



## City Research Online

### City, University of London Institutional Repository

---

**Citation:** Lundrigan, S., Weir, R., Newton, A., Agudelo, K. & Dhami, M. (2024). Patterns and Predictors of Stranger Rape Locations. *European Journal on Criminal Policy and Research*, 30(1), pp. 181-209. doi: 10.1007/s10610-022-09535-5

This is the published version of the paper.

This version of the publication may differ from the final published version.

---

**Permanent repository link:** <https://openaccess.city.ac.uk/id/eprint/29439/>

**Link to published version:** <https://doi.org/10.1007/s10610-022-09535-5>

**Copyright:** City Research Online aims to make research outputs of City, University of London available to a wider audience. Copyright and Moral Rights remain with the author(s) and/or copyright holders. URLs from City Research Online may be freely distributed and linked to.

**Reuse:** Copies of full items can be used for personal research or study, educational, or not-for-profit purposes without prior permission or charge. Provided that the authors, title and full bibliographic details are credited, a hyperlink and/or URL is given for the original metadata page and the content is not changed in any way.

---

---





# Patterns and Predictors of Stranger Rape Locations

Samantha Lundrigan<sup>1</sup> · Ruth Weir<sup>2</sup> · Andrew Newton<sup>3</sup> · Kelly Agudelo<sup>4</sup> · Mandeep Dhami<sup>5</sup>

Accepted: 25 November 2022  
© The Author(s) 2022

## Abstract

This paper examines the spatial, environmental, and temporal patterns of 10,488 stranger rapes committed over a 15-year period in Greater London, UK. We distinguished between two types of stranger rapes according to perpetrator method of approach, i.e. absent/fleeting interaction with victim on approach (S1) or extended interaction with victim on approach (S2). There were a range of locational settings in which perpetrators both encountered their victims and where the offence took place, and these differed by method of approach. The highest number of S1 offences occurred outdoors, with 74% of approaches and 55% of offences located recorded as outside. For S2 rapes, there was more variety in approach locations with only 32% outside. The level of locational correspondence between approach and offence location was 71% for S1 rapes and 28% for S2 rapes. A series of negative binomial regression models identified variables predictive of stranger rape offence location. There were significant associations with transport connections and the night-time economy for both S1 and S2 rapes. Other significant predictors were deprivation score, the percentage of one person properties, and the percentage of private rented properties in a location. The percentage of green space was a significant predictor for S1 rapes only. The current findings challenge the popular narrative that stranger rape occurs in a specific setting (i.e. outside in a secluded location at night) and have implications for place-based crime prevention policy.

**Keywords** Stranger rape · Method of approach · Perpetrator-victim interaction · Environmental · Spatial · Place-based crime prevention

---

✉ Samantha Lundrigan  
Samantha.lundrigan@aru.ac.uk

<sup>1</sup> Policing Institute for the Eastern Region, Anglia Ruskin University, Chelmsford CM11SQ, Essex, UK

<sup>2</sup> Violence and Society Centre, City University, London, UK

<sup>3</sup> School of Social Sciences, Nottingham Trent University, Nottingham, UK

<sup>4</sup> London Metropolitan Police Service, London, UK

<sup>5</sup> Department of Psychology, Middlesex University, London, UK

## Introduction

One of the main findings to emerge from studies of crime and place is that crime events are non-randomly distributed across time and place. Differing crime types will exhibit unique spatial patterns related to the distribution of potential victims/targets and offenders, and the physical and social characteristics of the environmental backdrop (Brantingham & Brantingham, 1981, 1993). Previous research has identified rape to be spatially concentrated, and that rape locations are related to several neighbourhood-level socio-demographic, land use, and social disorganisation factors (e.g. Andresen & Malleon, 2011; Hendrix et al., 2008; Hewitt et al., 2018). Studies have also sought to understand the micro-environments in which rapes take place (e.g. Ceccato, 2014; Ceccato et al., 2017; Rosay & Langworthy, 2003).

Unfortunately, a limitation of past research in crime and place studies is that it typically examines rape as a single crime type rather than distinguishing between rapes according to the relationship between the victim and perpetrator (i.e. stranger versus acquaintance) and studying them separately. Victim-perpetrator relationship is likely to exert an influence on the circumstances that rape occurs and thus, the spatial profiles of rape involving individuals with an existing relationship are likely to be markedly different from those involving those unknown to one another. For example, in a study comparing stranger and acquaintance rape, Friis-Rødel et al. (2021) found significant differences in the offence locations associated with each type of rape. Beyond this, there is a need for nuanced analysis of variation *within* these types of rape to fully understand the environmental profiles associated with each type. This is particularly important for stranger rape as it is often portrayed as an environmentally distinctive type of rape—synonymous with a surprise attack in an outdoor location, often a secluded park or alley way at night-time. This is part of the existence of the “real” rape stereotype, a pervasive belief of what rape looks like (Estrich, 1987; Munro & Kelly, 2009; Myhill & Allen, 2002; Temkin & Krahé, 2008). However, currently police forces in both the UK and other jurisdictions (e.g. New Zealand, Canada, the USA) distinguish two types of stranger rape according to the method a perpetrator uses to approach a victim. On the one hand are those rapes where there is little or no interaction with the victim prior to the offence, for example, a blitz or surprise style of approach or a brief exchange such as asking for the time (henceforth called S1 rapes). On the other hand are those rapes where there is a confidence approach involving a more extended interaction with the victim, for example, minicab pick-ups, Internet approaches, bogus authority figures, and encounter at a party/bar (henceforth called S2 rapes). Such a distinction has also been made in past research on stranger rape. For example, Beauregard et al. (2007a), in a qualitative analysis of the offence behaviour of 69 serial sex offenders, found that almost half of the offenders in their study preferred a method of approach that involved a more extended, confidence approach. Chopin et al. (2022), in an examination of 1551 solved stranger rape cases in France, found that 55% of offenders also used a confidence approach.

The locational, environmental, and temporal characteristics of the two approach styles are likely to differ according to the locational conditions necessary for each to be successfully employed and an offence completed. For example, an offender whose preferred approach involves interacting with a potential victim in a bar will require a location where groups of people gather to socialise. By comparison, an offender who prefers a surprise attack as their method of approach will require a location where there is an absence of potential witnesses to intervene. The choice of approach can also have a knock-on effect on the characteristics of the location where an offence takes place. Using the same example,

the offender targeting a potential victim in a bar will, by necessity, need to move to a different location to commit the offence. By contrast, the offender who uses a surprise attack may be less likely to require a different location for the offence as the approach location is likely to be more suitable for the offence to take place. Beauregard et al. (2007b) found evidence for such a relationship between behaviour and geography in the hunting processes of 72 serial sexual offenders. They identified three hunting process scripts that demonstrated the range of locations involved in serial sexual offending, and how types of location are related to types of strategy exhibited by an offender and how some strategies may be triggered by the types of location at which the offender and the victim meet.

Understanding the characteristics of the locations where stranger rape occurs can help inform the development of evidence-based crime prevention policy. A prevention approach is particularly important as stranger rapes are difficult for the police to investigate and where a suspect is identified, unfortunately many cases do not progress through the criminal justice system to a conviction (Santtila et al., 2008; Stern, 2010). Prevention opportunities surrounding acquaintance or domestic rapes usually focus on the known offender, this being in terms of arrest of the offender and removal from the physical environment to prevent reoffending where possible. Where an offender is unknown, such as in stranger rapes, although the priority is always on the identification and apprehension of an offender, where this is not possible, prevention opportunities can be found within the physical environment itself. For example, there are opportunities for police to work with partners, for situational crime prevention in locations identified as being hotspots for stranger rape. Initiatives such as improved street lighting and CCTV, street pastors, and increased availability of free transport may be considered by policing and community safety partners to reduce the attractiveness of a location for potentially motivated offenders (Cohen & Felson, 1979).

For situational crime prevention efforts to be effective, a detailed evidence-based understanding of the environmental and spatial characteristics of the crime problem is required. To date, no study has focused on the characteristics of places associated with stranger rape alone within a UK setting. The main goals of the current research are to identify the spatial, environmental, and temporal characteristics of sub-types of stranger rape and measure the utility of neighbourhood-level characteristics in predicting stranger rape locations within a large urban area in the UK. Below, we review the literature that has examined the spatial, environmental, and temporal characteristics of rape (which, as previously mentioned, does so regardless of relationship between victim and offender).

## Past Research on the Spatial, Environmental, and Temporal Characteristics of Rape

The locations where rapes occur are typically explained using opportunity-based theories of crime (see Beauregard et al., 2005 for a review). Originally developed by Cohen and Felson (1979), the central hypothesis of Routine Activity Theory is that “the probability that a violation will occur at any specific time and place might be taken as a function of the convergence of likely offenders and suitable targets in the absence of capable guardians” (Cohen & Felson, 1979, p.590). All three elements are necessary for the crime to occur. The routine activity explanation for offender spatial behaviour has traditionally been put forward to explain the target or victim selection stage of an offence as the approach focuses on the discovery of “opportunities” in the form of victims and targets during non-criminal

activities. Closely related to this is crime pattern theory (Brantingham & Brantingham, 1981). Targets or victims are selected from an offender's awareness space which is made up of all the locations about which a person has knowledge above a minimum level and includes an offender's activity space within which most of a person's activities are carried out. Brantingham and Brantingham (1981) propose that targets identified within these awareness spaces will be assessed primarily in terms of suitability and risk and specific targets selected based on these evaluations. Underlying both routine activity theory and crime pattern theory is a rational choice model of decision-making known as Rational Choice Theory (Cornish & Clarke, 1986). The main premise of rational choice theory is that offenders will seek to benefit themselves by their criminal behaviour and their decision-making will reflect an underlying rationality where the potential benefits of any criminal action will be weighed up against the effort and potential risks involved. In relation to stranger rape, the rational choice perspective places the focus on decision-making related to the situational characteristics of the locations involved in the commission of a rape.

Relatively few studies have investigated the spatial, environmental, and temporal characteristics associated with sexual offending and even fewer have focused exclusively on stranger rape. There are several stages in the commission of a rape, from the point of first encounter, to the actual rape, and ending with the release of the victim. Each of these stages can occur at different locations or they can all take place at the same location. Most past research has taken the location where a rape occurred as the spatial unit of measurement and examined the spatial patterns, related environmental characteristics (i.e. place and/or neighbourhood characteristics associated with rape locations) and/or the temporal characteristics of rape events.

## Spatial Patterns

To date, there are no studies that have looked exclusively at the spatial distribution of stranger rape. In a study of spatial patterns of recorded rape in a large UK metropolitan area, Muir and Macleod (2003) found that rape was not evenly distributed across the study area. They found that "high" rape areas concentrated in and around the city centre and of these, 50% were committed by strangers. Similarly, Ceccato (2014), in an examination of the spatial distribution of outdoor rape in Stockholm, Sweden, found that outdoor rape concentrated in inner city areas with less concentrated clusters in the periphery of the city. Konkell et al. (2019) examined the spatial distribution of violent sexual offences in two cities located in a Midwestern US County. The authors found that sexual offences were concentrated in relatively few small spatial areas with more than 50% of the offences in the study cities taking place in only 2% of street segments. In line with these spatial studies, we would expect that stranger rape would also be spatially concentrated but that spatial patterns would vary according to the type of stranger rape being considered. For example, S1 rapes may be more spatially concentrated than S2 rapes if, as previously discussed, S2 rapes are more likely to take place in locations separate to the point of encounter.

## Environmental Characteristics

The research that has focused on understanding rape locations has found that rape takes place in a range of different places. One of the most reported settings where rape takes place is an indoor, residential one. For example, Moran (1993) examined 450 cases of rape and attempted rape (of which 42% were committed by "known" offenders) in Queensland,

Australia, and found that most offences took place in a residential setting (61%). In a detailed study of reported adult, single perpetrator rape in eleven European countries, Lovett and Kelly (2009) found that most offences (61%) took place in a private location, most often the victim's or suspect's home. Rosay and Langworthy (2003) analysed 541 sexual assaults and rapes reported to the (US) Anchorage Police Department in 2000 and 2001. They distinguished between pick-up and offence location. The most common pick-up and assault locations were victim residence (20%, 22%) and offender residence (13%, 20%), respectively. Rape also takes place in public or semi-public settings. For example, Moran (1993) found that 22% of rapes took place in an outdoors public setting. Lovett and Kelly (2009) found that 18% of offences were committed in a public place, such as a street, park, shopping centre, or on public transport and 15% in a semi-public place such as pubs and clubs, schools, workplaces, vehicles, and institutional settings. Rosay and Langworthy (2003) found that streets/roads and bars accounted for 10% and 8.5%, respectively, of pick-up locations and 7.5% of offences took place in parks, fields, or woods. Ceccato (2014) combined police crime records, police protocols, and visits to a sample of rape sites to examine the distribution and spatial characteristics of outdoor rape in Stockholm. Visits to 76 outdoor rape locations revealed that in central city areas, rape happened in secluded locations with restricted visibility from the street. In locations on the periphery of the city, typical rape locations were forested areas, streets with poor surveillance, and near transport nodes. Furthermore, half of the visited rape sites were in a green space. Ceccato et al. (2017) examined the medical records of 157 rape victims from Stockholm and found that rape was most frequent in forested areas, street settings and in vehicles.

### Neighbourhood level factors

The research that has examined the influence of neighbourhood-level factors on rape has done so typically within urban settings. These neighbourhood-level factors can be classified into four groups, namely, socio-demographic, land-use, social disorganisation/ecological and sexual crime attractors. Table 1 presents a summary of this literature.

In relation to socio-demographic factors, two studies established a relationship with rape locations. Ceccato et al. (2018) found that areas with a high female population were significantly more likely to have higher rape rates. Hewitt et al. (2018) found that high rape areas also had higher percentages of females over 15 years and male inhabitants aged between 15 and 24. In relation to land use factors, only Ceccato et al. (2018) found a significant relationship between observed rape cases and the distribution of subway stations. For social disorganisation/ecological factors, Miethe and Meier (1990) found higher rape rates in areas characterised by ethnic heterogeneity, population mobility, single parent families, unemployment, and lower family income. Tewksbury et al. (2010) found that as the number of social disorganisation indicators increased, so too did the number of sexual offences. Ceccato et al. (2018) found a relationship between rape cases and high population turnover and a fearful local population. Hewitt et al. (2018) found that increase in residents with postsecondary education, medium income, and percentage of people moved into area within last year associated with decrease in the number of sexual crimes, whereas higher rates of gross rents and higher percentage of rentals were associated with an increase. Lastly, in relation to sexual crime attractors, Ceccato et al. (2018) found an association with liquor establishments and schools and Konkell et al. (2019) found a relationship at street segment level between sexual assault density and gang members, drug houses, and sex offenders.

**Table 1** Past studies examining the effect of neighbourhood-level factors on rape patterns

Authors	Sample characteristics	Method of analysis	DV and IVs	Statistically significant findings
Miethe and Meier (1990)	<p>Jurisdiction: Seattle and US cities</p> <p>Source: Uniform Crime report and Census reports</p> <p>Timeframe: 1980</p> <p>N=2180</p> <p>Type of abuse: Rape</p>	Multivariate logit models	<p>DV: Rape rate</p> <p>IVs:</p> <p>Social disorganisation: median family income; unemployment rate; % population moved in the previous five years; % children living with both parents; ethnic heterogeneity</p> <p>Sexual crime attractors: proximity to high crime areas; exposure to risky situations; target attractiveness; guardianship; types of predatory crime</p>	<p>Social disorganisation: Highest in areas of ethnic heterogeneity, population mobility, single parent families, unemployment and lower family income</p>
Tewksbury et al. (2010)	<p>Jurisdiction: Louisville, Kentucky</p> <p>Source: Reported police cases</p> <p>Timeframe: 2005</p> <p>N=681</p> <p>Type of abuse: all sexual assault – adult and children</p>	OLS	<p>DV: Total number of sex offences by census tract</p> <p>IVs:</p> <p>Social disorganisation measure made up of 11 concepts; presence of RSOs; schools; % female; females living alone; females aged 16–64 with a disability; aged 5–20 with a disability; foreign born population</p>	<p>Social disorganisation: As number of social disorganisation indicators increases, number of sexual offences increased by .117; number of offenders increases offences by .18; number of day-care centres increases offences by .313; proportions of women with disabilities increases by .09. Increasing proportions of female residents decreased number of sexual offences</p>
Ceccato et al. (2018)	<p>Jurisdiction: Stockholm municipality, Sweden</p> <p>Source: Police recorded cases</p> <p>Timeframe: 2008–2009</p> <p>N=237</p> <p>Type of abuse: Rapes and attempts; all relations</p>	Bayesian Hierarchical Poisson Regression	<p>DV: Observed rape cases</p> <p>IVs:</p> <p>Socio-demographic: Women aged 13–65</p> <p>Land use: subway station; proximity to city centre; forest; industrial</p> <p>Sexual crime attractors: alcohol outlet, education institution</p> <p>Social disorganisation: average income; fear of crime; population turnover; counts of street robbery</p>	<p>Two types of high-risk area: City centre with large numbers of alcohol outlets, high population turnover and high counts of robbery. Poor suburban areas with schools and large female resident population with subways and a fearful local population</p>

**Table 1** (continued)

Authors	Sample characteristics	Method of analysis	DV and IVs	Statistically significant findings
Hewitt et al. (2018)	<p>Jurisdiction: City, BC, Canada</p> <p>Source: Founded police contacts</p> <p>Timeframe: 2002–2006</p> <p>N=2180</p> <p>Type of abuse: all sexual assault—adult and children; all relations</p>	Negative binomial regression	<p>DV: number of sexual crimes</p> <p>IVs:</p> <p><u>Socio-demographic</u>: % of male children aged 0–14; % of female children aged 0–14; % of female adults aged 15 or over; % of Aboriginal individuals; % of visible minorities; % of males aged 15–34; % of single individuals; count of individuals</p> <p><u>Land use</u>: % commercial; industrial; institutional; recreational; residential; vacant; mixed land use</p> <p><u>Sexual crime attractors</u>: liquor premises; post-secondary education; recreational centres; schools; transit hubs</p> <p><u>Social disorganisation</u>: % houses in need of major repair; % old houses; % of individuals with post-secondary education; unemployment rate; % individuals on welfare; % low income individuals; average dwelling value; gross rent; median income; standard deviation of income; % recent immigrants; % single parent families</p>	<p><u>Socio-demographic</u>: % of females over 15, % male inhabitants between 15 and 34, % single people, increase in population count</p> <p><u>Crime attractors</u>: liquor establishments, schools</p> <p><u>Social disorganisation</u>: Increase in residents with postsecondary education, medium income, % of people moved into area within last year associated with decrease</p> <p>Higher rates of gross rents and higher percentage of rentals associated with increase</p>

**Table 1** (continued)

Authors	Sample characteristics	Method of analysis	DV and IVs	Statistically significant findings
Konkel et al. (2019)	<p>Jurisdiction: two cities in Midwest USA</p> <p>Source: Police recorded Timeframe: 2014–2016 N= 369</p> <p>Type of abuse: all sexual assault; adults and children; all relations</p>	Hierarchical linear modelling	<p>DV: Sexual assault density per 1000 ft</p> <p>IVs: Socio-demographic: % females aged 15–24</p> <p>Sexual crime attractors (measured at street segment scale): sex offender density, gang members density, drug houses density, bars density, high density housing, treatment centre density</p> <p>Social Disorganisation: disadvantage, heterogeneity, index of concen- trated extremes, % moved in past 5 years, violent crime rate</p>	<p>Street segment: gang members, drug houses, sex offenders, high density community housing positively associated</p> <p>Neighbourhood: Disadvantage, concen- trated poverty, racial heterogeneity, violent crime rate and suburban (vs. rural) areas positively associated; residential mobility negatively associated;</p>

## Temporal Characteristics

Past research has identified seasonal patterns in rape that is typical of outdoor crime in the Northern Hemisphere. For instance, Rosay and Langworthy (2003) observed strong seasonal effects with an increase in reported assaults from May to October. Similarly, Moran (1993) found that just under a third of rapes took place in the summer months—a pattern that was particularly acute in coastal centres. More recently, Ceccato et al. (2017) reported that most rapes continue to occur during the warmer months of summer and autumn.

Past research has also found noticeable patterns in the weekly and daily timing of rape offences, with an increase in incidents during the weekends and during night-time hours. The pattern of night-time incidents was earlier observed by Amir (1971) who found that two-thirds of rapes occurred between 8 pm and 8am. Moran (1993) later additionally found that 55% of cases occurred at the weekend and 75% occurred between 6 pm and 6am, with 30% taking place between midnight and 3am. Similarly, Rosay and Langworthy (2003) found that assaults were most likely to occur at weekends and more than 60% occurred between 10 pm and 6am. More recently, Ceccato (2014) found that, regardless of the area of Stockholm, the city under study, most rapes (> 85%) took place at night-time and at the weekends and holidays (> 60%; see also Ceccato et al., 2017).

## Limitations of Past Research

Several shortcomings of the previous research on rape limit our understanding of the geo-spatial and temporal manifestations of these crimes. Most significantly, as mentioned earlier, few geo-spatial studies have focused exclusively on stranger rape. Past studies into rape have typically combined a mixture of different victim-offender relationship types. Aggregating different types of rape cases may introduce variability in the data and makes it more difficult to identify and even hides some of the pertinent factors associated with each specific type of rape (Bownes et al., 1991). Therefore, much of what we believe we know about the rape of women by strangers may not be valid because of the comingling of data on stranger and acquaintance rape in the research, when the offenders, victims, and locations associated with the two types of sexual assault differ. Another limitation is that past research has been based on relatively small samples, over short time frames, potentially limiting the representativeness of the findings. Lastly, no such study has been undertaken within a UK context, which is important to inform UK specific, place-based policy.

Our study focuses on London as the capital and largest city in the UK. The London Metropolitan Police Service (LMPS) covers the Greater London area, excluding the “square mile” in the City of London. The force area covers 1579 km<sup>2</sup> with 8.6 million residents (Metropolitan Police, 2022). In addition to its resident population, London also hosts some 70,000 non-UK short-term residents and as the rail network expands, so the daily commuter population increases. It has a population density of 5701 people per square kilometre, which is ten times higher than that of the next most densely populated region of England (the North-West) (Park, 2020). It is by far the most ethnically and culturally diverse city in the UK with 40.2% of residents identifying as either Asian, Black, Mixed, or Other ethnic group in the 2011 Census (UK Government, 2018). London is divided into 32 boroughs, 12 in inner London, and 20 in outer London with populations of between 150,000 and 300,000. Inner London boroughs tend to be smaller, in both population and area, and

more densely populated than Outer London boroughs. In the year ending September 2019, there was a total crime rate of 101.5 per 1000 population compared to the England and Wales rate of 88.5 (Park, 2020). At the end of 12 months to March 2018, rape offences recorded by LMPS were 140% higher than those recorded in the period to March 2011 (MOPAC, 2019). Approximately 16% of rapes recorded by LMPS are classified as stranger rapes (LMPS, 2022).

## The Present Study

The main aims of the present study are (1) to describe the spatial, environmental, and temporal characteristics of stranger rape committed in an English urban conurbation; (2) to compare the spatial, environmental, and temporal profiles of S1 and S2 rape; and (3) to measure the utility of neighbourhood-level characteristics in predicting stranger rape offence locations within the same setting.

The present study makes several important contributions to the substantive literature on the geography of rape and is original in three ways. It is the first study to examine (1) the spatial and environmental characteristics of specific forms of stranger rape; (2) intra-offence locational similarity; and (3) the geography of stranger rape within a British urban context.

## Method

### Procedure

We analysed offence data from the sexual offense database maintained by the Sexual Offences Intelligence Unit of the LMPS. The database includes every sexual offence reported within the LMPS area. The information on each case describes characteristics of the alleged perpetrator (where known), alleged victim, and the offence.<sup>1</sup> This information is obtained from case files that contain several documents (e.g. police reports, victim statements). The quality of information gathered from victims has benefitted from the introduction of dedicated police units specially trained in the investigation of rape complaints (Stern, 2010). In addition, specially trained analysts and researchers use an established coding dictionary to code information in the documents when entering data into the database (SCOID SO Page Categories, 2015). This coding system is also used internationally in other jurisdictions (e.g. USA, New Zealand). All new analysts are required to undertake a rigorous data coding training program, utilise a “Quality Control Guide” to maximise consistency across analysts/researchers, and have their data inputting quality assured for the first three months in the unit.

### Sample

For present purposes, we extracted all lone<sup>2</sup> victim stranger rape cases, reported to the LMPS between 1 January 2001 and 31 September 2015. There were 12,310 crimes

<sup>1</sup> For ease of reading, hereafter, we use the terms ‘victim’ and ‘perpetrator’ even though not all cases resulted in a conviction.

<sup>2</sup> There were no cases of multiple victim rape in the dataset.

recorded during that period. Of these, 10,568 crimes had a spatial co-ordinate (easting and northing) for the rape location, and of which, 10,488 were within the LMPS area. All crime recorded outside the LMPS area or without grid references were excluded from the analysis. Of the 10,488 rapes, 3199 (30.5%) were categorised by LMPS as S1 rapes, where there was either no or minimal interaction with the victim on approach (e.g. a blitz attack or the perpetrator asked the victim for the time) and 7289 (69.5%) of the rapes were categorised as S2 rapes, where there was more extended time spent with the victim on approach (e.g. a confidence approach where the perpetrator and victim may have interacted in a bar or the perpetrator posed as a taxi driver). For the total sample, victims ranged from aged 12 to 98, with a mean age of 25 ( $SD=10.40$ ); 93% of victims were female; 66% were White, 23% African-Caribbean, and 6% Asian and 5% other.

## Variables

From the literature review and based on the availability of appropriate datasets, 14 variables were selected for use in the current study. Five variables captured the locational and temporal characteristics of the sample (see Table 2). These were approach location type (i.e. outdoors, victim's private dwelling, public building, transport, entertainment venue, suspect's private dwelling, unknown private dwelling, business venue), offence location type (as previous), time of day, day of week, and month of year offence occurred.

A further nine predictor variables were identified from the literature based associated with wider neighbourhood-level environmental characteristics. The location of pubs and bars was extracted from the 2019 Ordnance Survey Points of Interest data to identify the frequency of each in the analysed spatial units. Additional variables included deprivation data from the 2015 Index of Multiple Deprivation; percentage of BAME residents, population density, female population over 15 years, percentage one person properties, and % private rented properties from the 2011 census; public transport accessibility level average score from 2014 Transport for London data; and percentage green space from 2005 land use data (the most recent available at the time of the research). The list of predictor variables is provided in Table 3.

## Data Analysis

**Spatial Analysis** All spatial analyses were conducted using ESRI's ArcGIS Desktop 10.3.1, with statistical analysis carried out using the Spatial Analyst extension, and spatially geolocated using their co-ordinates (eastings and northings in the police data). The centre of London was defined using the sub-regions identified by the London Plan Consultation, 2009 (Mayor of London, 2009). The central sub-region consists of the boroughs of the following: Camden, City, Islington, Kensington and Chelsea, Lambeth, Southwark, and Westminster. As mentioned earlier, LMPS does not cover the City of London and so this was not included in the analysis.

Hotspot analysis was carried out using the Getis-Ord  $G_i^*$  hotspot statistic with a 1-km square grid and a 90%, 95%, and 99% confidence interval. The standardised risk ratio (SRR) formula for unit  $i$  is:

$$SRR(i) = \left[ \frac{O(i)}{E(i)} \right] 100$$

**Table 2** Demographic and environmental variables and descriptive statistics

Variable Description	% (N)/Mean (SD)	
	S1	S2
Victim age: Victim age at time of the offence	25.0 (11.6)	24.7 (9.8)
Victim ethnicity: Ethnic group recorded as:		
<i>White</i>	68.3	65.3
<i>African Caribbean</i>	21.6	23.2
<i>Asian</i>	5.7	5.7
<i>Other</i>	4.4	5.8
Victim gender:		
<i>Male</i>	8.4	6.1
<i>Female</i>	91.6	93.9
Approach location:		
<i>Outdoors</i> : (e.g. a park or street)	70.1	46.2
<i>Transport</i> : (e.g. train/bus station, bus stop, airport, in a car, train, bus)	4.9	16.6
<i>Entertainment venue</i> : (e.g. pub, bar, club, restaurant)	4.0	9.0
<i>Other public building</i> : (e.g. office, shopping centre, hospital, swimming pool)	0.4	4.7
<i>Victim's private dwelling</i> : (i.e. where victim resides)	8.6	9.0
<i>Suspect's private dwelling</i> : (i.e. where suspect resides/is believed to reside)	1.7	7.6
<i>Unknown private dwelling</i> : (i.e. unknown person's house)	3.9	8.3
Offence location:		
<i>Outdoors</i>	55.4	15.6
<i>Transport</i>	6.6	8.0
<i>Entertainment venue</i>	2.3	2.3
<i>Other public building</i>	9.7	11.7
<i>Victim's private dwelling</i>	9.6	15.2
<i>Suspect's private dwelling</i>	7.1	30.3
<i>Unknown private dwelling</i>	9.3	16.8
Approach and offence location		
<i>Same location</i>	71.3	28.2
<i>Different location</i>	28.7	71.8
Time of day:		
<i>Daytime</i> : (6am–6 pm)	23.6	23.4
<i>Night-time</i> : (6 pm–6am)	76.4	76.6
Day of week:		
<i>Weekday</i> : (Monday–Thursday)	47.7	44.1
<i>Weekend</i> : (Friday–Sunday)	52.3	55.9
Month of year:		
<i>Spring</i> : (March–May)	23.6	24.4
<i>Summer</i> : (June–August)	27.2	28.0
<i>Autumn</i> : (September–November)	24.8	23.8
<i>Winter</i> : (December–February)	24.4	23.8

where  $O(i)$  is the number of rapes observed and  $E(i)$  is the expected number of rapes (Cecato, 2014). The expected number of rapes was calculated by computing the overall risk

**Table 3** Neighbourhood-LSOA level model variables

			Range	
Variable name	Mean	SD	Minimum	Maximum
Dependent variables				
Count of S1 rape	0.6	1.2	0	30
Count of S2 rape	1.5	2.2	0	48
Total count of stranger rape	2.1	3	0	78
Independent variables				
IMD score	23.4	12.4	1.8	64.3
count of bars	2.5	2.5	0	67
% B.A.M.E	39.1	20.5	1.8	96.5
% non-domestic buildings	6.2	2.5	0	48.8
% one person properties	30.3	8.9	8.4	67.5
% private rented	23.5	12.4	1.6	87.9
population density	94.6	59.2	1.2	684.7
Public transport accessibility level average	13	12	0.2	107.9
% greenspace	20.4	18.5	0	92.7
Count of female over 15 population	912.1	175	374	2282

$N=4,942$

(i.e. number of rapes divided by the population of females over 15) and then multiplying this figure by the total at risk population (females over 15) for each Lower Super Output Area (LSOA).<sup>3</sup>  $E(i)$  is therefore the expected number of rapes in area  $i$  when it is assumed that rapes are randomly distributed throughout London. This figure was then mapped to identify relative risk.

**Neighbourhood Level Analysis** Individual offence level data, for all stranger rapes, S1 rapes and S2 rapes, were aggregated as frequencies for each LSOA in ArcGIS and exported to Stata. This spatial unit was chosen as it was the lowest level of granularity at which all predictor variables were available. A negative binomial regression model was constructed with three criterion variables: the count of stranger rapes, the count of S1 rapes, and the count of S2 rapes, all by LSOA (using 2011 LSOA boundaries).

There are several issues with analysing neighbourhood level crime patterns. Firstly, the limitations of using aggregate data need to be considered and acknowledged, notably the modifiable areal unit problem (MAUP), which refers to where the observed patterns and relationships can be changed by altering the boundaries (O'Sullivan & Unwin, 2003). Secondly, to make areas comparable, rates are often used to analyse crime at the neighbourhood level crime. However, the precision of the calculated crime rate will depend on the size of the population of the area that it has been aggregated to. If there are varying population sizes, the assumption that the error variance is homogenous will

<sup>3</sup> Lower Super Output Areas (LSOAs) are small areas with similar population sizes (approximately 1500 residents or 650 households). They are part of a hierarchy of areas that were developed to collect and report census data. LSOAs are an aggregation of Output Areas (OAs) the lowest level of granularity at which census data is published.

be violated. To address this issue, the research uses LSOAs, which have very similar population sizes (around 1500 people). Finally, when crime rates are small or zero, it cannot be assumed that the errors are normally distributed. To address this, crime counts were used rather than rates. The data did not follow the normal distribution and was found to be over dispersed, with the conditional variance exceeding the conditional mean. A negative binomial regression model, a method used to analyse over-dispersed count data, was therefore run.<sup>4</sup> This method is a generalisation of Poisson regression as it has the same mean structure as Poisson regression but includes an extra parameter which models the over-dispersion,  $\lambda_i$  (Osgood, 2000; Stata, 2022). The formula for negative binomial regression is:

$$P(Y_i = y_i) = \frac{\Gamma_{y_i+\varnothing}}{y_i! \Gamma(\varnothing)} \frac{\varnothing^\varnothing \lambda_i^{y_i}}{(\varnothing + \lambda_i)^{\varnothing - y_i}}$$

where  $\Gamma$  is the gamma and  $\varnothing$  is the reciprocal of the residual variance of underlying mean counts  $\alpha$  (Gardner et al., 1995).

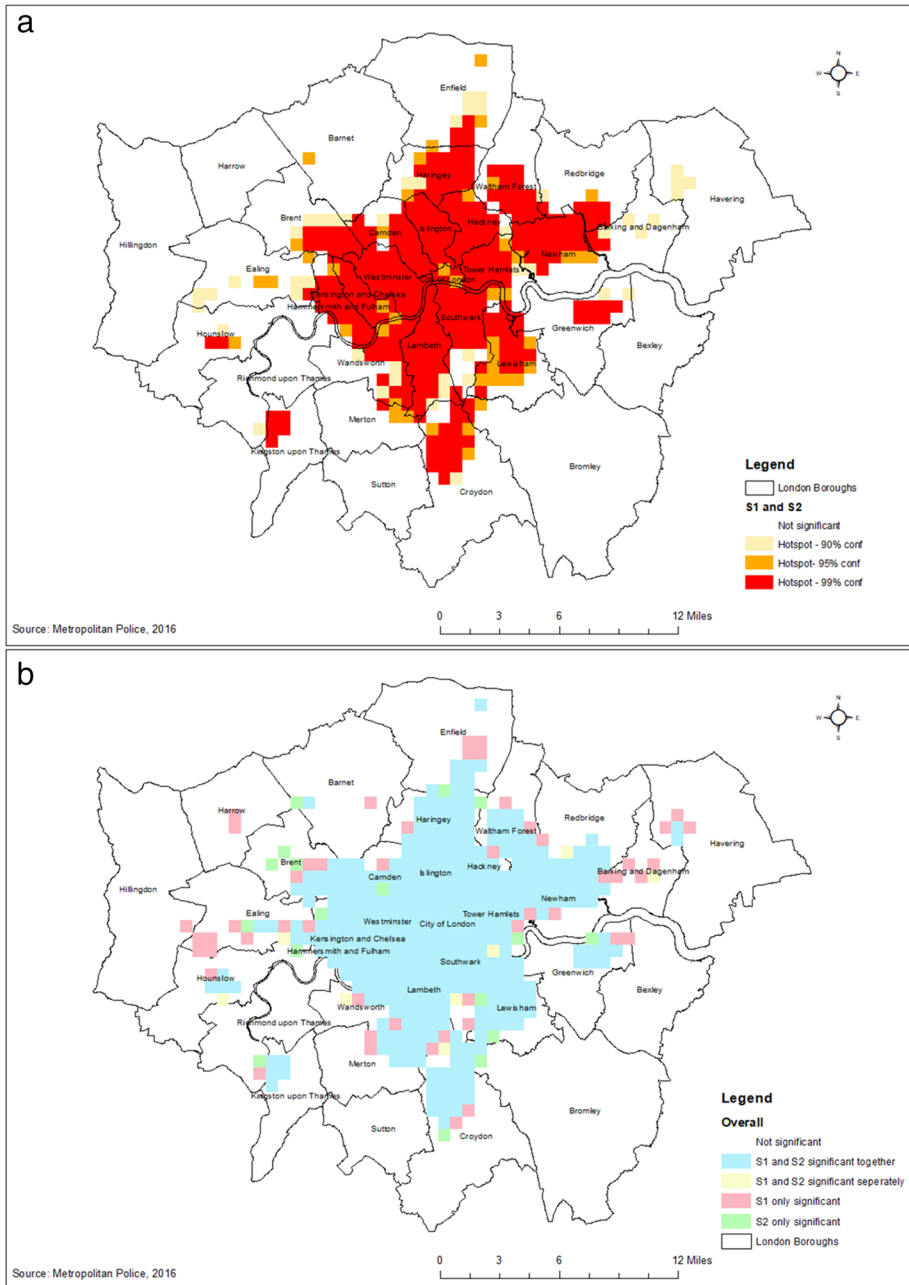
**Temporal Analysis** Temporal analysis was conducted using excel and calculations were made to split the time field into units of time for both S1 and S2 crimes. S1 and S2 rapes were also calculated across the 168-h week which is more representative of routine activities and lifestyles, than using hour of day or day of week separately (for a discussion of the methodology, see Newton, 2015). S1 and S2 rapes were classified into hourly time blocks across a full seven-day week, from 00.00 Sunday morning through to 00.59 on Saturday evening. This enabled the frequency of rapes to be calculated across 168 hourly time bins which represent a full week. The total frequencies of all S1 and S2 times in each hourly window (across all years of data recorded) were then displayed using a 2-cell moving average to support visualisation.

## Results

### Spatial patterns in stranger rape

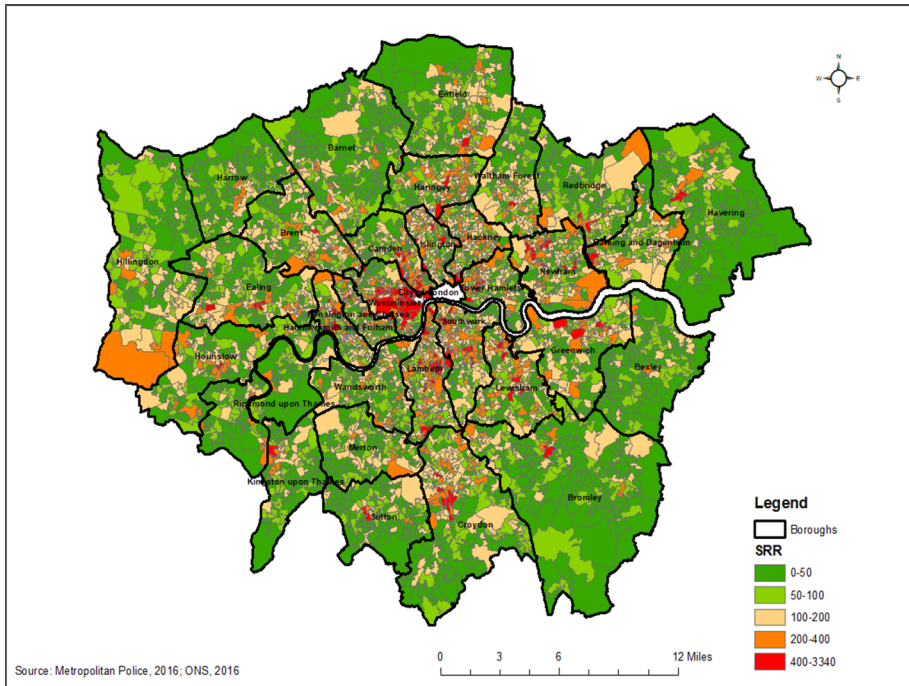
Figure 1A shows the Getis-Ord  $G_i^*$  hotspot analysis for S1 and S2 rapes combined. The map shows the highest intensity of clustering in the Westminster area of central London. Other hotspots are found in the central area of London with marked hotspots in the boroughs of Lambeth, Southward, Hackney, and Haringey. Although the hotspots for S1 and S2 largely coalesce, there are some differences as revealed in Fig. 1b. The pink areas are where the hotspots of only S1 rapes are significant (mean Z value = 2.55) and the green areas are where only the S2 hotspots

<sup>4</sup> A zero-inflated negative binomial regression and zero-inflated Poisson regression were also run. This method attempts to account for excess zeros in the counts. The method works by trying to account for “true zeros” and “excess zeros” in the data (Stata, 2022). A test was run in Stata to determine which was the most appropriate method to use with the dataset and the results found negative binomial regression to be the most suitable.



**Fig. 1** **a** Hotspots of S1 and S2 rape in London, 2001–2015.  $N=10,488$ . **b** Comparison of S1 and S2 rape hotspots in London, 2001–2015.  $N=10,488$

are significant (mean  $Z$  value = 2.12). In most of the central London area, both the S1 and S2 hotspots are significant when combined, but in a few areas, depicted in



**Fig. 2** Standard rape ratio for females over 15  $N=9761$

yellow, the hotspots are only significant when calculated separately for each type of stranger rape.

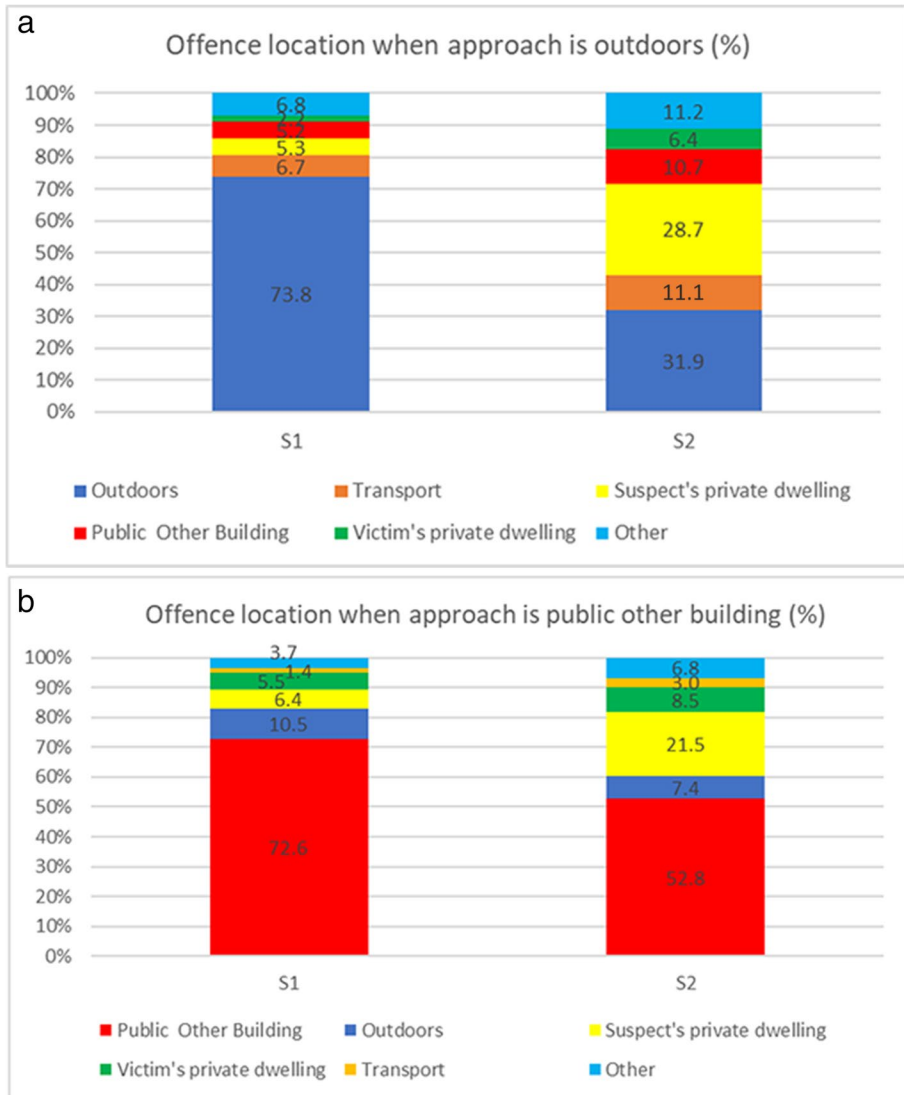
Figure 2 shows the Standardised Rape Ratio (SRR) for S1 and S2 rapes combined.<sup>5</sup> Areas coloured red represent those with higher-than-expected rape rates. Similar to the hotspot analysis, Westminster emerges as an area with increased risk. One issue with SRR is that it uses the resident population of females over the age of 15. However, areas like Westminster have high numbers of non-resident visitors (e.g. commuters, tourists, and those using entertainment venues) who will not have been included in the denominator. The map also identifies areas outside Westminster with increased risk, such as areas in Croydon and Kingston upon Thames.

## Environmental Characteristics of Stranger Rape

### Place Characteristics

The place characteristics of where the initial approach was made and where the offence took place were broken down for S1 and S2 rapes. The highest number of S1 offences occurred outdoors, with 74% of approaches and 55% of offences recorded as located outside. For S2 rapes, there was more variety in approach locations, with 32% outside, 20% in entertainment venues and the remainder in other public buildings (10%), suspect's private dwelling (10%), unknown other private dwellings (7%), transport (5%), and other or

<sup>5</sup> SRR analysis for S1 and S2 offences separately revealed no notable differences between the two and so were analysed together.



**Fig. 3** **a**  $N$ : S1=2430, S2=2697. **b**  $N$ : S1=219, S2=674. **c**  $N$ : S1=132, S2=1677. **d**  $N$ : S1=165, S2=603

unknown (4%). For S2 offence locations, the highest number (29%) was in the suspect's private dwelling, followed by victim's private dwelling and outdoors (17%) and unknown other private dwellings (15%).

The location of approaches and offences were classified by place type, broken down into a set of categories including outside, entertainment venues, other public buildings, transport, suspects private dwelling, and victims private dwelling. Figure 3a–d show the location classifications of the approach<sup>6</sup> and subsequent offence location for S1 and S2

<sup>6</sup> Only approach locations with over 100 offences were included.

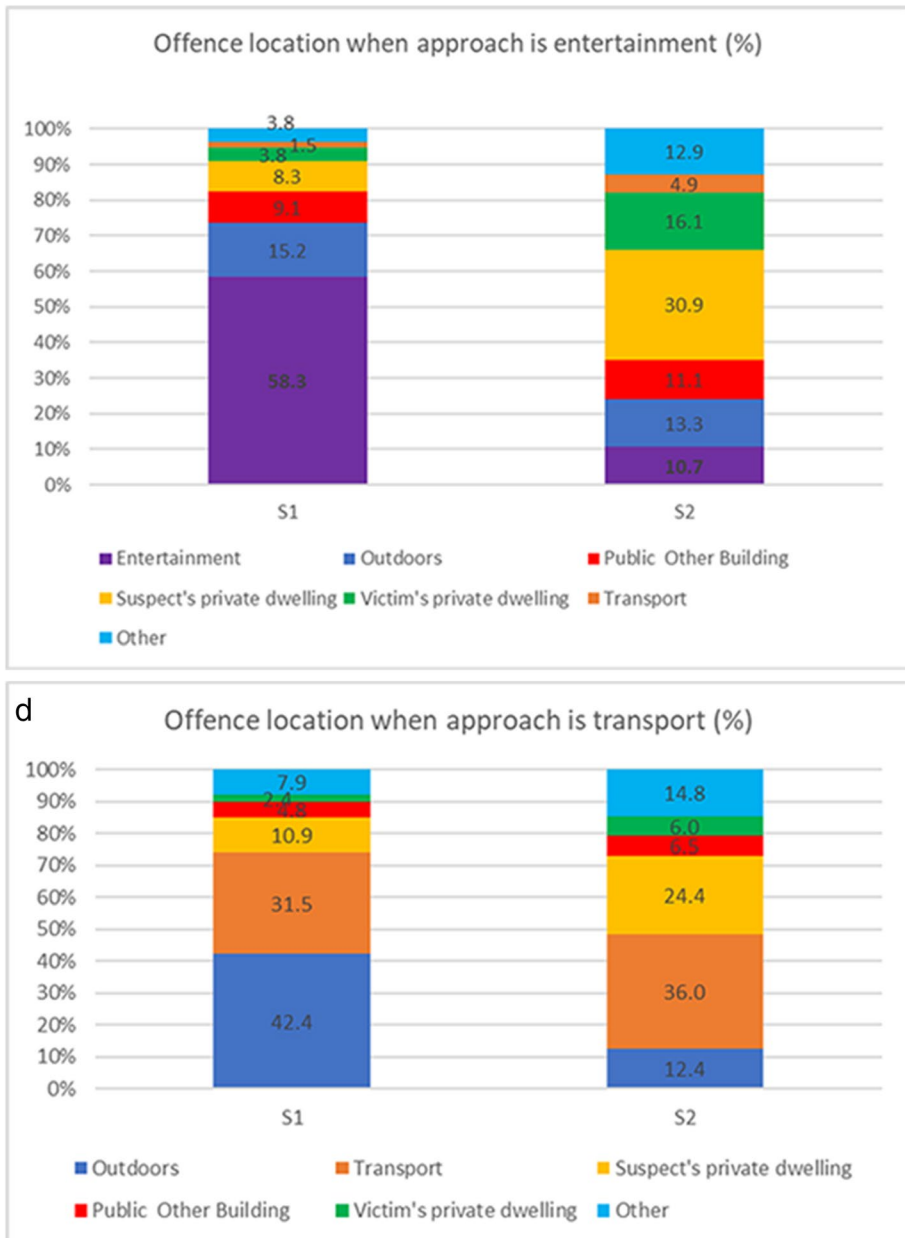


Fig. 3 (continued)

rapes. If, for example, an approach took place outdoors and the subsequent offence also took place outdoors, then these locations were deemed as correspondent. If, however, an approach took place in a public building and the subsequent offence in an outdoor location, then these locations were not deemed as correspondent. Note for corresponding approaches and offences, this does not identify these locations as occurring at the same place, rather

the approach and offence location as the same “type” of place. Approach and offence locations were correspondent in 71% of S1 rapes and 28% of S2 rapes. Overall, there was more locational variation in S2 rapes than S1 rapes, and that applied to both the approach and the offence location.

Figure 3a illustrates the subsequent offence locations when the approach type is outdoors. There is a statistically significant difference between S1 and S2 offence locations;  $X^2(5, N=5127)=991.8, p<0.001$ , primarily driven by difference in outdoor (S1=73.8%, S2=31.9%) and suspect private dwelling (S1=5.3%, S2=28.7%) offence locations. Figure 3b shows the subsequent offence locations when the approach is public buildings other. There is a statistically significant difference between S1 and S2 offence locations;  $X^2(5, N=893)=38.2, p<0.001$ , primarily driven by public other buildings (S1=72.6%, S2=52.8%) and suspect’s private dwelling (S1=6.4%, S2=21.5%) offence locations. Figure 3c shows the subsequent offence locations when the approach is entertainment. There is a statistically significant difference between S1 and S2 offence locations;  $X^2(6, N=1809)=233.4, p<0.001$ , primarily driven by entertainment (S1=58.3%, S2=10.7%), suspect private dwelling (S1=8.3%, S2=30.9%), and victim’s private dwelling (S1=3.8%, S2=16.1%) offence locations. Figure 3d shows locational correspondence for transport. If the approach is transport, there is statistically significant difference between S1 and S2 offence locations;  $X^2(5, N=768)=79.7, p<0.001$ , primarily driven by outdoors (S1=42.4%, S2=12.4%) and suspect private dwelling (S1=10.9%, S2=24.4%) offence locations. Transport is the only “approach” location where the subsequent offence location does not significantly change (transport approach and offence are similar for S1 and S2). For all approaches, S2 is markedly higher for suspect private dwelling offence locations than S1 offence locations.

## Neighbourhood-Level Predictors of Stranger Rape Locations

Several models were constructed using NBR to identify potential predictors of all stranger rape (S1 and S2), S1 only, and S2 only rape locations, all using the LSOA as the unit of analysis. Initially models were run to explore the individual predictors that offered the greatest explanation for the count of rape. More variables were then added or removed if they reduced the fit of the model, which was assessed using log likelihoods. The smaller the value of the log likelihoods, the better the fit of the model to the observed data. Table 4 lists the log likelihoods for all the model options that were explored. Overall, the models in Table 5 had the best fit.

To aid interpretation of the coefficient values, the incidence rate ratios (IRR) were calculated in Stata. For all stranger rape, the PTLA average score had the largest effect with a one-unit increase in the PTLA increasing the count of rape by a factor of 1.15, whilst holding all other variables in the model constant. The second highest effect was from the number of bars, with an increase in one bar resulting in an increase in the number of rapes by a factor of 1.05. The IMD score increased the rape count by 1.027, the percentage of private rented properties by 1.017, the percentage of one person properties by 1.015, the % BAME by 1.005, percentage greenspace by 1.002, and percentage of the female population aged over 15 by 1.001. The only variable to have a negative effect on all stranger rape was population density, a one-unit increase decreased the number of rapes by a factor of 0.998. All variables in the final model were significant. When broken down into S1 and S2 rapes,

**Table 4** Negative Binomial Regression models log likelihood

Model	All stranger rape log likelihood	S1 log likelihood	S2 log likelihood
Model 1 Count of bars	-8730.22	-4943.98	-7455.55
Model 2 IMD score	-8720.77	-4954.80	-7454.89
Model 3 % BAME	-8947.06	-5067.92	-7632.34
Model 4 Population density	-8997.51	-5105.69	-7659.28
Model 5 Public transport accessibility level average	-8431.17	-4845.77	-7188.11
Model 6 % one person properties	-8708.12	-4988.88	-7402.44
Model 7 % private rented properties	-8709.56	-4973.94	-7417.69
Model 8 % non domestic buildings	-8550.16	-4912.55	-7269.21
Model 9 % greenspace	-9046.79	-5123.49	-7704.09
Model 10 Female over 15 population	-8923.83	-5058.62	-7603.72
Model 11 Count of bars IMD score	-8298.61	-4748.64	-7123.69
Model 12 Count of bars IMD score % BAME	-8281.58	-4741.02	-7110.91
Model 13 Count of bars IMD score % BAME Population density	-8268.47	-4740.72	-7093.95
Model 14 Count of bars IMD score % BAME Population density Public transport accessibility level average	-8012.90	-4634.99	-6882.26
Model 15 Count of bars IMD score % BAME Population density Public transport accessibility level average % one person properties	-7959.88	-4628.34	-6826.60
Model 16 Count of bars IMD score % BAME Population density Public transport accessibility level average % one person properties % private rented properties	-7872.76	-4596.23	-6757.12

**Table 4** (continued)

Model	All stranger rape log likelihood	S1 log likelihood	S2 log likelihood
Model 17 Count of bars IMD score % BAME Population density Public transport accessibility level average % one person properties % private rented properties % non domestic buildings	-7866.16	-4596.14	-6747.17
Model 18 Count of bars IMD score % BAME Population density Public transport accessibility level average % one person properties % private rented properties % nondomestic buildings % greenspace	-7862.58	-4592.25	-6746.31
Model 19 Count of bars IMD score % BAME Population density Public transport accessibility level average % one person properties % private rented properties % nondomestic buildings % greenspace Female over 15 population	-7816.83	-4578.48	-6705.24

$N = S1 \text{ count} = 3011$ ,  $S2 \text{ count} = 6810$

all variables remained significant except for the percentage of green space, which was not a statistically significant predictor of S2 rapes.

### Temporal Patterns in Stranger Rape

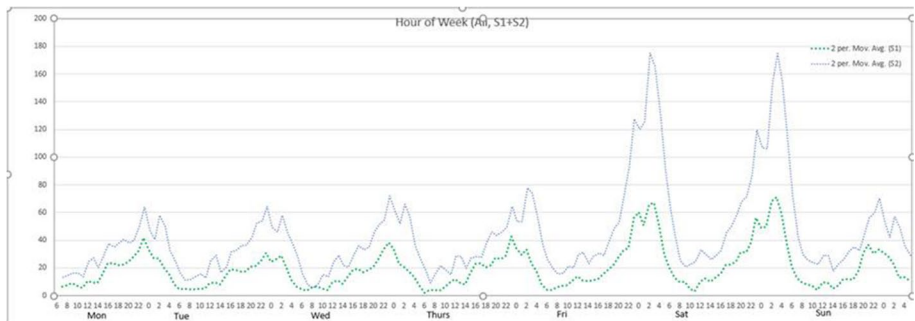
The timing of S1 and S2 offences were analysed based on season (spring, summer, autumn, and winter), time of day (daytime and night-time), and day of week (weekday-weekend). For a breakdown of these classifications, see Table 2. There was no statistically significant difference between S1 and S2 by time of the day;  $X^2 (1, N = 12,310) = 0.23, p = 0.879$  or by season;  $X^2 (3, N = 12,310) = 612, p = 0.455$ . However, there was a significant difference between S1 and S2 rapes when comparing weekdays with weekends. S1 offences were higher than expected on weekdays, and lower than expected at the weekend. S2 offences were lower than expected during weekdays, and higher than expected at the weekend;  $X^2 (1, N = 12,310) = 13.4, p < 0.001$ .

To explore these patterns further, we analysed the temporal data using the 168-h week as time T of day and day of week analysis are not particularly reflective of the underpinning literature (i.e., lifestyles and routine activities). The results can be seen in Fig. 4 where overall, the highest number of offences were recorded over the weekend, with peaks on both Friday and Saturday nights. For S2 rapes, there is a double peak in offending every night, with the first smaller peak

**Table 5** Final negative binomial regression model

Variable	All stranger rape model IRR coefficient (std error)	S1 model IRR coefficient (std error)	S2 model IRR coefficient (std error)
Count of bars	1.046 (0.005)***	1.055 (0.008)***	1.039 (0.005)***
IMD score	1.027 (0.016)***	1.030 (0.003)***	1.025 (0.002)***
% B.A.M.E	1.005 (0.001)***	1.005 (0.002) **	1.006 (0.001)***
Population density	0.998 (0.0003) ***	0.998 (0.0005)***	0.998 (0.0003)***
Public transport accessibility level average	1.151 (0.014)***	1.180 (0.023)***	1.141 (0.016)***
% One person properties	1.015 (0.002) ***	1.007 (0.003)*	1.018 (0.002)***
% Private rented properties	1.017 (0.001)***	1.017 (0.002)***	1.017 (0.002)***
% Non-domestic building	1.007 (0.002)**	1.0006 (0.004)	1.010 (0.003)***
% Greenspace	1.002 (0.0009)*	1.004 (0.002)**	1.001 (0.001)
Female over 15 population	1.001 (0.0001)***	1.0006 (0.0001)***	1.0007 (0.0001)***
Constant	0.104 (0.010)***	0.040 (0.006) ***	0.068 (0.007)***
Log-likelihood	-7816.83	-4578.48	-6705.24
AIC	15,657.66	9180.96	13,434.48
BIC	15,734.97	9258.27	13,511.80

Significance levels: \*  $p \leq 0.05$ ; \*\*  $p \leq 0.01$ ; \*\*\*  $p \leq 0.001$ .  $N = S1 \text{ count} = 3011$ ,  $S2 \text{ count} = 6810$

**Fig. 4** Temporal variations in stranger rape

recorded around midnight and the second larger peak around 3 pm. For S1 rapes, the double peak is not found on every night, but only observed on Tuesday night (where the second peak is slightly smaller than the first), Thursday night (with again a second smaller peak), Friday and Saturday (with a second larger peak similar to S2), and Sunday (with a very subtle second peak). These differences in offending levels between S1 and S2 are more marked at the weekend, with the gap between S1 and S2 offences greater on Friday and Saturday nights.

## Discussion

Rapes committed by perpetrators unknown to a victim make up a significant proportion of rape in England and Wales and countries across Europe (Flatley, 2018; Lovett & Kelly, 2009). Not only is stranger rape difficult to investigate, but the danger posed by attacks by

strangers can generate disproportionate levels of fear among women even though statistics show that women are more likely to be victimised by individuals they know (Scott, 2003). Stranger rape is often portrayed as an environmentally distinctive type of rape—synonymous with an outdoor location, often a secluded park or alley way at night-time. This is part of the existence of the “real” rape stereotype, a pervasive belief of what rape looks like (Estrich, 1987; Munro & Kelly, 2009; Myhill & Allen, 2002; Temkin & Krahé, 2008). This can impact on women’s interpretation of the characteristics of environments where they are at most risk of victimisation. However, there is a dearth of research on the locational characteristics of stranger rape and the range of settings and situations in which it occurs. This study represents the first to examine this particular type of rape geospatially.

## Spatial Characteristics of Stranger Rape

Overall, we found that S1 and S2 rapes displayed similar spatial distributions for offence locations. This was despite the finding that S2 rapes were more likely to take place in locations separate to the approach location and that these locations were more likely to be either the offender’s or victim’s residence. What this suggests is that, although S2 offenders display great spatial mobility, that mobility does not equate to large travel distances. Instead, these locations may reflect the relatively constrained awareness spaces of the offender and/or the victim (Brantingham & Brantingham, 1981).

Both the hotspot analysis and the standardised rape ratio analysis revealed greater densities in Westminster, which occupies much of the central area of Greater London including most of the West End, London’s principal entertainment district. The City of Westminster is served by 27 underground train stations and 10 lines which service an influx of people for both work related and social activities. This finding is similar to that of Ceccato (2014) who found that outdoor rapes in Stockholm were concentrated in inner city areas and accords with the routine activities of both potential offenders and suitable victims that such areas attract.

## Stranger Rape Settings

There were a range of locational settings in which perpetrators both encountered their victims and where the offence took place. Furthermore, we found that these differed according to the type of stranger rape being considered. S1 rapes conformed most closely to the commonly held belief that stranger rape occurs in secluded outdoor environments (Estrich, 1987) with the majority of S1 encounter and offence settings outdoors in the current study. This is in direct contrast to a number of other studies, all of which have examined either acquaintance rape or a mixture of different types of rape (Lovett & Kelly, 2009; Rosay & Langworthy, 2003). However, it does bear similarity to the “outdoor rape track” hunting process script found by Beauregard et al., (2007a, 2007b) in their study of stranger rape, whereby an offender uses outdoor locations for all elements of the offence.

We did find that there was greater variety in the encounter and offence settings for S2 rapes. The most common encounter locations were outdoors and entertainment venues, and the most common offence location was the suspect’s or victim’s dwelling. This variability may reflect the offender’s methods of victim selection in S2 rapes where offenders typically encounter victims in a legitimate activity and then moves to an environment suitable for rape. This is also reflected in the findings that S1 rapes displayed greater intra-offence consistency. In S2 rapes, perpetrators were more likely to move to another location type. This

may be a matter of necessity as the types of environments S2 perpetrators tend to encounter victims are not suitable to carry out the offence. This is similar to the “sophistication rape track” found by Beauregard et al. (2007b), whereby after an encounter in a public place, offenders attack and commit the sexual crime in an indoor private location.

Temporally, we found that the highest number of stranger rapes was recorded over the weekend, with peaks on both Friday and Saturday nights. This is consistent with much past research (Amir, 1971; Ceccato, 2014; Ceccato et al., 2017; Moran, 1993; Rosay & Langworthy, 2003) and reflects the relationship between the night-time economy and rape. However, our analysis also revealed a double peak in offending every night for S2 rapes and on some nights for S1 rapes. The timing of these peaks was around midnight and the second around 3am. These peaks may reflect the activities of potential victims as these peaks are at traditional closing time for bars and clubs. This would explain the greater consistency in S2 rapes which appear to be more tied to legitimate venues as encounter locations.

### Neighbourhood Predictors of Stranger Rape

The predictive model highlighted the importance of transport connections and the night-time economy, with both S1 and S2 rape counts growing as the PTAL score and number of bars in the area increased. Other significant predictor variables for both types of stranger rape were the IMD score, the percentage of one person properties, and the percentage of private rented properties, with the rape count increasing in areas that were more deprived and higher proportions of one person and private rented properties. Interestingly, this does not align with the findings of Kawachi et al. (1999), who in their study of crime, social disorganisation, and relative deprivation found no evidence of ecological correlates with rape (although they did find a correlation with a higher number of single mothers). The only variable that was not significant for both S1 and S2 rapes was the percentage of greenspace, with the rape count increasing for S1 rapes in areas where there is more greenspace, whereas the relationship with S2 rapes was not significant. This accords with the previous finding that significantly more S1 rapes took place outside than S2 rapes and further reinforces the association between a method of approach involving a sudden, surprise attack, and a suitable outdoors environment.

### Limitations

One potential limitation is that the current study relies on police reported rape data and therefore does not take account of crimes not reported to police. The Crime Survey for England and Wales finds that only 17% of victims had reported to the police (Flatley, 2018). However, there is evidence that rapes committed by strangers are more likely to be reported to the police thereby reducing the potential impact for “missing” data. Another limitation of this study is that the independent variables were only available at the LSOA level, and therefore, it is difficult to ascertain the influence of more local environmental variables which may influence the spatial locations of rape. For example, crime is known to be clustered at the street level (Konkel et al., 2019; Weisburd, 2015), and therefore within the neighbourhood level analysis, there may be spatial clustering at a scale that cannot be explored using the available independent variables. One future research avenue here would be to examine the spatial relationships between stranger rape and nearby land use types, for example, local bars, restaurants, cinemas, theatres, and parks, to examine whether particular facility types, or a mix of proximate facility types, offer more favourable opportunities

for offenders. A key question to be explored would be whether these vary between S1 and S2 rapes. Moreover, this facility data could also be compared with the approach and location of offences data, to enable a more nuanced exploration of this. The Ordnance Survey Points of Interest Dataset opens up possibilities for further research here. Lastly, the model does not consider any variation in the predictors over space.

## Implications for Crime Prevention Policy

The findings presented in this study have implications for crime prevention policy. They provide valuable evidence on the range of settings and circumstances within which stranger rape occurs and can therefore be used to focus situational crime prevention efforts in “risky” places to make assaults more difficult to commit. We argue that a better understanding of the temporal and spatial risk factors around linked to both the approach and offence locations of stranger rape enables crime prevention policy to be afforded at specific situations and settings that could be considered high risk for stranger rape. The onus is on place managers and designers to modify these environments.

Place-based crime prevention strategies should be designed to address aspects of neighbourhood and other community settings to make rape less likely. Such approaches could address community-level risk factors by changing, enacting, or enforcing laws, regulations, or organizational policies (e.g. alcohol policies) or by changing the physical environment, economic or social incentives (or consequences) for behaviour, or other characteristics of the community (e.g. ability to monitor and respond to problem behaviour, increased social controls). Community-level environmental approaches have potential for population-level impact, often at low cost for implementation (Basile et al., 2016). For example, offering safe, legal transportation to women leaving bars and night-clubs, walking home from work, or leaving night classes can limit the opportunities available to motivated offenders. For this response to be effective, analysis must accurately identify high-risk times and locations, as in this paper. Police should also identify illegal operated services (e.g. gypsy cabs) they have linked to sexual assaults. In 2002, it was identified that illegal minicab drivers committed a significant proportion of sexual assaults in London, attacking about 18 women per month. Transport for London, the Metropolitan Police Service, and London’s mayor raised public awareness of the problem, cracked down on illegal cabs, and provided safe late-night transportation in the area. Over four years, the number of sexual assaults of this type decreased by about 45 percent (Burton, 2006).

Whilst it was not possible to match individual approach and offence locations with the available data, we were able to detect some noticeable differences between S1 and S2 offences that have important implications for crime prevention. When the approach location was outdoors, a large proportion of S1 offences also occurred outdoors, whereas for S2 offences, fewer outdoor approaches resulted in outdoor offences, and there was an increase in offences in a suspect’s private dwelling. A similar pattern emerged when the approach was entertainment—a greater proportion of S1 offences were also entertainment whereas this did not apply to S2 offences—again for S2 more offences occurred in the private dwelling of the suspect. The likelihood is that when the initial encounter is more fleeting (S1), the offence is likely to occur in the vicinity of the approach given nearby places are likely to be of a similar type than more distant ones. As this distance increases between approach and offence so does the time the offender needs to remain in relatively close contact to the victim, potentially reducing the chances of success for the offender for S1 offences and

increasing the need for a longer interaction with the victim to build up trust. Therefore, efforts to support prevention, particularly at entertainment venues, should extend beyond the immediate vicinity of the entertainment venue, given offences are perhaps likely as the victim is walking home.

When the approach is made on transport, a large proportion of S1 offences also occur on transport—hence the need to develop concerted efforts to target prevention on the transport environment. A recent report to address violence against women and girls (VAWG) on transport put forward 13 potential crime prevention priorities (Transport Champions for Tackling Violence Against Women and Girls, 2022). Some of these recommendations could apply more broadly to reducing stranger rape including involving women in the design of entertainment settings and transport settings, making staff/guardians more visible in these locations or nearby (could they be positioned in a way to try and ensure women are not followed out of venues for example), and identifying better reporting mechanisms of S1 approaches to try and build a better evidence base of potential approaches.

Crime prevention efforts should also understand the differences between S1 and S2 offences and consider how support can be more tailored. For S1 offences, the data suggests the location of both approach and offence to be close and likely in similar environments. It is S2 offences that tend to occur further away, in a suspect's dwelling for example. One interesting crime prevention initiative explored within the VAWG arena more broadly which may apply to stranger rape is bystander intervention. However, this may need to be tailored—for S1 offences, this might need to occur close to the initial encounter which might be problematic as there is perhaps less awareness among both potential victims/targets and potential guardians/bystanders that a female might be at risk. However, for S2 offences, the offence may happen away from the approach, and it is likely there will be less bystanders present. It is clear we need to better understand the relationship between approach and offence in more detail, and to ensure we continue to make the distinction between S1 patterns and S2 patterns.

This study has presented an examination of the spatial and temporal patterns of stranger rape, demonstrating the importance of being crime-type specific in this type of study. Moreover, it explored the linkages between, and the geo-spatial characteristics of both the approach and the offence. It also highlights the importance of not analysing rape as a single crime type, and the importance of breaking it down into more nuanced categories considering such as stranger rape. It identified nuances between S1 and S2 stranger rapes, suggesting further research in this area is warranted. Whilst some neighbourhood characteristics were identified as predictive variables of these strange rape types, it is suggested that a more local level analysis is needed to explore micro settings of these rape offences, rather than across LSOAs. We have also identified several policy implications arising directly from our place-based analysis of stranger rape.

**Acknowledgements** The authors are grateful to the London Metropolitan Police Service for providing the data for this study.

## Declarations

**Competing Interests** The authors declare no competing interests.

**Open Access** This article is licensed under a Creative Commons Attribution 4.0 International License, which permits use, sharing, adaptation, distribution and reproduction in any medium or format, as long as you give appropriate credit to the original author(s) and the source, provide a link to the Creative Commons licence, and indicate if changes were made. The images or other third party material in this article are included in the article's Creative Commons licence, unless indicated otherwise in a credit line to the material. If material is not included in the article's Creative Commons licence and your intended use is not

permitted by statutory regulation or exceeds the permitted use, you will need to obtain permission directly from the copyright holder. To view a copy of this licence, visit <http://creativecommons.org/licenses/by/4.0/>.

## References

- Amir, M. (1971). *Patterns in forcible rape*. University of Chicago Press.
- Andresen, M. A., & Malleon, N. (2011). Testing the stability of crime patterns: Implications for theory and policy. *Journal of Research in Crime and Delinquency*, 48, 58–82. <https://doi.org/10.1177/0022427810384136>
- Basile, K. C., DeGue, S., Jones, K., Freire, K., Dills, J., Smith, S. G., & Raiford, J. L. (2016). *STOP SV: A technical package to prevent sexual violence*. U.S. Department of Health & Human Services, Centers for Disease Control and Prevention. Retrieved January 20 2022 from: <https://www.cdc.gov/violenceprevention/pdf/sv-prevention-technical-package.pdf>
- Beauregard, E., Jean Proulx, J., & Rossmo, D. K. (2005). Spatial patterns of sex offenders: Theoretical, empirical, and practical issues. *Aggression and Violent Behavior*, 10, 579–603. <https://doi.org/10.1016/j.avb.2004.12.003>
- Beauregard, E., Rossmo, D., & Proulx, J. (2007). A descriptive model of the hunting process of serial sex offenders: A rational choice perspective. *Journal of Family Violence*, 22, 449–463. <https://doi.org/10.1007/s10896-007-9101-3>
- Beauregard, E., Proulx, J., Rossmo, K., Leclerc, B., & Allaire, J.-F. (2007). Script analysis of the hunting process of serial sex offenders. *Criminal Justice and Behavior*, 34, 1069–1084. <https://doi.org/10.1177/0093854807300851>
- Bownes, I. T., O’Gorman, E. C., & Sayers, A. (1991). Assault characteristics and posttraumatic stress disorder in rape victims. *Acta Psychiatrica Scandinavica*, 83, 27–30. <https://doi.org/10.1111/j.1600-0447.1991.tb05507.x>
- Brantingham, P., & Brantingham, P. (1981). *Environmental criminology*. Waveland Press.
- Brantingham, P., & Brantingham, P. (1993). Nodes, paths and edges: Considerations on the complexity of crime and the physical environment. *Journal of Environmental Psychology*, 13, 1–28. [https://doi.org/10.1016/S0272-4944\(05\)80212-9](https://doi.org/10.1016/S0272-4944(05)80212-9)
- Burton, S. (2006). *Safer travel at night: Transport for London*. Transport for London.
- Ceccato, V. (2014). The nature of rape places. *Journal of Environmental Psychology*, 40, 97–107. <https://doi.org/10.1016/j.jenvp.2014.05.006>
- Ceccato, V., Wiebe, D. J., Eshraghi, B., & Vrotsou, K. (2017). Women’s mobility and the situational conditions of rape: Cases reported to hospitals. *Journal of Interpersonal Violence*, 35, 1–30. <https://doi.org/10.1177/0886260517699950>
- Ceccato, V., Li, G., & Haining, R. (2018). The ecology of outdoor rape: The case of Stockholm. *European Journal of Criminology*, 16, 1–27. <https://doi.org/10.1177/1477370818770842>
- Chopin, J., Paquette, S., & Beauregard, E. (2022). Is there an “expert” stranger rapist? *Sexual Abuse*, 34, 78–105. <https://doi.org/10.1177/1079063221993478>
- Cohen, L. E., & Felson, M. (1979). Social change and crime rate trends: A routine activity approach. *American Sociological Review*, 44(4), 588–608. <https://doi.org/10.2307/2094589>
- Cornish, D. B., & Clarke, R. V. (1986). Introduction. In D. B. Cornish & R. V. Clarke (Eds.), *The reasoning criminal: Rational choice perspectives on offending* (pp. 13–45). Springer-Verlag.
- Estrich, S. (1987). *Real rape*. Harvard University Press.
- Flatley, J. (2018). *Sexual offences in England and Wales: Year ending March 2017*. London: Office for National Statistics. Retrieved March 24, 2022 from: <https://www.ons.gov.uk/peoplepopulationandcommunity/crimeandjustice/articles/sexualoffencesinenglandandwales/ingmarch2017>
- Friis-Rødel, A.M., Mygind-Leth, P., & Schmidt-Astrup, B. (2021). Stranger rape; distinctions between the typical rape type and other types of rape. A study based on data from Center for Victims of Sexual Assault. *Journal of Forensic and Legal Medicine*, 80. <https://doi.org/10.1016/j.jflm.2021.102159>
- Gardner, W., Mulvey, E. P., & Shaw, E. C. (1995). Regression analyses of counts and rates: Poisson, overdispersed Poisson, and negative binomial models. *Psychological Bulletin*, 118, 392.
- Hendrix, P. N., Van Patten, I. T., & Bjerregaard, B. (2008). *The spatial context of rape: The fourth dimension of neighborhoods* [Paper presentation]. Meeting of the American Society of Criminology, St. Louis, MO. Retrieved 6 Sept, 2021 from <http://ivanpatt.asp.radford.edu/Research/Female%20Guardianship.pdf>

- Hewitt, A. N., Beaugregard, E., Andresen, M. A., & Brantingham, P. L. (2018). Identifying the nature of risky places for sexual crime: The applicability of crime pattern and social disorganisation theories in a Canadian context. *Journal of Criminal Justice*, 57, 35–46. <https://doi.org/10.1016/j.jcrimjus.2018.03.003>
- Kawachi, I., Kennedy, B. P., & Wilkinson, R. G. (1999). Crime: Social disorganization and relative deprivation. *Social Science & Medicine*, 48, 719–731. [https://doi.org/10.1016/s0277-9536\(98\)00400-6](https://doi.org/10.1016/s0277-9536(98)00400-6)
- Konkel, R.H., Hafmeister, A.J., & Daigle, L.E. (2019). The effects of risky places, motivated offenders and social disorganisation on sexual victimisation: A microgeographic and neighbourhood level examination. *Journal of Interpersonal Violence*, ePub ahead of print. <https://doi.org/10.1177/0886260519849693>
- Lovett, J., & Kelly, L. (2009). *Different systems, similar outcomes? Tracking attrition in reported rape cases in eleven countries*. London. Retrieved Dec 5, 2021 from: [https://cwasu.org/wp-content/uploads/2016/07/different\\_systems\\_03\\_web2.pdf](https://cwasu.org/wp-content/uploads/2016/07/different_systems_03_web2.pdf)
- Mayor of London. (2009). *Areas for intensification points (London Plan Consultation 2009) - London Data-store*. Retrieved Dec 11, 2021 from: <https://data.london.gov.uk/dataset/areas-intensification-points-london-plan-consultation-2009>
- Metropolitan Police. (2022). *The Met's area of jurisdiction* | Metropolitan Police. Retrieved Jan 13, 2022 from: <https://www.met.police.uk/police-forces/metropolitan-police/areas/about-us/about-the-met/jurisdiction/>.
- Miethe, T.D., & Meier, R.F. (1990). *Crime and its social context: Toward an integrated theory of offenders, victims, and situations*. SUNY Press.
- Moran, A. (1993). Patterns of rape: A preliminary Queensland perspective. In P.W. Eastale (Ed.), *Without Consent: Confronting Adult Sexual Violence: Proceedings of a Conference held 27–29 October 1992* 35–53. Australian Institute of Criminology.
- LMPS. (2022). Crime reporting information system. Statistics retrieved July 10 2022.
- Muir, G., & Macleod, M. D. (2003). The demographic and spatial patterns of recorded rape in a large UK metropolitan area. *Psychology, Crime & Law*, 9, 345–355. <https://doi.org/10.1080/1068316031000093423>
- Munro, V., & Kelly, L. (2009). *A vicious cycle? Attrition and conviction patterns in contemporary rape cases in England and Wales*. In: M.A. Horvath, & J. Brown (Eds) *Rape: Challenging Contemporary Thinking*. Willan Publishing, 281–300.
- Myhill, A., & Allen, J. (2002). *Rape and sexual assault of women: the extent and nature of the problem: findings from the British Crime Survey*. Home Office Research, Development and Statistics Directorate.
- Newton, A. (2015). Crime and the NTE: Multi-classification crime (MCC) hot spots in time and space. *Crime Science*, 4, 1–12. <https://doi.org/10.1186/s40163-015-0040-7>
- O'Sullivan, D., & Unwin, D. (2003). *Geographic information analysis*. John Wiley & Sons.
- Osgood, D. W. (2000). Poisson-based regression analysis of aggregate crime rates. *Journal of Quantitative Criminology*, 16(1), 21–43.
- Park, N. (2020). *Population estimates for the UK, England and Wales, Scotland and Northern Ireland, provisional*. Retrieved Sept 23, 2021 from: <https://www.ons.gov.uk/peoplepopulationandcommunity/populationandmigration/populationestimates/bulletins/annualmidyearpopulationestimates/mid2019>
- Rosay, A. B. and R. H. Langworthy (2003). *Descriptive analysis of sexual assaults in Anchorage, Alaska*. Final report to the Bureau of Justice Statistics, Alaska Justice Statistical Analysis Center, Justice Center, University of Alaska Anchorage.
- Santtila, P., Laukkanen, M., Zappala, A., & Bosco, D. (2008). Distance travelled and offence characteristics in homicide, rape, and robbery against business. *Legal and Criminological Psychology*, 13, 345–356. <https://doi.org/10.1348/135532507X238673>
- SCOID SO Page Categories. (2015). London Metropolitan Police Service Internal Document.
- Scott, H. (2003). Stranger danger: Explaining women's fear of crime. *Western Criminology Review*, 4(3), 203–214.
- Stata. (2022). Nbrreg – Stata, Retrieved Sept 12, 2021 from: <https://www.stata.com/manuals13/rnrbreg.pdf>
- Stern, V. (2010). *The stern review: An independent review into how rape complaints are handled by public authorities in England and Wales*. Government Equalities Office.
- Temkin, & Krahé, B. (2008). *Sexual assault and the justice gap* (1st ed.). Hart Publishing.
- Tewksbury, R., Mustaine, E. E., & Covington, M. (2010). Offender presence, available victims, social disorganisation and sex offense rates. *American Journal of Criminal Justice*, 35, 1–14. <https://doi.org/10.1007/s12103-010-9070-6>
- The Mayor's Office for Policing and Crime [MOPAC]. (2019). *The London Rape Review: A review of cases from 2016*. Mayor of London Office for Policing and Crime. Retrieved Oct 5, 2021 from: [https://www.london.gov.uk/sites/default/files/london\\_rape\\_review\\_final\\_report\\_31.7.19.pdf](https://www.london.gov.uk/sites/default/files/london_rape_review_final_report_31.7.19.pdf)
- Transport Champions for Tackling Violence Against Women and Girls. (2022). *Recommendations to make our transport networks safer for women and girls*. Transport for West Midlands. Retrieved Sept

- 15, 2022 from: <https://www.wmca.org.uk/media/xqhi4z3b/violence-against-women-and-girls-recommendations-by-the-transport-champions-final-version-1.pdf>
- UK Government. (2018). *Regional ethnic diversity – GOV.UK Ethnicity facts and figures*. Retrieved Sept 10, 2021 from: <https://www.ethnicity-facts-figures.service.gov.uk/uk-population-by-ethnicity/national-and-regional-populations/regional-ethnic-diversity/latest>
- Weisburd, D. (2015). The law of crime concentration and the criminology of place. *Criminology*, 53, 133–157. <https://doi.org/10.1111/1745-9125.12070>

**Publisher's Note** Springer Nature remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.