* 23(*3*), 201–219. doi: 10.1007/s10940-007-9025-3

Jones, K. (2000). A Regrettable Oversight or a Significant Omission? Ethical considerations in quantitative research in education. In Simons, H. & Usher, R. (Eds.), *Situated ethics in educational research (*pp. 147-161). London: Routledge.

Jørgensen, T.T. (2010). "Hot spots". En effektevaluering af Kobenhavns politis saerlige innsats mot vold i nattelivet. *Justisministeriets Forskningskontor.*

Knutsson, J., & Søvik, K.E. (2005). *Problemorientert politiarbeid i teori og praksis.* PHS-Forskning.

Koper, C.S. (1995). Just enough police presence: reducing crime and disorderly behavior by optimizing patrol time in crime hot spots. *Justice Quarterly,* 12(*4*), 649-672. doi: 10.1080/07418829500096231

LaFree, G., Dugan, L., Xie, M. & Singh, P. (2012). Spatial and temporal patterns of terrorist attacks by ETA 1970 to 2007. *Journal of Quantitative Criminology*, 28(*1*), 7–29. doi: 10.1007/s10940-011-9133-y

Lee, Y-J., Eck, J., SooHyun, O., & Martinez, Natalie. (2017). How concentrated is crime at places? A systematic review from 1970 to 2015. *Crime Science*, 6(*1*), 1-16.

Levi, M. (1997). Violent crime. In Maguire, M., Morgan, R. & Reiner, R (Eds.) *The Oxford Handbook of Criminology.* Oxford: Oxford University Press.

Levin, A., Rosenfeld, R., & Deckard, M. (2016). The Law of Crime Concentration: An Application and Recommendations for Future Research. *Journal of Quantitative Criminology,* 33(*3*), 635-647. doi: 10.1007/s10940-016-9332-7

Linneman, T.J. (2010). *Social Statistics: Managing Data, Conducting Analyses, Presenting Results.* New York: Routledge

Linning, S.J. (2015). Crime seasonality and the micro-spatial patterns of property crime in Vancouver, BC and Ottawa, ON. *Journal of Criminal Justice*, 43(*6*), 544-555. doi: 10.1016/j.jcrimjus.2015.05.007

Loukaitou-Sideris, A. (1999). Hot spots of bus stop crime: The importance of environmental attributes. *Journal of the American Planning Association*, 65(*4*), 395–411. doi: 10.1080/01944369908976070

Maltz, M.D., Gordon, A.C., & Friedman, W. (1991). *Mapping crime in its community setting: event geography analysis.* Springer: New York

Marklund, F., & Holmberg, S. (2015). Kameraovervakning på Stureplan och Medborgarplatsen. Slutrapport. BRÅ-rapport 2015:21. BRÅ: Stockholm.

Mazeika, D., & Summerton, D. (2017). The impact of geocoding method on the positional accuracy of residential burglaries reported to police. *Policing: An International Journal of Policing Strategies and Management*, 40(*2*), 459-470. doi: 10.1108/PIJPSM-03-2016-0048

Mayhew, P., Aye Muang, N., & Mirrlees-Black, C. (1993). *The 1992 British Crime Survey*. London: HMSO

Mirrlees-Black, C., Budd, T., Partridge, S., & Mayhew, P. (1998). *The 1998 British Crime Survey*: England and Wales. London: HMSO

Mirrlees-Black, C., Mayhew, P., & Percy A. (1996). The 1996 British Crime Survey: England and Wales. London: HMSO.

Murray, R.K., & Roncek, D.W. (2008). Measuring diffusion of assaults around bars through radius and adjacency techniques. *Criminal Justice Review,* 33(*2*), 199-220. doi: 10.1177/0734016808316777

Nelson, A.L., Bromley, R.D., & Thomas, C.J. (2001). Identifying micro-spatial and temporal patterns of violent crime and disorder in the British city centre. *Applied Geography*, 21(*3*), 249-274. doi: 10.1016/S0143-6228(01)00008-X

Patten, I.T., Mckenlden-Coner, J.M., & Cox, D. (2009). A micro-spatial analysis of robbery: Prospecive hot spotting in a small city. *Crime mapping: A journal of research and practice*, 1(*1*), 7-32. Rand, M.R., Sabol, W.J., Sinclair, M., & Snyder, H. (2010). *Alcohol and crime: Data from 2002-2008.* US. Department of Justice, Office of Justice Programs. Bureau of Justice Statistics, Washington.

Ratcliffe, J.H. (2000). Aoristic analysis: the spatial interpretation of unspecific temporal events. *International Journal of Geographic Information Science*, 14(*7*), 669-679.

Ratcliffe, J. (2004). Geocoding crime and a first estimate of a minimum acceptable hit rate. *International Journal of Geographical Information Science*, 18(*1*), 61-72. doi: 10.1080/13658810310001596076

Ratcliffe, J.H. (2006). A Temporal Constraint Theory to Explain Opportunity-Based Spatial Offending Patterns. *Journal of Research in Crime and Delinquency*, 43(*3*), 261-291. doi: 10.1177/0022427806286566

Ratcliffe, J. (2009). Crime mapping: spatial and temporal challenges. *Handbook of Quantitative Criminology*, 5-24.

Ratcliffe, J.H., & McCullagh, M.J. (1998). Identifying repeat victimization with GIS. *British Journal of Criminology*, 38(*4*), 651-662.

Ratcliffe, J. H., & Rengert, G. F. (2008). Near-repeat patterns in Philadelphia shootings. *Security Journal*, 21(*1-2*), 58–76. doi: 10.1057/palgrave.sj.8350068

R Core Team (2018). R: A language and environment for Statistical Computing, Vienna, Austria. URL: https://www.R-project.org/.

Rosenbaum, D.P. (2006). *The Limits of hot spots policing.* In: Weisburd, D., Braga, A.A. (ed.) Police innovation: Contrasting perspectives. Cambridge University Press, New York.

ResSegr (2018). Residential segregation in five European countries. A comparative study using individualized scalable neighborhoods. Interactive maps. Department of Human Geography, Stockholm University, Department of Sociology and Human Geography, University of Oslo, and Statistics Denmark.

Rosser, G., Davies, T., Bowers, K., Johnson, S., & Cheng, T. (2017). Predictive Crime Mapping: Arbitrary Grids or Street Networks? *Journal of Quantitative Criminology,* 33(*3*), 569-594. doi: 10.1007/s10940-016-9321-x

Schinasi, L.H., & Hamra, G.B. (2017). A time series analysis of associations between daily temperature and crime events in Philadelphia, Pennsylvania. *Journal of Urban Health,* 94(*6*), 892-900. doi: 10.1007/s11524-017-0181-y

Schnell, C., Braga, A., & Piza, E. (2017). The Influence of Community Areas, Neighborhood Clusters, and Street Segments on the Spatial Variability of Violent Crime in Chicago. *Journal of Quantitative Criminology,* 33(*3*), 469-496. doi: 10.1007/s10940-016-9313-x

Shaw, C. R., & McKay, H.D. (1969). *Juvenile delinquency and urban areas.* Chicago: University of Chicago Press.

Shepherd, J. (1990). Violent crime in Bristol: an accident and emergency department perspective. *British Journal of Criminology,* 30(*1*), 289- 305.

Shepherd, J. (1994). Violent crime: the role of alcohol and new approaches to the prevention of injury. *Alcohol and Alcoholism*, 29(*1*), 5-10.

Sherman, L.W., Gartin, P.R, Buerger, M.E (1989). Hot spots of predatory crime: routine activities and the criminology of place. *Criminology,* 27(*1*), 27-56. doi: 10.1111/j.1745-9125.1989.tb00862.x

Sherman, L. W., & Weisburd, D. (1995). General deterrent effects of police patrol in crime "hot spots": A randomized, controlled trial. *Justice Quarterly,* 12(*4*), 625-648. doi: 10.1080/07418829500096221

Sorg, E.T, Haberman, C.P, Ratcliffe, J.H., & Groff, E.R. (2013). Foot patrol in violent crime hot spots: the longitudinal impact of deterrence and post-treatment effects of displacement. *Criminology,* 51(*1*), 65-101. doi: 10.1111/j.1745-9125.2012.00290.x

Sousa, D.C.B., Pitombo, C.S., Rocha, S.S., Salgueiro, A.R., & Delgado, J.P.M (2017). *Violence in public transportation: an approach based on spatial analysis.* Revista de Saude Publica, 51(*127*). doi: 10.11606/s1518-8787.2017051007085.

Steenbeek, W., Völker, B., Flap, H., & Van Oort, F. (2012). Local businesses as attractors or preventers of neighborhood disorder. *Journal of Research in Crime and Delinquency* 49, 213–248. doi: 10.1177/0022427810397948

Steenbeek, W., & Weisburd, D. (2016). Where the Action is in Crime? An Examination of Variability of Crime Across Different Spatial Units in the Hague, 2001-2009. *Journal of Quantitative Criminology*, 32(*3*), 449-469. doi: 10.1007/s10940-015-9276-3

Stene., R.J. (2017). *De nye kriminalstatistikkene.* Statistics Norway. Retrieved from: https://www.ssb.no/sosiale-forhold-og-kriminalitet/artikler-og-publikasjoner/de-nye-kriminalstatistikkene. [Accessed: August 20th 2019]

Statistics Norway. (2019a). *Kommunefakta Oslo 0301 (Oslo).* Retrieved from: https://www.ssb.no/kommunefakta/Bergen

Statistics Norway. (2019b). *Kommunefakta Bergen 1201 (Hordaland).* Retrieved from: https://www.ssb.no/kommunefakta/bergen

Squires, P. (2017). Community Safety and Crime Prevention: A Critical Reassessment. In Tilley, N. & Sidebottom, A. (Eds.), *Handbook of Crime Prevention and Community Safety* (pp. 32-54). London: Routledge.

Telep, C.W., Mitchell, R.J., & Weisburd, D. (2014). How much time should the police spend at crime hot spots? Answers from a police agency directed randomized field trial in Sacramento, California. *Justice Quarterly*, 31(*5*), 905-933. doi: 10.1080/07418825.2012.710645

Telep, C.W., & Weisburd, D. (2012). What is known about the effectiveness of police practices in reducing crime and disorder? *Police Quarterly*, 15(*4*), 331-357. doi: 10.1177/1098611112447611

Tita, G. E., & Radil, S.M. (2011). Spatializing the social networks of gangs to explore patterns of violence. *Journal of Quantitative Criminology*, 27, 521–545. doi: 10.1007/s10940-011-9136-8

Valente, R. (2019). Spatial and temporal patterns of violent crime in a Brazillian state capital: A quantitative analysis focusing on micro places and small units of time. *Applied Geography*, 103, 90-97. doi: 10.1016/j.apgeog.2019.01.006

Vandeviver, C., & Steenbeek, W. (2017). The (in)stability of residential burglary patterns on street segments: The case of Antwerp, Belgium 2005-2016. *Journal of Quantitative Criminology*, 35(*1*), 111-133. doi: 10.1007/s10940-017-9371-8

Van Nes, A., & López., M. (2010). Macro and micro scale spatial variables and the distribution of residential burglaries and theft from cars: An investigation of space and crime in the Dutch cities of Alkmaar and Gouda. *Journal of Space Syntax*, 1(*2*), 296-314.

Van Wilsem, J. (2009). Urban streets as micro contexts to commit violence. In: Weisburd, D., Bernasco, W., & Bruinsma, G. J. N. (eds.) *Putting Crime in Its Place*. New York: Springer, 199–216.

Weisburd, D. (2015). The law of crime concentration and the criminology of place. Criminology, 53(*2*), 133-157. doi: 10.1111/1745-9125.12070

Weisburd, D., & Amram, Shai. (2014). The law of concentrations of crime at place: the case of Tel Aviv-Jaffa. *Police Practice and Research,* 15(*2*), 1-14. doi: 10.1080/15614263.2013.874169

Weisburd, D., & Braga, A.A. (2006). *Police Innovation. Contrasting Perspectives.* Cambridge: Cambridge University Press.

Weisburd, D., Eck, J., Braga, A., Telep, C., Cave, B., Bowers, K., & Yang, S.-M. (2016). *Place matters: Criminology for the 21st century*. Cambridge, UK: Cambridge University Press.

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

Weisburd, D., Hinkle, J.C., Famega, C., & Ready, J. (2012). *Legitimacy, Fear and Collective Efficacy in Crime Hot Spots.* Washington DC: National Institute of Justice

Weisburd, D., & Lum, C. (2005). The diffusion of computerized crime mapping in policing: linking research and practice. *Police Practice and Research*, 6(5), 419- 434. doi: 10.1080/15614260500433004

Weisburd, D., Wyckoff, L.A., Ready, J., Eck, J. E., Hinkle, J., & Gajewski, F. (2006). Does crime just move around the corner? A controlled study of spatial displacement and diffusion of crime control benefits. *Criminology*, 44(*3*), 549-592. doi: 10.1111/j.1745-9125.2006.00057.x

Welsh, B.P., & Farrington, D.C. (2008). Effects of improved street lighting on crime: a systematic review. *Campbell Systematic Reviews*, 4(*13*). doi: 10.1002/CL2.14

Wikstrom, P.H. (2010). *Routine Activity Theories: Oxford Bibliographies Online Research Guide.* USA*:* Oxford University Press.

Wilcox, P., Gialopsos, B.M., & Land, K.C. (2013). Multilevel Criminal Opportunity. In Cullen, F.T. & Wilcox, P. (Eds.), *The Oxford Handbook of Criminological Theory.* New York: Oxford University Press

Wilcox, P. & Land, C. (2015). Social Disorganization and Criminal Opportunity. In *Challenging Criminological Theory: The Legacy of Ruth Rosner Kornhauser*, edited by Francis T. Cullen, Pamela Wilcox, Robert J. Sampson, and Brendan D. Dooley. Vol. 19 of *Advances in Criminological Theory*. New Brunswick, NJ: Transaction.

Wortley, R., & Mazerolle, L. (2008). *Environmental criminology and crime analysis: Situating the theory, analytic approach and application*. London: Wilan Publishers

Yu, S-SV. (2011). *Do Bus Stops Increase Crime Opportunities?* El Paso, TX: LFB Scholarly Publishing.

APPENDIX

Table 9. Results of the multiple linear regression model for Oslo without 'AC' variables.

	Violent Crime
Transit Station	1.028***
	(0.245)
Residential Area	-0.146*
	(0.081)
Commercial Area	0.760***
	(0.221)
Major Roads	0.279***
	(0.105)
Constant	0.572***
	(0.072)
Note:	*p**p***p<0.01
R^2: 0.0073	

Table 10. Results of the multiple linear regression model for Bergen without 'AC' variables.

	Violent Crime
Transit Station	0.564**
	(0.270)
Residential Area	0.065
	(0.043)
Commercial Area	0.731***
	(0.254)
Major Roads	0.212***
	(0.072)
Constant	0.217***
	(0.037)
Note:	*p**p***p<0.01
R^2: 0.0062	