Infectious Burglaries: A Test of the Near Repeat Hypothesis

Article *in* British Journal of Criminology · June 2003

DOI: 10.1093/bjc/azg615 · Source: OAI

3 authors:

Michael Kenneth Townsley
Griffith University

Ross Homel
Griffith University

Janet Chaseling
Griffith University

BRIT. J. CRIMINOL. (2003) **43**, 615–633

INFECTIOUS BURGLARIES

A Test of the Near Repeat Hypothesis

Michael Townsley, Ross Homel and Janet Chaseling*

This paper explores one aspect of spatial dependence for the offence of burglary, utilising epidemiological methods for the study of infectious diseases to investigate the phenomenon of near repeat victimization. The near repeat burglary hypothesis states that proximity to a burgled dwelling increases burglary risk for those areas that have a high degree of housing homogeneity and that this risk is similar in nature to the temporarily heightened risk of becoming a repeat victim after an initial victimization. The near repeat hypothesis was tested on 34 months of police recorded burglary data across a high crime area of Brisbane, Australia. Near repeats were shown to exist in the study area, mainly in suburbs containing homogeneous housing. Little or no housing diversity, in terms of the type of physical construction and general appearance of dwellings, serves to restrict the extent of repeat victimization. Housing diversity allows offenders a choice of targets, and favoured targets will be 'revisited' by burglars. Near identical targets usually present no motive for an offender to favour one property over another. Thus in areas with low housing diversity, victim prevalence should be higher than in areas with heterogeneous housing.

Introduction

Over the last 20 years the phenomenon of repeat victimization has been the subject of considerable academic attention and evaluation, and its existence has been exploited to reduce crime dramatically in a range of crime prevention experiments (Chenery *et al.* 1997; Farrell and Buckley 1999; Forrester *et al.* 1988; Hanmer *et al.* 1999). The prevention of repeat victimization has been acknowledged as an example of best practice by Waller and Welsh (1998) and appears in the *What Works* compendium (Sherman *et al.* 1998). In recent years the UK Home Office has used repeat victimization as a key performance indicator for police forces.

The theory is comparatively simple: a small number of individuals or households experience a disproportionate amount of crime and by focusing prevention resources on these repeat victims, the impact on crime will be greater than if entire communities were targeted. The best predictor of victimization in the future is victimization in the past, over and above socioeconomic status (Pease 1998).

The other notable aspect of repeat victimization is that in the wake of a criminal incident, the victim is at higher risk of experiencing further victimization than non-victims, but this increased risk is not enduring (Polvi *et al.* 1990, 1991). Victim risk is at its

* Michael Townsley and Ross Homel, School of Criminology and Criminal Justice, Griffith University; Janet Chaseling, Australian School of Environmental Studies, Griffith University. Contact address: Jill Dando Institute of Crime Science, University College London, Third Floor, 1 Old Street, London, EC1V 9HL; e-mail m.townsley@ucl.ac.uk.

The authors would like to acknowledge the assistance of the Queensland Police Service, for the use of their data, and the Queensland Criminal Justice Commission for the use of their mapping facilities.

zenith immediately following an incident and monotonically decreases over the following months. Post-victimization risk reaches pre-victimization levels between six and 12 months after the initial victimization, although some research suggests that victims will continue to carry some risk higher than non-victims (Pease 2001).

Numerous policing experiments have demonstrated the efficacy of focusing resources at the prevention of repeat victimization rather than the prevention of wholesale victimization. Chenery *et al.* (1997) documented a 20 per cent decrease in overall car crime and a 30 per cent decrease in burglary by concentrating on individuals already victimized. Forrester *et al.* (1988) described efforts to eliminate repeat burglaries on a housing estate that resulted in substantial decreases in overall levels of burglary—75 per cent over three years with no displacement. Hanmer *et al.* (1999) outlined a project aimed at preventing future domestic violence incidents. They demonstrated that the proportion of repeat offenders fell by over half (34 per cent to 15 per cent).

Virtually all crime types, with the exception of murder and manslaughter, have a component of repeat victimization. Exhaustive reviews of the repeat victimization phenomenon can be found in Farrell (1995), Farrell and Pease (1993) and Pease (1998). A recent edition of *Crime Prevention Studies* was devoted entirely to repeat victimization (Farrell and Pease 2000).

Research rationale

The discovery of the phenomenon of repeat victimization is an important theoretical breakthrough that has permitted the development of new tools for targeting resources to achieve reductions in crime. The concept does not, however, stand in isolation from other features of victimization patterns, such as ‘hot spots’. For example, Townsley *et al.* (2000) found that some burglary hot spots that were unstable over time consisted largely of repeat victim addresses, while other, more stable, hot spots were more related to enduring aspects of the immediate physical and social environment. The general point is that crimes are both spatially and temporally interdependent, particularly through the process of ‘exposure’ resulting from proximity to where offenders live and to areas with criminogenic characteristics, and through the process of ‘diffusion’ of crime effects arising from sequences of social interactions. As Morenoff *et al.* (2001: 523) put it, ‘The diffusion perspective focuses on the consequences of crime as they are played out over time and space . . . The concept of exposure focuses on the antecedent conditions that foster crime, which are also spatially and temporally ordered.’ These concepts, although not necessarily the specific terminology, are well illustrated by recent research into burglary. Diffusion effects are illustrated by the research of Anderson *et al.* (1995), which identified an increased risk period for properties nearby to burglary victims. Anderson and colleagues selected streets at random and a reference property for each street was selected as the first burgled property in that street. The distance between the reference burglary and the next recorded burglary was then calculated using the respective house numbers. The researchers concluded that where repeat burglaries did not occur, burglaries of separate households in the street were more likely.

Morgan (2000) suggested that victimization might be dispersed spatially in certain circumstances, effectively suppressing the extent of repeat victimization. He observed that, in a Perth suburb (Australia), several ‘one-time victims’ tended to cluster around a repeat victim in certain instances. He found the repeat victim addresses occurred first and the one-time victims were burgled shortly after, suggesting some form of 'contagion' process at work. Morgan named the surrounding one-time victims *near repeats*.

Shaw and Pease (2000) describe a concept called the *penumbra of risk* of victimization within a street. They describe patterns of burglary within street segments that have clear conceptual parallels with near repeats. For instance, '[i]f a housebreaking is of a home with an even number, on over two thirds of occasions (68 per cent) the *next* house-breaking on the street will also be of an even number. The same applies to odd-odd sequences' (Shaw and Pease 2000: 39, emphasis in original).

This study attempts to identify patterns of repeat victimization that are not immediately apparent. Briefly, we argue that the penumbra of risk may operate in certain areas to a degree that lowers the apparent extent of repeat victimization. We have explored this using Morgan's notion of *near repeats*, which is a special case of repeat victimization.

The Research Question

Pease (1998) defines 'virtual repeats', where criminal acts may be linked by virtue of victim (or target) similarity. He uses racial attacks (all *x*'s look the same) and same-model car theft as examples. The reason these incidents are considered repeats is that the offender is the same person and the targets were selected due to their similarity. The logic on the part of the offender is understandable—*target suitability can be assessed in terms of similarity to prior targets*.

Morgan's (2000) identification of near repeats is linked to the concept of virtual repeats. Virtual repeats involve practically identical targets at different locations. Near repeats differ from virtual repeats with respect to the spatial component; they are geographically close. Where virtual repeat targets are selected solely on the basis of their similarity to previous victims, regardless of location, near repeat targets are selected based on their similarity *and* their proximity to previous victims.

The near repeat burglary hypothesis

The hypothesis to be tested is that proximity to a burgled dwelling increases burglary risk for those areas with a high degree of housing homogeneity. The near repeat mechanism relies on two concepts. The first, *homogeneous areas,* is based on the idea that areas with homogeneous housing types will have greater levels of victim prevalence than more heterogeneous housing areas. The second, *a contagion process of victimization,* involves the idea that victimization risk is inversely related to the distance from a previously victimized property. The two concepts combine so that the contagion process has a greater impact in homogeneous areas than other areas. That is, the risk to addresses close to burgled addresses will be greater in homogeneous areas, all other things being equal. The rationale behind each concept is set out below.

Homogeneous areas

The housing of an area is homogeneous to the degree that dwellings in the immediate area exhibit similar characteristics or features. In the context of burglary, housing with similar security features, either strong or weak, would tend to contribute substantially to the similarity of an area's housing. Similar floor plans and external features would also contribute to the degree of housing homogeneity of an area. An area that has homogeneous housing is one that an offender perceives to have a high number of similar targets, regardless of whether they are good targets or not. This perception relies heavily on external cues rather than factors such as the amount of goods contained within the property. Some external cues provide information about the household, like occupancy.

Areas with homogeneous housing are likely to experience higher rates of victim prevalence because offenders are not greatly advantaged by repeatedly breaking into the same house. That is, if an offender operates in an area with homogeneous housing consisting of a favoured dwelling type, it is expected that the offender would not necessarily concentrate on a particular address, but would 'visit' other addresses that share similar features.

An area is unlikely to have higher victim prevalence simply due to similar housing. The victimization composition of an area is also dependent on the suitability of targets in the area (for example, an entire community of identical Fort Knox-style residences would probably have little burglary) and exposure to offenders. Suitable targets in the presence of motivated offenders result in vulnerable properties. This means areas most likely to contain near repeats are those with high proportions of similar houses that are generally vulnerable burglary targets.

Contagion process of victimization

The contagion model of near repeat victimization predicts that victimization can be 'passed' from victim to victim in a similar way to that which occurs in diseases. This could occur because as routine activities and lifestyle theories (Cohen and Felson 1979; Hindelang *et al.* 1978) predict, the greater the amount of exposure a potential offender is given to a suitable target the greater the probability of a crime occurring. This means that houses located along streets that an offender travels regularly are at greater risk of experiencing burglary due to repeated offender observation compared to an identical street that is not exposed to repeated offender scrutiny. The offender may only have time to observe closely one or two houses of a specific street each trip, but if the trips are frequent enough, the offender could develop a body of knowledge about that street.

Little is known about the movement patterns of burglars in concrete terms. Research has confirmed that offenders predominantly select addresses that they observe while engaging in legitimate activities, such as travelling to places of work or recreation (Brantingham and Brantingham 1985; Rengert and Wasilchick 1985). One thing that is known for certain is that an offender was present at each burgled residence at the time of a burglary. Also, it is safe to assume that the offender also observed other properties in the street segment containing the victimized address on the occasions leading up to the offence, at the commission of the offence and afterwards. It is expected that at the commission of an offence burglars would take more precautions and observe closely the surrounding area for signs of surveillance, which would include observing the surrounding properties. During the commission of the offence the offender not only scrutinizes the target for signs of security weakness but also observes the surrounding dwellings. This extra observation means that dwellings in close proximity to victims are at higher risk than those that are not close.

If this argument is correct, then the situation for households located close to repeat victims is even more serious. Findings from repeat victimization research highlight that offenders often return to the site of previous burglaries. We can be confident that in the majority of cases the same offender is involved in repeat burglaries (Pease 1998), but this is not the most important point. Repeat addresses are 'visited' by offenders, whether it is the same person(s) or not, and therefore the surrounding dwellings have been scrutinized more intensively due to the presence of the repeatedly visited address.

If victimization risk can be influenced by the victimization of proximate dwellings, it can be thought of as an infection. Real and McElhany (1996) identified three criteria for successful disease propagation: (a) a suitable host, (b) close contact between carrier and potential hosts and (c) a lack of resistance or immunity. This means disease transmission is achieved by close contact between an infected individual and a susceptible individual during the former's *infective period* (the length of time an infected person remains contagious). Thus, if a susceptible person came into contact with the infected individual outside the infective period, no transmission of disease would occur. Likewise, if the susceptible person was not in close proximity to the infected individual during the infective period, transmission would not occur.

Victimization contagion needs to be demonstrated by close proximity in space *and* time. The infective period for burglary would intuitively be the time period of heightened risk subsequent to a victimization. As houses are stationary we will assume close contact means only those dwellings in the same street or the same 'segment' of a long road or some other suitable short distance. The other qualifier for 'catching victimization' is susceptibility. The offender will only burgle a proximate dwelling if he perceives the target as suitable.

The research question for this study is 'Do near repeats exist in areas containing homogeneous vulnerable housing?' In other words, 'Does burglary risk increase for those properties situated geographically close to burgled premises in areas with similar housing? If so, does the increased risk diminish over time in a similar way to repeat victims?'

Data

The area chosen for investigation was a police division, located in south east Queensland, Australia. This area has been used in previous work documented in Townsley *et al.* (2000). At the time of research it had the sixth highest burglary rate for the state. Demographic data reveal it to be a low socioeconomic area, with relatively high levels of unemployment, public housing, poverty and crime (see Table 3).

To quantify housing diversity and identify areas of recent large-scale land development, a real estate agent with considerable experience in the area was interviewed. The socioeconomic status of the area was measured using ABS (Australian Bureau of Statistics) census data. The ABS did not produce an index of housing similarity or diversity (ABS 1996).

Thirty-four months (two years and ten months) of police recorded crime data were used for the location of burglary victims. All the recorded burglaries in the police division between 1 January 1995 and 31 October 1997 were included in the data set. The data set contained the address of burgled properties, in addition to the time and date of the burglary.

The Crime Information System for Police (CRISP) information system contains recorded crime data for the Queensland Police Service. It records burglary times in a similar manner to most police information systems, with ‘start’ and ‘finish’ time fields. For consistency, the time of the burglary was taken as the earliest possible start time. It was felt that as long as a consistent approach was taken, any time estimate would yield similar results. Only the date component of the start time was used and the time of day was not required. In a worst case scenario the difference between using time and date compared to date only would be an additional 24 hours. The units used for the time dimension were days.

The data were geo-coded in MapInfo, a Geographical Information System (GIS), to determine the spatial distribution of the burglaries. Eighty-five per cent of the incidents occurred in five suburbs, all of which were urban in nature and therefore contained reliable street information. The rest were rural areas and the reliability of the street map used could be questioned. Street maps of rural areas often contain incomplete information, such as missing house numbers for street segments and unknown street names, which influences the accuracy of geo-coding. Those incidents not geo-coded were excluded from the analysis. The units used for the space dimension were metres.

Method

Determining homogeneous areas and target vulnerability

The five main suburbs of the police division were studied and assessed for similarity of housing and target vulnerability. These suburbs are urban areas that comprised the bulk of the police division’s residential population and crime. The remainder of the police division was semi-rural. The demographic variables and real estate agent interview were compiled for each of the urbanized suburbs in order to develop a profile.

A suburb was deemed to have homogeneous housing if evidence of similar housing could be demonstrated. At one stage it was proposed to develop a typology of housing types in the area and survey each suburb, noting the pockets of identical housing. This strategy was rejected due to the time and cost involved in rigorous implementation. It was decided that areas with recent large-scale land development would be the operational measurement of homogeneous housing. This was used because in areas of large-scale land development, where properties are marketed as house and land packages, the range of house plans is limited to about five or six designs. Normally a single company will construct all the properties.

Several suburbs in the police division have developed this way and there are many pockets of nearly identical dwellings. There are even cul de sacs comprised of exactly the same model house. There are older, more established parts of the division that exhibit considerable diversity of housing types, which provided enough overall variability to analyse levels of housing homogeneity throughout the police division.

The second criterion for near repeats was target vulnerability. This was operationalized as a combination of burglary rate and demographic indicators. The level of unemployment, public housing and low-income households were used to give an estimate of the resident offender population for each suburb. Suburbs with low socio-economic status and high burglary rates were considered to be comprised of vulnerable properties, that is suitable burglary targets that have been exposed to a high level of offender scrutiny.

Contagion model

Epidemiologists have studied the transmission of disease for nearly two and a half centuries (Bailey 1975). Methods have been developed to quantify temporal clustering as well as spatial clustering of infections (Pike and Smith 1968). Pinkel and Nefzger (1959) proposed a 'cell occupancy' approach to test for spatial-temporal clustering. This approach detects clustering in both space and time but was also susceptible to clustering in either space *or* time (Mantel 1967). Knox (1963, 1964a, 1964b) proposed a test for clustering in space and time that was impervious to purely spatial or temporal clustering. The test has become widely used and is still a popular method of testing for space-time interactions (Diggle *et al.* 1995), particularly in cases where the etiology of a disease is not well understood (Mantel 1967).

Knox's test is remarkably simple. Using the terminology of epidemiologists, each case of infection was paired with every other case, so that N cases would produce $N(N-1)/2$ distinct pairs. The distance and time between the cases for each pair were recorded. Cases occurring within a certain distance d of each other were considered close in space. Likewise, cases within t days of each other were deemed close in time. This resulted in a 2 by 2 contingency table such as Table 1. The number of cases that were close in space *and* time (X) was compared to the number expected by chance. If the number of observed close pairs was excessive compared to expectation, then disease transmission was said to have some contagious component.

It is important to note that the X close pairs do not all have to occur in the same small area or in a single short time period. A close pair occurs when two cases were within a distance d and time t of each other. This means it is entirely possible to have two close pairs that were on opposite sides of the study area.

The choice of values for d and t is at the discretion of the researcher and could be a source of bias if the selection of values is not based on theory but data driven. For this reason, Knox (1963) partitioned both the space and time dimensions into a number of categories that resulted in a larger contingency table, such as Table 2.

TABLE 1 *Example of the original Knox test*

Time apart (days)	Distance apart (metres)		
	0 to d	Over d	Total
0 to t	X	Y	T_1
t or greater	W	Z	T_2
Total	D_1	D_2	$\frac{N(N-1)}{2}$

TABLE 2 *Example of revised Knox test*

Time apart (days)	Distance apart					Total
	0 to d_1	d_1 to d_2	d_2 to d_3	. . .	Over d_{n-1}	
0 to t_1	n_{11}					$n_{1.}$
t_1 to t_2						
t_2 to t_3			n_{ij}			$n_{i.}$
. . .						
t_{m-1} or greater						
Total	$n_{.1}$		$n_{.j}$			$n_{..}$ (total number of pairs)

n_{ij} refers to the cell frequency corresponding to the ith row and the jth column. Subscripts with a '.' represent summation (e.g., $n_{.1}$ is the summation of all cells in the first column).

In order to test whether near repeats are present in the data, departures from expected frequencies for each cell need to be determined. A global test of independence, such as the classic χ^2 test, is not required because this test would not show which cells were different from the expected frequencies. Instead a residual analysis is conducted, outlined below.

Application to burglary and identifying near repeats

The Knox method does not locate concentrations of incidents, but tries to reflect one aspect of the underlying process of disease propagation, in this case burglary risk propagation.

If burglary risk is contagious, then an excess of observed pairs, compared to that expected by chance, for short distances and short times would be expected. What is meant by 'short' is difficult to quantify (this point is dealt with in full later), but it was expected that a concentration in space and time would be evident if near repeats were present.

It could be argued that a variety of other phenomena could produce excess pairs. Hot spots, small areas of high enduring crime levels, are likely to produce an excess of pairs close in space, but *not in time*. Their presence should produce an abundance of pairs for short distances, reflecting the spatial concentration of crime, but dispersed across time—reflecting the long-term nature of the high crime level. If incidents occur uniformly with time, then the number of short times will equal the number of long times. Another phenomenon that may obscure results is a spate of crime across an area. This is the inverse of a hot spot: concentration in time, but not in space. If such a crime wave were present in the data, we would expect an abundance of pairs in a short time but across all distances (see Figure 1 for examples of the spatial-temporal timing of near repeats, hot spots and crime waves).

Limitations of the Knox method

The epidemiological literature identifies three potential major problems with the Knox method: *arbitrary cut-offs*, *fluctuating population densities* and *edge effects*.

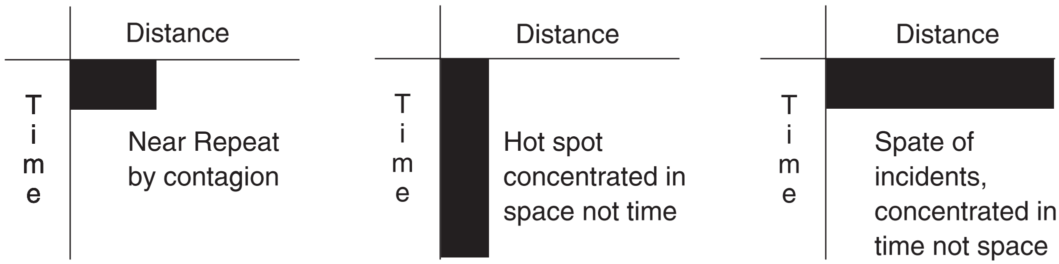

FIG. 1 Hypothetical results of Knox method for different underlying phenomena (cells with an excessive number of pairs have been shaded)

The only means to avoid the bias of arbitrary cut-offs is to link them to prior empirical findings. Of the two dimensions, space presents the most difficulties in terms of finding empirical support for any cut-off. Little work has been conducted to explore how close to the site of previous offences burglars re-offend. Most of the journey-to-crime literature reviewed (robbery, rape) reported mean distances but not standard deviations (van Koppen and Jansen 1998; Warren *et al.* 1998).

The other dimension is time, about which we do know something. The time course of repeat victimization for burglary generally follows a pattern of heightened risk for the first two months following the initial burglary (Farrell and Pease 1993; Polvi *et al.* 1990; Townsley *et al.* 2000). The risk diminishes substantially by six months and by 12 months nearly equals the original pre-burglary level.

Given that little is known about the spatial dimension for current purposes, it is difficult to justify using an approach that selects an arbitrary cut-off. With this in mind, it was decided to construct a contingency table with a range of cut-offs for both space and time dimensions. It was anticipated that short distances (the length of a street segment, approximately 100 to 200 metres) and short times (probably one or two months) would have more pairs than expected if near repeats were present. These may vary slightly depending on the particular area.

The police division does not suffer from population fluctuations. Over the last five years, there has been a marginal population growth. The community, whilst experiencing a higher than normal transient population, has relatively stable overall numbers of residents.

Edge effects occur when administrative boundaries are imposed on areas that are arbitrary or do not reflect the natural geography of the space. The obfuscation of crime patterns caused by police beat boundaries is a typical example. In the study area the possibility of 'edge effects' was considered low. Geographically the division, and the suburbs within it, has distinct natural boundaries such as rivers, highways, arterial roads and vacant land that should minimize any edge effect in the spatial dimension. In terms of the temporal dimension, nearly three years of data seemed an adequate time frame to use given that the size of other data sets is typically 12 months (Bennett and Durie 1999; Bowers *et al.* 1998; Chenery *et al.* 1997; Farrell and Buckley 1999; Hanmer *et al.* 1999; Johnson *et al.* 1997; Read *et al.* 1999; Sherman *et al.* 1989). If the risk of edge effects was higher, then a correction proposed by Diggle *et al.* (1995) could be adopted which mitigates the impact for both dimensions.

Contagion process of victimization

A Knox test was performed using a range of cut-offs for the space and time dimensions. All pairs closer than 1,000 m and 360 days apart were included in the analysis. The space and time dimensions were partitioned in 100 m intervals and monthly time periods (using a uniform 30 days as the month size). This resulted in a contingency table with 10 columns and 12 rows.

Each burglary address had a victim status of single or repeat. Single victims were those addresses that experienced only one burglary in the 34 month time period and repeat victims were addresses that recorded more than one. Because addresses could be one of two types of victims, there were three types of possible pairings: single and single (SS), single and repeat (SR), repeat and repeat (RR). For the purposes set out here, it was not important to determine which member of the pair occurred first. Thus, a single address infected by a pre-existing repeat was counted in the same category as a repeat address infected by a pre-existing single address.

A contingency table was constructed for each of the five main suburbs of the police division and each of the three variations of pairs: SS pairs, SR pairs, and RR pairs—resulting in 15 separate tables.

The Knox test was conducted to identify near repeats. There was a risk, however, of including incidents of repeat victimization within the contingency tables and thus obscuring the results. This would only occur for RR pairs and where the spatial distance was zero (indicating each burglary was part of a repeat burglary series). All pairs with spatial distances equal to zero were therefore excluded from all tables. It is acknowledged that burglaries of separate dwellings at the same address (for example units or apartment blocks) were under-represented because of this, but these types of addresses are not common in the police division so this should not influence results too much. These pairs would have a distance of zero because they were geo-coded to the same location (street address).

Residual analysis

For each table the expected count for each cell (e_{ij}) was calculated in the usual manner utilizing marginal row and column totals.

$$e_{ij} = \frac{n_{.j} \times n_{i.}}{n_{..}}$$

where $n_{i.}$, $n_{.j}$ and $n_{..}$ are represented in Table 2.

An adjusted residual (r_{ij}) was then calculated to determine those cell frequencies that deviated from the expected frequencies. The adjusted residual is approximately normally distributed with mean zero and standard deviation approximately one (Agresti and Finlay 1997).

$$r_{ij} = \frac{n_{ij} - e_{ij}}{\sqrt{e_{ij}(1 - \text{row proportion of } n_{ij})(1 - \text{column proportion of } n_{ij})}}$$

The residual scores measure how many standard deviations the observed frequency is from the expected. It was decided to only look at the pattern of residuals greater than positive three, because of the reduced chance of Type I errors. Each contingency table contained 120 cells (10 space intervals by 12 monthly intervals). With a 5 per cent chance of committing a Type I error, corresponding to residuals greater than two, it was expected that six cells (5 per cent of 120 cells) with residuals greater than two would occur by chance. If only considering residuals greater than three, the chance of committing Type I errors would be 1 per cent, equivalent to observing one cell with a residual greater than three by chance. In addition, according to Agresti and Finlay (1997: 262) '[a] large adjusted residual provides evidence against independence in that cell; a cell value exceeding about 3 provides strong evidence'.

Contagion model validation

Prior to using the burglary data, it was decided to apply the Knox method to data that contained no near repeats, to observe the baseline pattern of residuals. The contagion model was tested using a series of randomly generated data sets. The *x* and *y* coordinates and the times of burglaries were generated using a random number function for 500 burglaries. Values could range from 0 to 1,000 and were distributed according to the uniform distribution—every value was equally likely to occur. This was replicated 20 times. No apparent patterns of high positive residuals were observed across the test data sets. Cells with standardized residuals greater than positive three tended to be located in the bottom right of the table (cells with long space and time combinations), in the bottom left of the table (cells with short space but long time combinations) or in the top right of the table (cells with long space but short time combinations). There were no cells with adjusted residuals greater than positive three in the top left corner.

Testing the Knox method using randomly generated data provided confidence that the results for the data can be treated as an objective measure of near repeats. Given that no high positive residuals were located for cells with short distances and times, it is reasonable to argue that any evidence of excessive close pairs, that is statistically significant residuals, in the top left corner will be the result of features of the data and not the measurement indicator.

Results

Socioeconomic status/area demographics

Based on their values for the SES indicators, the suburbs could be partitioned into two groups (Table 3). The first group consisted of Suburb A and Suburb C and the second group contained Suburb D, Suburb E and Suburb B. The suburbs within each group had similar values for the number of dwellings, unemployment rate, percentage of renters, percentage of public housing and the percentage of households earning less than $500 per week. The only indicators not consistent within the groups were area and dwelling density, but these were influenced by rural tracts of land in two suburbs.

TABLE 3 *Suburb profiles*

	Suburb A	Suburb B	Suburb C	Suburb D	Suburb E	Police Division[a]
SES						
Area (sq km)	7.6	12.7	13.8	6.7	4.2	296.2[b]
Number of dwellings	3209	1683	3259	1470	1930	14646
Dwelling density (dwellings/sq km)	422.3	132.7	236.8	218.9	459.7	49.4
Unemployment rate	17.1	11.4	22.1	10.2	9.8	13.4
Renters (percent)	39.0	20.9	40.4	30.1	23.9	29.9
Public housing (per cent)	11.1	10.3	15.5	1.4	4.8	8.4
Household income < AU$500/week (per cent)	47.1	37.7	49.0	23.0	32.7	38.2
Real estate agent						
Average price of property	$130,000	$115,000	$85,000	$125,000	$135,000	N/A
Average age of property	20 years	8 years	6 years	6 years	6 years	N/A
Age <10 years (percent)	5	8	60	50	70	N/A
Large-scale development	No	No	Yes	No	Yes	N/A
Burglary						
Burglary rate[c] (per 100 dwellings)	20.6	10.7	23.4	15.9	10.4	16.2
Prevalence[c,d]	13.3	8.7	16.2	10.7	7.9	11.4
Concentration[b]	1.55	1.23	1.44	1.48	1.31	1.41
Divisional burglary proportion (percent)	27.9	7.6	32.1	9.9	8.5	100.0

[a] Police divison encompasses the whole division, not just the five suburbs
[b] Estimate only
[c] Based on a 34-month dataset
[d] Percent of addresses burgled

The first group, Suburb A and Suburb C, had very low values for the SES indicators and a high burglary rate. The second group, however, had values closer to the divisional average for SES indicators and burglary rate.

Real estate agent

The average price of properties in each suburb was in the range $115,000–$135,000, except for Suburb C where the average price was $85,000. The average age of properties was consistent across most suburbs, between six and eight years, except for Suburb A, which had an average of 20 years. The percentage of properties less than ten years old for Suburb A and Suburb B was 5 and 8 per cent respectively. The majority of dwellings in Suburb C, Suburb D and Suburb E were less than ten years old. Only Suburb C and Suburb E experienced large-scale development in recent years. It was thought originally that Suburb D would fall into this category as well, but it turns out that when the suburb was opened for residential purposes all builders were allowed free access. In comparison, both Suburb C and Suburb E were developed by companies offering house and land packages. There were only a few designs and the same builders built large pockets of identical properties. Although many of the houses in Suburb D were similar in age, because they were not built by one organisation or from a small number of plans, an element of housing diversity was achieved.

Burglary

As for SES, the suburbs can be partitioned into two groups based on the similarity of burglary rates. The first group, Suburb A and Suburb C, had very high values for incidence (burglary rate), prevalence, concentration and proportion of total burglary for the division. The other group, Suburb D, Suburb E and Suburb B have similar values to each other on the burglary measures, but they were generally lower than the first group and more in line with the rest of the division.

Types of housing

The criterion for an area to be deemed to contain predominantly homogeneous housing was pockets of relatively new identical properties. This was operationalized as having large-scale land development and a low average age for properties.

Suburb A and Suburb B have not experienced large-scale land development. They were first settled at roughly the same time and their housing population has developed over a number of years. Only a minority of dwellings in these suburbs has been built in the last decade.

The only suburbs with large-scale land development were Suburb C and Suburb E. Both had a high proportion of properties that were young, 60–70 per cent being less then ten years.

Target vulnerability

The criterion for high target vulnerability was the relative size of the local offender population. The size of the offender population was determined by assessing the socio-economic status and burglary rates.

Suburb A and Suburb C were similar with respect to SES and burglary rates, and Suburb E could be grouped with Suburb D and Suburb B because they all shared similar values for SES and crime. Suburb C had a higher burglary rate than Suburb A and a higher prevalence, but this was reversed for concentration. Suburb E's concentration was between Suburb D and Suburb B.

Both Suburb C and Suburb E were considered to have homogeneous housing, as they satisfied the criterion of recent large-scale land development. Suburb A, Suburb D and Suburb B were used to contrast the results of the contagion model at Suburb C and Suburb E. This allowed a separation of homogeneity and target vulnerability that could possibly be confounded otherwise. Figure 2 shows the conceptual relationship between the suburbs along two axes, housing homogeneity and target vulnerability.

The locations of all suburbs within Figure 2 are indicative only. For instance, while Suburb E and Suburb D are located in the first quadrant—low vulnerability and homogeneous housing—the former was considered to comprise higher levels of similar housing than the latter, therefore Suburb E was located closer to the extreme along the Housing axis.

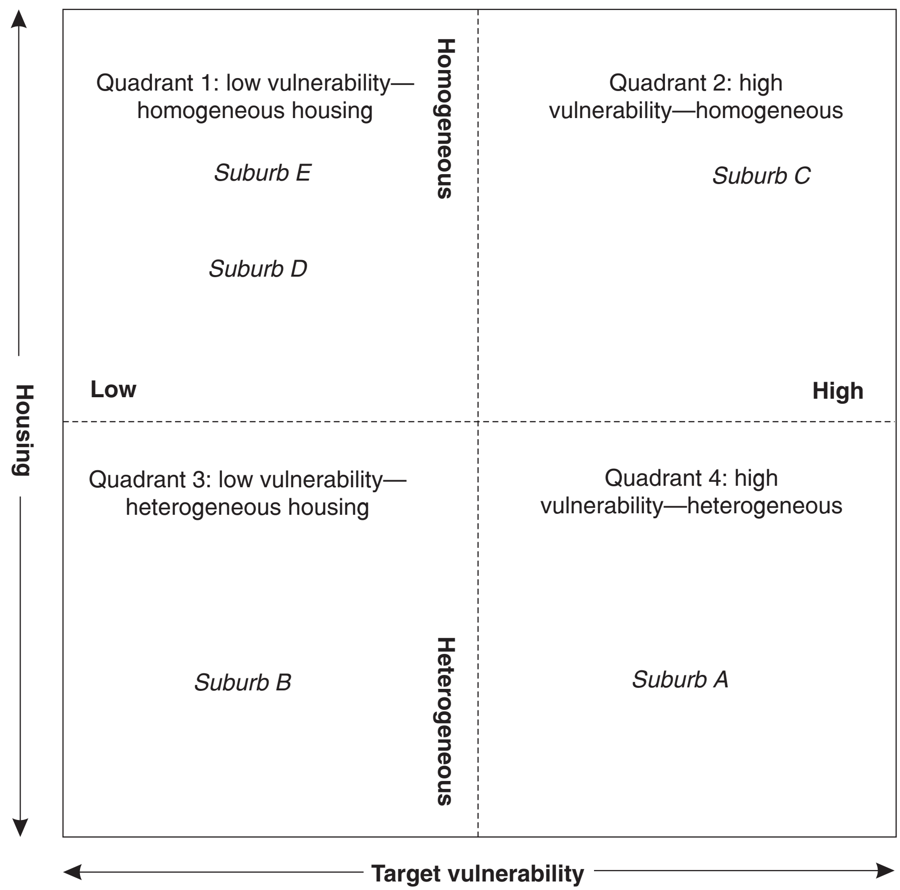

FIG. 2 Pictorial representation of the suburbs' housing homogeneity and target vulnerability

Contagion model

The results of the Knox method were calculated for each area. Within each area the results for the three types of pairings (SS, SR, RR) were calculated. Only a summary of the 15 tables is presented here. A full discussion of the residual analysis is available from the first author.

Near repeats were observed in a range of suburbs throughout the police division. Evidence for near repeats for the five suburbs varied for the different types of pairings. Table 4 shows a summary of the results.

Of the 15 possible suburb-pairing combinations, five were considered to display an excessive number of close pairs. SS pairs exhibited signs of contagion for Suburb A, Suburb C and Suburb E. SR pairs showed evidence of contagion in Suburb C. Suburb D had excessive RR pairs close in space and time. The excessive number of close pairs was confined to spatial distances of 200 metres and temporal distances of two months.

The strength of evidence for near repeats largely corresponded with the housing diversity of the area. For homogeneous areas, near repeats were identified as expected.

TABLE 4 *Results for near repeats across the different suburbs and pairing types*

Housing diversity	Target vulnerability	Suburb	Evidence of excessive close pairs		
			SS pairs	SR pairs	RR pairs
Homogeneous	High	C	Yes	Yes	No
	Low	E	Yes	No	No
Limited heterogeneous	Low	D	No	No	Yes
Heterogeneous	Low	B	No	No	Not available[a]
	High	A	Yes	No	Not available[a]

[a] Due to small cell frequencies

Suburb D was not considered strictly homogeneous or heterogeneous housing, but did provide some evidence of near repeats. In addition, there was evidence in Suburb D of an unanticipated form of near repeat victimization, sharing similar timing to near repeats, but not close in space. Heterogeneous areas largely performed as predicted except for SS pairs in Suburb A, however the evidence for SS pairs was weak with a somewhat patchy pattern of residuals in the top left corner.

A plausible explanation for the existence of near repeats in Suburb A is the contribution of target vulnerability. The near repeat mechanism operates for those areas that contain homogeneous housing and are suitable targets for burglary, but the condition of target suitability is dependent on exposure to offenders. Thus, areas with vulnerable similar housing are more likely to contain near repeats. While the evidence for near repeats in Suburb A is weak, this evidence was most likely caused by the suburb's high levels of target vulnerability.

Suburb C and Suburb A are the two suburbs with high target vulnerability and both exhibited evidence of near repeats. Suburb E, the other homogeneous housing area, does not have a high burglary rate, compared to the division, yet it displayed evidence of near repeats. Thus, areas with either similar housing or target vulnerability, through high burglary rates and low socio-economic status, may contain near repeats, but more importantly, areas with both of these characteristics will experience near repeats to a greater extent.

Discussion

The research question for this study concerned the spread of victimization risk to nearby dwellings as a consequence of an initial burglary. This also involved quantifying the increased risk in both spatial and temporal dimensions. While some authors have pointed to a neighbour effect in victimization risk (Anderson *et al.* 1995; Morgan 2000; Shaw and Pease 2000), none have been able to describe fully the relationship between victims and neighbours in space *and* time. The research presented here is the first demonstration of the spatial and temporal dimensions of victimization risk.

Strong evidence was demonstrated for the existence of near repeats. Burglaries occurring in close proximity to recent burglary incidents were observed at higher rates than expected for certain suburbs. It was hypothesized that areas experiencing recent, rapid, large-scale residential development may not provide the variation required for offenders to prefer 'revisiting' previous victims. In areas with little housing diversity, it was anticipated that the risk of burglary was related to proximity to other burglary victims. The other component required for the near repeat mechanism was suitable housing for burglary coupled with exposure to offenders, resulting in vulnerable properties. An area was more likely to be vulnerable if the size of the local offender population was high.

One way to think of the relationship between housing diversity and target vulnerability is through the infection analogy. At the risk of stretching the analogy too far, housing diversity is an indicator of how contagious burglary victimization is, in that similar areas allow transmission of burglaries, whereas diverse areas restrict transmission. The level of vulnerability is an indicator of offender activity and therefore, the prevalence of infection/burglary in the area. High levels of vulnerability mean there are many already infected/victimized addresses, which increase the opportunity for transmission of burglary victimization, while low levels make victims rare. So, low crime, homogeneous housing areas can transmit infections/victimizations easily but the small volume of burglaries do not provide enough opportunities to generate substantial numbers of near repeats. The situation for high crime, heterogeneous housing areas is the exact opposite. Transmission of victimization in these areas is difficult due to housing diversity, but the high volume of crime ensures sufficient opportunity for even low probability trials to succeed. Low crime, heterogeneous housing areas are unlikely to have near repeats because victimization is difficult to transmit in these areas and the volume of crime does not provide enough opportunities to produce near repeat victimization. High crime, homogeneous housing areas will have higher levels of near repeats because the housing diversity is low (so victimizations are transmitted easily) and the overall volume of burglary provides large numbers of infectious addresses.

The results support the above explanation. The three suburbs containing near repeats were Suburb A, with heterogeneous housing, high vulnerability and weak evidence of near repeats; Suburb C, with homogeneous housing, high vulnerability and very strong evidence of near repeats; and Suburb E, with homogeneous housing, low vulnerability and strong evidence of near repeats. These results indicate that near repeats are dependent on both homogeneous housing and target vulnerability, but that housing diversity is the more powerful explanatory factor of the two because the presence of homogeneous housing resulted in strong evidence of near repeats despite the level of target vulnerability.

The empirical evidence supporting the near repeat hypothesis has theoretical and applied implications. That housing diversity affects patterns of victimization highlights the importance of the consideration of place in analysing crime, a finding consistent with the theoretical perspective of environmental criminology (Brantingham and Brantingham 1981). The near repeat mechanism is likely to be an important explanatory factor in the extent of repeat victimization for other areas experiencing rapid residential housing expansion, such as many areas of the United States. The most obvious applied implication is that areas with similar housing should implement a modified version of cocoon neighbour watch (Forrester *et al.* 1988), aimed at targeting near repeats *as well as* repeat victimization. Crime prevention strategies will need to be varied according to the extent of housing homogeneity and should allow for the overall crime rate in the area.

A number of qualifications need to be made. First, the sample size of five suburbs is quite small and would not be considered sufficiently large to be irrefutable. Repetition in other locales will be necessary to further acceptance of the hypothesis of neighbour risk. This is currently being carried out in the Merseyside region of the UK to test the original hypothesis set out here and to help explain offender target selection (Johnson *et al.* 2000). Second, the premise of the present study is centred on external cues informing offenders of target suitability. The lifestyle choices of householders have not been considered here, despite a wide-ranging literature suggesting their importance on victimization risks. This decision was based more on measurement difficulties than any other criteria. However, we would predict that different communities would be more similar than different with respect to routine activities of their residents.

This study has answered the research question, but has also raised several issues worthy of further exploration. The incorporation of the near repeat mechanism into explanations of hot spot and repeat victimization interactions should be carried out. In previous work, Townsley *et al.* (2000) identified two types of hot spots (stable and unstable) for the study area. Routine activity theory explains the level of crime for both types of hot spots in different ways. Stable hot spots had high levels of burglary due to the large number of offender-victim intersections caused by the presence of crime generators, places that attracted large numbers of people for non-criminal purposes (Brantingham and Brantingham 1995). Unstable hot spots, located primarily within areas of homogeneous housing, did not contain crime generators so did not have the same volume of offender-victim intersections. Thus, due to the lack of crime generators, it is likely that only local offenders were active in these unstable hot spots and the homogeneity of housing suggests the potential for the near repeat process to be operating. Both of these factors support the argument that use of the notion of near repeats may shed some light on the relationship between repeat victimization and hot spots.

It was not important, for the purposes of answering the research question, to determine which properties were infectious, or what areas within similar housing estates facilitated the contagion. This would be the logical next step in exploring near repeat victimization. An analysis of the temporal ordering of near repeats for single and repeat pairs, by establishing which member of the pair was victimized initially, may provide additional insights into offender target selection.

A final topic of interest would be the application of the near repeat mechanism to other crime types. Clearly the infectious period will be different for different crime types, due to the specific dynamics of each. The utility of the near repeat concept is likely to be closely related to how offenders process cues for target selection. Offences like robbery, that require a degree of rationality and planning, should exhibit some evidence of a near repeat process.

References

ABS (1996), CDATA 96, *Australian Bureau of Statistics.*

Agresti, A. and Finlay, B. (1997), *Statistical Methods for the Social Sciences*, 3rd edn. New Jersey: Prentice Hall.

Anderson, D., Chenery, S. and Pease, K. (1995), *Biting Back: Tackling Repeat Burglary and Car Crime*, Crime Detection and Prevention Series Paper No. 58. London: Home Office.

Bailey, N. T. J. (1975), *The Mathematical Theory of Infectious Diseases and Its Applications*, 2nd edn. London: Charles Griffin and Company.

Bennett, T. and Durie, L. (1999), *Preventing Residential Burglary in Cambridge: From Crime Audits to Targeted Strategies*, Police Research Series Paper No. 108. London: Home Office.

Bowers, K., Hirschfield, A. and Johnson, S. (1998), 'Victimisation Revisited: A Case Study of Non-Residential Repeat Burglary on Merseyside', *British Journal of Criminology*, 38/3: 429–51.

Brantingham, P. and Brantingham, P. (1981), 'Introduction: the Dimensions of Crime', in P. Brantingham and P. Brantingham, eds., *Environmental Criminology*. Beverly Hills, CA: Sage Publications.

——(1985), 'Burglar Mobility and Crime Prevention Planning', in R. Clarke and T. Hope, eds., *Coping with Burglary*. Boston, CA: Kluwer-Nijhoff.

——(1995), 'Criminality of Place: Crime Generators and Crime Attractors', paper presented at the Fourth International Seminar on Environmental Criminology and Crime Analysis, Cambridge.

Chenery, S., Holt, J. and Pease, K. (1997), *Biting Back II: Reducing Repeat Victimisation in Huddersfield*, Crime Detection and Prevention Series Paper 82. London: Home Office.

Cohen, L. and Felson, M. (1979), 'Social Change and Crime Rate Trends: A Routine Activities Approach', *American Sociological Review*, 44: 588–607.

Diggle, P. J., Chetwynd, A. G. and Morris, S. E. (1995), 'Second-Order Analysis of Space-Time Clustering', *Statistical Methods in Medical Research*, 4: 124–36.

Farrell, G. (1995), 'Predicting and Preventing Revictimisation', in M. Tonry and D. P. Farrington, eds., *Building a Safer Society: Crime and Justice*, Vol. 19. Chicago: University of Chicago Press.

Farrell, G. and Buckley, A. (1999), 'Evaluation of a UK Police Domestic Violence Unit Using Repeat Victimisation as a Performance Indicator', *Howard Journal*, 38/1: 42–53.

Farrell, G. and Pease, K. (1993), *Once Bitten, Twice Bitten: Repeat Victimisation and Its Implications for Crime Prevention*, Home Office Crime Prevention Unit Paper 46. London: Home Office.

—— (eds.) (2000), *Repeat Victimization: Crime Prevention Studies*, Vol. 12. Monsey, NY: Criminal Justice Press.

Forrester, D., Chatterton, M. and Pease, K. (1988), *The Kirkholt Burglary Prevention Project, Rochdale*, Crime Prevention Unit Paper 13. London: Home Office.

Hanmer, J., Griffiths, S. and Jerwood, D. (1999), *Arresting Evidence: Domestic Violence and Repeat Victimisation*, Police Research Series Paper 104. London: Home Office.

Hindelang, M., Gottfredson, M. R. and Garofalo, J. (1978), *Victims of Personal Crime: An Empirical Foundation for a Theory of Personal Victimisation*. Cambridge, MA: Ballinger.

Johnson, S. D. and Bowers, K. (2000), 'An Investigation into Isomorphic Re-Victimisation', Home Office project.

Johnson, S. D., Bowers, K. and Hirschfield, A. (1997), 'New Insights in the Spatial and Temporal Distribution of Repeat Victimisation', *British Journal of Criminology*, 37/2: 224–41.

Knox, G. (1963), 'Detection of Low Intensity Epidemicity', *British Journal of Preventive and Social Medicine*, 17: 121–7.

——(1964a) 'Epidemiology of Childhood Leukaemia in Northumberland and Durham', *British Journal of Preventive and Social Medicine*, 18: 17–24.

——(1964b) 'The Detection of Space-Time Interactions', *Applied Statistics*, 13: 25–9.

Mantel, N. (1967), 'The Detection of Disease Clustering and a Generalized Regression Approach', *Cancer Research*, 27: 209–20.

Morenoff, J. D., Sampson, R. J. and Raudenbush, S. W. (2001), 'Neighborhood Inequality, Collective Efficacy, and the Spatial Dynamics of Urban Violence', *Criminology*, 39: 517–60.

Morgan, F. (2000), 'Repeat Burglary in a Perth Suburb: Indicator of Short-Term or Long-Term Risk', in G. Farrell and K. Pease, eds., *Repeat Victimisation: Crime Prevention Studies*, Vol. 12. Monsey, NY: Criminal Justice Press.

Pease, K. (1998), *Repeat Victimisation: Taking Stock*, Crime Detection and Prevention Series Paper 90. London: Home Office.

——(2001), Personal Communication, 18 May.

Pike, M. C. and Smith, P. G. (1968), 'Disease Clustering: A Generalization of Knox's Approach to the Detection of Space-Time Interactions', *Biometrics*, 24: 541–54.

Pinkel, D. and Nefzger, D. (1959), 'Some Epidemiological Features of Childhood Leukaemia in the Buffalo, NY Area', *Cancer*, 12: 209–20.

Polvi, N., Looman, T., Humphries, C. and Pease, K. (1990), 'Repeat Break and Enter Victimisation: Time Course and Crime Prevention Opportunity', *Journal of Police Science and Administration*, 17/1: 8–11.

——(1991), 'The Time-Course of Repeat Burglary Victimisation', *British Journal of Criminology*, 31/4: 411–14.

Read, T., Tilley, N., White, J., Wilson, M. and Leigh, A. (1999), 'Repeat Calls for Service and Problem-Oriented Policing', *Studies on Crime and Crime Prevention*, 8/2: 265–79.

Real, L. A. and McElhany, P. (1996), 'Spatial Pattern and Process in Plant-Pathogen Interactions', *Ecology*, 77/4: 1011–25.

Rengert, G. and Wasilchick, J. (1985), *Suburban Burglary: A Time and A Place for Everything*, Springfield, IL: Charles Thomas.

Shaw, M. and Pease, K. (2000), *Research on Repeat Victimisation in Scotland: Final Report*. Edinburgh: The Scottish Executive Central Research Unit.

Sherman, L., Gartin, P. and Buerger, M. (1989), 'Hot Spots of Predatory Crime: Routine Activities and the Criminology of Place', *Criminology*, 27/1: 27–55.

Sherman, L., Gottfredson, D., MacKenzie, D., Eck, J., Reuter, P. and Bushway, S. (1998), *Preventing Crime: What Works, What Doesn't, What's Promising*. Washington: National Institute of Justice.

Townsley, M., Homel, R. and Chaseling, J. (2000), 'Repeat Burglary Victimisation: Spatial and Temporal Patterns', *Australian and New Zealand Journal of Criminology*, 33/1: 37–63.

van Koppen, P. J. and Jansen, R. W. J. (1998), 'The Road to Robbery: Travel Patterns in Commercial Robbery', *British Journal of Criminology*, 38/2: 230–47.

Waller, I. and Welsh, I. (1998), 'Reducing Crime by Harnessing International Best Practice', *National Institute of Justice Journal*, October: 26–32.

Warren, J., Reboussin, R., Hazelwood, R. R., Cummings, A., Gibbs, N. and Trumbetta, S. (1998), 'Crime Scene and Distance Correlates of Serial Rapes', *Journal of Quantitative Criminology*, 14/1: 35–59.