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SPATIAL VARIATIONS IN ROAD COLLISION PROPENSITIES IN LONDON

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Abstract

Propensity to be involved in a road traffic collision in Greater London is likely to depend on many factors, including personal mobility, lifestyle, behaviour, neighbourhood characteristics and environment. This paper seeks to identify in terms of geodemographic type the propensity of individuals to be involved in collisions and to examine geographic variations in such propensities with distance from Central London. Results for Central London suggest only a small number of Mosaic types portray a higher than average index score (over 100), translating into a higher risk for a smaller proportion of London's geodemographic types. This contrasts with results which show a larger number of Mosaic classifications having higher than average index scores further from Central London. The results highlight a need, through enhanced spatial analysis, for better understanding of the spatially incidence of collisions which are putting at risk the lives of London residents.

Introduction

In the field of road traffic safety research, continued emphasis has been placed on identifying factors that contribute to increased collision risk, both to drivers and other road users such as pedestrians and cyclists, with the primary goal of reducing the impact and frequency of collisions. In this study the aim is to identify those people more at risk than others, in terms of their socio economic status and lifestyle choice based on where they reside. Research in this field has often been confined to analysing poverty and social exclusion with reference to particular vulnerable road user groups (for example, children). This analysis will be conducted on the casualties and drivers of past collisions and their wider socio-economic status (rather than one aspect, such as poverty). To sum up, this study will be conducting a geographically extensive and inclusive analysis by evaluating collision risk for London residents with reference to their socio economic and lifestyle choices within a distance constraint.

Introduction to study area

By placing emphasis on the spatial patterns of risk with distance from a defined central point within Greater London (Charing Cross station); the presumption that as socio economic residential patterns change spatially the further from Central London this pattern will influence road collisions risk.

To our knowledge, no study has studied the relationship between road collision risk in terms driver and casualty risk and spatial patterns of socio-economic status within Greater London. The principal aim of this study is to try and interpret and explain the changing nature of risk propensity for people living in London with regard to distance from Central London. The nature of this relationship will be discussed throughout the first two sections of this paper. This analysis is based on two datasets;

1. Driver details
2. Casualty details

Both datasets derive from the STATS19 database collected by the Metropolitan Police on every road collision to result in injury in the London area. These two particular datasets are the total collisions over five years (January 1998 – December 2002) whereby postcodes have been recorded for both the drivers and the casualties involved[1]. Appended to each postcode is

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[1] It is worth noting that drivers could also have been injured in the collision and their details are recorded in the 'casualty' dataset as well.

a geodemographic classification code[2] based on a range of data including Census 2001, MORI surveys and lifestyle information.

Within London there are notable differences with regard to traffic flow, employment population, pedestrian density and so forth. Inner London is a prominent hub for employment and mobility within the region (both pedestrian and transport) and is one of the most 'significant' town centres within the UK (Smith 2004). The main justification for profiling residents based on a distance from Central London is due to the increased traffic density, more comprehensive road network, pedestrian mobility and employment opportunities, all of which are centred in a small area of Central London, including areas such as a The City, Oxford Street and Westminster. The Central Place Theory by Christaller, was concerned with ranking and ordering settlements and with regards to this, distance from Central London is seen as a strong indicator of changing patterns within society including notably fewer services, less public transport opportunities. With all these attributes, their characteristics change the further from the centre of London. For example employment opportunities in the city of London and surrounding areas are most dense and decrease density the further from Central London (Census 2001). Within Central London the number of residents is less dense than further outside of central London. People's propensity to be involved in a collision depends of many different criteria, mainly due to peoples travel behaviour, for example people living in Outer London who travel into Central London for employment purposes have different type and level of collision exposure than those who may both live and work in Central London.

Profiling residential areas and the subsequent risk those people who live there are at risk to be involved in a collision (as either a driver or casualty), and how this risk (or better termed propensity) to be involved in a collision varies depending on how far one lives from a central point in London has important policy and safety implications for a number of major services. Potential services and how they would benefit are summarised below:

Police: As correlation with health problems there may or may not be correlation of high crime rates with propensity to be involved in a collision. It is not the purpose of this study to claim there is a relationship merely the possibility of future work in this area which would mean improved allocation of resources and possibly better outcomes for reduction.

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[2] See section on 'Geodemographics and collision risk: Is there a relationship?' for a detailed explanation of geodemographics with reference to this study

Education: Different types of road safety educational measures possibly could be aimed at different types of school depending on where the school was situation both from distance from central London and where they lived in relation to the location of the school.

For the purpose of this study, it is important the reader understands what is being implied when the term 'risk' is mentioned as it means many different things to different people (see Heino *et al* 1996, Summala 1996, Adams 1999, Lonero 2002). For the purpose of this research the term risk will be kept simply to 'the likelihood of being involved in a collision'. This definition will overlook the severity of the collision which is sometimes used as an indicator of increased collision propensity, however because this paper does not differentiate between the severity of collisions there is no meaning for it. As basic as this definition may imply to some, it is clear that a more in-depth discussion of whether risk can be measured, an argument held by 'hard' scientists or whether it is culturally constructed (a social scientists view) is not necessary here (see Adams 1995, Adams 1999).

Government and borough policy

London's Road Safety Plan is the framework which provides London with road collision reduction strategies and targets (Transport for London, 2004). It covers all of Inner and Outer London as one entity and highlights a threefold need to:

1. Concentrate on safety through partnership
2. Managing speeds – by reducing excessive and inappropriate speeds
3. Protecting vulnerable road users

These aims primarily use past statistical evidence of collision events. This STATS19 database collects over fifty variables for every collisions including information on gender, age and what is being used for this study, postcode data. This London plan is loosely based on the framework put forward in the UK wide road safety proposal 'Tomorrow's Roads: safer for everyone' (Department of Transport 2001).

The London road safety plan identifies patterns and trends of road collisions occurring to a wide spectrum of road users and also vehicle types. However the main focus of analysis of Transport for London is understanding patterns of road collisions occurrences with particular reference to vulnerable road users (for example, the elderly and children) and how their involvement in collisions varies spatially (see LAAU topic 2001-6, 2001and LAAU topic 2001-1, 2001, Levels of Accident Risk in Greater London, Issues 9,10, 2003 and 2004). It is

evident from this literature that a broad spatial understanding of collision propensity for all London's residents and how this propensity varies spatially is being neglected.

This broad spatial understanding mentioned above can be subdivided into two main challenges facing the road safety management in Greater London primarily at the borough level. At the latter level, each borough has individual policies for road safety management and reduction. One of the consequences of this is the restriction of not being able to compare outcomes, schemes and residential road user risk patterns across boroughs accurately. The second challenge faced is at a 'local' level meaning smaller than a borough level whereby as with the challenges at the borough level there is no spatial framework within which analysis can take place and be compared with regards to residential road user risk and how this changes with distance from central London, which is a notion which can be applied to all boroughs.

Approaches to road safety vary from borough to borough. However key themes are notably London wide, for example education initiatives for vulnerable road users such as children. Although they may not be analytically similar in terms of say for example, variables collected in order to analyse the risk the aims of reducing collisions are universal. With regards to analysing road user risk with relation to where they live and their socio economic status, it is a potential tool for road safety policy makers. The analysis of postcode data of the drivers and casualties living in a particular borough (whereby their collisions may not necessarily occur in the same borough) would potentially lead to a deeper understanding of residential risk patterns (and eventually the different types of collision occurring, for example the level of severity or whether they are more likely to be involved as a driver or casualty).

It is evident therefore that there is a necessity for the analysis and understanding of risk for not just what the data identifies as 'vulnerable' road users but society as a whole. Coupled with this analysis there needs to be quantitative measurement of the differing levels people experience which may change for example over time or depending on the type of journey they make. This will be discussed more in the next section.

The relationship between static and dynamic risk: why it is important?

Some kinds of people are more at risk of being involved in a collision than others (Standish 2003). For example a strong implication of whether someone is more likely to be involved in a collision is their age. In particular, children aged between 12-16 are high at risk from being

involved in a road collision (www.thinkroadsafety.gov.uk, 2005). The reasons for this increased risk are subject to debate, as it is difficult to underpin the exact causes for collisions, however one in ten teenagers across the UK involved in a collision say they were not paying attention (www.thinkroadsafety.gov.uk, 2005). Road use is highly prone to risk consciousness because other people are perceived as a threat in what have been dubbed our 'risk societies' by Ulrich Beck (1992). The development of risk consciousness is an outcome of profound social change implying that society has problems that cannot be resolved, only managed (Furedi 1997). People tend to think that the risks of driving come from other road users. However transport safety does not exclude our own roles as road users. The key issue surrounding this notion of risk is that when choosing a mode of transport, individuals look towards their own 'perceived risk level' instead of the objective risk level when making their decisions.

The traffic environment is constantly changing. It has been suggested that the greatest factor contributing to collision severity is an underestimation of the level of risk a traffic environment presents. All road safety research places a static risk level or understanding on individuals or areas in what is a dynamic traffic environment. The road traffic environment is constantly being referred to as dynamic and this is because it is constantly changing, varying from second to second. In other words someone's chances of being involved in a road collision regardless of whom they are, where they are from can change within seconds. At an urban city wide scale this static measurement is useful in determining a wide ranging understanding of the risk patterns in a spatial environment.

Often when measuring and trying to manage risk, road safety analysts categorise road collisions and those involved in terms of severity of the collision. This method however according to Adams (1995) does not provide the best allocation of risk measurement. This is partly due to the small numbers of actual fatal collisions that occur, since they are both infrequent and scattered across space and time. Thus in this study, data concerning both fatal and non fatal collision victims have been merged together in order to create a better indication of the patterns of risk. Another risk inherent in using only fatal or severe collision victim data is the uniqueness of London as an urban road network. Adams (1995) summarises the argument that there is a higher proportion of minor collisions in London compared to the rest of the UK urban road network, and attributes this to the fact that London is so congested and traffic speeds are so slow that there are large numbers of minor collisions but that high speed crashes resulting in more serious injury are more rare. Adams also notes the uniqueness of London's road user risk, as it presents the highest urban UK proportion of cyclist and

pedestrian related collisions (1999). This presents a strong rationale for a broad societal risk analysis and evaluation.

Attempts to define road user risk

Road user risk has been defined in a variety of different contexts (see Fin *et al* 1986, Lawson 1990, Rolls *et al* 1992, Cathey *et al* 1995, McKenna *et al* 1998, Alder 1999, Dobson *et al* 1999, Akerstedt *et al* 2001, LaScala *et al* 2003, Hall 2004, Hasselberg *et al* 2004, Moller 2004). What we are concerned with in this study is attempts to define road user risk in terms of disaggregated groups within society, whether that is male or females, the elderly, children or young male drivers. Four different studies are discussed here; young male drivers driving at night, locally born people and immigrants, gender differences and young and old drivers. Each will be discussed in term their how the author or authors have contributed to defining road user risk how it should be defined in terms of social groups. It terms of identifying these high risk road user groups, much of the literature has concentrated on demographic groupings such as 'new' drivers (see Gregerson *et al* 1994), however little attention has been focused on the spatial dimension of this issue. For example there are likely to be high risk user groups being present at certain times and at certain locations within an urban area. An example of this somewhat neglected spatial and temporal perspective defined a high risk road user as one (or more) of the following:

- New drivers
- Drivers with the infringements that are tracked by the loss of points (e.g. speeding)
- Drivers with criminal convictions
- Drivers with an unusual number of crashes or crash type, in a particular time period or location
- Drivers with certain medical conditions

(Pietro 2001)

Each of these categories is defined by one main phenomenon and that is the notion of risk. There are different types of risk within road safety that range from intentional risk taking to unintentional risk taking, each of which plays a part in determining certain types of accidents and profiling of the type of people that cause them in certain spatial locations.

Let us first consider the research conducted into discriminating between different age groups and the types of different counter measures are required to reduce collisions (see Massie *et al* 1995). Research in Western Australia has concluded that the age group most at risk (from past

collision analysis) of involvement in a collision is the under 20 year olds: however it did emphasize that the rates of collisions for people aged between 70-79 were comparable (Ryan *et al* 1998, see also Keskinen *et al* 1998 and Zhang *et al* 2000). It supports the findings from Dulisse (1997) that although older drivers have different types of collision from young drivers, they do not actually pose any more risk on the road to other road users. This information is important when developing an accident taxonomy that seeks to identify similarities in the types of collisions that different aged people are involved in and from different social backgrounds.

There is a certain presumption that there are predetermined risk groups in the traffic environment due to societies assumptions. This predetermination is somewhat influenced by our society, in other words the term 'stereotype' could be used in order to sum up these groups of society which are believed to have a higher risk of being involved in collision. These include perhaps more general groups within society such as young male drivers (Corfitsen 1999), women drivers (Dobson et al 1999) and older drivers (Ryan et al 1998) or pedestrians (Keall 1995) to the not so obvious stereotypes that have been identified in the literature and other public services as being of at a higher risk of being involved in a collision. These groups include older male motorcycle riders, children from ethnic backgrounds (Christie 1995), and elderly pedestrians of an ethnic minority origin.

In the earlier section it was mentioned that there has been little direct evidence concerning the relative road safety of immigrants. Recent American studies have identified race as an important road safety issue. A study by Dobson *et al* (2003), focusing on the increased accident rate among the immigrant population in New South Wales broke road users into drivers, passengers, pedestrians and other road users. However the results were inconclusive, indicating that there was no evidence to suggest that drivers born in other countries were more likely than Australian born drivers to be involved in collisions resulting in death or injury requiring hospitalisation. As with the majority of literature in this area of determining road user risk groups, there was little no spatial dimension which looked at the neighbourhood variations at a local level

Geodemographics and road collisions: Is there a relationship?

The use of geodemographics to analyse road safety is a recent innovation. Its influence is supported by research linking socio economics variables such as unemployment, low income, area of residence, educational level and road collision risk, race and marital status (for example Lawson 1990 and Haepers and Pocock 1993, Christie 1996, Kposowa *et al* 1998,

Murray 1998, Abdalla 1999, Road Safety Report No 19 2001 Department of Transport). Most of the reports and research conducted in this field have been focused on children and only a handful of studies have bridged the notions of road collisions and geodemographics. The studies that have been carried out relate an aspect such as urban and rural differences to changing collision risk (see Blatt *et al* 1998 and Lu *et al* 2000).

Road collision analysis has been slow to acknowledge the relationship between area social characteristics and road collision drivers and casualties. Social class as a discriminator for road collision risk has been addressed only by a minority of research papers (see Hasselberg *et al* 2004, Hasselberg *et al* 2005, Laflamme 2005). Research in Scotland (see Abdalla 1997 and Abdalla *et al* 1997) has considered deprivation indicators[3] from the 1991 Scottish Census as an indicator for road collision involvement. One of the key findings concluded that child casualties who came from families in social classes IV or V (semi skilled or unskilled jobs) were overrepresented in the total number of child casualties (Abdalla 1997). The influence and effect of certain residential layouts and housing types has also been found to cause an overrepresentation in collisions involving children (Christie 1996). Furthermore research undertaken by Hasselberg *et al* (2005) presents results for Swedish young adults that show that drivers with a basic and secondary education show a greater risk of crashes of all types than drivers with a higher education. In addition, the study found children of manual workers showed a 60% greater risk to be involved in any time of collision. These findings support the potential use of geodemographics as being a good indictor for understanding the 'who' and the 'where' of the people experiencing increased road user risk.

Two leading geodemographic providers dominate the UK markets, Experian Ltd (Mosaic) and CACI Ltd (A Classification of Residential Neighbourhoods: ACORN). For this analysis Mosaic will be used to categorise the unit postcodes (of the drivers and casualties) into neighbourhood types. These types are based on social and demographic proximity and built environment characteristics. Geodemographic classifiers cluster small areas on the basis of social similarity rather than locational proximity (Webber and Longley 2003). The core of this paper lies in the relationship between geodemographic attributes used to create the neighbourhood types and how they can assist the profiling of high risk road users. Mosaic classifies 1.6 million British unit postcodes into 52 'lifestyle' types. These types describe socio-cultural and socio-economic behaviour. There are more than 350 variables taken from sources such as the 2001 Census, Family Expenditure Survey's, MORI's financial surveys

[3] Variables included; proportion of unemployed people, proportion of people with no car, proportion of people at pensionable age, proportion of people in a lower social class.

and Experian Lifestyle Surveys. This data are used in statistical cluster analysis to build the 52 neighbourhood types which can be aggregated to 12 Mosaic groups.

Existing approaches to understanding road user risk in area social terms has been centred on using Census data, specifically deprivation indicators to determine a relationship between those people who have an increased level of deprivation and their overrepresentation in road collision statistics. This paper uses geodemographics instead of Census data primarily because of the large potential geodemographics offers in terms of the wide ranging data sources which are included in the cluster analysis. Using geodemographics for road collision research enables the user not only to create a more succinct profile of the high risk user but also to target reduction strategies more effectively because of the inclusion of information regarding the most commonly used media outlets and preferred retail chains used by each Mosaic Type.

In a recent paper by Webber (2004), findings suggest that neighbourhood effects such as income profiles, consumer behaviour, social grade and marital status are present at a range of scales. In a correlation matrix is was evident that behaviours for which Mosaic type is a good discriminator tend to be the same behaviours for which social grade, tenure, terminal education age and income are also powerful discriminators. In contrast to this finding, the behaviours for which Mosaic is a powerful discriminator tend to be ones for which marital status, age or gender are relatively poor discriminator and vice versa. Therefore neighbourhoods are more homogenous in respect of status than life stage (Webber 2004). These neighbourhood affects which cover a wider geographical spread than just a street or postcode, and geodemographics incorporates these contextual effects in ways which are akin to multi level modelling. An area for future research would be to show whether social class, age or geodemographic category has the greatest effects in accounting for variations in accident rates.

In a wider context, since 1997 there has been a renewed interest in academia and government in the use of neighbourhood classifications (Longley 2005). In policy terms, these developments have arisen from the opportunity to improve efficiency by targeting preventative communication programmes to those most at risk (Longley 2005). In recent years, these programmes have centred on policing and health needs (see Ashby & Longley 2005), and with these public service applications comes the opportunity and methodological feasibility to apply geodemographics to road safety research. In response to the narrow research base is the issue that nearly all research in this domain is restricted to children and their socio-economic risk as been shown in the previous discussions. There has been limited

work achieved understanding the risks faced by adults within neighbourhoods and what can be deemed their 'risk exposure'.

Hauer (1980) gives a formal definition of exposure (related to the risk of a collision) as follows:

'A unit of exposure corresponds to a [probabilistic] trial. The result of such a trial is the occurrence or non occurrence of an accident (by type, severity etc). The chance set up is the transportation system (physical fatalities, users and the environment) which is being examined, and the risk is the probability (chance of an accident occurrence in a trial) and this describes the safety property of the transportation system examined'

Thus the ideal measure of exposure is one which is closely related to the opportunity of a road collision i.e. exposure is 'a condition which must be present in order to have an accident' (Tobey et al 1983).

Research by Julian *et al* (2002) on Paris stated that the majority of people who travelled on foot during the day were children, those not in paid work and the elderly, and she concluded that these pedestrians were at higher risk of being involved in a collision than other types of pedestrian. This study indicates that different levels of risk exposure do prevail between different groups in society, predominantly associated with mobility. Mobility and constraints on mobility have often been referred to with respect to the elderly and children. A person's mobility will in effect influence their exposure to traffic collision risk. Scheiner *et al* (2003) summarise that certain lifestyle groups (based on employment and income) have specific forms of mobility. Mobility here refers to 'short term' mobility (travel) rather than long term mobility (for example housing mobility) and in turn we can relate this mobility to differences in risk exposure.

From this section it appears that there is a clear need for a greater understanding of the effect of socio-economic factors as discriminators of road collision risk. However there is a need to progress to a more rounded conception of driver and casualty lifestyles in order to appreciate the nature of risk.

Urban parameters and methodological guidelines

This paper presents a research design in order to understand how people's risk based on their Mosaic type changes with increased distance from a central London point (Charing Cross). The methodology will identify, firstly, how geodemographic classifications of the total

population (within each concentric ring) changes the further from central London. The study then goes onto measure the total number of people involved in a collision aggregated by Mosaic type set within the distance constraint from central London. The overall result is an indicator of the Mosaic types with the highest indexes indicating a higher propensity to be involved in a collision (in terms of population for each concentric ring) and the corresponding risk index of being involved in a collision for each Mosaic type. It is important to stress that this study is not analysing the location of the collision, but rather the residential location (postcode reference) of both the driver and the casualty involved in all collisions in Greater London from January 1999 to December 2003.

Interactions between land use and transportation decisions play a huge role in a persons propensity to be involved in a collision depending on where they live. Many studies have explored the combined effect of roadway geometries and environmental factors on road safety. The spatial environment can be apprehended in many ways. For example land use was considered by Petch *et al* (2000), Ivan *et al* (2000), Ossebbruggen et al (2001) and Noland (2003). Land use, infrastructure and transportation networks play a significant role in determining road user risk. Its changing role and dynamic within a city has been discussed in detail by Batty and Longley (1994). The growth of a city outwards will almost never be exactly concentric and even, cities usually organised into neighbourhoods enough to support educational and retail functions (Batty and Longley 1994). With this in mind, the concentric rings created for this study may overlook this neighbourhood effect of land use and infrastructure in relation to changing urban residential risk patterns. However, studies have neglected the link between distance from a central city point and the changing road user risk. The significant environmental and spatial factors which relate to the changing city attributes with distance from a city centre include changing land use and changing road network (usage and density) (see Anas *et al* 1998). London's land use and infrastructure is unique with respect that it is a capital city and its growth has produced an agglomeration whose road network, land use and city centre have experience continued growth and change.

The effect of this urban form will have an impact on the Mosaic types in each of the concentric rings around London. This impact will be largely reliant on employment, transport and local infrastructure and the associated changing collision risks associated with these factors. Financial factors such as income often play the largest role in deciding where people live and as we have seen from the literature in previous sections of this paper, being less financially mobile means a larger risk of being involved in a road collision primarily due to factors such as having a higher propensity to walk in order to complete a journey and a higher propensity to live in areas with high traffic volumes, and therefore a an increased risk of being

in the traffic environment as a victim. The importance of urban morphology and urban structure plays a vital role when measuring people's risk in terms of residential location and distance from central London.

The following questions act as a guideline for the method and analysis:

1. How does the proportion of different Mosaic types vary with distance from central London?
2. What are the patterns of the Mosaic groups? Are the Mosaic types similar or different within each concentric ring?
3. Can the changes (if any) of the Mosaic types (using the index scores) with distance from Central London be explained?
4. Are there any anomalies, and if so, can these be explained?
5. How reliable are the data and methodology in explaining collision risk with distance from Central London?
6. How can this methodology and subsequent results enable a clearer understanding of road collision causation and risk exposure within London?

The differing risk exposure of the residents of London is likely to be unique (in terms of London's Mosaic population) because of its status as a world city and its characteristic social and economic structure. The results of this study will be influenced by the shape of London's urban growth and notably its sprawl. (see Torrens *et al* 2000, Batty *et al* 2003). The concentric rings created around London and their subsequent values will be influenced by the distribution of population scattered within Central and Greater London. This effect will be discussed further in the results.

For the purpose of this study, only spatial patterns of how road user risk varies from Central London are examined. Temporal considerations have been excluded (but their importance in collision occurrence cannot be stressed enough) from the study because of time restrictions. Appreciation of the temporal aspect which contributes to road user risk (see Levine et al 1995 and Folkard 1997) should not be neglected and further studies will address this attribute when outlining patterns and reasons for risk.

Research design

Using a buffering tool

A GIS makes it possible to perform operations that are essential in decision analysis and decision-making: redistricting of boundaries, definition of buffer areas, and determination of the distance between objects. In redistricting, the boundaries of one territory can be modified or joined to those of another in order to form a new territory and to sum the values of constituent attributes. Buffering allows contiguous or non-contiguous territories or objects of different shapes and dimensions to be selected in order to form a virtual region or area without having to modify boundaries. Both redistricting and buffering capture the information on attributes of an area or region so that they can be managed or analyzed. Distance determination makes it possible to calculate the distance between two or more points on a map or the area of a territory.

To create the concentric rings or 'buffer zones' around Greater London ERSI's ArcGIS was used as it has the capabilities to create easily modifiable buffers around a specific point. Charing Cross was chosen as the official central point of London (as suggested by Webber 2004 and as used in many cartographic maps of Greater London) and it grid reference was used as the point from which the buffers were determined. Using a buffering tool within ArcGIS, concentric rings were created around London at 3 mile intervals. Therefore in total there were 6 rings of the following distances:

- 0-3 miles
- 3-6 miles
- 6-9 miles
- 9-12 miles
- 12-15 miles
- 15-18 miles

The proposed stratum was set at 3 miles in order to cover the whole of Greater London and enable a meaningful comparison between them. It was proposed that a three mile radius around the centroid point provided coverage for specific inner London areas including the city and kings cross areas.

The data used to determine the collision victim location were obtained from the widely used road accident database STATS19, where information regarding many elements of the collision are recorded such as time of day, collision location, how many people were involved and what class they are (in terms of driver, passenger, pedestrian, cyclist). For this study a five year dataset for Greater London was used covering the years from 1998-2003: this included postcode data for both the driver and the casualty (disregarding whether the driver

was injured in the collision or not). Each postcode for the driver and casualty was subsequently linked to a postcode point dataset which meant a point could be displayed on the map which represented a postcode (which represents approximately 15 households, Royal Mail 2005). For each concentric ring, the total number of postcode points were collated and a Mosaic Type was appended to each postcode.

Stats19 database: Preparation and explanation

Collision data for London are collected and maintained by the Metropolitan Police in what is known as the 'Stats19' database, which records all injury collisions within Greater London. This database is collected at the scene of the collision and consists of 64 attributes for each collision including road type, weather, age and sex of casualties and driver, vehicle position information and so forth. This information is divided into three separate datasets which include:

- *Attendant circumstances*

This records the grid reference (to the nearest 10 metre) of the collision, the severity of the collision, number of people and vehicles involved, weather, type of road, textual description and crash reference number which is appended to each of the casualties and drivers involved, so each collision has a unique reference.

- *Casualty details*

This dataset records information for each of the casualties involved in the collision, information collected includes the casualty age and sex, class of casualty (passenger, driver, pedestrian, cyclist etc), the severity of their injuries, and postcode information of their place of residence.

- *Vehicle details*

This information is collected for each of vehicles involved, it records details of the driver (injured or not injured) and the age and sex and the manoeuvres (such as turning right, or left) prior to the collision.

For purposes of this paper the dataset has been disaggregated by driver and casualty, just using the latter two datasets for this analysis (as the location of the collision is not been analysed). Both the driver and casualty datasets are kept separate for the purpose of maintaining the structure of the original data collection procedure and to omit any confusion between the two datasets. A large proportion of the data was omitted from the datasets for the purpose of this study as the necessary data requirements for this paper, consisted of only postcode data and Mosaic Type for each postcode (which has been appended to the dataset),

crash reference and the easting and northing centroid point for the postcode in order to plot the residential location as point data in order to select the points within each concentric ring.

Within each buffer zone there are a number of postcodes which are incomplete which could not be identified due to incomplete Stats19 collision records, these records were omitted as an accurate Mosaic type could not be appended to this data. These unclassified postcodes constitute roughly 1% in each buffer zone of the total postcode counts.

Establishing a risk index

Establishing a risk index for each concentric ring around London entailed identifying the base population and Mosaic Type counts, and counts of the collision victims Mosaic types. The next step was then to calculate the Mosaic count for each type within each buffer zone, and the related Mosaic count for the drivers and the casualties. Below is the equation used to determine the index (a measure of differing scale with '100' being the expected or 'normal' value and if the number is below 100, the value is under represented and if is higher than 100 then the value is over represented).

1. **Expected value**

Total postcode count casualty/driver (buffer zone)   X   Individual   Mosaic type total
                        Total base population household for buffer area

2. **Index value**

Casualty/driver total for each MOSAIC type   X   100
                        Expected value

In order to make the results meaningful, the 10 highest counts of total Mosaic household counts in each buffer zone were used (representing the greatest proportion of household in that buffer and therefore more accurate to the base population rates).

Results

Mosaic type	Mosaic count	0-3 mile %	Casualty Index	Driver Index
F36 Metro Multiculture	256971	36.16	129	126
E28 Counter Cultural Mix	140721	19.80	98	96
A01 Global Connections	133965	18.85	56	61

MOSAIC type				
E29 City Adventurers	73677	10.37	79	89
D26 South Asian Industry	14874	2.09	108	110
D27 Settled Minorities	11066	1.56	189	181
A02 Cultural Leadership	8662	1.22	82	91
E30 New Urban Colonists	8053	1.13	86	103
E33 Town Gown Transition	7744	1.09	57	52
F39 Dignified Dependency	7675	1.08	119	88

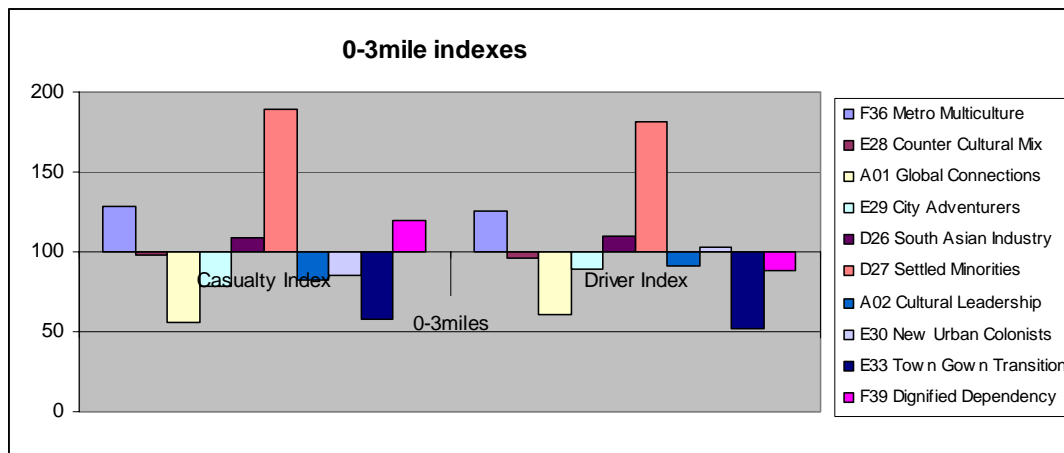Table 1: Table of 0-3 mile buffer values for top ten Mosaic types in London

Figure 1: Graph of index values of 0-3 mile buffer zone

MOSAIC type	MOSAIC count	3-6 mile %	Casualty Index	Driver Index
F36 Metro Multiculture	411870	22.94	109	104
E28 Counter Cultural Mix	379520	21.14	110	106
E29 City Adventurers	227194	12.65	82	86
E30 New Urban Colonists	196893	10.96	91	95
D27 Settled Minorities	196611	10.95	128	126
A01 Global Connections	144411	8.04	64	67

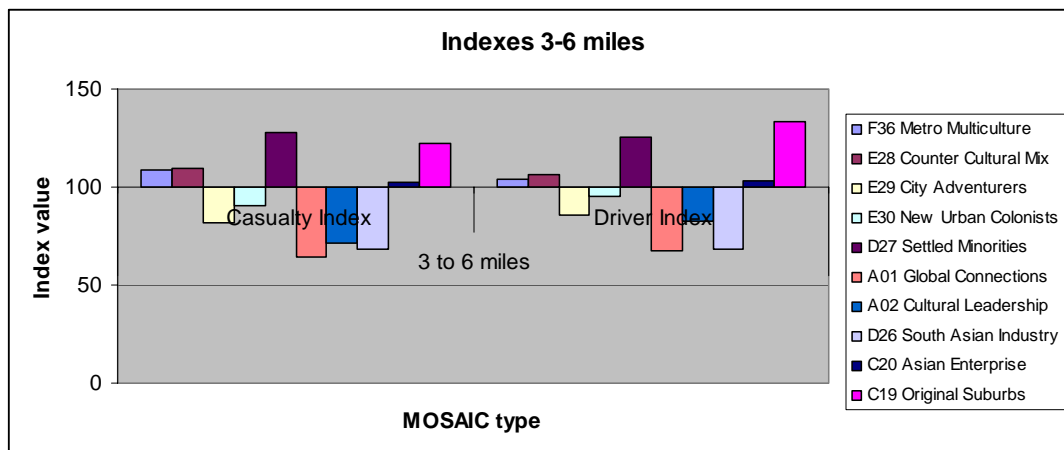|			
A02 Cultural Leadership	90620	5.05	72	83
D26 South Asian Industry	17773	0.99	69	68
C20 Asian Enterprise	16038	0.89	103	103
C19 Original Suburbs	14545	0.81	122	133

Table 2: Table of index values for 3-6 mile buffer zone

Figure 2: Graph to show the index values for 3-6 mile buffer

Mosaic type	Mosaic count	6-9 mile %	Casualty Index	Driver Index
D27 Settled Minorities	488843	23.56	111	109
F36 Metro Multiculture	218624	10.54	115	102
C20 Asian Enterprise	179541	8.65	107	111
E30 New Urban Colonists	176332	8.50	75	80
C19 Original Suburbs	143555	6.92	104	112
A02 Cultural Leadership	141434	6.82	78	84
E28 Counter Cultural Mix	111087	5.35	100	105
H46 White Van Culture	101562	4.90	119	105
E29 City Adventurers	67439	3.25	68	74
D26 South Asian Industry	56324	2.71	110	114

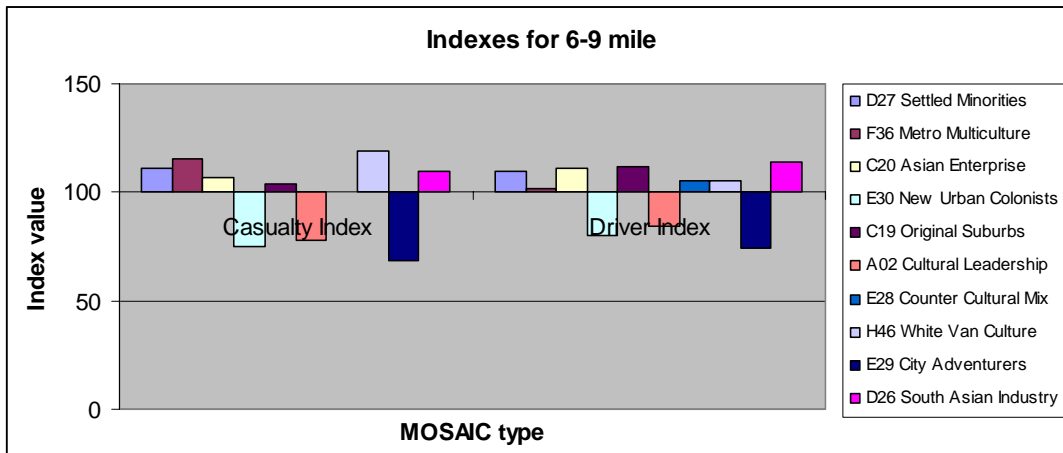Table 3: Table of indexes for 6-9 mile buffer zone

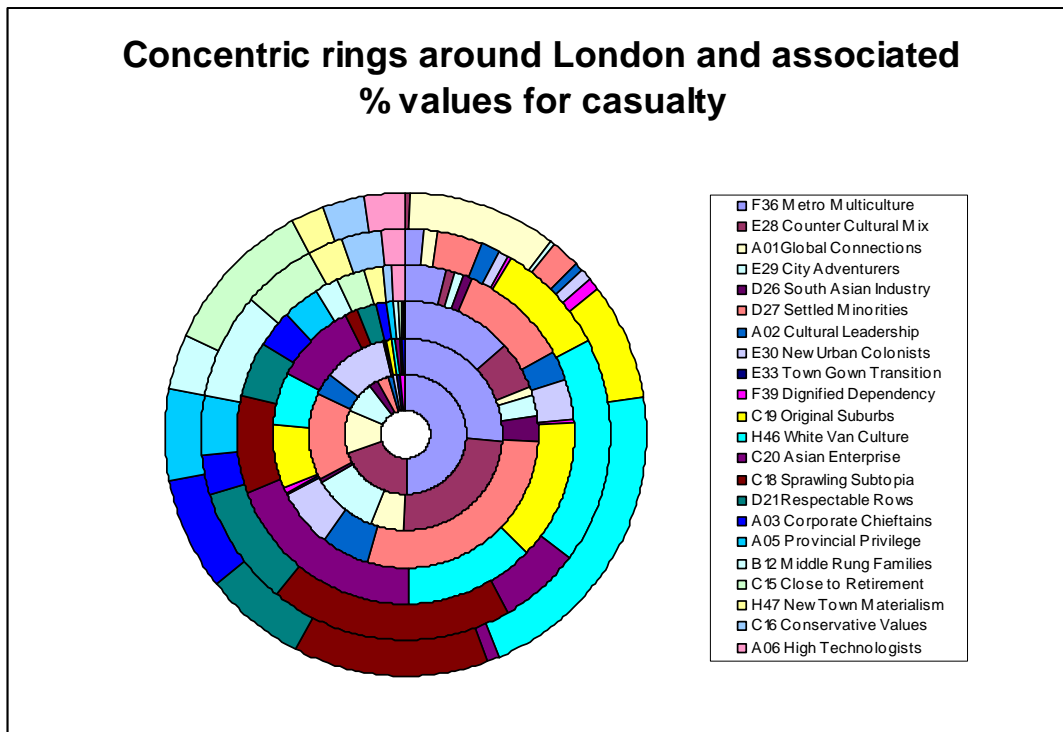Figure 3: Graph of index values for buffer zone 6-9 miles

Figure 4: Schematic diagram to show the percentages of people within each Mosaic type and their associated collision risk based on the index values

Concentric rings around London and associated % values for drivers

Legend:
- □ F36 Metro Multiculture
- ■ E28 Counter Cultural Mix
- □ A01 Global Connections
- □ E29 City Adventurers
- ■ D26 South Asian Industry
- ■ D27 Settled Minorities
- ■ A02 Cultural Leadership
- □ E30 New Urban Colonists
- ■ E33 Town Gown Transition
- ■ F39 Dignified Dependency
- □ C20 Asian Enterprise
- □ C19 Original Suburbs
- ■ H46 White Van Culture
- ■ C18 Sprawling Subtopia
- ■ D21 Respectable Rows
- ■ A03 Corporate Chieftains
- □ A05 Provincial Privilege
- □ B12 Middle Rung Families
- □ C15 Close to Retirement
- □ H47 New Town Materialism
- □ C16 Conservative Values
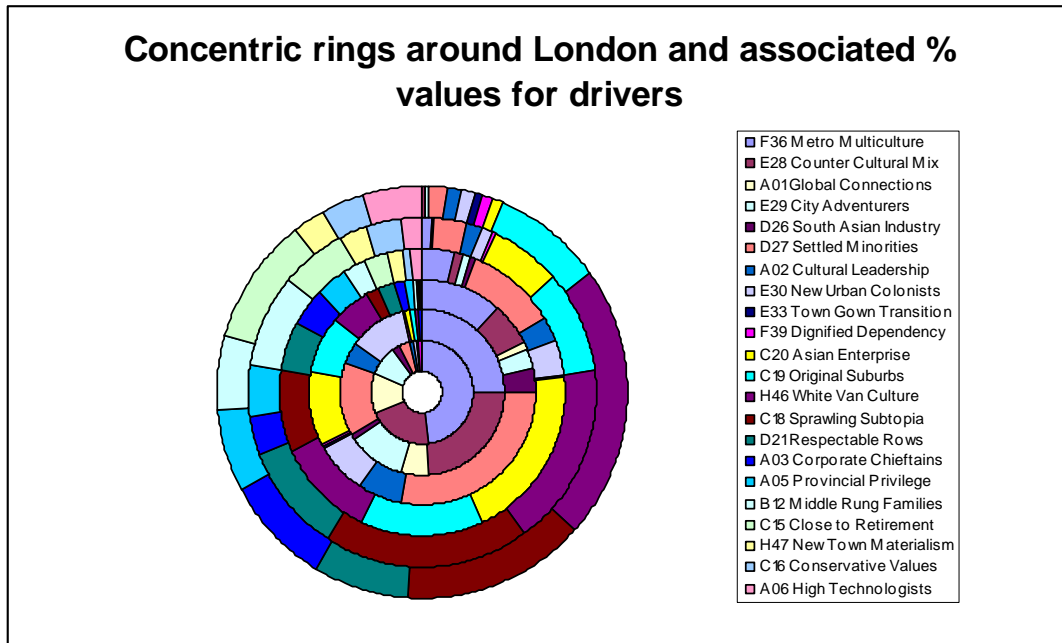- ■ A06 High Technologists

Figure 5: Schematic diagram to show the percentages of people within each Mosaic type and their associated collision risk based on the index values

This type of diagram was chosen with the intention to visually display the percentages of Mosaic types within each buffer zone. This type of diagram can be easily used to determine how the Mosaic types become less polarised in their risk the further from central London. Although the diagram is not to scale it gives a visual impression which can be applied easily to real world policies.

Analysis and findings

The tables and figures highlight a varied risk exposure index the greater the distance from Central London. It is important to note the similarities for both the driver and casualty scores: however this can be explained by the layout of the dataset whereby there are drivers who are also recorded as casualties, and so the two databases contain some identical records. The most important values are the indexes which have a value over 100 and are therefore being over represented within that specific area. In the first buffer within a 3 mile radius from Charing Cross the most prolific risk category is Metro Multiculture, having index values of 129 and 126 respectively (suggesting a slightly higher proportion of passenger and pedestrian collisions). Metro Multiculture possesses the highest proportion of the total 0-3mile population with 36.6% of the population belonging to this type. They are predominately found in London (96.1% of the UK total population households of this group are located in

London). There are more likely to live in Central London, such as the East (Whitechapel), South East (Southwark), West Central, East Central and North (such as Hackney). Generally these people fall between the age of 25-45 and have low income employment and are usually multi-ethnic areas. From Figure 1 it is clear that Central London is extremely dominated by a small number of Mosaic types which becomes less pronounced the further from Central London. Within 0-3 miles the second most dominant risk group is D27 Settled Minorities with a risk index of 189 and 180 respectively. Settled minorities feature within the first three zones from Central London, with an over represented risk index every time. Within London, they are more likely to be found in areas such as Tottenham or Walthamstow. As with Metro Multiculture, this Mosaic type is highly multi ethnic, living in terrace housing with high levels of unemployment. There is a marginally higher risk index for casualties rather than drivers which suggests a greater risk as a pedestrian, cyclist or passenger in a vehicle.

By the second and third buffer, it is clear that the Mosaic type C19 'Original Suburbs' features highly in terms of an over represented risk index for all collisions. Their risk index is over represented within the 3-6 mile buffer with index values of 122 and 133 respectively. This Mosaic type is generally found in areas such as High Barnet or Raynes Park. With incomes slightly higher and the more family orientated structure, a higher proportion of this type owns cars and also uses public transport. By 6-9 miles, the risk index becomes more even, with more types having an over represented index, but the indexes are above average measures but only just so. Mosaic Type H46 'White Van Culture' is absent as a high risk group in Central London, until 6-9 miles outside of London when type H46 has a casualty index score of 119 rising to 142 in zone 9-12 miles outside of London, and then dropping to an index score of 125 by 12-15 miles. 'White Van Culture' areas in Greater London include Borehamwood, Stevenage and Morden. In zone 12-15 miles, the highest risk index is C15 'Close to Retirement', with a considerably higher proportion of the total in the driver category.

With distance from the centre the risk indexes appear to dissipate and the proportion of Mosaic types becomes more evenly spread. Therefore it is necessary to include more than the top ten Mosaic types based on household counts for the last two buffer zones. An example of this is Mosaic type E32 'Dinky Developments': this type falls into the top 15 in the buffer zone 12-15 miles and 15-18 miles. Within 12-15 miles, type E32 has a casualty risk index of 124 increasing to 139 in the next zone. The driver risk index increases from 131 to 157 respectively. Type E32 (which stands for 'Dual Income No Kids Yet') are to be found in areas such as Uxbridge, Croydon and Watford. They tend to live in terrace house cul-de-sacs, typically are moderately well off and a high proportion own cars.

From the results overall, they show the further out of London the less likely the patterns of risk are to follow the urban population density pattern. For example, it is clear that the high risk indexes nearer the urban centre are higher among less well off and increasingly deprived Mosaic types. This mirrors the population make up as a whole for that buffer zone. Mosaic types such as A01 'Global Connections' in buffer 0-3 miles are actually highly under represented with a casualty index score of 56. The indexes of the first few buffer zones are extremely skewed with values ranging from 189 (Settled Minorities) to 56 (Global Connections). This skew becomes less pronounced with increasing distance from London, for example, in buffer 12-15 miles the smallest risk propensity index score is 76 (Provincial Privilege) to 125 (H46 White Van Culture). The risk indexes follow an consistent pattern with the only exceptions occurring when analysing a more wide ranging collection of Mosaic types the further from the centre. This, as mentioned highlights differing and increasing risk indexes. Whether the risk index is high or low, there is a tendency to focus on the Mosaic types which possess a high index score and therefore a higher likelihood of being involved in a collision. However the lower than expected scores are equally as important (for example type A02 Cultural Leadership's index score drops significantly between zones 0-3miles, where it is nearly 200, to the next zone 3-6 miles where the score is 60). These negative findings pose just as an important finding for policy makers than the positive scores.

Summary

The importance of this study lies in the wider understanding of the socio-economic based risk distribution from Central London and how important buffer zones can be in analysing risk dispersion. Although there has been little research and literature within the transport applications and accident analysis domain in terms of measuring distance and socio economic indicators of risk (of bring involved in a collision) this theme of socioeconomic and lifestyle classifications, urban form and risk exposure, the work in this paper presents a clear and incontestable relationship between the three variables and motivation for continued use of such methods and use of Mosaic classifications for other area of collision analysis.

This research has sought to demonstrate and analyse the risk exposure of London's residents of being involved in a road collision. It highlights only one of the many causal factors associated with underpinning patterns and processes of road collisions in a spatial context. This study has been analysed at the global scale by taking the whole of Greater London. Possibly in future studies, town centres within London and their associated buffer values could be analysed as this would yield a better understanding of the nature of residential

collision risk at a more local level. By taking these results at face value one runs the risk of neglecting some important spatial issues such as the modifiable unit problem (Openshaw 1984). This spatial phenomenon is the direct result in this study of the choice of concentric ring size. It is apparent from the paper that there has been no previous studies and therefore no possible guidelines with which to use for the ring size.

The nature of this paper brings into question the spatial scale of analysis with regards to measuring risk in an urban area. This paper has shown that collision risk for residents is uneven, the further from Central London; however the use of other spatial scales of analysis may yield different results. For example using arbitrary neighbourhood boundaries and analysing the varying risk with a greater emphasis on the social and economic boundaries of London may determine more local policy indicators for collision risk reduction. In the future it is hoped that this type of research between road collision risk and geodemographics will be able to inform and assist the public and associated bodies in bringing awareness to an important public safety issue within the capital city.

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