Anthropogenic Accidental Dwelling Fire: Incident Distribution, Theory and the Fire and Rescue Service

Thesis submitted in accordance with the requirements of the University of Liverpool for the degree of Doctor in Philosophy

by Steven Merrall

September 2002 (December 2007)

PAGE NUMBERING AS ORIGINAL

Acknowledgements

I would like to extend my thanks and gratitude to all of the people and organisations that have supported and encouraged this work. I would especially like to thank my supervisors Professor Alex Hirschfield and Dr. Peter Brown for their constant encouragement, help and support over the years, Professor David Shaw for his advice and patience and also my valued colleagues in the Department of Civic Design, many of who have helped along the way.

I would also like to thank my examiners Professor Peter Batey and Dr. Robert Barr for their challenging examination and constructive criticism which helped improve this research.

I also thank the Greater Manchester Fire and Rescue Service for their participation and co-operation in the research study, with specific thanks to the Chief Fire Officer, Senior Divisional Officer Alan Stoker and D.O. Dave Rainford for all of their help.

To my daughters

Emily and Grace. X

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List of Abbreviations

Abbreviation	Full Text
AADF	Anthropogenic Accidental Dwelling Fire
ANOVA	Analysis of Variance
BA	Breathing Apparatus
BCS	British Crime Survey
BRE	Building Research Establishment
CFS	Community Fire Safety
CPA	Comprehensive Performance Assessment
DCLG	Department of Communities and Local Government
DSS	Department of Social Security
DTLR	Department of Transport, Local Government and Regions
ED	Enumeration District
FDR1	Fire Damage Report 1
FEMA	Federal Emergency Management Agency
FRA	First Response Areas
FRS	Fire and Rescue Service
FSEC	Fire Service Emergency Cover
GIS	Geographic Information System
GM	Greater Manchester
GMC	Greater Manchester County
GMCFS	Greater Manchester County Fire Service
GMFRS	Greater Manchester Fire and Rescue Service
ID 2000	Indices of Deprivation 2000
ILD	Index of Local Deprivation
IMD	Index of Multiple Deprivation
IRMP	Integrated Risk Management Plan
NFPA	National Fire Protection Association
NFRIS	National Fire Incident Reporting System
ODPM	Office of the Deputy Prime Minister
OS	Ordnance Survey
SSA	Standard Spending Assessment
UCAS	University and Colleges Admissions Service

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Steven Merrall

Abstract

Over the past decade the Fire & Rescue Service (FRS) has attended an average of 67,000 residential dwelling fires a year, resulting in an annual average of 14,000 casualties and 450 deaths in the UK (DCLG, 2007).

Anthropogenic Accidental Dwelling Fire (AADF) is not a random phenomenon, and through the use of spatial and temporal pattern analysis, it can be shown to be disproportionately concentrated in areas that share common social, economic and environmental characteristics. Developing robust theory and methodology will improve the understanding of the nature of the problem and the ability to effectively target resources to areas of greatest need.

This thesis presents the development of a new theoretical model of Anthropogenic Accidental Dwelling Fire incidence, bridging the theory gap in the existing research literature. The theoretical model developed identifies the component factors of potential domestic activity fire risk and the key role of trigger events, by act or omission, that combine to significantly increase the risk of fire within a dwelling.

Spatial and temporal analysis of the distribution of over 17,000 individual AADF incidents, from the Greater Manchester area, was conducted utilising the nationally comprehensive and consistent ward level Indices of Deprivation 2000 (IMD) and the Enumeration District (ED) level SuperProfiles geodemographic typology. The analysis revealed statistically significant variation in the profile of incident distribution, operationally valuable to the FRS and of major policy importance.

An AADF Routine Activities Time Classification was produced and an analytical methodology developed to derive temporal profiles for incidents across both area characteristic classifications and ignition categories. The AADF spatial-temporal ignition profiles were shown to vary significantly, providing valuable new empirical evidence in support of the implementation of the theoretical model and the utilisation of the methodology developed, informing both strategic policy and service delivery management of a modernising Fire & Rescue Service.

A comprehensive national survey of FRS was undertaken and the results are critically reviewed, providing a snap shot of the data, systems, analysis and skills of the FRS, exploring the potential capacity of the organisation to utilise theory based research with evidence lead targeting and resource allocation.

A practical application of the use of the IMD as a proxy for Fire & Rescue Service demand is then developed and tested, addressing a perverse incentive within the Standard Spending Assessment used to fund the FRS. A simple weighted model was over fitted to the known incident distribution of the case study area of Greater Manchester. The IMD group weightings derived were then extrapolated to national population distributions within IMD classes and the SSA recalculated.

Finally the principal findings of the research are presented, the outcomes critically reviewed, policy implications discussed and recommendations made.

Chapter 1: Introduction

1.1 Context and Statement of Applicability

This research was conducted during the period between 1998 and 2002. It develops a theoretical model of Anthropogenic Accidental Dwelling Fire (AADF) and a methodological framework for the analysis of fire incidents. The research reviews literature and uses case study data contemporary to the study. The applicability of the theoretical model proposed, methodological framework developed, analytical results and an update on the literature review and policy context are discussed in the conclusions of the thesis.

1.2 Anthropogenic Accidental Dwelling Fire: The Nature and Extent of the Problem

Anthropogenic accidental dwelling fire can be defined for the purposes of this thesis as those incidents of fire resulting from the interaction of people and their domestic dwelling environment. The incidence of non-deliberate / accidental residential dwelling fires is predominantly the result of the activities of people within those dwellings. National statistics for England and Wales report that, in 1999, over 90% of non-deliberate ignition dwelling fire incidents resulted from the activities of people within those dwellings (Watson et al, 2000, table 3, p 54).

There are few events that wield greater destructive power in terms of injury, trauma, and economic loss than a fire. The overall cost of fire to the UK economy is estimated at £6.9 billion a year, based upon 1999 figures, with domestic dwelling fire incidents accounting for £1.7 billion. The direct costs of fire service response to residential dwelling fire incidents amounts to £245 million a year (Weiner, 2001, table 4.1, p 20). The human costs are devastating, with an estimated 663 deaths from

fires and 18,100 non-fatal casualties in 1999, of which Accidental Dwelling Fires accounted for 466 deaths and 14,600 non fatal casualties (Watson et al, 2000).

This thesis is based upon the premise that anthropogenic dwelling fire is not a random phenomenon, and through the use of spatial and temporal pattern analysis, it can be shown to be disproportionately concentrated in areas that share common social, economic and environmental characteristics. The identification of individual, and combinations of, area characteristic risk factors, temporal profiles and spatio-temporal variation will enable area dwelling fire risk profiles to be developed providing an empirical evidence base for both strategic and service delivery management of a modernising fire service, improving the understanding of the nature of the problem and the ability to effectively target resources to areas of greatest need.

1.3 Research Context and Significance

Historical Home Office (then DTLR, now ODPM) aggregate, brigade level fire statistics (Watson, 2000) and findings from the British Crime Survey 2000 (BCS), (Aust, 2001), show that fire is selective in terms of those who are most vulnerable (e.g. the elderly, the disabled and young families) and the property types and areas affected. However, there is a surprisingly small literature in the field of fire risk factor identification and incidence pattern analysis. The research conducted to date, highlights the need for further research into the social, economic and environmental risk factors that are common to the incidence of different types of fires and their geographical and temporal distribution. Almost all of the limited research conducted has however been outside the UK or is based upon data that is now relatively old and has limited potential for application within a modernising fire service and policy environment.

Historically the Fire Service has not been afforded the same high level of political interest that has been very evident in terms of law and order and the need to reduce the incidence of crime. With an increasing focus on public expenditure and the drive to achieve 'Best Value' in all the public services, the Fire Service has come under increasing scrutiny. The 1995 Audit Commission report 'In the Line of Fire' considered the need for, and proposed, an 'agenda for change', recommending that research should be conducted to inform a future policy framework for the provision of fire cover based upon empirical evidence. They also stated that, whilst maintaining the current high standards of response options, priority should be given to the development and implementation of effective fire prevention measures.

Following this the Home Office commissioned and then published a report 'Elaboration of a risk assessment toolkit for the UK Fire Service' (ENTEC, 1996), this report addressed the feasibility and applicability of a risk based 'toolkit' for the production of national standards for the provision of local fire cover. It considered and proposed the use of classifying areas based upon the levels of fire incidents experienced, the rate of casualties and fatalities per a given number of incidents, and examining these rates in relation to discrete demographic groups and building types. The report then considered the use of the derived area classification and vulnerable demographic groups for the purpose of targeting and delivering fire safety initiatives and fire cover. A subsequent report by ENTEC concluded;

'the variation in fire incidence and fire casualty rates could be measured directly for the purpose of assessing fire cover needs, with assessment of local social-economic and demographic factors completed for the purpose of targeting fire safety education and prevention work on the highest risk households'

(ENTEC, 1998, p26).

If we are to consider the primary aim of the fire service 'to safeguard people's lives' then the main focus of our efforts should be directed at the identification of those groups of the population most at risk and their location. The report of the community Fire Safety Task Force ' As Safe as Houses', published in 1997, was produced by appointment of the Home secretary with the following terms of reference;

'To propose a community fire safety strategy and supporting action plans which will significantly reduce the numbers of fires and fire related casualties in dwellings'

(Community Fire Safety Task Force, 1997, p1).

The Task Force stated that;

'we believe that the majority of domestic fires are preventable. They are mostly the result of a lack of care or inappropriate behaviour.'

(Community Fire Safety Task Force, 1997, p 4).

The report stated that there was a need to ensure that brigades adopted a new culture of prevention as their primary aim. Organisational changes were required to accommodate a new strategy and vision involving the inception of a National Community Fire Safety Centre to provide a national framework within which Community Fire Safety (CFS) would develop. The report also expressed surprise in that 'the Government currently has no targets on fire or casualty reduction nor forecasts for the future' (para. 4.2), along with a lack of quantifiable performance indicators in this area. There was also a lack of planning both locally and nationally and little or no monitoring and evaluation of CFS work. Great emphasis was placed upon the need for empirical evidence derived from data analysis and targeting of

resources based upon this analysis at the local level to identify and reach at risk groups.

The current structure of the Fire Service is inherently spatial in terms of both administrative and service delivery organisation. To a great extent the Fire service is defined by a hierarchy of spatial boundaries nesting within national boundaries and falling under the overall responsibilities of the Home Office for England and Wales. Individual Brigades are often sub divided into Divisional areas or Commands and then into smaller Station areas. National fire statistics are compiled and published by the Home Office Research, Development and Statistics Directorate on an annual basis and report aggregate data at the Brigade level. Any reporting or analysis of fire service incidents below the level of the brigade has historically been left to individual brigades to undertake. This has resulted in the Fire Service, for various reasons, failing to undertake or develop any meaningful structure and methodology for the collection, manipulation, analysis and dissemination of fire related data and information below the brigade level. This is not to say that individual brigades and individuals within brigades have not conducted research and implemented initiatives based upon the results. It does however mean that there has been a lack of communication, collaboration and focus upon the possible benefits to be derived from a greater use of evidence based risk analysis within the Fire Service as a whole.

The challenge for the Fire Service is to reduce the incidence of fire and casualties through a new focus on prevention through Community Fire Safety whilst maintaining the current high level of response options. The drive is for a more effective, more efficient and more proactive service that is informed by robust empirical evidence.

This thesis will consider the theoretical basis for distribution of AADF and adapt and develop methodological innovation in the field of fire incident research. It will increase the understanding of the distribution of fire incidents and the knowledge base within the field, examine the policy implications of the research findings and consider the potential benefits of an evidence based service delivery framework for fire incident reduction.

Within growing budgetary strictures, research delivering evidence based information of this type will enable justification, monitoring and evaluation of geographically targeted fire reduction / safety initiatives. The use of area profile risk classifications will be shown to have potential utility in the targeting, content and delivery mechanisms of Fire Safety packages, contributing to Crime and Disorder audits and strategies, and informing resource requirements and allocation issues.

1.4 The Scope of the Research

This study will focus on the anthropogenic fire issues relating to England and Wales. There is no such entity as the UK Fire Service as parliamentary responsibility for the fire service for England and Wales falls under the DTLR (now ODPM). Practical issues relating to access to and compatibility of fire incident data and the explanatory variables used in the analysis, have necessarily restricted the study to England and Wales only. However the research findings may be considered, to a greater or lesser extent, to be applicable to the rest of the UK and also internationally.

Direct international comparisons are also not made beyond the consideration of previous research findings and generic organisational considerations, requirements and priorities. However the theoretical model and methodological framework to be

developed are based upon area characteristics defined by social, economic and environmental factors specific to the UK but this should not be interpreted as restricting applicability to the UK only. Variations in international societal structures, lifestyles, built environments and economic profiles of the populations act to influence the availability and choice of the specific explanatory variables used, but have little impact upon the validity of theoretical model or methodological framework proposed.

The research will be based upon a case study analysis of the fire incident database of the Greater Manchester County Fire Service (GMCFS). GMCFS is one of seven metropolitan Brigades and the second largest brigade in the England and Wales, London being the largest. The brigade area is predominantly urban in nature and has significant levels of deprivation across a large proportion of its population. The focus of the research will be on Anthropogenic Accidental Dwelling Fire incidents, the single largest cause of fatalities and casualties, which in comparison with crime incidents costs more than all but the most serious of crimes (Brand and Price, 2000).

1.5 Aim and Objectives of the Research

Aim

To develop an understanding of the non-random spatial and temporal distribution of anthropogenic accidental dwelling fire incidents in relation to social, economic and environmental factors, and to exemplify the potential utility of such knowledge to inform evidence based Fire Service policy and management.

Objectives

- To identify gaps in the existing evidence base on links between anthropogenic fire and social, economic and environmental factors.
- To develop a theoretical model of accidental residential dwelling fire incidents.
- To identify patterns in the spatial and temporal distribution of fire incidents.
- To demonstrate the extent to which there are observable links between fire rates and area characteristics.
- To explore the extent to which the use of data analysis to extend the evidence base is a feasible prospect nationally.
- To test the potential application of area based fire risk indicators within the Fire Service Standard Spending Assessment (SSA) funding methodology.

Through the perusal of the aim and objectives stated in this section the research will develop not only the level of knowledge in the field but will also demonstrate the applied potential of the findings in targeting those areas most at risk from Anthropogenic Accidental Dwelling Fire.

1.6 Thesis Structure and Overview

Chapter 1 has provided an introduction to the subject area and the need for the research. The significance of the research has been outlined in terms of the need for methodological innovation, theoretical development and application frameworks within the current political, policy and technological context. The scope of the research has been defined and will be further elaborated upon throughout the thesis. A brief introduction to the case study area has been given and justification for this

approach will be further discussed in subsequent chapters. The research aim and objectives are also stated. The following chapter outlines provide an overview of the structure and content of the thesis.

Chapter 2 is a review of the research on dwelling fire incident analysis, specifically in relation to geographical and temporal distribution, demand for fire service attendance, and its links to deprivation, housing type and other social, economic and environmental factors. The literature review has necessarily been expanded to examine the related research theories and concepts that have been developed or adopted and applied to the study of crime, health and other fields in relation to spatial and temporal pattern analysis, risk factor identification and resource targeting. This has significantly added value to the research undertaken, identifying the applicability of established theory and methodology to the problem of anthropogenic accidental dwelling fire incidence in England and Wales. Five distinct but inter-related gaps in the literature are identified and elaborated upon.

Chapter 3 builds upon the findings of the literature review considering the need for a theory of anthropogenic accidental dwelling fire. The gaps that have been identified are discussed further and the components of the theory identified. These components are then combined to develop a theoretical model of anthropogenic accidental dwelling fire that is then presented. The implications of the theoretical premise presented are then introduced in respect of the management of and resource allocation within the fire service.

A series of research questions are then posed that will be used to test the theoretical premise that anthropogenic accidental dwelling fire is not a random phenomenon, the extent to which the distribution of incidents can be shown to be both spatially and temporally concentrated, the association of social, economic and

environmental indicators, and the need for and capacity of the fire service to utilise the potential of such a model and statistical outputs.

Chapter 4 introduces the selection criteria for a case study area, which are then defined and applied. The resulting study area of Greater Manchester is introduced and the identification, availability and selection of data sources for the research are presented. Issues of data quality, processing, spatial and temporal analysis are detailed. The choice of units of spatial aggregation for the research is made and justified and anticipated research limitations are identified.

Chapter 5 presents the analysis of the fire incident data set, results and discussion. The methodology for each stage of the analysis is described including issues of data access, standards, quality and compatibility. The stages of spatial, temporal and spatio-temporal analysis are presented and the results and statistical significance are presented and discussed.

Chapter 6 takes the research theory and results forward and considers their use in the development of evidence-based management and service delivery within the fire service. The capacity of the fire service to adapt to and implement an evidence based approach to service delivery is assessed through a comprehensive national fire brigade survey. The results of which are presented and discussed along with the definition of minimum data, process and system requirements required for robust evidence lead policy and fire service management information.

Chapter 7 demonstrates a potential applied use of the research findings in the modelling of demand for service based upon the known distribution of all fire incidents from the GMCFS case study area, by Index of Multiple Deprivation (IMD) ward level scores. The model addresses the current perverse incentive contained within the standard spending assessment for the fire service. The GMCFS based

weighting derived are then applied to the national known distribution of population by IMD ward groups. The finding are presented and discussed.

Chapter 8 summarises the principal research findings drawing together the theoretical, analytical and applied outputs, examining the methodological innovations, application and policy implications. A critical review of the research is then undertaken followed by a discussion of problems encountered, unexpected research findings and recommendations for further research.

Chapter 2:

A Review of the Research on and Applicable to Residential Dwelling Fire Incidence

2.1 An Introduction to the Literature Review and its Proposed Scope

This chapter reviews the published and in some cases unpublished literature on the incidence of fire. Its primary purpose is to examine and critically assess the literature on Residential Dwelling Fire and to establish the extent of the evidence for associated risk indicators or factors. Common theoretical themes are identified, methodologies assessed and findings discussed.

The overarching theoretical theme of the research contained in the literature review is that of Human Ecology, encompassing multiple related and interacting theoretical themes specifically; socio-economics, ecology, behavioural psychology, epidemiology and environmental criminology. Within these theoretical themes there are two principal areas of literature that are considered, namely those studies that deal with the spatial and temporal analysis of fire incidents and those studies that have developed theory and methodology that may be relevant to the study of fire, with the later drawing upon the literature relating to crime pattern analysis, a field with a more extensive and theoretically based body of research than that currently relating to fire incidence.

The literature specific to fire incident analysis and the fire service is far from comprehensive but does address a range of issues including; spatial and temporal distribution, deprivation, demographics, the built environment, risk modelling and resource allocation. All of these components are drawn upon, analysed and critically

assessed to provide an overview of the existing body of literature and are then used to inform and contribute to the specification and achievement of the aim and objectives of this thesis.

The starting point and principle upon which this thesis is based is that fire is not a random phenomenon and can be shown to be disproportionately concentrated both spatially and temporally. In isolation the fire incident data provides no more than records of fires classified and coded to enable the production of basic counts of incident characteristics. The addition of a spatial and temporal framework within which social, economic and environmental characteristics can be introduced provides a contextual backcloth against which research can be conducted, exploring associative links with fire incidents and risk. It is not that the explanation of the causes of fire incidents is thought to be primarily spatial or temporal in nature, rather that spatial and temporal analyses provide a consistent framework within which research can be scientifically conducted.

To this end the main focus of the literature review is on the use of spatial and temporal analysis of the distribution of fire incidents in relation to the nature of the interaction of people and their environment. Narrowing the focus further the review will seek to concentrate on the body of research that examines the nature of the differential residential dwelling fire risk in relation to socio-economic and environmental contextual risk factors. The review also encompasses theoretical propositions and models drawn from the field of environmental criminology and which may be applicable through adaptation to the development of a theory based model of anthropogenic accidental dwelling fire incidence.

The chapter will go on to critically review the existing body of research, its applicability to the UK dwelling fire profile and the extent to which further research is needed.

2.2 General Background to the Research Conducted to Date

A number of studies have been carried out over the past few decades that have examined the incidence of fire in relation to a range of social, economic and environmental factors. The major studies reviewed have been conducted primarily in the United States in the early to late 1970s, funded by the National Fire Protection Association (NFPA) at a time when there was significant political attention surrounding the problem of fire in the US.

> *'Only people can prevent fires. We must become constantly alert to the treat of fires to ourselves, our children, and our homes. Fire is almost always the result of human carelessness. Each one of us must become aware, not for a single time, but for all the year, of what he or she can do to prevent fires'*
> President Richard M. Nixon, September 7, 1972 (in America Burning, NCFPC, 1973, pI)

It was against this background of political interest in the United States that the bulk of the existing research was funded and undertaken. A relatively small research community has continued to investigate and build upon that early work, primarily US based and with little or no reference to the applicability of the research beyond the study areas examined and without consideration of the applicability findings outside of the US.

The research conducted in the UK was also conducted predominately in the late seventies and early eighties. The review will consider the applicability of the findings of research conducted some 20 years ago in relation to the significant changes in both the built and socio-economic environment. It is pertinent to ask if the factors that characterised areas of high risk of fire some two and three decades ago still hold fast in today's society and if the same, comparable or improved data sets and information is available today for use within the research. The review will address these issues, drawing upon past findings, examining the direction in which the research field had developed, and identifying opportunities for new research.

The two significant, more recent pieces of research to be reviewed were again conducted in the US and are based upon the 1990 US census. Both take the form of unpublished doctoral thesis (Goetz, 1991; Jennings, 1996). The findings show that household income level, as reported by the US census, was a significant variable in the explanation of differential residential dwelling fire incidence. No such direct measure is available within the UK, our own Census of Population does not contain a household income question, and as such we rely upon individual and groups of proxy variables for income, the review will seek to identify suitable proxies and evidence for alternative approaches.

Ecological and behavioural psychology themes will be examined in relation to the issue of fire risk and the extent to which the individual's behaviour within the dwelling is the principal factor resulting in the ignition of a fire and contributing to the outcome of a fire in terms of casualties and fatalities. Whilst only 4% of the public of England and Wales consider that they are likely to have a fire in the home, the respective figures for burglary and road accidents are 44%and 35% (Community

Fire Safety Task Force 1997, p11, para. 3.3). This represents a very low level of risk perception in relation to a serious threat to life and property.

The theoretical theme of ecology is further explored through the literature relating to environmental criminology. The relationship between risk and event, as presented in the theoretical model of routine activities and predatory crime by Cohen and Felson in their 1979 paper, provides an interesting opportunity for adaptation and development of a model of anthropogenic accidental dwelling fire. This is discussed in greater detail in the review and developed in the following chapters.

The following section presents the literature review, summarising the extent, strengths and weaknesses of the current theory and evidence base in relation to residential dwelling fire; identifying the potential to build upon this and conduct an original piece of research that makes a significant contribution to the body of knowledge in the field.

2.3 Literature Review

A significant proportion of the existing body of research conducted to date has been carried out in the US and has limited theoretical grounding or reference to published research, although there are some notable exceptions to this. The lack of theoretical and methodological sophistication employed to date within the study of urban fire incidence requires by necessity the imposition of a framework and classification of theoretical themes within which the review can be meaningfully undertaken and presented. As stated previously the overarching theoretical theme that encompasses the majority of the research conducted to date is that of Human Ecology, within which the contributing theoretical themes will be used to structure the review to be conducted.

2.3.1 Social and Socio-economic Research

Early research efforts in the US were driven by the concerns voiced by politicians about the human and economic costs of fire (NCFPC, 1973). Subsequent funding and continuing interest saw the most prolific period of fire research develop during the late seventies and early eighties.

One of the earliest studies emanating from this period of research activity in the US used fire incident data for structural fires, for one year from November 1973 through to October 1974, for five boroughs of New York, along with population figures and income levels drawn from the 1970 census of population (Munson, 1976). The study although limited and described as a pilot study by the author, examined the relationship between urban population density and fire incidence. Only five data points were used, the five city boroughs, and a slight positive association was observed, 'it appears that the incidence of structural fires does increase slightly as residential density increases' (p59).

The research used the percentage of households with an income of less than $5000 in each borough to the test the proposition that being poor increases the likelihood of fire. The results are far from being statistically significant but the study states that they 'indicate that the urban poor ... experience a disproportionately heavy incidence of structural fires' (p59). The author acknowledges the limitations of the use of aggregate data at the borough level, with only five areas having data available for use in the study, but it does introduce two possible correlates of increased fire risk; high population density and low income. However the paper is weakened by referring directly to the urban poor as a group of individuals within an area based study whilst failing to address the problems of the ecological fallacy

(Robinson, 1950) intimating that the characteristics of the area relate directly to the urban poor within that area.

The author went on to develop this work and conduct an analysis of structural fire data for 60 census tracts from the year 1973, using the 1970 census population and household figures as the denominators for the calculation of incident rates (Munson & Oates, 1983). Data was also obtained for 36 cities and municipalities, and 54 larger cities in the US. The study's spatial scales and fire incident data periods are common to several studies conducted in the US, utilising the common source of aggregate data from the National Fire Protection Association (NFPA).

The study is structured around a series of 7 hypotheses with the stated aim of testing for systematic relationships between the likelihood of fire and a wide variety of structural, socio-economic and climatic variables, based upon the author's premise that there are certain characteristics 'that we suspect influence the probability of fire' (p61).

The hypotheses of this study are listed and the results commented upon below:

Hypothesis 1 – the probability of fire occurrence is inversely related to income.

The results showed that higher income areas had lower fire rates than lower income areas, with an increase in income of around a $1000 equating to a 10% decrease in fire rate.

Hypothesis 2 – Fires are less likely in owner-occupied dwelling than in rented dwellings.

The fire rates were tested against the proportion of owner occupied property in each area. The results showed that higher ownership areas had lower fire rates with a 10% increase in ownership resulting in a 10% decrease in fire rate.

Hypothesis 3 – The likelihood of fire is greater in dwellings with children present.

There was no data available to test this hypothesis directly so a proxy variable was used derived from the proportion of population below the age of 15 years. The results obtained using the proxy variable did not support the hypothesis; however the proxy variable was not considered robust enough to rule out the presence of children contributing to high fire incidence rates.

Hypothesis 4 – Increased levels of social tension in a community are conducive to a higher fire incident rate

The findings are inconclusive across all study areas with reference to unemployment and race related variables showing some association with higher levels of fire rates, but there is little or no substantive support for use of these variables as proxy for social tension.

Hypothesis 5 – A higher degree of crowding increases the likelihood of fire

The tests for this covered a range of crowding definitions covering population density, persons per room, and the percentage of multiple housing unit structures. The findings showed varied results with no clear pattern evident or relationship derived.

Hypothesis 6 – The better the condition of structures, the less probable the occurrence of fire is.

The tests again used measures that were based upon a subjective classification and based upon proxy indicators. The results showed only marginally significant associations with the proposed hypothesis that were not significant or robust enough to support the proposition that poor condition of a structure would increase the occurrence of fire.

Hypothesis 7 – Colder climates increase the likelihood of fire

The results of the test for hypothesis 7 supported the proposition that colder climates increase the likelihood of fire. The results were however somewhat crude in their derivation and based upon a single test that would require further refinement before the being deemed robust enough to use as a control variable for the previous six hypotheses.

The authors stated that although their research was methodologically limited, that 'based on the findings of this study, it is possible to enumerate a set of community characteristics that are likely to go hand in hand with high fire incidence rate' (p72).

Beyond the empirical findings of the research the authors raise two significant points, suggesting that public policy decisions and direction can influence fire safety both directly and indirectly, they cite the promotion of home ownership as a moderating factor of the American fire problem. The proposition being that as home ownership increases due to promotion and economic facilitation of home ownership, the rate number of dwelling fires will decrease in line with the findings of the research on the differential fire rate between owned and rented property. They go

on to state that due to the economics of household safety prioritisation, poorer households are less likely to prioritise fire protection measures such as smoke alarms, contributing to their higher fire rate.

The study was not able to separate out dwelling fires from all building fires and no details were available on the likely proportions of dwelling fires to non-dwelling fires in the study population. This is problematic as the whole focus of the study is upon the incidence of dwelling fires in relation to a range of proposed risk factors. The inability to identify the relative levels of dwelling fires captured within the buildings classification diminishes the reliability of the results and relationships reported in the study. The authors fail, as in their previous study, to explicitly control for the problems of the ecological fallacy, in this case the possibility of a high fire rate area experiencing large numbers of 'structural fires' but there is no way of knowing how many of them, if any, are actually dwelling fires, as such the results report on structural fires rather than dwelling fires as purported by the authors.

One of the most commonly cited pieces of research into the relationship between fire incident rates and community characteristics is the 'Schaenman report', produced for the National Fire Protection Agency in 1977. The study examined fire incident data, aggregated to the level of the city and finer level of the census tract. He employed regression analysis to examine the explanatory power of a series of social and economic variables drawn from the 1970 US census. This was a considerably larger and more sophisticated study than that undertaken by Munson (1976), although based only upon 6 months fire incident data.

The results found that at the level of inter city analysis there was little explanatory power in the range of variables tested to explain the differential fire rates between the cities. Initial correlation coefficients showed that the percentage black

population was highly positively correlated with increasing fire rate. This was then tested using a simple regression with fire rate and was found to explain only 14% of the observed variation. The study considered a range of variables across census tracts from the cities included in the study. They found that there were three variables that showed a high degree of association with the observed distribution of fire incidence namely; the percentage of children under 18 years of age living with both parents, the percentage of families with annual incomes of more than $15,000, and the percentage of the population over the age of 25 with less than 8 years formal education. The researchers suggested that the lack of both parents in a household with children under the age of 18 resulted in a lower level of parental supervision and therefore a higher level of risk of fire.

Census tract data from 4 communities was brought together and a stepwise regression using percentage of children under 18 years of age living with both parents, under-education, housing vacancy, and poverty level, to predict rates of residential fires per 1,000 resident population. The resulting equation predicted 60% of the variation with parental presence in the household explaining 52% of the variation on its own. However it was not possible, using the data available to the study, to show that the cause of ignition was directly associated with a lack of supervision of children resulting specifically from single parent family household structures. Multi-colinerarity of the explanatory variables was also an issue in the resulting equation as poverty, vacancy levels and single parent households are likely to be highly correlated yet this was not adequately discussed and no justification or control measures were presented in the research and results. The findings were however suggestive of a definable relationship between fire incidence and

identifiable social, economic and environmental area characteristics (Schaenman,1977).

Building upon the work done by Schaenman, Karter and Donner (Karter, 1977) used the same range of variables derived from the 1970 census to study the relationships between fire rates and census characteristics at the census tract and block levels. Eleven census variables under the general heading of 'population' were considered along with five additional housing characteristic variables:

Population variables

1. Percentage population black
2. Poverty – percentage of persons below the government defined poverty level
3. Affluence – percentage of families earning at least $15,000 per year
4. Unemployment – Percentage of males aged 16 and over in the labour force who are unemployed
5. Race x Poverty – (Percentage of persons who are black) x (percentage of persons below the poverty level)
6. Under-education – percentage of persons 25 and over who have less than 8 years of schooling.
7. Race x Under-education – (percentage of persons black) x (percentage of persons 25 and over who have less than 8 years schooling)
8. High school education – percentage of persons 25 or over who are highschool graduates
9. Transience – percentage of persons 5 and over who were in the same housing unit in 1965
10. Family stability – percentage of persons who are under 18 and live with both parents

11. Aged – percentage of persons aged over 65

Housing Characteristics:

1. Ownership – percentage of year round housing units that are owner-occupied
2. Age of structure – percentage of year round housing units that are in structures built before 1940
3. Crowdedness - percentage of year round housing units that have at least 1.01 persons per room
4. Vacancy - percentage of year round housing units that are vacant
5. Size of structure - percentage of year round housing units that are one unit structures

The fire data was collected by census tract for nine communities across five separate states of the US. A single year's fire data was collected for each area, although due to availability the specific year's data used varied by area ranging from 1973 to 1976, and both calendar and financial years were used. No reference was made in the paper to any control for variations in national fire trends over the years spanning the study, which may have influenced the findings at the inter city level of analysis.

The study was confined to residential fire incidents due to lack of data available on commercial property at the census tract level, this however is beneficial to this review as the focus of the research to be conducted is based upon residential dwelling fire incidents. Only permanent residences were considered, as defined by the census bureau, consisting primarily of one or two family dwellings and apartments. The study used fire rates per 1000 population and per 1000 households, both were used for the intra-community study and only fire per 1000 population for the inter community analysis.

The methodology employed was based upon the use of aggregate fire statistics at the census tract level. Average fire rate per 1000 pop ranged from 1.74 to 4.4 and 4.78 to 12.79 per 1000 hhlds, both show a significant level of variation.

An earlier study (Karter, 1977, 2) considered the potential use of different regression models in the analysis of fire incident data, considering all variables untransformed, dependant variables untransformed and independent variables transformed to a logarithmic scale, and all variables transformed to a logarithmic scale. They found no appreciable difference in the performance of the models. This study used model 1, untransformed, after the exploratory analysis showed little variation in performance. For the analysis to be conducted in this thesis, the idea of transformation of variables is problematic as the study is intended not only to add to the academic body of knowledge in this field but to also have a practical application within the Fire and Rescue Service. Transformation of variables by any methodology would severely restrict the potential of the research results use in the management of the fire service due to the level of expertise required to apply and interpret the methodology used and scepticism about the validity of results and associations derived from transformed variables.

A simple linear regression model was used by Karter which is based upon the assumption that as the independent variable (poverty) increases the dependent variable (fire) will increase at a constant rate. This provides a logical basis for the analysis of fire incidents in line with previous research findings (Schaenman, 1977, Munson, 1976, Munson & Oates, 1983) and one that fits in with the assumptions commonly made about fire and deprivation within the fire service policy and service delivery fields.

The models tested were the 11 population variables (combined), the 5 housing variables (combined) and the two sets of variables combined (16 variables in total). The models were tested at the census tract level for each of the nine communities. 'For all communities and both fire rates, each set of characteristics was found to be highly significant'(p12).

They did however observe that for two of the areas tested, the variation explained by the regression models differed appreciably for the two fire rate enumerators, with rate per 1000 hhlds performing better in both cases. This however was not satisfactorily pursued, with no elaboration on the variation in the explanatory power of hhlds over population in the two areas. No details were provided on the household compositions of these areas in comparison to the other areas where little variation in the explanatory power of the choice of rate enumerator was observed.

The study then tested the 'adjusted effect' of each set of characteristics 'Population' and 'Housing' evaluating the relative effect of each set of variables. The results obtained from an F test showed that both sets of variables were important in that they contributed significant additional level of explanation when found in the presence of each other. There was however no reference to the fact that many of the variables used in the study from both groups of variable were in themselves likely to be highly correlated, as in the studies conducted by Schaenman, 1977 multi-colinearity was not explicitly elaborated upon or controlled for in the resulting models. The author found that both sets of characteristics are critical in the explanation of why some tracts of a community have high fire rates and other tracts low fire rates. The use of the term community when referring to census tracts is somewhat of a misnomer, as the delineation of a community is unlikely to conform to the administrative boundaries of the census tract. A common problem when

analysing social phenomenon using an area based framework of analysis (Openshaw, 1995).

A second study was presented within the report and considered the finer level of census geography the block group. One fire department was found to have the capability and data standards to provide aggregate block level fire incident data. Again they utilised the 1970 census variables in the study and this time used a more comprehensive 6 year span of data from 1970 –1975 inclusive. The census tract is designed to be uniform with respect to population characteristics, economic status, and living conditions, with an average population of 4,000 residents. The block group is a subdivision of the tract with an average population of 1,000 residents. Again the dependant variables used were fire incident rates per 1000 population and households. Correlation coefficients were calculated for census characteristics and fire rates at both the tract and block group level for both 1970 and 1975 fire data. The results showed that the at the tract level indicators of relative poverty were highly correlated with higher fire incidence levels, e.g. Telephone availability (percentage of households with a telephone available) had a coefficient of –0.73. Aged persons also reported a significantly high correlation coefficient of 0.4. At the finer level of the block group the corresponding results were significantly lower with 13 of the 15 tested variables being at least 50% lower than at the tract level. Openshaw (1995) demonstrates that larger unit of aggregation the larger the correlation coefficient achieved, but as the number of observations reduces it becomes increasingly difficult to obtain a significant result.. Larger areas are comparatively more homogeneous with each other than smaller areas that make up the larger areas, when compared across the whole area. This is a function of averaging the incidents in within larger units of aggregation. The perception of incident patterns alters as the unit of analysis

is made smaller. This is the geographical concept known as the 'cone of resolution'. Apparent homogeneous areas become heterogeneous when the size of the areal unit of analysis is made smaller (Brantingham, 1976).

The study examined the similarity of intra-tract block groups versus block groups en masse for both fire rates studied, by means of Analysis of Variance (ANOVA). The findings reported that 'for the values of a particular fire rate or census characteristic, block groups within a tract tended to be more alike than block groups outside their tract'(p35). They interpreted the findings to imply that there is 'strong neighbourhood factor which the tract level encompasses' (p35).

Key findings from the research were that residential fire rates were closely associated with selected census variables, specifically those related to poverty, housing and education. There was also a statistically robust strong neighbourhood association of fire risk, reported at the census tract level. The larger census tract area, average population of 4000, performed better as a spatial unit for delineation of fire risk than the smaller block group.

Methodological issues of concern are that there was no control for variation in national and regional trends in fire incident rates when they used an incident data set that varied over a period of several years within the first study by area, which may have had influence on the results obtained across the study areas. The selected independent variables used were not explicitly shown to be independent of each other and as such the validity and robustness of the findings are compromised to some extent. There was little reference made to previously published work and there was a complete lack of any theoretical basis for the research. The fact that the larger census tract areal unit performed better than the block sub divisions should not be

interpreted as a barrier to smaller area analysis, but it does challenge research to identify alternative effective theory, methodologies and variables.

Another study by the author (Karter, 1978), examined a range of demographic variables at the census tract level for data from 1976. The study found strong associations between fire rates and population characteristics, such as poverty, with higher rates of fire observed in areas of greater poverty, family stability / the presence of both parents in households with children experiencing lower levels of fire incidence than those households with only one parent present, this is common to the findings of Schaenman, 1977. Strong associations were also observed with housing factors such as overcrowding and owner occupation with lower levels of fire found in areas of comparatively higher levels of owner occupation, supported by work done by Karter et al,1977 and Goodsman et al, 1985.

The use of a direct measure of income had been established in several studies based on early 1970s data. A study by Gunther (1981) builds upon the income factor introducing and incorporating race as a sub-classification. He also uses a sub-classification of fire cause to examine the proportion of fires attributable to people versus equipment. The US based study, used data for Toledo Ohio, for the period 1976-1979, which was available through the National Fire Incident Reporting System (NFRIS), providing access to fire incident data that has been collected in a standardised format and coded to US census tract level. The study divided city tracts into 5 different income-race groups: inner city, low income white, low income mixed white and black, middle income white, high income white. The assignment of census tracts into the socio-economic groups was done subjectively based purely upon local knowledge. This is unusual as census variables reporting both race and income factors would have been available to the study, and would have provided an

empirical basis for the classification which could be replicated in other studies. Such a subjective classification system may provide interesting localised results but lacks the robustness to inform the wider body of knowledge in the subject area. Not withstanding the reservations raised, the study is described and the results are presented below.

Seven fire cause categories used were: incendiary suspicious, smoking, children playing, cooking, heating, electrical distribution and appliances, all remaining causes are grouped into an 'other category. These causes are grouped into non equipment and equipment causes, with the first three making up the non equipment causes group and the next four the equipment group. I would however take issue with the inclusion of cooking in the equipment group, as it is more likely that the behaviour of the person undertaking the cooking is the more significant factor than any fault or characteristic of the equipment.

Initial results indicated that 'race bears little relation to overall fire rate'p54 and that there is a 'strong relationship between income and overall fire rates'p54. Each of the socio-economic group fire rates were then plotted for each cause sub category. The results showed that each group had a different fire cause profile. For the inner city and low income white group the leading cause was incendiary suspicious, followed by smoking and cooking. In the two upper income white groups the leading cause was cooking followed by heating and appliances. In the intermediate low income mixed race group cooking was the highest followed by incendiary suspicious and smoking.

The general trend was shown to be lower incident rates with increased income, which was particularly pronounced for the non equipment cause groups. Whilst the equipment causes group showed about the same level of incidence across

all five socio-economic groups. Within the equipment group cooking related causes mirrored the pattern observed for non equipment causes with the lower income groups having higher incidence rates. The author accepts that misuse is the largest component of the cooking related ignitions and as such could be classed as a 'people cause'.

Non-equipment causes results report the 'inner city fire rate between 8.5 and 14.4 times as large as in the upper income group'p58. Obviously the magnitude of the differential fire rate factor is subject to the choice of class boundaries for the study.

The study showed that family income was more important than race but there is also a relationship between race and income. Whilst introducing a measure of differential fire rate across a classification of the population based upon income and race, the author also introduces a fire cause profile to the classification. This is an important development in the research field as it is not just the total numbers or rates of fires that can be shown to vary by area and socio-economic group, but the types of fires that they experience also can be shown to vary.

The author recommends that in light of the findings that in the case of dwellings 'people caused fires' and the 'social and behavioural patterns that lead to fires' (Gunther, 1981, p58) should form the basis of further research and be used to inform and target public education.

A study of arson and fire in general conducted by Murrey (1987), examined the relationship between arson and socio-economic variables in the form of a cross sectional of 50 states of the US for a single years data from 1981. Initial correlation analysis showed significant association between selected socio-economic variables, arson and total fire rates. From the initial correlation analysis composite variables

were produced by the authors, these were: general climate, socio-economic/income structure, economic climate, and social structure. Using the composite variables a regression model for state level total fire rate explained 30% of the variation between states and the arson model explained almost 48%.

Of particular interest to my own work are the use of poverty level, education levels, and income levels within the socio-economic/income structure variable along with unemployment levels in the economic climate variable. An interesting finding is that the poorer states, as measured by per capita income had lower rates of arson than the comparatively wealthier states 'this finding indicates that poverty is not a particularly strong arson motive'p71. However this study used all arson figures rather than just dwelling arson figures, it may well be that each component of the total arson figure may well have different relationships with the composite variables used.

Another interesting finding was that states with a lower divorce rate are likely to have more fires, this goes against the generally held view that family instability is associated with higher fire risk, (Schaenman, 1977, Karter, 1978). Although the state based analysis showed that the use of factor analysis and regression demonstrated relationships between arson and socio-economic variables, the paper concludes that 'the best way to fight arson (and fire in general) in a given community is by using localised data'p72.

Two further US based studies are worthy of mention as they introduce the subjects of Government, policy and the organisation of the fire service and their respective roles in fire and how to address the problem. This has already been alluded to in the study by Munson & Oates, 1983, in which they state that the policy initiatives of government influence the fire profile of the US. They cite the

encouragement of home ownership and smoke alarm ownership as two policies having a beneficial effect on fire rates. The studies by Fenner (1990) and Goetz (1991) question the ability of Government and the fire service to provide effective fire cover without more sophisticated analytical methodologies to provide information on the fire profiles and associated geodemographic profiles of the areas which they serve.

Fenner conducted a single city study at the census tract level. The study was concerned with demand for the fire service and so used total calls for service as the dependant variable in a regression analysis. She found that although socio-economic variables produced satisfactory equations to predict demand for the fire service at the tract level, this was a city specific model and that further research would be needed to test the wider applicability of her findings.

Interestingly she stated that based on the observed distribution of incidents and associated risk factors the practice of providing uniform fire cover for the whole city was questionable and resources should be targeted to take into account the differential fire risk. Goetz (1991) similarly found that the organisational and service delivery structure failed to utilise the data available to them to inform resource allocation. The study used residential fire and arson rates in a regression analysis to define equations again for census tracts for a single city. The resulting equation explained 60% of the variation using income, housing values, race and vacant property as the independent variables. The studies raised the policy issue of differential fire cover related to risk and the failure of fire departments to utilise data to inform such policy decisions. However it is likely although not shown in studies to date, that many fire departments would be unlikely to have the data, skills or software systems to undertake the robust analysis required to inform such decisions.

Enquiry into these issues will form a significant part of the research to be conducted in this thesis.

Up to this point all of the research reviewed has been conduced in the US. The studies have shown that at the city, census tract and block levels, differential fire rates can be shown to be related a range of factors without implying causality. The factors used in the studies include income levels, poor and substandard housing, overcrowding, social class, race, a lack of family stability, and the proportions of young and elderly in the population. These findings indicate that there is a definable and quantifiable relationship between a range of interacting factors and fire incidence levels in the US, but there is little evidence to confirm the wider applicability of the relationships defined outside of the US. Even within the US the research indicates that there is a need for further research to develop a more universally applicable model that could be used across cities rather that just within cities (Jennings, 1996, p242). Although the US based fire incidence research is the single largest body in the field stimulated by the political interest and associated funding during the 1970s, a small amount of research was conducted in UK at around the same time.

In the first of two studies Chandler (1979) examined residential dwelling fires in London in relation to 'housing and other factors'. The work was undertaken on behalf of the Building Research Establishment (BRE) and was published as a BRE 'Information Paper'. The 1971 census of population was used as the principal source of housing and social data for the study along with 1971 fire incident data from the London Metropolitan Fire Brigade. The spatial unit of analysis for the research conducted was the London Local Authority borough. Simple correlation coefficients were used to examine the relationship between fire incidence and selected socio-

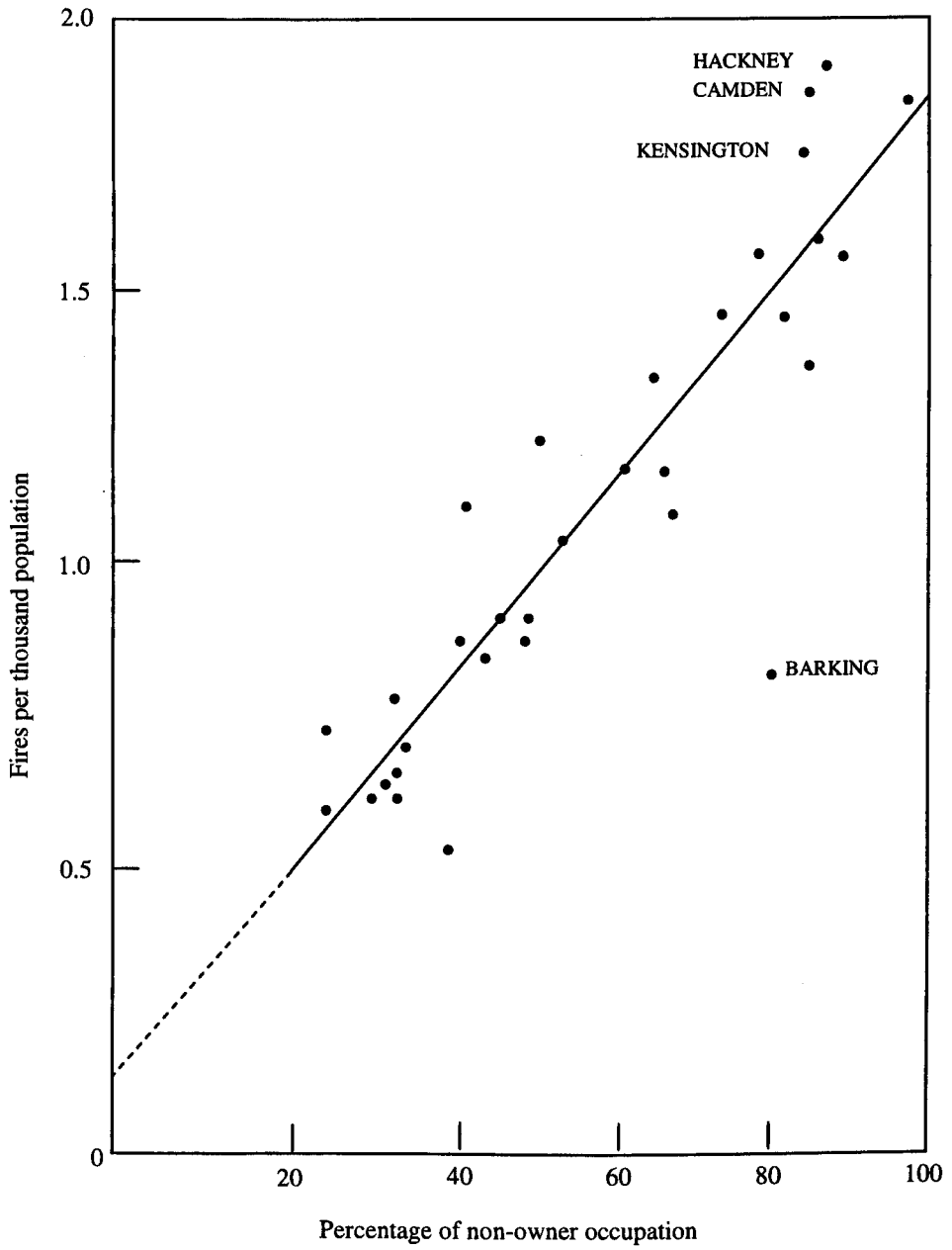
economic and housing factors. The study found that there were significant correlations between increased fire incidence and the variables selected as proxy measures of poverty. An interesting finding was that in areas of London with relatively high levels of dwelling fires, there was a proportionally greater incidence of deliberate and careless ignition fires. This is again of interest as it places people and their actions at the centre of the dwelling fire problem.

Significant variables associated with the distribution of dwelling fire incidents included, levels of owner occupation (figure 2.1), lack of basic amenities (as measured and reported by the 1971 census), children in care and percentage population of African or Caribbean decent. Figure 2.1 clearly shows that borough level incident data when plotted against percentage of non owner occupation housing in indicates a high level of association between increased incidence of fire and increasing levels of non owner occupation.

Access to local authority records of numbers of children in care at the borough level was used as a measure of family cohesion, and areas of higher levels of children in care had higher levels of fire incidence. However there was no access to data on individual families and their fire experience and also no information on the presence of other children in the household where one or more child was in care. US studies which make use of a measure of family cohesion in the form of single parent households propose that the higher fire rate is due to a lower level of parental supervision (Scheanman,1977, Karter, 1978) although this is not proven. Chandler's measure assumes the absence of a child whilst in care, which is a wholly different proposition, as the assumed risk of lack parental supervision is not applicable unless we know that there other children remaining in the household. These are two very different measures of community cohesion and household structure and as such there

is limited scope for comparison between studies in relation to these measures. The use of the borough as a spatial unit of analysis also limits the explanatory power of the findings, as the aggregate characteristics of such a large area are likely to mask significant variations in the characteristics of smaller areas and the fire rates experienced.

Figure 2.1 Borough Fire Rate Plotted Against Levels of Non-Owner Occupation



From Chandler, 1979

Chandler went on to develop his work using a multiple case study approach, examining the urban fire problem, using 1981 census data and fire incident data for London, Birmingham and Newcastle (Chandler et al, 1984).

The data used in the study was accessed directly from the brigades and was comprised of London data from 1971 and 1981, for Birmingham the data was averaged for the years 1978 and 1979, and data for part of the Newcastle area (the three central fire stations) was obtained for the period June 1979 to July 1981. The paper does not explicitly detail the methodology used in the analysis of the fire incident data but it is implied that the correlation coefficients are derived, where possible, from ward level analysis of annual aggregate dwelling fire incident data.

The generalised findings of the correlation analysis were that 'fire incidence is related to socio-economic factors' (p20). The best performing variables in terms of the correlation with fire incidence rate across the three areas and the varying years data used were the proportion of the resident population in social groups IV and V as classified by the Department of Employment Classification of Occupation, and unemployment levels, which averaged correlation coefficients of around 0.6. The authors suggest that in areas with high levels of 'social stress' there is a greater tendency towards carelessness and a fatalistic attitude towards fire (p20). This has some resonance with the concept of 'learnt helplessness', discussed further later in this chapter, were people are aware of the potential risk but have become de-sensitised to the risk taking little or no action to mitigate against that risk (Bowers, 2001).

Additional findings include a low level of fire incidence correlation with the tested variables in areas of high proportions of the population 'from the Indian subcontinent' (p20). They suggest that this may be related to the assumption of the

'cultural values placing a high level of emphasis on the family', with fire incidence being lower in close knit communities in which the population has be resident for a long time and there is a sense of local community.

Reference is made to the analysis of casualty data for the '1971 London data and the Birmingham study', 'both sets of data showed highly significant correlations with owner occupation (inverse), overcrowding or sharing, low socio-economic group, illegitimacy or children in care, and people born in the Caribbean or Africa.'(p20). The literature relating to studies of casualties and fatalities from fire is reviewed in the following Epidemiological section of this chapter. Again the paper does not provide any detail of the data used, test parameters, time scales, etc. and as such the findings are limited in their academic value as they fail to meet the rigours of scientific tests of validity.

The authors state that the findings had indicated that 'problem areas are often very localised, usually at a level much smaller than a borough, electoral ward or fire station ground' (p20), and as such more work is required to provide a greater depth of understanding of the problem of fire and how incidence levels vary by area type and source of ignition. The study recommended that a cost benefit analysis would support targeted fire prevention initiatives at both a national and localised level using mapped high risk areas, enabling 'publicity campaigns to be targeted at areas of greatest need' (p20).

This theme is developed by Sutton (1994) whose unpublished New Zealand based research examines the community characteristics of residential fire risk. The study aimed to use analysis of the geographical distribution of residential fire incidents to identify those areas of high fire rates and then to identify the socio-economic and demographic characteristics of those areas. The objective was to use

the findings of the study to assist in the mounting of a campaign to reduce the incidence of fires in the communities most at risk.

The New Zealand fire service is geographically divided into fire districts across the two islands, which collectively provide fire cover for the whole country. These districts are sub divided into 431 First Response Areas (FRA) and these are used as the geographical unit of aggregation for the study. The dependant variable for the study is the rate of residential fire incidents per head of population over a three year period 1991-1993. The fire incident data used relates to permanent private dwellings only. The authors selected variables that were both logically and intuitively potentially associated with fire risk and also readily available from the Government Statistics Office for use within the study. The independent variables included a measure of average income, proportion of the population in receipt of state benefits, levels of home ownership, ethnicity and area temperature records, these were used in a stepwise regression.

Limited details on the results obtained were presented in the internal fire service report produced, with generalised statements presented. The results discussed concluded that that percentage of people on benefit was a strong indicator of fire risk, whilst analysis of just the income variable produced a U shaped curve with both high income and low income experiencing higher fire rates. This was suggested to be a function of higher levels of electrical equipment in more affluent areas. This was examined further and it was reported that 'the increase in fires in the high-income areas is associated with equipment, particularly electrical equipment and wiring, but also cooking' (p11). Whilst the higher levels of fire incidence in areas of low income and high levels of benefit recipients was associated with the whole range of ignition causes rather than any specific cause or group of causes.

This is an interesting finding as there is little previous research into the differential fire risk and the ignition causes across areas distinguished by either fire incident prevalence or social, economic and environmental area characteristics. This represents a significant gap in the understanding of and the methodology for investigating area fire risk profiles, without which the management of a modernising fire service lacks the knowledge and tools to maximise the resources available to them for the prevention of and response to dwelling fire incidents.

Summary Social and Socio-economic Literature

The socio-economic literature relating to dwelling fire incidents has demonstrated the common methodological framework of the use of administrative spatial boundaries, predominately census derived, and aggregate fire incident data for a single aggregate period of time. There is a lack of theoretical reference or development in the studies conducted, leading to a lack of clear direction within the field and individual studies reviewed.

The review did identify that there is a body of evidence which, though not definitive, does show that there are strong associations between differential fire incident levels and a range of socio-economic variables, 'based on the findings of this study, it is possible to enumerate a set of community characteristics that are likely to go hand in hand with high fire incidence rate' (Munson & Oates, 1983,p72). The majority of the research lacks scientific rigour and consistency of results. Income and associated indicators of poverty are common correlates of fire across many studies, but with no direct measure of income available in the UK census of population proxies or suitable alternatives will have to be sought.

Importantly Munson & Oates, (1983), identify the impact of social policy upon fire rates in relation to the positive affect of increased home ownership in the US. They also identify the impact of socio-economic issues in relation to the ability of the 'poor' to prioritise fire safety measures within the home. Such findings have significant policy and operational implications internationally and will be addressed further within the thesis.

Spatial analysis issues are raised in the discussion of the findings by Karter, (1977, 2) where at the finer level of the block group, as opposed to the larger census tract, the corresponding correlations between variables and fire rates, were significantly lower with 13 of the 15 tested variables being at least 50% lower than at the tract level. This will be considered when developing the methodology as apparent homogeneous areas become heterogeneous when the size of the areal unit of analysis is made smaller, known as the 'cone of resolution' (Brantingham, 1976).

A further significant finding was made by a Gunther (1981), whose research showed differing fire cause profiles within the fire data and that in light of the findings that in the case of dwellings 'people caused fires' that the 'social and behavioural patterns that lead to fires' should be identified and inform fire service policy. This finding is central to the aim of developing a theoretical model of dwelling fire risk that focuses on people and their actions.

Fenner (1990) and Goetz (1991) question the ability of Government and the fire service to provide effective fire cover without more sophisticated analytical methodologies, however there is a lack of information or evidence within the literature in relation to the ability of the fire service to undertake this work. This is comprehensively addressed in chapter six of this thesis where a national survey will be presented.

The following section will review the associated ecological dwelling fire research.

2.3.2 Ecological Research

Addressing the role of people's interaction with their environment in relation to fire incidents is attempted in a study conducted by Gilliam (1985). Using census block and tract data along with individual incident level data for Highland Park, Michigan, for the years 1970 and 1977, Gilliam examined the relationship between specific categories of fire incident, namely; arson, cooking, smoking, electrical, and other. The study reported that a chi-square analysis found cooking and smoking related incidents were increasingly common in households living in rented accommodation and that electrical and appliance initiated fires were more common in owner occupied housing. He also found that there were different patterns of association between specific fire incident types and socio-economic variables. This is the most interesting area of the study as it implies that there is differential fire risk both in terms of frequency and fire type across areas that can be defined by area characteristics. This is particularly important in understanding how to use information on the distribution of fire incidents to tailor intervention and education campaigns to meet the risk characteristics of a particular area, neighbourhood or socio-economic group.

He used a block level comparison group methodology in which he compared those blocks that had experienced fire incidents during study period and those who had not. However the methodology and data used limited the potential to derive significant fire risk profiles that addressed the role of the occupant in relation to the level of fire risk. The study found no significant difference between the bock groups. This may have been due to the sample size and the temporal extent of the study, the

small number of blocks within the study population and the fact that two discrete years of data were used for the study meant that the low frequency of dwelling fire incidence may well have placed severe restrictions on the conclusions that are able to be drawn from the study. Fire in incidents resulting in a request for the attendance of the fire service is a relatively low frequency occurrence at the individual household level and as such short duration studies even at the aggregate level of the US census block may result in blocks experiencing few or no fire incidents during that period.

Up to this point the research reviewed has not effectively addressed the role of people in fires. Research by Ducic (1980) considers the role of people in accidental residential dwelling fires, examining the cause of ignition of the fire. The study used a case control methodology, analysing individual level incident data. Ducic focused on accidental fires only, in census tract areas characterised by low incomes and old housing. Incidents were classified as serious or non serious based upon the level of property damage caused by the fire and the resources used to fight the fire. Smoking was the leading cause of serious fires identified in the analysis of the study data set, with significant associations between serious fires and the age of the occupants, smoking habits, namely smoking in bed and previous experience of fire in the household. The researchers came to the conclusion that for the vast majority of accidental residential dwelling fires that the cause of ignition was people dependant and that delay in discovery of the fire was the most common factor differentiating between serious and minor fire incidents. They recommended that education and intervention programmes focus on the wider use of smoke alarms and also the dangers of smoking and alcohol in relation to increased fire risk Although limited in detail and lacking academic rigour these studies begin to use ignition

categories as sub-classifications of fire incidents and associating the finding with people being the cause of the majority of dwelling fires.

Goodsman and Mason (1985) considered the incidence of dwelling fire incidence for two metropolitan boroughs, namely Tameside and Gateshead. Again this work was funded and reported by the BRE. The paper uses data from 1981 and 1982 for two areas accessing individual dwelling fire incident data and classified the type of dwelling in which the incident occurred. Instead of trying to identify area types or population characteristics that may be indicators of fire risk this paper looks specifically at the housing type as a denominator of risk. The housing type data used was drawn from the local authorities who had compiled information on the structure of the households from surveys of the areas.

The fire incident data was obtained for the period 1981 to December 1982, nearly 600 incidents for Gateshead and for Tameside just under 500 fire incidents were captured for the period October 1980 to September 1982. Address matching to provide verified addresses was problematic due to the standards of the records held by the fire service and as such not all incidents were matched to a verified address reducing the sample population, although details of the proportion of incidents that failed to be matched were not available. The property types were classified into houses and flats and by private, council or housing association. The study also considered the 'rateable value of properties' as a rough proxy for likely social group of the occupants, although they do state that care should be taken in the interpretation of the rateable value results as this is often a function of location of the property and not always reflect social class of occupants. They also looked at the distribution of fires by enumeration district for the two years data 1981 and 1982 combined for the Gateshead area. '7% of enumeration districts accounted for 31% of fires'p5, although

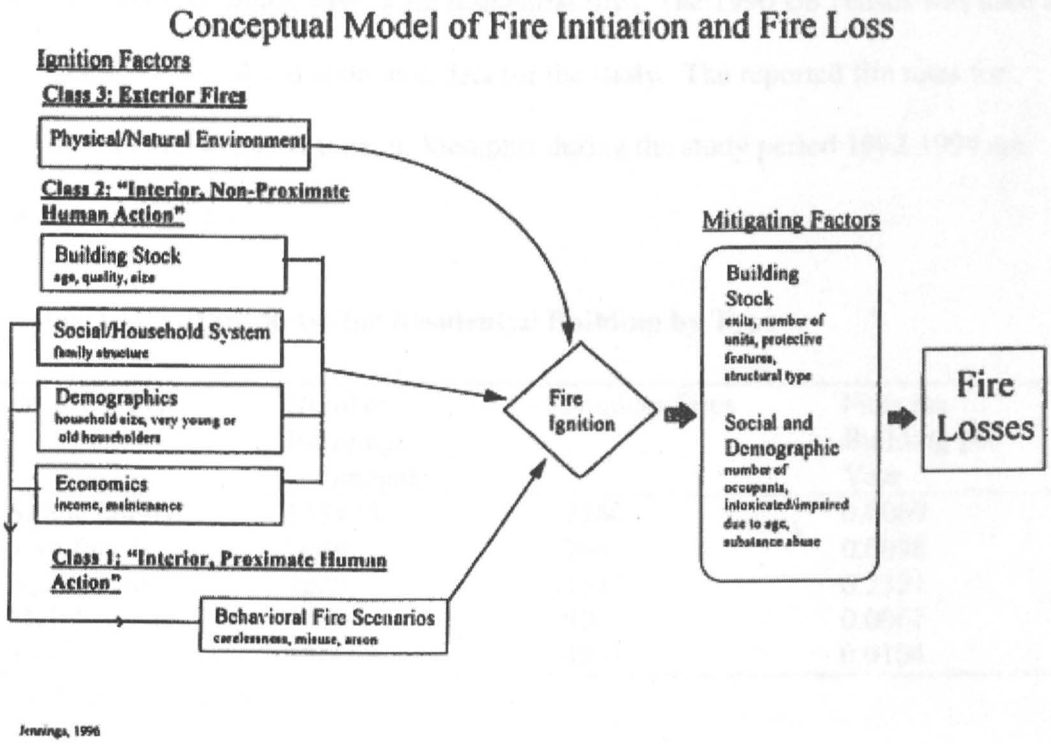
the study was not able to analyse the socio-economic characteristics of those EDs, although local knowledge suggested 'that these appeared to be in the more deprived areas'p5. The research to be undertaken and presented in this thesis will use the ED as a spatial unit of analysis and attempt to use the characteristics of the EDs to provide an area based fire risk profile at the ward and enumeration district level.

Key findings from Goodsman and Mason were that council flats were most likely to experience fire and fires with casualties. They found that 37% of Gateshead dwellings experiencing fires during the study period (151 households) had had some contact with social services over the past twelve months prior to the fire, although no figures were available for comparison this was thought to be a much higher level than the borough as a whole. The authors suggest that the value of the research lay in the direction of intervention initiatives through application of data analysis.

The lack of theoretical models in the field of fire incidence studies is addressed in work conducted by Jennings (1996). Jennings attempts to develop a conceptual model of fire incidence in which he divides dwelling fires in to three broad classes: Exterior fires, Interior non proximate human action, and Interior proximate human action. Exterior fires are those caused by the physical/natural environment that effect the physical structure of the dwelling. Interior non proximate human action are those ignition events that are due to mechanical failure of inanimate objects that results in fire. The final typology proposed is proximate human action, these are fire events that directly linked to human behaviour. The model proposed by Jennings is shown as figure 2.2, and illustrates the three typologies and their conceptual linkage to the ignition event. The research again considers the US fire incidence problem, focusing upon 'Urban Residential' fires.

The author aims to develop a conceptual model of fire incidence and explore the relationships that underlie the theoretical propositions presented.

Figure 2.2



The components of the model are elaborated upon by Jennings who states that the model was developed based upon an extensive review of the existing literature and examination of fire data in other studies. The model is intended to be applicable at the small area level, using the individual household as its unit of analysis.

Jennings's own research is based on data from the National Fire Incident Reporting System, for the city of Memphis, Tennessee. Census tract geography used as the unit of aggregation for the analysis of the fire data. Arc info used to geocode the individual level incident data. The fire records held within the NFIRS include an estimated measure of dollar loss resulting from incidents, this is something that is not recorded by the fire services in the UK. NFIRS is administrated centrally by the

Federal Emergency Management Agency, (FEMA), and software is freely made available to those fire services who wish to participate in the system. 3 years data was obtained for the period 1992-1994. The data set consisted of 5,936 structural fire incidents, of which 4991 were residential fires. The 1990 US census was used as the source of social and economic data for the study. The reported fire rates for residential buildings, by type, in Memphis during the study period 1992-1994 are shown in table 2.1

Table 2.1 Fire Rates for Residential Building by Type

Property Type	Number Buildings (estimated)	Number Fires	Fires per Building per Year
Single family	153478	3150	0.0069
Two family	8849	264	0.0098
Apartments	2225	1547	0.2321
Mobile homes	1496	30	0.0067
Total	166048	4991	0.0104

Jennings,1996, p160

A 60% address match was achieved between the fire service incident address data and the data from the county assessor's office (verified addresses and geocodes). This is indicative of the problems encountered when trying to use address data for spatial analysis purposes, were non standard and incorrect address capture, structure and storage, results in an often significant loss of data. A t-test was used to examine the difference in means of the two groups based upon dollar loss for the incidents. The test showed no significant difference between the two groups and therefore the author states that the matched sample could be used as being representative of the residential dwellings that experienced a fire during the study period.

Jennings focused upon the single family dwellings and found that on average the buildings in which fires occurred were almost 25 years older than the average age

of all buildings. He used vacancy levels as a proxy for neighbourhood health, with high levels of vacancy indicating low levels of neighbourhood health, as defied by low income, high crime and little social cohesion. He used single female headed households with children as a social structure indicator, stating that 'these types of household are more likely to have unsupervised children present; leading to more fires caused by children playing or carelessness in cooking undertaken by minors'p165, which is supported by work conducted by (Schaenman,1977). Age structure of the population is also considered within the study as a secondary influence on residential fire rate, the young and the old are proposed as potential higher risk cohorts with an age split of population over 65 and under 16 years used.

A direct income question is included in the US census and as such median income data for the census tracts was available and used in the study. Tracts were classified either high or low income and fire rates between the high and low income tracts were compared using a t-test. The results showed that there was a highly significant difference between the two groups with the low income group experiencing a fire rate almost double that of the high income group, p171. Results showed 'Median household income and residential fire rate are very clearly negatively associated' (Jennings, 1996, p173).

The variables selected for inclusion in the study were derived from an extensive literature review of the US based studies of fire incidence. A simple correlation analysis showed the expected and intuitively sensible direction of association with fire incident rates (inc. percentage vacant property), results are shown in table 2.2.

Table 2.2 Selected Correlations, Memphis Fire Data (tract level)

Variable	Total Res. Fire Rate	Class 2 (mechanical) Fire Rate	Class 1 (Human) Fire Rate
Median Income	-.66	-.52	-.64
Sum % pop over 65 and under 16	.52	.30	.54
% Vacant Housing units	.49	.38	.42
% Single female headed hhlds with children	.52	.50	.68
% of pop over 18 with > high school degree	-.62	-.41	-.61

Adapted from Jennings (1996) p177

The table shows a high level of correlation was observed between the selected variables and fire rates with the authors classification between Human and mechanical showing a greater level of association between '*human*' related incidents than mechanical initiated incidents, supporting the widely held view that residential fire is strongly people dependant and related to specific identifiable population and economic area characteristics.

From the initial and preliminary analysis of the data and using the information gained from the literature review Jennings used multiple regression analysis to explore the relative power of explanation of the variables that showed some promise in terms of simple correlation coefficients. A four variable model was developed to explain the variation in residential fire rate. The variables were chosen on two criteria: consistency with the author's conceptual model and strong correlation with fire rate. The variables meeting the criteria and selected for inclusion in the model were: median household income selected to provide a measure of economic characteristics of the area; percentage of the population over 65 years and less than 16 years of age, this variable was selected by the author to represent the

demographic structure of the area; the percentage of vacant dwellings, which served as a proxy for the quality and obsolescence of the housing stock; and percentage of female headed households with children, representing the social/household system and levels of child supervision. The dependant variable used in the regression was the number of residential dwelling fires per 1000 resident population from 1992-1994.

Jennings found that the equation derived from the combination of the 4 variables selected explained 63% of the observed variation in residential dwelling fires per 1000 population in Memphis during the study period, at the census tract level. The author used a least squares regression and found that all of the variables were significant at the 10% level and three of the variables significant at the 1% level. Table 2.3 shows a summary of the results of Jennings' model.

The author states that there were no significant problems of multicollinearity and that the residuals and outliers were examined and no 'unduly influential points were detected'p180. Table 2.3 shows that median household income is the strongest explanatory variable in the model. The regression analysis itself is consistent with the results obtained in previous US based studies that have been reviewed earlier in this chapter.

Table 2.3 Analysis of Variance for Four Variable Multiple Regression Model for Residential Fire Rate

Source	DF	Sum of Squares	Mean Square	F Value	Prob > F
Model	4	2108.270	527.067	63.971	0.0001
Error	150	1235.883	8.239		
Total	154	3334.153			
Root MSE	2.870	Dep. Mean	7.879	R-square Adj. R-square	0.6304 0.6206
Variable	Parameter Estimate	Standard Error	Standard Coeff.	t for Parameter	Prob. > t
Median Household Income	-0.127	0.02225	-.3815	-5.710	0.0001
Percent Single Female	7.471	4.221	.1105	1.769	0.0788
Percent less than 17 or over 64	16.104	3.401	.2814	4.735	0.0001
Percent Vacant Housing Units	28.652	4.453	.3449	6.434	0.0001

From Jennings 1996

Heteroscedasticity was observed in the results and Jennings uses a weighted least squares regression to compensate for this in the regression analysis. He used the inverse of the predicted fire rate to reduce the influence of high fire rates. The resulting regression equation explained 83% of the variance in residential fire rate. The fact that heteroscedasticity was observed, should not have been unexpected as fire rates are known to be variable over time with daily, weekly and seasonal variations well documented along with annual variations often dependant upon the variation in seasonal temperature ranges. Controlling for such variation is in fact masking the very issues that underlie the understanding of the fire problem. We need to explore the differential variation observed not only in fire rate over one period of time but develop an understanding of the profile of variation in different areas exhibiting different spatial and temporal fire patterns.

A principle components analysis was carried out using twelve variables drawn from a range of social, economic and housing indicators. The author reported that 'interpretation of the components was not empirically straightforward and thus casts some doubt on the use of this technique' (p191). The author noted 'the trade off between reduced multicollinearity and interpretability favors weighted least squares regression' (p191).

The research found that high residential fire rates are most strongly associated with low household income. Demographic factors namely the presence of children and the elderly were also found to be significant risk factors along with child supervision, as measured by the proportion of single female headed households with children, and the housing characteristics of a neighbourhood. The author found that the conceptual model was supported by the findings as social, economic and environmental factors are significant factors in the observed variation in the 'behavioural fire scenarios' that result in 'proximate human action' fires.

Although the research model is aimed at small level applicability using the household as the unit of analysis, results are reported at the census tract level. The research again adds to the evidence base for the potential to use area based characteristics to build a classification of relative fire risk. Although the model specifies a proximate human action as a distinct category the research methodology limits the findings relevance in supporting or elabourating upon the independence of the class within the model. Further research is required that specifically examines the differential risk associated with specific classes anthropogenic fire risk activities and variation by both area type and temporal variation.

The focus of the research review has been on the community characteristics that may enable profiling of fire risk and the tailoring and targeting of prevention and

response resources. Every incident occurs at an identifiable location and at a specific time. The patterns in space and time of fire incidence can be considered through a human ecological framework. Hawley (1950) proposed a theory of community structure, derived from the study of the relation and interaction of people or groups of people and their environment. His theory of Routine Activities states that 'space and time are separable from one another only in abstraction ... a temporal pattern is implicit in each and every spatial pattern' (p288). 'Time is a dimension on which all activities and their interrelations are measurable' (p314), within which there are discernable component of 'Rhythm, Tempo and Timing'. Time is experienced as duration and recurrence, rhythm is the regular periodicity with which events occur and tempo pertains to the number of events per unit of time or the rate of recurrence. It is the 'functional rhythms' that are observable in our domestic lifestyles that provide a basis for the analysis and possible explanations of the spatio-temporal distribution profiles of residential fire types.

Virtual communities based upon lifestyle, influenced by age, family/household structure, income, education are identifiable as discrete risk groups within definable spatial units. However it is the spatial unit not the individuals within the unit that we are able to classify, subject to the constraints ecological fallacy (Robinson, 1950). This is due to the lack of availability of individual level data on the occupants experiencing fire incidents, rather the available information takes the form of aggregate data sets representing predefined spatial areas e.g. census based data. Identifying suitable individual or combinations of variables associated with anthropogenic accidental fire risk, has been shown to have merit, through examination of discrete classes of incident types in detail the research aims to produce powerful discriminatory fire risk profiles.

While correlation and comparative analysis is useful in examining simple relationships between variables and groups, a more detailed analysis of structural relationships may provide further meaningful insight into the associations between social, environmental and economic factors and the incidence of fire. Factor analysis provides a means of data reduction through the generation of composite variables derived from the individual variable of interest. The composite variable may prove to be far more powerful in terms of its relationship with the observed fire incident rate distribution. Research into the area of natural disaster vulnerability conducted by Hearn Morrow (1999) 'Identifying and mapping community vulnerability' has shown that individual variables when considered in isolation may prove inert in terms of a given hypothesis, but when they occur in combination with one or more additional variables may prove highly significant. The research examines vulnerability at the household level, and finds that far from being mutually exclusive, risk factors tend to occur in combinations (or may arise from combinations) and intensify risk exponentially. It is proposed that the same rational may be found to be applicable when dealing with the component factors of risk in terms of residential dwelling fire incidents. Consideration will be given to a range of aggregate and disaggregate means of area characteristic profiling in order to identify suitable contributory data sets for use within the empirical analysis to be conducted.

Summary of Ecological Research

The ecological fire research is defined through focusing on identifying the various components within the dwelling fire incident that can be sub classified in terms of the actions of the person involved and their interaction with their environment.

Gilliam (1985) identified this area as key to the fire risk issue and examined the variation in specific categories of fire incident, namely; arson, cooking, smoking, electrical, and other. He found that there were different patterns of association between specific fire incident types and socio-economic variables, indicating that ignition specific fire risk profiles could be generated.

Although limited in detail and lacking academic rigour Ducic (1980) used ignition categories as sub-classifications of fire incidents and associated the findings with people being the cause of the majority of dwelling fires.

A theoretical model was proposed by Jennings (1996) which identified proximate human action as a specific category of fire cause. The research identified household income, unsupervised children and housing factors as significant discriminatory variables in a range of statistical analyses, although there was little direct or elabourated support for the proximate human action referred to in his model. The results did however add to the evidence base supporting both the use of area based characteristics to develop a classification of relative dwelling fire risk and also the need for a theoretically based model that identifies the central role of people in dwelling fire risk.

The additional and essential component lacking in much of the research conducted to date is drawn from Hawley's (1950) theory of Routine Activities, in which he states that a temporal pattern is implicit in each and every spatial pattern. This is a significant component of the dwelling fire profile and will be essential to the development of any theory and methodology attempting to develop the understanding of the issue.

The following section reviews the Epidemiological fire literature.

2.3.3 Epidemiological Research

A further group of studies relating to fire risk are those dealing with those incidents resulting in casualties and fatalities. These incidents represent about 20% of all dwelling fire incidents in the UK (Watson, 2002), although a significant proportion of the reported casualties are accounted for by those persons present in the dwellings subjected to / advised to seek a precautionary medical check up. Epidemiological studies of fire conducted primarily in the field of public health, again in the US, and stemming from the political interest and associated availability of funding, focus on the incidence of residential dwelling fires resulting in fatality. As such the studies provide us with a valuable source of information in relation to the contributory risk factors involved in fire incidents with the most serious of outcomes, injury and death. Combined with studies of general residential fire risk characteristics these studies, often based upon much more detailed data than generalised aggregate area based studies, add to the body of knowledge and inform the targeting of education and intervention initiatives in terms of the gravest of risks.

Case studies of individual incidents in which poverty was thought to have been a contributory factor formed part of a study by Fahy (1989) whose work looked at how being poor effects fire risk. The research was comprised of a US based review of research into residential fire and poverty, with specific detail of individual case studies in which the fires and their victims were the result of ignition sources, lifestyle and housing conditions linked to living below the poverty level in the US. The study used aggregate fire and fatality data for 50 US cities with a population of over 250,000 obtained from the NFPA for the years 1986 or 1987 and plotted both the fire rate and fatality rates against the proportion of population below the poverty level in each city. Figures 2.3 and 2.4 summarise the findings.

Figure 2.3

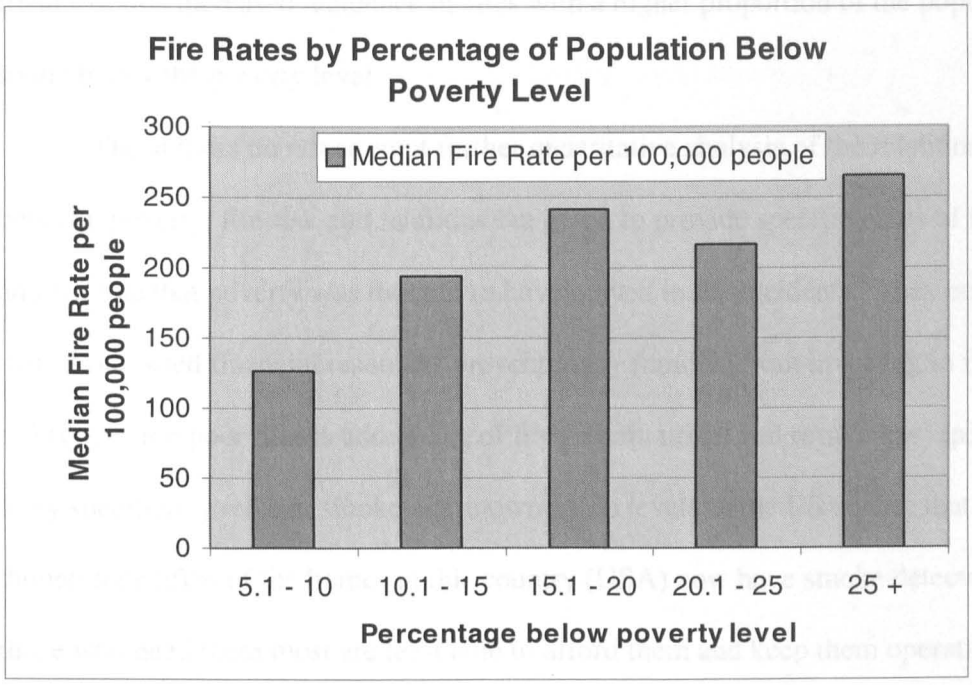
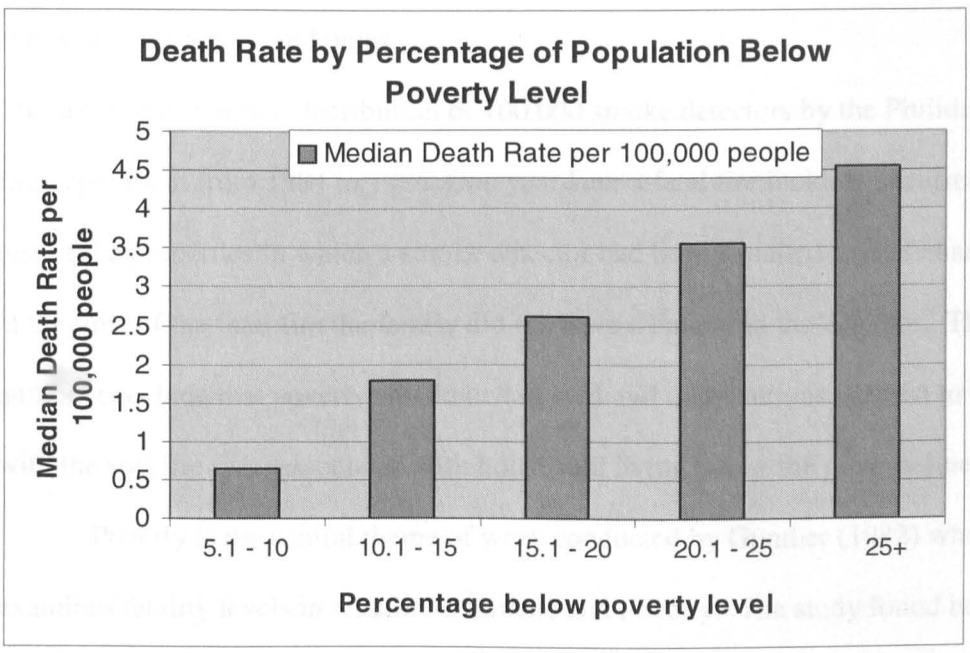


Figure 2.4



The charts show that 'cities with higher levels of poverty do have higher levels of residential fires and deaths in residential fires' (Fahy, 1989, p32), although

the poverty classes do not result in a linear relationship with fire incidence, there is a trend towards increased incidence in cites with a higher proportion of the population living below the poverty level.

The authors do not attempt further quantitative analysis of the relationship between poverty, fire risk and fatalities but go on to provide specific cases of fatality and the role that poverty was thought to have played in the incidents. They conclude that 'diminished financial resources prevent many families from investing in fire safety... being poor means added risk of fire in both urban and rural areas' (p34). They specifically refer to smoke alarm ownership levels in the US stating that 'even though four fifths of the homes in this country (USA) now have smoke detectors... those who need them most are least able to afford them and keep them operational' (p36). This mirrors the ownership levels in the UK (Watson, 2002), yet there is little reliable published evidence on the distribution of ownership and the operational status of the detectors in homes.

The study sites the free distribution of 100,000 smoke detectors by the Philidelphia fire department from 1984 to 1986. One year later a fatal fire incident occurred in one of the properties in which a smoke detector had been installed free of charge but at the time of the fatal fire the family did not have a battery in the detector. The authors conclude that poverty should be targeted and interventions tailored to deal with the specific risks associated with household living below the poverty line.

Poverty is the central theme of work conducted by Gunther (1982) who examines fatality levels in relation to climate and poverty. The study found heating related fire deaths were significantly correlated to climatic conditions in the US with the situation compounded by poverty. Poverty influences fire risk and fire outcomes dependent upon other area characteristics, which may or may not be directly

associated with fire risk independently of other interacting factors. Work to identify these potential risk factors in fatal residential fires was conducted by Runyan (1993) who conducted a US based study of predominantly rural fire deaths.

The data used consisted of 51 fatal fires from the North Carolina area, over a period of 13 months from January 1st 1988 through to January 31st 1989. Interviews were conducted with fire service personnel to collect the data on the fatal fire incidents. National figures reported that there were 552,500 residential fires in the US during 1988 resulting in 5,065 fatalities. Dwelling fires accounted for 23% of all fires, 73% of injuries from fires and 80% of fatalities. The study found that fatality rates are higher for persons over 64 years of age and those below 5 and that death rates are higher for people who live in mobile homes than in any other type of dwelling. 31% of fatal fires occurred in mobile homes which account for only 11% of the housing stock.

In terms of the source of ignition in the fatal fire incidents, 39% of fatal fires were attributed to heating equipment and 31% to smoking materials. The author also found that 'fatal fires were more likely to occur on weekends and during sleeping hours'p186, which introduces an elementary temporal element to the research which is lacking in almost all of the previous research conducted. However this line of enquiry is not pursued further and constitutes a significant potential research area if we are to gain a better understand the nature of the residential fire problem.

Referring back to the proposition made by Fahy (1989) that poverty reduces the likelihood and ability of those living below the poverty line to prioritise and purchase smoke alarms, Runyan's study (1993) found that 'seventy seven percent of fatal fires and half the non fatal fires occurred in houses without smoke detectors'(p186). The author does not supply any information on the underlying levels of smoke alarm

ownership in the study area but national estimates for the US are that around 88% of households have at least one smoke detector (FEMA, 1994). Hall (1989), states that 25% to 33% of residential smoke detectors in US homes are thought not to be operational, although Runyan does not provide any comment upon or evidence of fatalities in household with smoke detectors and whether or not they were operational at the time of the fire. They found that in terms of fatalities the lack of a smoke detector or operational smoke detector resulted an increase of 3.4 times the risk of death. Runyan concludes that 'our results demonstrate that smoke detectors are beneficial in almost every instance' (p191).

In terms of ignition sources and contributory risk factors in fatal fires research by Mierley (1983) examined fatal residential fires using data from Baltimore, Maryland, in which the researchers found that at the census tract level fire death rates increased with decreasing levels of income. The tracts were split into quintiles by median rental value of property as a proxy for income levels. All fire incidence rates were found to decrease with increased income levels, with cigarettes being a leading cause of ignition across all groups. 39% of all fatalities were found to have blood alcohol levels of a significant level at the time of death. Earlier research again conducted in the US (Hollis, 1973) had already found that in a study of fire death reports from the city of Memphis in 1973, (a city also studied in some depth later by Jennings, 1996) that in the cases of those deceased between the ages of 16 and 60 post-mortem examination reported that 80% of study group had alcohol in their blood at the time of death. The study also reported that although they had no empirical evidence, anecdotal suggestion was that there was also a link between fatalities of children and the elderly in house fires when other adults were under the influence of alcohol which may have contributed to the fire cause and also inhibited

their ability to aid in the escape of others in the household. A UK based study conducted by Harland, (1979) in the city of Glasgow found that there was a direct causal link between residential dwelling fire fatalities and blood alcohol levels in those killed, and that poverty was linked to both higher fatality rates and the presence of alcohol in the deceased.

The most comprehensive study into fire related deaths conducted was again in the US and funded through the NFPA. The research conducted by Berl and Halpin, (1978), used fire death incident records and post mortem reports from 468 fatalities resulting from fire incidents. The incident records were from the State of Maryland between 1972 and 1977. The enquiries into the circumstances of the deaths found that 55% of victims over the age of 20 years had consumed alcohol that was present in their bodies at the time of death and subsequently measured at post mortem. The acts of ignition were found to be predominately the result of human misjudgements or deliberate fire setting. Most of the victims were found to have been overcome by the effects of smoke inhalation and heat whilst attempting to escape from the fire. They also reported that from the medical evidence/opinion available to them that the effects of alcohol on the cardiovascular systems of the victims would lower the tolerance levels of the products of fire, namely heat and smoke and reduce the victims ability to effect their escape.

In terms of the source of ignition in fatal dwelling fires carelessly discarded smokers materials is the leading cause, accounting for 41% of ignitions in fatal accidental dwelling fires in the year 2000, in the UK (Watson, 2002, p27). A study by Ballard et al, (1992) was conducted in Washington between 1986 and 1987 examined fire injury rates from residential property fires. The study employed a population based case control methodology from which the findings reported that the

rate of injuries from fires was significantly higher for households with cigarette smoking residents than those households with no resident smokers. This supports the findings reported by Runyan, (1993) in which smoking was found to be the leading source of fatalities (31%) in residential fires.

An earlier study further study by Clarke and Ottoson (1976) utilised a wholly different methodology in which they examined the circumstances of incidents resulting in fatalities in the US and identified six characteristics that they considered to be central, and available, to the study and analysis of the incidents. They used the characteristics to develop over 1000 fire death scenarios which they proposed should be used to develop and target education and fire safety campaigns. The most significant finding of the research was that two thirds of fire deaths in the US resulted from just 14 of the possible 1000 scenarios derived from the analysis, and that the leading cause of these fires was carelessly disposed of smokers materials within residential dwellings igniting furniture.

Epidemiological review

This literature is primarily public health related and dealing with injuries and fatalities resulting from dwelling fire incidents. The studies in general show that alcohol consumption is a major contributory cause to fatalities resulting from dwelling fires, and that smoking is the largest single category of ignition.

Runyan (1993), found that fatal fires were more likely to occur on weekends and during sleeping hours (p186), which introduces the important temporal element which is lacking in almost all of the previous research conducted, he recommended that smoke detectors are essential in all dwellings and as a priority in households with a relatively high dwelling fire risk.

Smoke detectors are a major theme within the epidemiological literature, with the likelihood and ability of those living below the poverty line to prioritise and purchase smoke alarms reduced, Fahy (1989). This supports the findings of Munson & Oates, (1983) '... those who need them most (smoke alarms) are least able to afford them and keep them operational' (p36). There is little reliable published evidence on the operational status of smoke detectors in homes, and this is a significant gap in the knowledge base, addressed within the analytical component of this thesis.

2.3.4 Behavioural Psychology

The importance of the role of people in the observable differential fire risk becomes apparent through critical review of the existing literature, we now consider studies that begin to address the behavioural psychology aspects of fire risk.

A study of high fire incident areas in New Orleans, Louisiana, was conducted by Bertrand (Bertrand, 1976), in which households were questioned about fire risk, fire experience and efforts to minimise the risk to their property. The results showed that residents had a high level of awareness of the dangers and consequences of dwelling fires, yet they failed to prioritise fire as a high risk and as such took little responsibility for minimising the risk or mitigating for the effects of any ignition. The research reported that the residents had a 'fatalistic' attitude towards the risk of fire. The findings also pointed to a lack of community identity or cohesion and that they felt the authorities had little to offer in the way of support or practical help. They found that fires resulting from 'carelessness' were frequent and there was little evidence of optimism for the future of the area. Again this was described by the authors as a 'pilot study', with limited scope and population size, although the findings are supported by more recent work in the field of Environmental

Criminology, where a study of repeat victimisation of small businesses found that there was a culture of 'learnt helplessness' (Bowers, 2001). This refers to the finding that some businesses had decided to take only minimal anti-crime measures as nothing seemed to work against the criminals who targeted them and so took little responsibility to protect themselves.

This is an important concept in relation to anthropogenic fire risk as it shows us that awareness of risk and knowledge of how to mitigate such risk does not automatically mean that people will act. The implications of such knowledge for areas of existing or developing high fire rates is significant in that education based intervention programmes are less likely to influence behaviour or initiate fire protection actions in such areas. As education and publicity are the principal tools of fire prevention in the UK, this would suggest that an increased focus on targeted direct action initiatives, such as the Home Fire Risk Assessment programmes and smoke alarm distribution and fitting being delivered by some brigades may be a better use of resources in these areas.

People are the principle actors in the interaction of action, ignition source and combustible material. Fire incidents of this nature account for 83.25% of all accidental dwelling fires in the UK (Watson, 2002). A study of human behaviour in fire was conducted by Canter (1985), in which the author studied the behaviour of individuals during fire events in dwellings, multiple occupancies, hospitals, and public buildings. A total of 14 domestic fires and the actions of 41 people were studied. He reported a generalised sequence of events in the case of dwelling fires. There was often an initial misinterpretation of evidence of the fire, leading to early signs being ignored. Males were more likely to ignore any early signs of smoke or fire. Upon detection of the fire both males and females tend to seek first hand

confirmation, with males more likely to do so if informed by a female. Investigation of the source of the cues e.g. smells or sounds, lead to encountering the fire and its products (smoke and heat), resulting ion increased risk of injury or fatality. Males are also less likely to seek help from neighbours and attempt to fight the fire or search for people in the dwelling than females, (pp 21-22).

These findings are supported by national fire statistics that show that males are more likely to be casualties of dwelling fire incidents than females (Watson, 2002). The research indicates that people are generally slow to interpret the early signs of a fire and are then likely to place themselves in danger by investigating the source of the indicators of fire, placing themselves in the immediate proximity of the fire and or its products (smoke and heat). This has implications for the development and targeting of education initiatives in terms of the need for early recognition of the signs of fire, actions on discovery of a fire, pre-incident escape planning and to whom the education programmes should be targeted. The study does not however address the behavioural patterns that lead to the ignition. Preventative programmes of fire education and fire protection mitigation measures such as smoke alarms and sprinkler systems require information and evidence on those most at risk and the spatial and temporal scenarios leading to ignition. The research to be conducted will address these issues through analysis of the detail of fire incident reports.

Behavioural Psychology Summary

There is a very limited literature on the behavioural psychology of people in relation to dwelling fires, which represents a significant gap. Bertrand, (1976) found that residents had a high level of awareness of the dangers and consequences of dwelling fires, yet they failed to prioritise fire as a high risk, this is supported by the findings of the Community Fire Safety Task Force, (1997) which reports that 'only

4% of the public of England and Wales consider that they are likely to have a fire in the home' (p11, para. 3.3). Bertrand's results showed that fires resulting from carelessness were frequent, a similar set of behavioural characteristics classified as 'learnt helplessness' (Bowers, 2001), which is highly significant in terms of policy development and delivery.

Canter's (1985), study identified significant patterns of risk behaviour in dwelling fire situations contributing to casualty and fatality rates, which again have implications for education policy and intervention in relation to early warning alarm systems, e.g. smoke alarms.

Although very limited, the literature has significant policy implications which will be incorporated into the research to be conducted.

2.3.5 Environmental Criminology

Having considered the literature directly related to fire incidence, it has been found that there is very little reference to theory within the literature. In order to explore the potential for the development of a theory or theoretically based model of fire risk it was necessary to look for a suitable alternative literature that may support that aim. Previous experience in the field of Environmental Criminology and the links to Hawley's human ecology paper (1950), directed the review to Cohen and Felson's (1979) adaptation of the work done by Hawley, which relates routine activity to the incidence of crime. The basic principle of the theory proposed by Cohen and Felson is that crime occurs when motivated offenders converge in time and space with suitable targets and there is a lack of capable guardianship.

This work is developed and exemplified in a study utilising routine activities theory, conducted by LeBeau and Coulson (1996). The research examined how calls for police service varied with the routine activity patterns of two residential areas in

Charlotte, North Carolina. The data used in the study is the record of calls for service received by the police department in 1986. The areas selected for the study were chosen for their differences in quality of life characteristics, in an attempt to exemplify the impact of routine activities on demand for service.

The paper introduced a modification to the framework of routine activities by classifying days and periods of days into discretionary and obligatory activity time periods, with obligatory time periods relating to periods with constraints imposed upon choice of activity undertaken, e.g. work or school periods, whilst discretionary time periods have less constraints and are those periods not subject to obligatory activity patterns. Rhythms and their associations with obligatory and discretionary activities are discernable not only over days, weeks and months but also seasonally.

They proceeded from the assumption that 'different parts of the city create different rhythms of activities because of differences in function' (p4). They analysed the temporal distribution of all calls received in three hour blocks of time plotting them in three dimensional diagrams depicting the observed distribution. The results showed that for the police department area as a whole the activity profile fitted the general proposed pattern of obligatory and discretionary time periods with a greater demand for service during periods of discretionary time which was most pronounced over the Friday night through Saturday night early hours of Sunday morning period. Seasonal rhythm was also observed with daily rhythm rates increasing through spring and summer and reducing as autumn and winter. 'Therefore the amount of time available for discretionary activities influences the level of calls' (p7). The selected characteristics of the two contrasting census tracts used in the study are shown in table 2.4

The socio-economic characteristics of each tract were intended to demonstrate the extreme variation in the general characteristics of the two tracts. The crime and demand for service figures showed that tract 50 has more than three times the total crime than tract 28, and over twice the total number of calls for police service.

Table 2.4 Selected Characteristics of Tracts

Selected Characteristics	**Tract 28**	**Tract 50**
Total population	3287	3322
Percent black	0	100
Persons per household	2.48	2.73
Percent female head of household	10	67
Percent single family detached dwellings	77	19
Percent people below poverty level	1.6	45
Median house value (per $1000)	98	18
Area (acres)	698	259
Crime and calls for service figures 1996		
Assault	4	310
Residential Burglary	18	80
Total crimes	157	587
Total call for police service	1705	3975

Adapted From LeBeau and Coulson, 1996

In terms of the temporal pattern of the distribution of calls for service interesting results include those that show in the wealthier tract 28 most of the crime occurs in the obligatory periods of time when according to the authors there is a lack of capable guardianship whilst the residents are away from their homes at work, which is supported by Cohen and Felson's routine activity theory (1979). Also of interest are the findings that in the 'poorer' tract appears to have call rates that are high during hours normally reserved for obligatory activity, however this is

explained by 'chronic unemployment and poverty shortening obligatory activity time' (p11). The adaptation of Hawley (1950) by Cohen and Felson (1979) and the subsequent use of the theory within the field of environmental criminology (LeBeau and Coulson, (1996) exhibit potential for the development of a theoretical model of dwelling fire incidence.

Further work incorporating and developing Cohen and Felson's (1979) routine activity theory is presented as 'Pattern Theory' by Brantingham and Brantingham (1993). In which crime is considered in terms of routine activities, activity space, awareness space and a crime template and the interaction of trigger events. In terms of fire the relationships are simpler, as the person responsible for the ignition event is usually one in the same as the victim. In relation to dwelling fire the routine activities are those undertaken within the residential dwelling. The activity space is the home, the residents are familiar with the space and the activities that they undertake in that space (awareness space), some of which have an inherent risk attached but that under normal circumstances would be mitigated by exercising due care. The backcloth or template for the routine activity will always be unique although significant patterns and commonality will exist for repeat activities. The triggering event is the act or omission that results in ignition.

The authors provide some useful questions (p285) that although posed for the purposes of crime analysis are relevant to the study of dwelling fire:

Do templates vary with culture?

A question that has been raised in terms of population ethnicity variation in previous fire studies (Munson,1976, Chandler, 1984, Sutton 1994), with poverty related concentrations of specific ethnic groups exhibiting more significant relationships with increased fire incidence, conversely Chandler (1984) observed that

a low level of fire incidence in areas of high proportions of the population 'from the Indian subcontinent'(p20), whilst areas with similar social, economic and environmental profiles exhibited significantly higher fire incident rates. The authors suggest that this may be related to the assumption of the 'cultural values placing a high level of emphasis on the family', with fire incidence being lower in close knit communities in which the population has be resident for a long time and there is a sense of local community.

Are templates highly dependant on which country is being studied?

This raises the question of the applicability of US based fire research to the UK fire problem. Internal UK ethnic minority cultural differences in templates, the background cloth of circumstances and environment within which the events take place may be significantly different than those found in the US study areas.

How strong do triggering events have to be?

In terms of fire incidence we have already mentioned that ignition risk is inherent in many of the activities that we undertake in dwellings yet these activities result in dwelling fires in a very small minority of cases. Is it possible to define the characteristics of areas in which the presence of combinations of risk factors are more likely to result in an uncontrolled fire than in others?

Do media increase readiness by providing examples?

The media is used to deliver fire awareness and prevention messages. We can ask the question does awareness increase readiness? Bertrand (1976) found that people in high fire incidence areas were aware of the risks and the potential prevention measures that they could take, however they were found to take little

action to avoid high-risk activities and had a 'fatalistic' attitude towards fire. There is no such thing as 'perfect rational man' (Weber, 1929), people often do only what they feel is necessary to minimise the risk to a level that they feel comfortable with either consciously through their explicit actions or subconsciously through their behavioural patterns.

The authors use the idea of routine activity space which 'places people in situations, both physically and temporally, where crime triggering events are more or less likely to occur' (p269), in the case of fire this is the dwelling and it is the interaction of the occupants with their domestic environment that results in the majority of incidents. Lifestyle theory as presented by Hindelang (1978) elaborates on the propensity of lifestyle to crime and victimisation from crime, in terms of dwelling fire incidence lifestyle is more to do with the activities, behavioural patterns and domestic environments of people which involve fire risk and may result in ignition. The adaptation and application of elements of these theories provides a solid foundation for the development of a theory that encompasses the key elements of accidental residential fire, placing people at the centre of the fire problem. Without the interaction of people, their environment and risk, the urban residential fire problem would be confined to those incidents resulting from acts of nature or equipment failure, accounting for only 16.75% of the UK incidence in the year 2000 (Watson, 2002).

It is only over the last few years that with growing political attention in the UK that the fire agenda has come to the attention of academics, and fire services across the country are increasingly focussing on the use of research and its outputs to inform policy and service delivery. The links between differential fire incident rates and social, economic and environmental factors have been identified as an important

area for research, yet they remain largely unexplored in the UK. The spatial and temporal analysis framework of routine activities and the developments of the theory in relation to the study of environmental criminology represent a basis upon which further research can be developed and conducted.

Environmental Criminology Summary

Hawley's human ecology paper (1950), directed the review to Cohen and Felson's (1979) adaptation of Routine Activities to crime and then LeBeau and Coulson's (1996) application and development of the theory within the field of environmental criminology using area characteristics and a temporal classification to explain demand for service from a Police department. This provides a theoretical framework for the study and explanation of the components of differential crime patterns, which can be adapted and developed in relation to dwelling fire.

'Pattern Theory' by Brantingham and Brantingham (1993), introduces the concept of a trigger event into the routine activities based crime analysis, a component that acts to significantly increase the risk probability of an event. Finally the review draws upon Lifestyle theory as presented by Hindelang (1978), which elaborates upon the variation of lifestyle characteristics in relation to increased exposure to and risk of victimisation from crime.

The adaptation and application of elements of these theories provides a solid foundation for the development of a theory that encompasses the key elements of accidental residential fire, placing people at the centre of the fire problem.

2.3.6 Summary of Selected Papers

A summary table of selected papers is shown as table 2.5, identifying the principal author, the time period of the data on which the study was based, the location of the study, the spatial scale used in the analysis, a brief description of the methodology used, data sources, key findings in relation to fire incidence levels and distribution, and significant identified limitations of the paper reviewed.

Table 2.5 Summary of Selected Literature Review

Reference	Study period	Location / spatial scale / methodology	Data sources / descriptions	Key findings in relation to fire incidence levels	Significant Limitations
Munson, 1976	November 1973 through to October 1974	US based study Borough level analysis Five boroughs of New York Basic quantitative methods	1970 census data Aggregate borough structural fire statistics	Increased fire incidence was observed with increased proportions of pop with income less than $5000. Increased structural fire rates with increased residential housing density.	Only five data points used in the analysis. Borough level aggregation provides very little detail. All structural fires used, it was not possible to select only residential fires. No temporal analysis Interpretation of results falls foul of the Ecological Fallacy No theoretical basis for the research
Wallace,1981	1968-1979	US based study New York Neighbourhood level / block level Basic quantitative / qualitative	Fire incident data Levels of property vacancy / abandonment	Neighbourhood decline may lead to the development of a culture of deliberate fire setting and further decline. Residents develop a fatalistic attitude towards fire risk and the future prospects of the area	Lacked quantitative rigour and objectivity in qualitative analysis in relation to the finding of interest to this study as the primary focus of the research was on the effects of the withdrawal of fire services from these areas. No theoretical basis for the research
Munson & Oates, 1983	1973	US based study. Charlotte, North Carolina. Census tract level analysis and Inter City level analysis. Basic quantitative. Hypothesis testing.	NFPA aggregate fire statistics. 1970 census data	Both an increase in income and / or home ownership of 10% was found to result in a corresponding decrease in fire incident rate of 10% across most areas.	Methodologically limited All structural fires used, it was not possible to select only residential fires No temporal analysis No theoretical basis for the research

Reference	Study period	Location / spatial scale / methodology	Data sources / descriptions	Key findings in relation to fire incidence levels	Significant Limitations
Bertrand, 1976	1975	US based study New Orleans Individual household level. Interviews and basic quantitative analysis	Fire records and interviews of householders about their experiences and attitudes towards fire	High fire rate areas had a fatalistic attitude towards fire. They had a high level of awareness of risk but did little to mitigate the risk. Fires resulting from carelessness were common	Described by the authors as a pilot study of limited population size and a targeted non case controlled selection was used to identify interviewees. No spatial or temporal analysis of the data in relation to the social, economic and environmental context of the study areas No theoretical basis for the research
Schaenman, 1979	6 months data	US based study City level analysis Census tract level analysis Statistical analysis Regression analysis utilised	Aggregate fire incident records supplied by the NFPA. 1970 census data	Three variables showed a high degree of association with increased fire rates: percentage of children under 18 years of age living with both parents (-) the percentage of families with annual incomes of more than $15,000 (-), and the percentage of the population over the age of 25 with less than 8 years formal education(+). The resulting equation explained 60% of the observed variation, with parental presence accounting for 52% of the variation,	Multi-colinearity was likely to be present in the independent variables used. A single time period was used for the study, no temporal analysis undertaken. No theoretical basis for the research

Reference	Study period	Location / spatial scale / methodology	Data sources / descriptions	Key findings in relation to fire incidence levels	Significant Limitations
Karter and Donner, 1977	A single years fire data was collected for each area, although due to availability the years data used varied by area ranging from 1973 to 1976	US based study census tract level for nine communities across five separate states of the US Census block level analysis for one community, using six years incident data Statistical analysis Simple linear regression model	Aggregate dwelling fire incident data. 1970 census data. 11 population variables and 5 housing variables	Tract level indicators of relative poverty were highly correlated with higher fire incidence. The corresponding block level correlations were on average 50% lower. Intra-tract block groups were more alike than block blocks outside the tract, indicating a strong neighbourhood factor captured at the tract level.	There was little reference made to previously published work. The variation in the years fire data used was not controlled for. Multi-colinearity was likely to be present in the independent variables used but was not addressed. No theoretical basis for the research
Gilliam, 1985	1970 and 1977	US based study Highland Park, Michigan Census tract and block level analysis used. Basic quantitative analysis	Categorised aggregate dwelling fire incident data. 1970 census data	There is differential fire risk both in terms of frequency and fire type across areas that can be defined by selected characteristics.	Low numbers of incidents within the study area created problems in the interpretation and statistical significance of the results. There was little reference made to previously published work. No theoretical basis for the research.
Jennings, 1996	Three years data 1992-1994	US based study City of Memphis, Tennessee Census tract analysis Statistical analysis Multiple regression	Individual level dwelling fire incident data from the NFIRS. 4991 records obtained and a 60% address match was achieved for geocoding purposes. 1990 census data used	A conceptual model of fire risk was proposed, based upon an extensive literature review. A four variable regression equation using income, population age, property vacancy and single parent households explained 63% of the observed variation.	Attempts to develop a theoretical basis for the research without reference to existing theory on spatial and temporal distribution of human / environment interaction.

Reference	Study period	Location / spatial scale / methodology	Data sources / descriptions	Key findings in relation to fire incidence levels	Significant Limitations
Chandler, 1979	Single years data 1971	UK based study. London. Local Authority borough level analysis. Basic correlation analysis	Aggregate borough level dwelling fire incident data. 1971 census data	Significant correlations between increased fire incidence and variables selected as proxy measures of poverty. Areas of high fire incidence had proportionally more deliberate and careless ignition incidents. Single parent families were thought to increase the risk of fire due to a lack of supervision.	Little reference to previously published work. Single time period, no temporal analysis. Aggregate characteristics of such large areas are likely to mask significant variations in the characteristics of smaller component areas and the fire rates experienced. No theoretical basis.
Chandler, 1984	London 1971 & 1981 Birmingham 1978 - 79 Newcastle 1979 / 81	UK based study London, Birmingham and Newcastle. Ward level analysis. Basic correlation analysis	Aggregate dwelling fire incident data from the brigades. 1981 census data DoE social class scale	Fire incidence is related to socio-economic factors. Social classes IV and V experience relatively higher fire rates. High levels of unemployment and social stress were highly correlated with increased fire incidence. Low level of fire incidence correlation with the tested variables in areas of high proportions of the population from the Indian subcontinent. Social cohesion reduces fire risk.	Limited analytical methodology. No temporal analysis. No theoretical basis. Little elaboration of the significance of the findings to the fire service or the wider research field.

2.4 Elaboration of the Identified Gaps in the Literature to be Addressed Within the Research

The review of the research and discussion presented shows that there is considerable scope within the field of fire dwelling fire research for additional work to be undertaken. There are five inter-related components identified as requiring further research within the literature review:

1. Much of the research conducted to date has been undertaken with little or no theoretical grounding or reference to other peoples work. Jennings (1996), introduces a conceptual model of residential dwelling fire incidence, but although his work is well researched and draws heavily upon an extensive literature review, it fails to identify or make use of contributing relevant theory from other fields and lacks strength of support from the empirical research within his work. There is a clear need for a theory of accidental dwelling fire incidence, which identifies the key components of risk and the interaction factors, providing a clearly justified basis for further investigation of the problem.

2. Almost all of the research reviewed identified that there are strong links between the characteristics of an area and the fire incident rate. The most commonly identified and strongest link was that of income as measured directly in the US by the census and in the UK based research of the British Crime Survey, Fires in the home module (Aust, 2001). However in England and Wales the Census of population does not contain a direct question on income and as such we have to rely on proxies (Hirschfield, 1994, Openshaw, 1995). The identification of relevant and contemporary fire risk indicators

within England and Wales is essential in furthering the understanding of the problem and aiding the practitioners in dealing with fire.

3. The use of geodemographics in fire research and analysis has been used by the BCS identifying those households at a higher risk of experiencing a fire. However the BCS is unable to break down the types of fires that households are most at risk from and as the research indicates that fire risk and incident type prevalence varies with area characteristics this is a further gap in the research at this time. Geodemographics represent a sophisticated and readily available source of area classification that will be investigated and reported upon in this thesis.

4. The spatial analysis of fire is the basis for most of the literature conducted to date, yet there is nothing but the most cursory reference to the temporal variation in fire incidence in the research. This constitutes a significant gap in the body of knowledge as fire is likely to vary both spatially and temporally and exhibit differential spatio-temporal patterns across areas with different socio-economic, demographic and environmental profiles. Parallels have been drawn with research theory and models in Environmental Criminology and justification made for adaptation, development and application to the dwelling fire incidence.

5. The organisational impact of the current body of research on the fire service has not figured heavily in the published literature to date and as such the ability of the fire service to provide the relevant data, analytical and interpretation skills, and how the improved operational intelligence would be utilised has not been widely addressed. Again many papers make direct reference to the utility of their research findings for the fire service and planners to map risk and target resources but they do not investigate or

discuss the organisational capacity of the fire service to replicate or use the information provided by the research or the potential policy implications of the use of their findings.

The literature review has identified that there are five clear areas that need to addressed in terms of the understanding of the observed pattern of fire distribution and its association with area characteristics, both internationally and specifically from a UK centric perspective. This thesis will address and bring together each of the five areas through a comprehensive analysis of accidental residential dwelling fire incidents. The following chapter sets out the need for and the development of a theoretical model, the aims, objectives and specific research questions to be explored and answered.

Chapter 3

A Theoretical Model of Anthropogenic Accidental Dwelling Fire: Model Development and Research Questions

3.1 Introduction

The review of the research conducted and presented in chapter two, identified five clear, distinct and inter-related gaps in the current body of knowledge relating to fire distribution, people and their social, economic and built environment. This research builds upon the existing literature developing a more cohesive theoretical and empirically based body of knowledge on differential fire risk, spatial and temporal distribution patterns, area based risk indicators and classification methodologies.

This chapter states the need for a theoretical model of accidental residential dwelling fire and considers the potential components of such a model based upon: the findings of the literature review, theoretical models applied to the study of crime, and specific stated assumptions to be explored and tested by the research. A theoretical model of anthropogenic accidental dwelling fire is developed and research questions and hypotheses are presented that will require analysis, discussion and interpretation in order to meet the aim and objectives of the research. An overview of the methodology developed is stated providing a clear explanation of the path taken to deliver the empirical evidence required to meet the aim of the research.

3.2 The Need for a Theoretical Model of Anthropogenic Accidental Dwelling Fire

If we are to identify the single most important component of the fire problem in the UK, we need to consider the primary purpose of the fire and rescue service. The principal aim of the fire service 'to safeguard people's lives' through reducing casualties and fatalities from fire (CFSTF, 1997), as such the main focus of our efforts should be directed at the identification of those groups of the population most at risk from fire and their location. This focus on people is a priority for both research and the development of a framework within which research findings will inform the utilisation of evidence based fire and rescue service resource allocation and targeting. Fire in the UK remains a significant problem and risk to life. In the year 2000 local authority fire brigades attended 936,000 calls for service in the United Kingdom, a figure which represents no change in the total workload from the previous year 1999. Fires accounted for almost 51% of all incidents of which dwelling fires represented 15% (70,900) of the workload.

Findings from the British Crime Survey 2000 (BCS, 2000), show that the brigades are only called for assistance in somewhere between 13% and 26% of all dwelling fires, with the remained being dealt with by the occupants or having been relatively small and causing little damage. The majority of dwelling fires are accidental in their origin of ignition, with the figures for 2000 showing a 3% reduction on the previous year to 58,400 around 80% of all dwelling fires. Although accidental dwelling fires account for only 6% of all fire service incidents they are responsible for around 75% of all fire fatalities and 82% of all non fatal casualties in the year 2000, equating to about 14,400 non fatal casualties and 447 fatalities.

The report of the Community Fire Safety Task Force 'As Safe as Houses', published in 1997, was produced by appointment of the Home Secretary with the following terms of reference, 'To propose a community fire safety strategy and supporting action plans which will significantly reduce the numbers of fires and fire related casualties in dwellings' (Community Fire Safety Task Force, 1997, p1). The Task Force stated that 'we believe that the majority of domestic fires are preventable, they are mostly the result of a lack of care or inappropriate behaviour' (Community Fire Safety Task Force, 1997, p4). The report stated that there was a need to ensure that brigades adopted a new culture of prevention as their primary aim. Previous research has shown that in the United States of America there is a relationship between poverty and fatality rates (Fahy, 1989), whilst a limited study in the UK found that households accommodated within council flats in areas of relative poverty were most likely to experience dwelling fires and casualties form those fires (Goodsman and Mason, 1985). The research indicates that there is significant potential gain to be achieved through further investigation into the nature of the residential dwelling fire problem.

Accidental dwelling fires are the major incident type resulting in casualties and fatalities in the UK (Watson, 2002), accounting for around 80% of all non fatal casualties and 75% of fatalities. The focus upon accidental dwelling fires within this research is based upon the need to better understand both the distribution of incidents and characteristics of those areas most at risk in order to enhance the ability of the fire and rescue service to adapt to the demands of a research and evidence lead approach to the problem.

Residential dwelling fires occur from the result of a range of ignition sources which can be classified as follows: Deliberate; Accidental; Nature; and Structural.

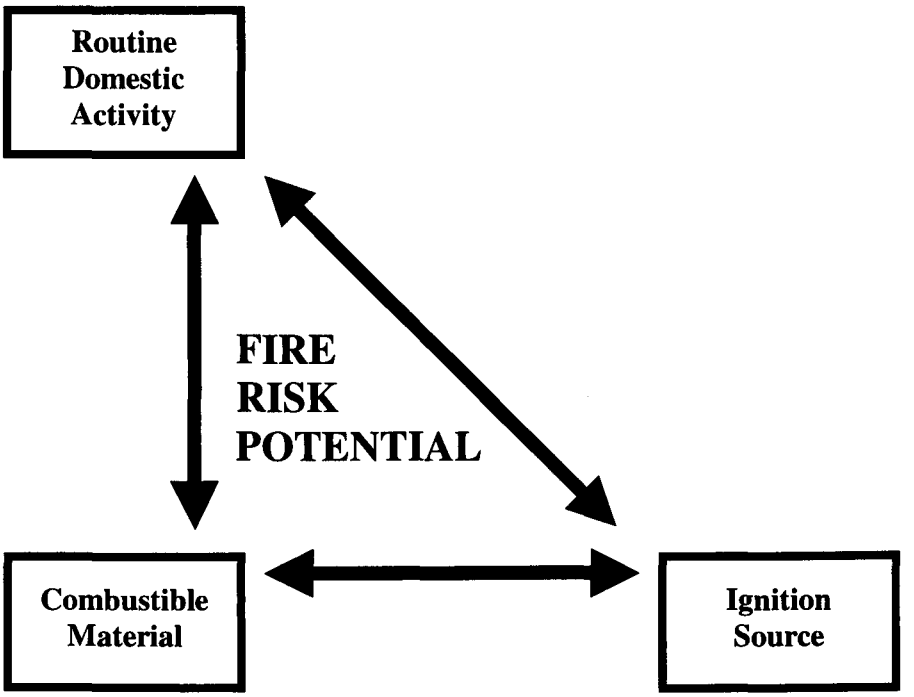
Each of the casual classification groups has its own component interaction factors which are dynamic in nature and can combine to result in the ignition of an unwanted and uncontrolled fire incident. The clear focus of this thesis is to explore those incidents that result from accidental human action. This excludes deliberate ignition dwelling fire incidents which involve a different range of factors specific to the perpetration of an act of arson; these include the complex offender-victim relationships that lie outside the scope and resources of the research to be conducted.

This thesis explores the incidence of the anthropogenic accidental residential fire. The term anthropogenic is important as it places people at the centre of the dwelling fire problem. It is the interaction of people and their environment, in the case of this study their dwelling, which is manifested in unwanted and uncontrolled fires that have the potential to destroy property, injure, and kill. The national fire statistics show that 83% of accidental dwelling fires are initiated by the actions or omissions of the occupants of the dwellings (Watson, 2002). Better understanding the nature and causes of differential distribution of incidents, by ignition type, area characteristics, time and outcome provides a valuable potential source of information for the fire and rescue service and community safety professionals. Evidence derived from such information will aid the development, tailoring and targeting of education, intervention and prevention initiatives. We need to identify the component factors of dwelling fire incidence, the role they play in generating differential risk and the dynamic interaction processes that combine to result in ignition of an unwanted and uncontrolled dwelling fire.

3.3 The Components and Development of a Theoretical Model of Anthropogenic Accidental Dwelling Fire

Anthropogenic accidental dwelling fire incidents are the result of the interaction of people, the occupants at or around the time of ignition, with their domestic environment. It is essential to break down the fire incident event into its component parts in order to better understand the dynamics of the processes that may lead to increased fire risk and increased fire incidence. Many of the routine activities that are undertaken within a domestic dwelling have an inherent potential fire risk. It is the combination of 'Routine Domestic Activities' that involve a 'Potential Source of Ignition' in the proximity of 'Combustible Materials', such as cooking and smoking that present a potential risk of fire and are the principal components of a theory of potential fire risk. Figure 3.1 shows the three core component factors that in combination generate the potential fire risk.

Figure 3.1 Components of Domestic Fire Risk Potential



The components of the partial theoretical model shown in figure 3.1 are defined for the purposes of this model as follows:

1. The first component is Routine Domestic Activities which are defined as the day to day actions and behaviours of the occupants that are undertaken within the dwelling unit. Importantly it is proposed that the types of activities that result in a potential fire risk have identifiable temporal patterns that can be described in terms of 'Rhythm, Tempo and Timing' (Hawley, 1950).

Rhythm - regular periodicity with which events occur, as with the cooking of an evening meal

Tempo - number of events per unit of time, such as the number of fire incidents in a specific area in a specific time period

Timing - period between identifiable pulsations

These were three principal components of Hawley's work on the temporal aspects of community structure and ecological organisation. It is the temporal aspects of the activities undertaken within a community structure that Hawley termed 'Routine Activities' and it is upon this principle that the development of the theoretical model of accidental anthropogenic dwelling fire builds.

2. The second component is a source of ignition, which may take the form of any item or material that has the potential to generate sufficient heat, friction or chemical reactions to produce a spark or flame. These potential ignition sources are numerous within the dwelling environment and are often an essential or chosen component of many common domestic routine activities, e.g. cooking or smoking.

3. Finally the third component is a requirement for proximity to a source of combustible material, which assuming the presence of oxygen, is anything that has the potential to burn and act as fuel for the development of the fire.

It is important to stress that each of the components in isolation from the other factors is relatively inert in terms of fire risk and as such it is the processes of interaction that results in the potential risk.

Accidental dwelling fire is a relatively low frequency event with only 56,700 incidents in the UK in the year 2000 (Watson, 2002), whilst the activities that have a potential fire risk, such as cooking, smoking and the use of fires and other sources of heat, are common to all or many of the UK's 24.5 million households every day. As such there is clearly an additional interaction component that

increases the potential fire risk and may result in a fire that remains to be incorporated into the theoretical model.

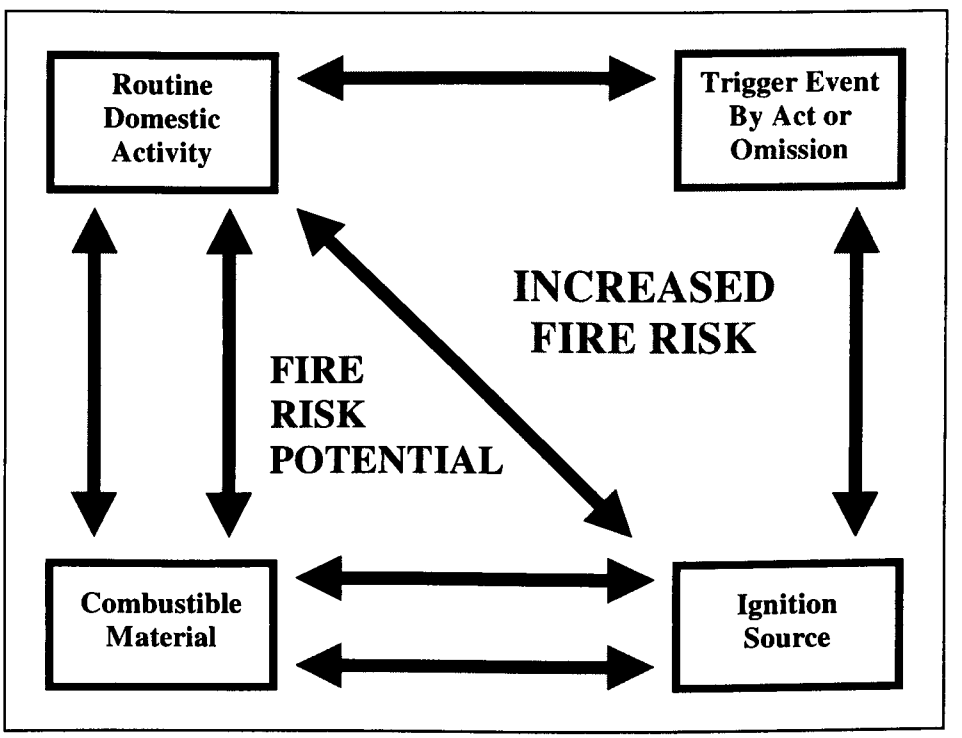
The additional forth component of the theoretical model is defined as the 'trigger event either by act or omission' which acts to increases the potential fire risk, resulting in higher frequencies of conversion from potential to actual fire incidence. Such trigger events are proposed to take the form of either acts or omissions in the failure to undertake such routine activities with due care and attention. Examples of trigger events would include: placing an article too close to a source of heat, leaving a pan containing oil unattended on a cooker hob and so on. It is this component that clearly defines the class of anthropogenic fire incidence, by placing the actions of people at the centre of the accidental dwelling fire problem.

It can be seen from figure 3.2 that the three core components of potential fire risk remain in place and form a triangle of interaction that is common to all occupied residential dwellings. The potential risk posed by routine activities, a source of ignition and proximity to combustible material represents the underlying potential fire risk and is shown in black type; the black arrows indicate the interconnectivity of the factors in generating the risk. The addition of the forth component of the model, the trigger event by act or omission, is shown in red type and includes the three basic risk components but now results in the increase of fire risk due to a lack of due care and attention in conducting or supervising routine activity potential fire risk interactions.

The theoretical model now encompasses the potential risk and the trigger event, a concept that has been adapted from work done by Bantingham and Brantingham (1993), which as discussed in the previous literature review chapter was also developed from Hawley (1950) and Cohen ad Felson (1979), in which they

use the term trigger event in terms of crime and place and the symbiotic relationship between victim and offender. In terms of anthropogenic accidental dwelling fire the relationship is simplified with offender and victim being one in the same, as it is the actions of the occupier that result in the fire incident. What is clear is that anthropogenic dwelling fire incidence requires the presence and interaction of all three key components plus the addition of the trigger event to produce unwanted and uncontrolled fire. The absence of any one of the three key components of the model removes the risk of fire from this specific class of ignition. Cooking is a potential source of fire risk, yet when undertaken responsibly and in the absence of accidents is a generally relatively safe and low risk activity. Smoking a cigarette presents very little direct independent fire risk yet when combined with careless disposal may result in the ignition of a fire if in contact with combustible material.

Figure 3.2 Anthropogenic Accidental Dwelling Fire Risk



The specific nature of the circumstances of the trigger event are likely to be highly variable in relation to the specifics of each incident, but they share common component factors associated with behavioural risk. The data and information consistently gathered and generated in relation to the ignition of a fire enables basic routine activity fire ignition classes to be generated in order to further explore the nature of differential fire risk and how we can use the theoretical model to develop improved policy and intervention fire and rescue services.

A further additional component of the theoretical model is that of location. Each incident occurs at an identifiable location which relates to both the location and function of the dwelling space within which the fire originated and also the wider geographic context of the addressable location of the dwelling. This provides us with the potential to place the incident in a spatial context, enabling us to analyse the incident and aggregations of incidents incorporating socio-economic and geodemographic factors. Such information will enable area based classification of incident concentrations, quantification of relative risk in association to applied and derived classes of area type, and statements of statistical significance to be calculated.

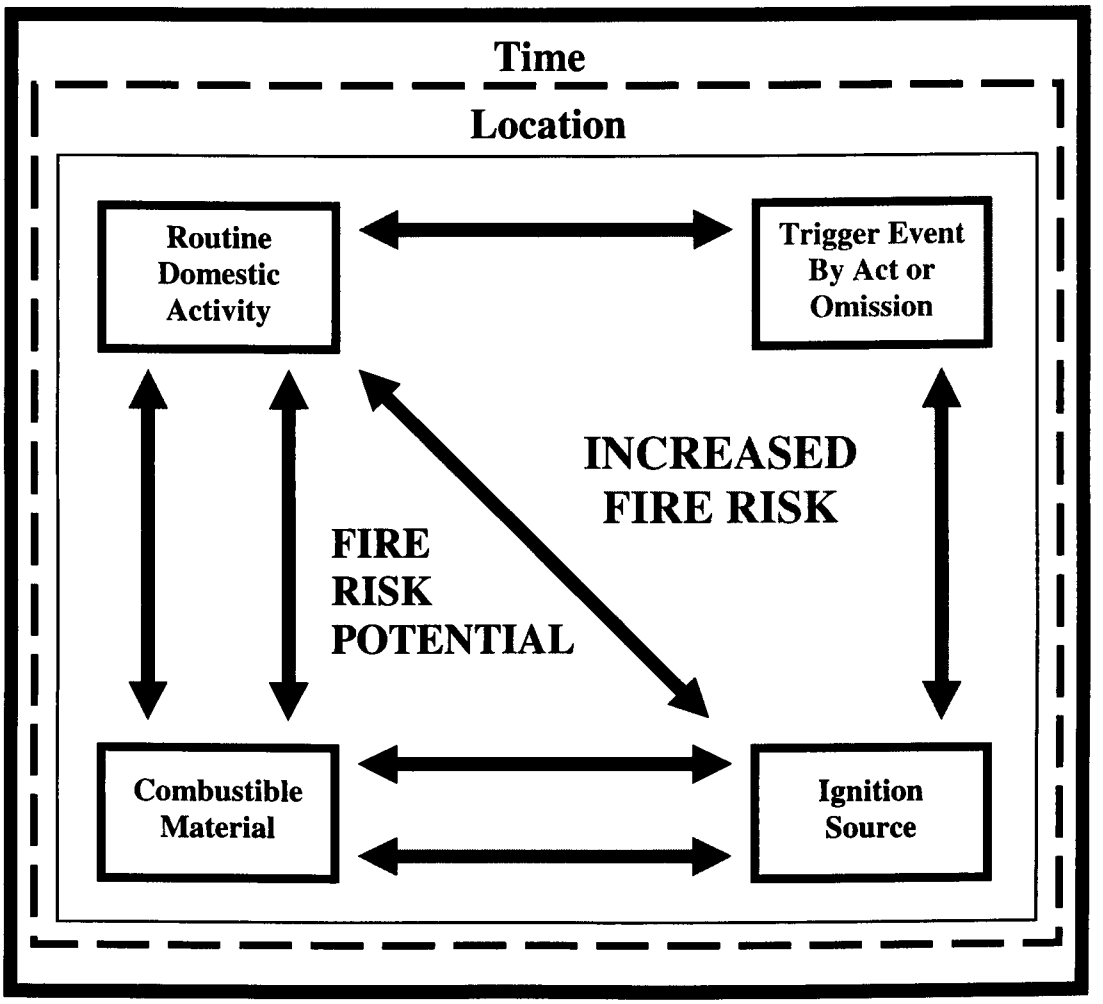
The final component of the theoretical models adds the dimension of time. It is postulated that calls for assistance from the fire and rescue service to deal with anthropogenic accidental dwelling fires are related to the temporal profile of the routine activities of domestic lifestyles. As such there should be discernable temporal patterns of incident distribution both throughout the day and by day of the week as people undertake activities associated with obligatory and discretionary time periods (Chapin, 1974). Work conducted by LeBeau and Corcoran (1990) demonstrated that, in terms of calls for service to the police, days of the week present

differential opportunities in the pursuit of discretionary activities. Not only do routine activities vary by time of day but also by day of the week, with traditional working and education activity patterns dictating the pattern of domestic activity for a significant proportion of UK residents. LeBeau and Corcoran (1990) found that discretionary time rhythms explained rhythms of calls. Calls for police service were shown to have distinctly different spatial and temporal profiles across two selected case study areas at opposite ends of the affluence and quality of life spectrum. A key finding of their research was that high unemployment resulted in the wider dispersal of calls throughout the day as obligatory time periods were less evident as employment accounts for a significant proportion of obligatory time periods. This may be mirrored in the dwelling fire profiles of areas as it is proposed that patterns of routine activities in respect of dwelling fire risk are also influenced by the temporal distribution of obligatory and discretionary time periods.

Figure 3.3 illustrates the final development of the theoretical model to be proposed at this stage, although future research may inform adaptations or reworking of the theory. The temporal and spatial location of incidents complete the routine activities based theoretical model which can be stated as such:

> **Anthropogenic accidental dwelling fires result from the pursuit of domestic routine activities that involve the convergence in space and time of a potential source of ignition, proximity to combustible material and a trigger event by act or omission.**
>
> *Adapted and developed from Hawley (1950), Cohen and Felson (1979), & Brantingham and Brantingham (1993).*

Figure 3.3 A Theoretical Model of Anthropogenic Accidental Dwelling Fire



Adapted and developed from Hawley (1950), Cohen and Felson (1979) & Brantingham and Brantingham (1993).

The model provides a theory based, structured framework within which analysis of dwelling fire incidents can be undertaken to develop the improved understanding of the nature of the problem. It identifies the core components of the potential anthropogenic accidental dwelling fire risk within a spatio-temporal context which will through analysis enable information to be derived about the associative inter-relationships that result in differential fire risk.

The literature review has clearly shown that previous research into residential dwelling fire incidents and fire incidents as a whole has been shown to lack a theoretical basis. The theoretical model proposed in this thesis clearly identifies the core components of anthropogenic fire incidence risk, their interaction and dependence upon each other and the key role of trigger events that act to significantly increase the risk. It draws upon the extensive body of research in the field of environmental criminology and the significant work conducted in the field of human ecology by Amos Hawley. The resulting theoretical model of Anthropogenic Accidental Dwelling Fire, for the first time, provides a theoretical basis for research into the nature and manifestation of the problem of AADF.

The aim is to use the model as a framework to identify area characteristics that are associated with varying AADF profiles, which although not to be assumed as causally related, can be utilised to differentiate, quantify and classify variation in AADF by area. This information would significantly enhance the ability of the fire and rescue service to more effectively identify areas of greatest need and tailor and target resources based upon specific fire risk profiles.

3.4 Key Research Questions

The research review has identified a range of social, economic and environmental factors that have been associated with increased incidence of fire at varying spatial levels. However the identified gaps in the research require a series of research questions to be answered in order to provide evidence in support of the theoretical premise that anthropogenic dwelling fire is not a random phenomenon and can be shown to disproportionately concentrated in areas that can be classified by indicators of relative deprivation and geodemographic typology.

The temporal aspect of the theoretical model is based upon the routine activities of people in their homes and as such questions will be posed to test the applicability of the model using time series data from actual incident records. This data will also be queried to ascertain the spatio-temporal distribution of incidents and the association with indicators of deprivation and routine activities combined. The empirical research will test the proposition that the stated model has relevance and will significantly add to the field of knowledge on fire incidence and social conditions.

A series of key research questions is presented below guiding the empirical research, including fire incident distribution, fire and rescue service structure and capacity to adopt an evidence based framework for operational intelligence lead resource targeting.

Key Research Questions

1. Can incidents of anthropogenic accidental dwelling fire (AADF) be shown to be spatially concentrated?
2. Does the observed distribution of incidents of AADF vary temporally?
3. Are differential spatial and temporal frequencies of incidents of AADF associated with identifiable socio-economic indicators?
4. Can AADF be shown to be disproportionately concentrated in areas of relative deprivation?
5. Does the observed distribution of incidents vary by cause of incident ignition?
6. Do areas with different socio-economic characteristics exhibit different patterns of incidents, both in terms of incident type and time profile?

7. Do the outcomes of fires in terms of casualties and fatalities vary by area characteristic?
8. Does the ownership of smoke alarms vary by area characteristic, and how does this relate to casualty rates in those areas?
9. What are the organisational implications of a theory of AADF for the fire and rescue service?
10. To what extent do brigades have the capacity and skills to adopt evidence lead, risk based service delivery and resource targeting?

The research questions will be used to direct the research and provide information and evidence to meet the aims and objectives previously stated, testing the applicability and robustness of the new theoretical model developed. They will also be used to assess the organisational and policy implications for the fire and rescue service.

3.5 Summary of Chapter

This chapter has drawn upon the findings of the literature review to develop a new theoretical model of Anthropogenic Accidental Dwelling Fire. The core components were identified and the relationships and interactions defined. This provides a theoretical basis for, and framework within which the empirical research will be conducted, which has been lacking in previous research. A set of research questions have been posed that will guide the direction of the analytical component of the thesis.

The following chapter places the research in the context of the fire and rescue service as an organisation, policy and priorities. The selection criteria for a case

study area are defined and applied. The resulting study area of Greater Manchester is introduced and the identification, availability and selection of data sources for the research are presented. Issues of data quality, processing, spatial and temporal analysis are detailed; limitations and research boundaries are identified.

Chapter 4:

Setting the Research Context:

Case Study Selection Criteria and Data Issues

4.1 Introduction

Having introduced the nature of the problem of fire incidents and reviewed the literature, specific gaps have been identified, research questions posed and the focus of the research has been identified as accidental anthropogenic dwelling fire incidents. A new theoretical model of AADF has been proposed and is to be tested through empirical research. This chapter goes on to develop the methodology for the research and places the research in the wider context of the fire and rescue service, the organisation charged with the task of trying to reduce AADF and associated casualties and fatalities. The chapter begins with an introduction to the organisational structure of the fire and rescue service, and to what extent, in order to answer the research questions posed, the brigades have the current and potential capacity to adapt to and incorporate research and evidence lead fire incidence reduction and resource targeting.

The selection criteria for a case study area to be used in the research are defined and applied. The selected study area of Greater Manchester is then introduced and the identification, availability and selection of data sources for the research are presented. Issues of data quality, processing, spatial and temporal analysis are detailed and the scope and limitations of the research are identified. Finally the methodology to be undertaken is introduced.

4.2 The Fire Service: An Overview

The Fire and Rescue Service in the UK falls under the responsibilities to parliament of the Minister for Local Government, Department for Communities and Local Government (DCLG). This responsibility is devolved to the Local Authority level, more specifically to a committee of elected representatives forming a Fire Authority. It is the responsibility under The Fire and Rescue Services Act 2004 of the Local Authority through the election of a Fire Authority to provide a Fire and Rescue Service. The primary responsibilities of the Fire and Rescue Service are to safeguard people's lives and minimise damage caused by fire to property.

Historically the Fire service has not been afforded the same high level of political interest that has been very evident in terms of law and order and the need to reduce crime. However with an increasing focus on public expenditure and the drive to achieve 'best value' in all the public services, the Fire and Rescue Service has come under increasing scrutiny. The 1995 Audit Commission report 'In the Line of Fire' considered the need for, and proposed an 'agenda for change', recommending that research should be conducted to inform a future policy framework for the provision of fire cover based upon empirical evidence. They also stated that whilst maintaining the current high standards of response options that priority should be given to the development and implementation of effective fire prevention measures.

Following this the Home Office Commissioned and then published a report 'Elaboration of a risk assessment toolkit for the UK Fire Service' (ENTEC, 1996), this report addressed the feasibility and applicability of a risk based 'toolkit' for the production of national standards for the provision of local fire cover. It considered and proposed the use of classifying areas based upon the levels of fire incidents experienced, the rate of casualties and fatalities per a given number of incidents, and

examining these rates in relation to discrete demographic groups and building type. The report then considered the use of the derived area classification and vulnerable demographic groups for the purpose of targeting and delivering fire safety initiatives and fire cover. A subsequent report by ENTEC concluded;

"the variation in fire incidence and fire casualty rates could be measured directly for the purpose of assessing fire cover needs, with assessment of local social-economic and demographic factors completed for the purpose of targeting fire safety education and prevention work on the highest risk households"

(ENTEC, 1998, p26).

If we are to consider the primary aim of the fire service 'to safeguard people's lives' then the main focus of our efforts should be directed at the identification of those groups of the population most at risk and their location. Fire Statistics United Kingdom 2005 reports that over three quarters of all fatalities and casualties result from residential dwelling fires (DCLG, 2005). The report of the community Fire Safety Task Force ' As Safe as Houses', published in 1997, was produced by appointment of the Home secretary with the following terms of reference: 'To propose a community fire safety strategy and supporting action plans which will significantly reduce the numbers of fires and fire related casualties in dwellings' (Community Fire Safety Task Force, 1997, p1).

The Task Force stated that 'we believe that the majority of domestic fires are preventable. They are mostly the result of a lack of care or inappropriate behaviour.' (Community Fire Safety Task Force, 1997, p4). The report stated that there was a need to ensure that brigades adopted a new culture of prevention as their primary aim. Organisational changes were required to accommodate a new strategy and vision involving the inception of a National Community Fire Safety Centre to

provide a national framework within which CFS would develop. The report also expressed surprise in that 'the Government currently has no targets on fire or casualty reduction nor forecasts for the future' (para. 4.2), along with a lack of quantifiable performance indicators in this area. There was also a lack of planning both locally and nationally and little or no monitoring and evaluation of CFS work. Great emphasis was placed upon the need for empirical evidence derived from data analysis and targeting of resources based upon this analysis at the local level to identify and reach at risk groups.

The current structure of the Fire and Rescue Service is inherently spatial in terms of both administrative and service delivery organisation. To a great extent the Fire and Rescue Service is defined by a hierarchy of spatial boundaries nesting within national boundaries and falling under the overall responsibilities of the DCLG. Individual Brigades are often sub divided into Divisional areas or Commands and then into smaller Station areas. National fire statistics are compiled and published by the DCLG on an annual basis and report aggregate data at the FRS level. The FDR1 Fire Damage Report form was introduced in 1978 and is used to capture incident data in a standardised, categorised format for all property fires. From 1979 data from this paper based system was captured in electronic format, centrally by the Home Office. However in 1988 the coding was amended and a further revision was made in 1994, this remains the form used by brigades today. A copy of the FDR1 form and list of variables captured is shown as appendix 1. Any reporting or analysis of FRS incidents below the level of the brigade has historically been left to individual FRS to undertake. This has resulted in the Fire and Rescue Service, for various reasons, failing to undertake or develop any meaningful structure and methodology for the collection, manipulation, analysis and dissemination of fire

related data and information below the FRS level. This is not to say that individual FRS and individuals within brigades have not conducted research and implemented initiatives based upon the results. It does however mean that there has been a lack of communication, collaboration and focus upon the possible benefits to be derived from a greater use of evidence based risk analysis within the Fire Rescue Service as a whole.

The challenge for the Fire and Rescue Service is to reduce the incidence of fire and casualties through a new focus on prevention through Community Fire Safety whilst maintaining the current high level of response options. The drive is for a more effective, more efficient and more proactive force that is informed by empirical evidence derived from data analysis and research.

4.3 Case Study Selection Criteria

National statistics (DCLG, Fire Statistics United Kingdom) show that there are significant variations in the numbers of incidents attended by FRS and the workload distribution in terms of the types of incidents attended. The primary focus of this research is on accidental residential dwelling fires and the associated high proportion of casualties and fatalities for which they account. As demonstrated in the literature review, the existing body of research clearly identifies that there is a need for further research into the links between deprivation and urban residential dwelling fire. To this end the case study area should incorporate areas of urban residential development exhibiting a range of levels of deprivation, providing for comparative studies to be undertaken. For the purposes of this study it was important to identify a FRS area or FRS areas that would meet the following criteria:

- A FRS/FRSs willing to provide access to its incident data and work with the researcher to facilitate the achievement of the stated aims and objectives.
- A FRS/FRSs with a demographic and built environment profile which would enable the study of the distribution of dwelling fire incidents across a range of discrete geographical areas, which include areas of similar and dissimilar social, economic and environmental profiles.
- A FRS/FRSs with both a representative or relatively high number and rate of dwelling fire incidents and also average or above average fatality and casualty rates.
- A robust and comprehensive existing incident database that contains key variables essential to the research.
- Historical data held for a period of at least 3 years providing a large enough sample of incidents for statistically significant and robust research to be conducted.

An established research relationship with the Greater Manchester FRS was in place and had been instrumental in the initial conception of the Ph.D. proposal. Using the stated criteria, examination of the national fire statistics and census profiles was conducted. This resulted in several additional FRS being identified as potentially suitable case study areas. The FRS were contacted and asked if they would be prepared to participate in the proposed research. Discussions were held with the FRS and their data holdings were examined and assessed for suitability for the purposes of the research. The predominant impediment to the participation in the research was that of a lack of data suitable for the analysis. The only suitable and willing participant identified was the Greater Manchester Fire and Rescue Service (GMFRS).

GMFRS had already demonstrated their interest in this area of research having previously commissioned a study into 'Fires, Land Use and Social Conditions', which was conducted by a research team based at Liverpool University and with which I was involved. GMFRS were actively pursuing a policy of fire prevention lead by their Community Fire Safety department and needed to develop their intervention programmes based upon empirical evidence based research findings. Their intention was to build upon skills and capacity of their established statistics department and develop their use of geographical information systems. Having identified that GMFRS met the case study area criteria, utilising the established relationship with GMFRS provided an excellent base upon which the research was developed.

4.4 Greater Manchester County Fire Service Case Study Area: Background Information

The data set available at the time of the empirical analysis component of the Ph.D. research was for the period from the date of the 1991 census of population, the 21st of April 1991 through to the 10th of September 1999. The data set provided a comprehensive and consistent record of each individual FRS incident reported for the entire period. For the purposes of the following analysis all additional data sets used were contemporaneous to the FRS data set and Ph.D. research period.

GMFRS serves the 10 metropolitan districts of Bolton, Bury, Manchester, Oldham, Salford, Stockport, Tameside, Trafford and Wigan which collectively make up the Greater Manchester area. The FRS itself is the second largest brigade in the UK serving a resident population around 2,500,000, 1 million households (ONS, census 2001), and covers a geographical area of almost 500 square miles. Fire and

Rescue services are delivered from 41 fire stations serving on average a population of 63000 people and 24000 households. Figure 4.1 shows the ten metropolitan districts that make up the Greater Manchester area and their boundaries. The division of the area by station ground boundaries is shown as figure 4.2 within which the boundaries of the 214 electoral wards, that sub divide the area, are visible.

Figure 4.1

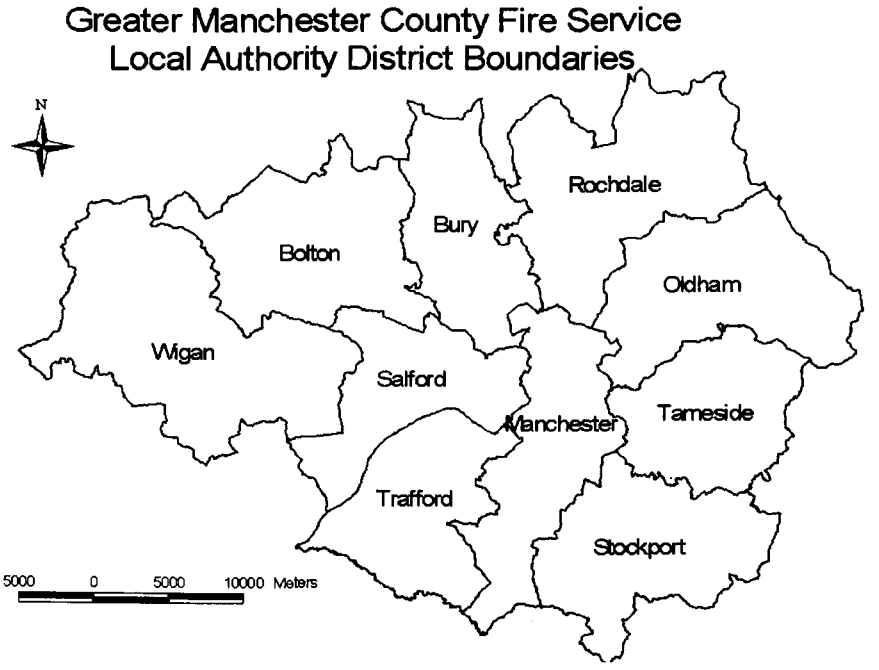
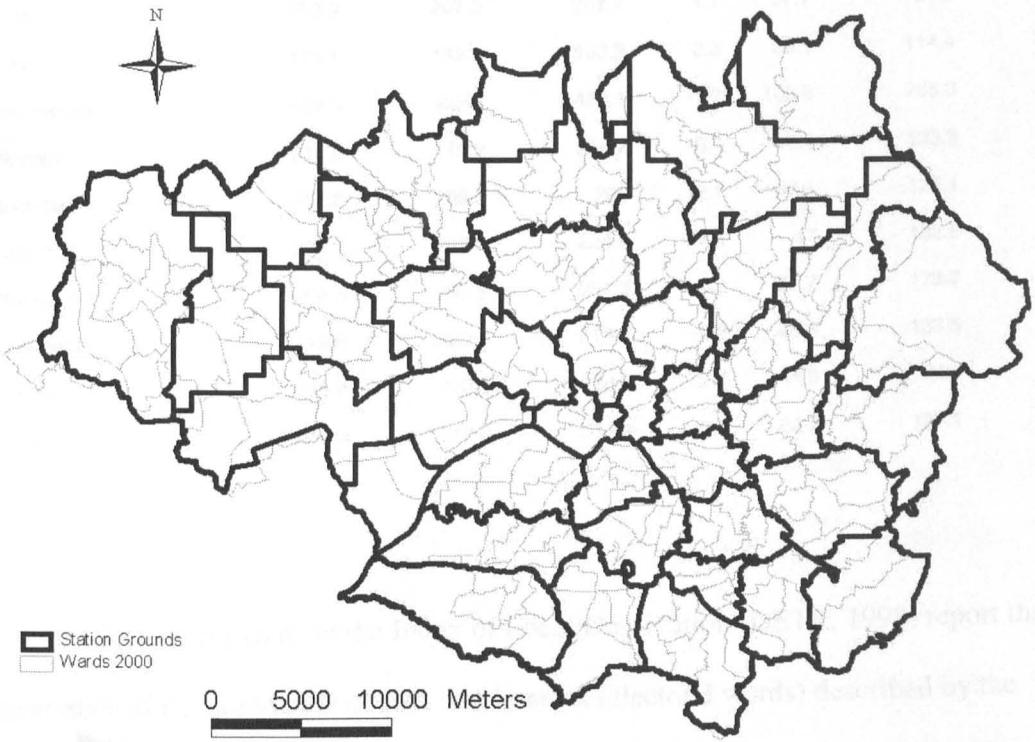


Table 4.1 provides details of the populations of each of the ten metropolitan districts along with estimated % change from the 1991 census to 1999. This table indicates that there has been a 0.3% increase in population since the 1991 census, a relatively small increase which is likely to have little effect upon a Greater Manchester wide study of AADF distribution.

Each year the FRS responds to an average of 65,000 incidents. Of these incidents around half will be false alarms, with accidental dwelling fires accounting for around 6% of the workload activity of the brigade. However this relatively small proportion of the total incidents resulted in 1496 casualties and 22 fatalities (Watson, 2002).

Figure 4.2 GMCFS Station Area Boundaries with Ward Divisions



Residential dwelling fires generate 88% of GMFRS fatal casualties compared to 68.7% nationally (England and Wales) and 78.5% of non-fatal casualties compared to 80.5% of non-fatal casualties nationally. The relatively small number of fatal casualties gives rise to larger observed variation in the percentage comparisons due to the problems associated with small numbers.

Table 4.1 Population and Estimated % Change from the 1991 Census by District

Table	ONS 1991-1999 Population Estimates and change						
Units Thousands	Mid-year population 1991	Mid-year population 1998	Mid-year population 1999	% change 1991-99	Age 0-15	Age 16-64M/59F	Age 65M/60F & over
ENGLAND	48208.1	49494.6	49752.9	3.2	10097.4	30665.2	8990.3
NORTH WEST	6885.4	6890.8	6880.5	-0.1	1431.5	4199.8	1249.2
GMC	2570.5	2577.4	2577	0.3	552.6	1589.6	434.9
Bolton	262.9	267.5	267.4	1.7	57.7	164.6	45.2
Bury	179.1	182.8	183.2	2.3	38.1	114.4	30.7
Manchester	438.5	429.8	431.1	-1.7	100.9	266.3	63.9
Oldham	219.6	219.2	218.7	-0.4	49.4	133.3	36
Rochdale	204.8	208.2	209	2.1	47.1	128.1	33.7
Salford	230.9	225.9	224.8	-2.6	47	136.6	41.3
Stockport	288.3	292.8	291.9	1.2	57.7	178.7	55.4
Tameside	219.8	220.4	219.4	-0.2	46.6	135.5	37.2
Trafford	215.8	220.3	220.2	2.1	44.9	135	40.3
Wigan	310.9	310.5	311.4	0.2	63.2	197.1	51.1

Figures drawn from the Index of Local Deprivation (DETR, 1998) report that over 80% of the population of GM live in areas (electoral wards) described by the Index as deprived. This index has now been superseded by the Indices of Deprivation 2000, which will be discussed in further detail later in this chapter. The fact that such a high proportion of the wards are described as deprived should not go unmentioned when one of the aims of the research is to consider the utility of such indices as indicators of risk. The high level of relative deprivation may make it more difficult to identify variation in fire incident rates using deprivation as a denominator. Area with a more heterogeneous profile in terms of such characteristics may show a

greater comparative variation across their population and areas in terms of fire incidence than that of the GMFRS. However it was the availability and extent of the GMFRS incident database that placed it head and shoulders above the other potential FRS participants.

Having identified the case study area for the research, the nature of the data and additional data sources needed to be explored. Issues of accessibility, standards and compatibility, and the development of a methodology capable of meeting the aims and objectives of the research had to be developed.

4.5 Fire Incident Data Set and Related Issues

The research requires that the data meet certain standards of precision, resolution and accuracy whilst containing minimal levels of error. Each incident must be captured at the individual disaggregate level, providing the maximum potential for analysis and aggregation to, and association with, any chosen compatible data that is available or generated for the research. Crucially the GMFRS as a matter of course maintained detailed incident records in computer format for almost 20 years. Old magnetic tape data had been stored capturing individual level, geographically coded and detailed incident variables. The magnetic tapes were to be disposed of in the early 1990's but the FRS statistician had the foresight to realise their potential worth and had the data transferred to a more modern media and the records from 1988 onwards were saved. The incident database represents the most comprehensive and temporally extensive record of fire incidents that I am aware of, consisting of almost 1 million individual incident records spanning a 14 year period. For the purposes of this research data was made available from the date of the 1991 census (April 21st) through to the date of the FRS changing over from one command

and control system to a new one on the 11th of September 1999, a period of almost eight and a half years.

In terms of the data captured for each incident the first job was to check the content in terms of variables and coding of incidents and then for the precision, accuracy and error that may compromise the potential for the data to be analysed spatially via the locational data captured in each record. Preliminary examination of the data set was very promising with each individual incident being captured in a standardised format with a full coding manual available for each of the variables on the FDR1 form. These variables included details of the location, time, incident type, ignition category and outcome in terms of casualties and fatalities, along with a wealth of additional data a full list of which is attached as appendix 1.

The crucial factor was then to establish the:

Precision - the minimum distance that can be recorded

Accuracy - how close a measurement is to the true location

Error - the deviation of the measured from the true location

of the locational data held for each incident. Initial visits to the brigade command and control and statistics departments had enabled the extraction of the data in a standard export format which was able to be read into SPSS software and the individual variables coded from the manual provided. Validation checks were made through a random selection incidents for which the original paper copies of the FDR1 were located and the coding was checked. Of a sample of 50 individual incidents all cases were found to be 100% correctly coded, a credit to the coding and validation procedures of the brigade, a process that all incident records are subjected to prior to submission to what was then the home office for national statistical records.

However the locational data held in the computer database had several significant flaws and problems. The first problem encountered was that of the geographic reference captured in the form of an Ordnance Survey (OS) national grid reference. The FRS mobilisation system was designed for the emergency dispatch of vehicles to deal with 999 calls for assistance, it conforms to the requirements of the FDR1 (94) guidance notes (Home Office 1994) which states that the purpose of the form is 'To collect information on the address, or geographical location, of the fire. ...OS grid references should be provided from Command and Control systems where possible. If available give the full eight-digit OS national grid reference. Alternatively give the six-figure number by omitting the last digit of both four-figure references. ... If the grid reference is not available, leave the box blank' (FDR1(94) Guidance Notes, Section 2).

The capture of the locational data for an incident by the GMFRS system was based upon a combination of address information, a local grid based geographia, similar to an A-Z type map book and the generation of an Ordnance Survey national grid reference. An initial examination of the data appeared to show that it was of reasonable quality with what appeared to be an eight figure grid reference identifying a 100m grid square along with an address that would enable refinement of that grid reference. Having imported the incident data into ArcView geographic information system software and plotting the distribution of the incidents it became apparent that the grid reference was actually an eight-figure grid reference for a 500m grid square. In terms of spatial accuracy this created severe problems for the attribution of incidents to specific spatial units for the anticipated analysis. Figure 4.3 shows the area covered by a 500m grid square and the maximum error of attribution calculated

from the length of the hypotenuse of the right angled triangle created by the grid square.

The intention to use ward and enumeration district (ED) level aggregations of incidents and associated area discriminators was severely jeopardised by the lack of locational resolution. An illustration of which is provided in figure 4.4 which again shows a 500m grid square this time overlaid on ED boundaries. The figure shows the possible number of EDs in which an incident attributed to a single point within that grid, as done in the GMFRS data set, could have occurred. The yellow shaded EDs number 14, and may well have entirely different socio-economic and demographic profiles. The potential for this error is shown in figures 4.5 & 4.6, in which the attributed location of dwelling fire incidents and the actual location of those incidents is plotted against a digital aerial photograph and then overlaid with SuperProfiles.

The figures show that there is significant error in not only the difference in the actual location within the grid square used by the GMFRS geoegraphia but also that incidents have also been recorded within the incorrect 500m grid. The effect of this at the level of enumeration district analysis is clearly shown in figure 4.6, in that in all the dwelling fire incidents attributed to the lifestyle described as 'Younger mobile' actually occurred within different EDs described as 'Lower income older people'.

Figure 4.3 Scale Photograph of a 500m Grid Square and Maximum Distance of Error

Figure 4.4 Locational Error in the GMFRS Incident Data Set 1

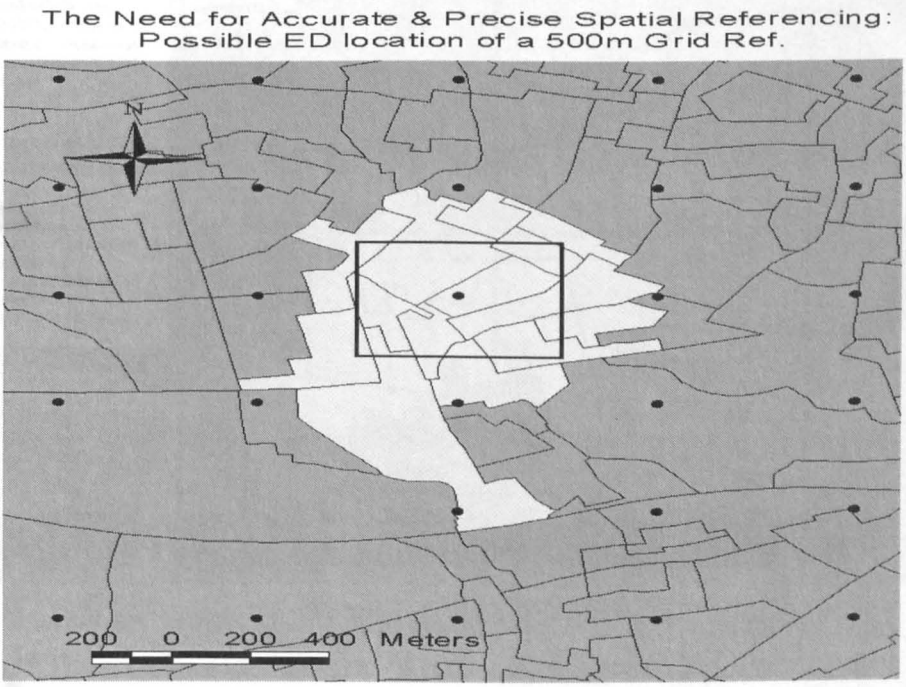


Figure 4.5 Locational Error in the GMFRS Incident Data Set 2

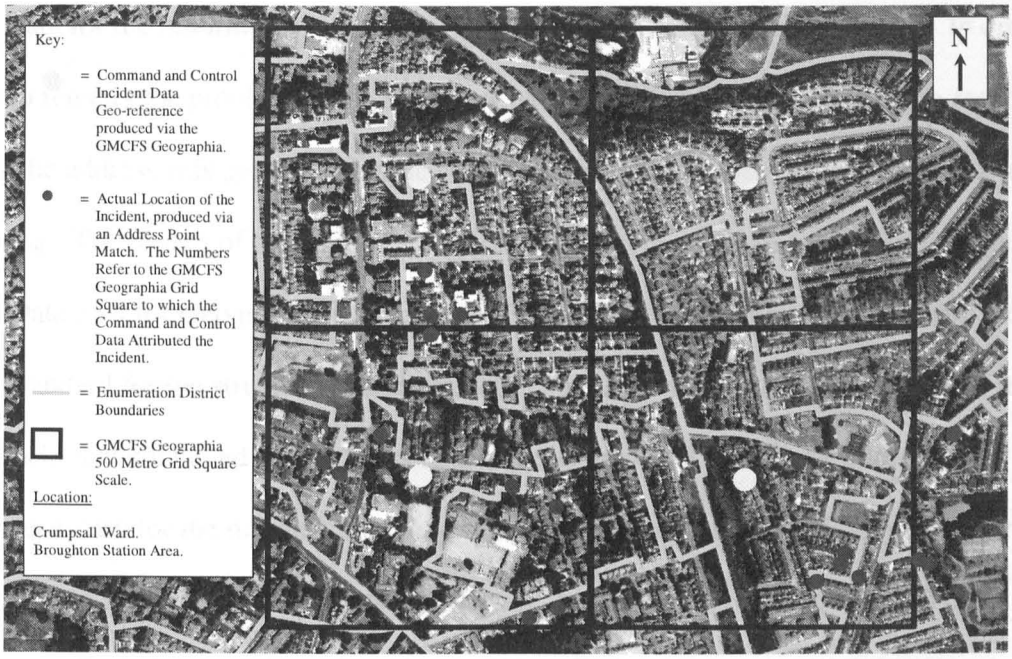


Figure 4.6 Locational Error Effect on SuperProfile Attribution to Incidents

This has obvious implications for any potential research or applied use of the data for the tailoring or targeting of intervention and fire safety initiatives. In order to remedy the problem it was necessary to turn to the address field for each record. The address was generated by the command and control system from the incident log. The format of the address field did not however conform to BS7666, Spatial Data Sets for Geographic Referencing (BSI, 1993), which provides a recommended standard for the structure of address data. The field was an unstructured single text field that contained both address data and contextual location data where though necessary for the dispatch of emergency vehicle. Examples of which include, across the road from, above shop, behind, outside, around the corner and so on. This complicated the manipulation of the address field, which was essential to improve the geographic reference held for each incident. Further to this the address field itself had been specified to allow a maximum of 20 characters when transferred from the command and control system which itself did not have a limit on the size of the address field. Unfortunately the command and control data was not kept and as such there was no way to retrieve the full address field originally held.

The potential improvement of incident geographic references through address matching is restricted to residential dwelling fire incidents for which a property name or number and partial street name are captured within the first 20 characters of the address field. A long and complex series of data manipulation and restructuring resulted in a file of dwelling fire incidents with the potential to be improved using address matching software that utilises the Address Point data set. Matching sequences were then run that resulted in a sample population of almost 23,500 individual dwelling fire incidents with verified addresses and full 12 figure OS national grid references.

The incident type and temporal distribution of the matched and unmatched data sample was compared and found to have no statistically significant variation and as such the matched sample population of incidents can be assumed to be representative of the wider population. As it was not possible accurately locate the incidents that were not matched it was not possible to consider the spatial distribution pattern of that group. However it seems unlikely that there would be a significant spatial bias to the quality of address data recorded and as such it is assumed that there is no difference between the sample population and the wider population as a whole. The derived data sets form the basis of the empirical research to be conducted.

4.6 Selection and Justification for the Choice of Additional Data Sets

The following section considers the range and utility of contextual and explanatory data sources to be used within the research. AADF is examined within the context of social, economic and environmental factors that are theorised to have explanatory power in relation to the spatial and temporal distribution of AADF and as such may have the potential be used as risk indicators and in the application of an area risk classification.

The data sets discussed and selected provide a range of contextual and explanatory variables drawn from differing sources and employing various methodologies of derivation and classification. In seeking to identify the most appropriate risk factor indicators for an area based study of differential incident frequency it is important to recognise that social, economic and environmental classification systems are subjective and aggregate area based classifications/typologies are further complicated by the imposition of boundary

systems whose robustness is subject to the limitations demonstrated by the modifiable aerial unit problem (Openshaw, 1984), further discussion of which will follow in the next section of this chapter. The initial data set to be considered is the Census of Population.

4.7 Census Data

The UK Census, undertaken every ten years, collects population and other statistics considered by many as essential to those who have to plan and allocate resources. The Census of Population 1991 provides the most comprehensive and consistent source of demographic and social data available at the small area level. From a relatively small number of questions a large number of cross tabulations are made available providing a wealth of information which is drawn upon by many other area based classifications. The smallest geographical unit for which census data is made available is the enumeration district (ED). The census data is collected at the individual household level and aggregated up to a range of administrative output areas.

The Enumeration District is the basic building block of the 1991 census outputs. An ED typically contains between 300 and 600 residents, with Greater Manchester being composed of 5182 of these administrative ED areas. The EDs nest within the larger areas of the Ward, of which there are 214 in Greater Manchester with an average population of around 11500 residents and 4600 households. The ED and the ward provide a predefined nationally comprehensive set of spatial units which are commonly used by many organisations and for which the data from the census is available. Both the ward and ED represent spatial units of aggregation to which incidents of AADF can be attributed in order consider the area characteristics

that may be found to be associated with areas of relative high or low incident frequency.

Whilst acknowledging the problems associated with the modifiable areal unit problem, the selection of commonly used comprehensive and consistent predefined boundaries is made to minimise the problem of the User Modifiable Areal Unit Problem (Openshaw, 1984), which is described by Openshaw as the proliferation of user defined areal units to suit specific functions. This results in the problems associated with non continuity of data sets which leads to difficulties for sharing and integrating data. For these reasons census geography has been adopted as the unit of analysis for the fire incident data, providing a consistent and comprehensive national set of boundaries for the analysis. These boundaries are both recognised and utilised by a wide range of people and organisations and for which both census data and other data sets are available.

The raw census data itself is considered to be about 90-95 % accurate (Openshaw, 1995, p 9) whilst variables based upon a 10% sample of data are more problematic and may be less reliable. EDs with small numbers of specific counts may have an uncertainty level of around 50% due to small number problems. Issues such as sampling error, 10% variables, data-blurring, imputation of missing data, non random error in the distribution of missing data, coding error, incorrect answers supplied by individuals, and data ageing particularly in the later period of the inter census decade are all criticisms of the use of census data.

However the fact that the census is the single largest, most comprehensive source of socio-economic and demographic data available makes it a valuable source of information that has not yet become redundant. With the development of

computing and the information rich society in which we now live there are now numerous alternate sources of data which avoid some of the pitfalls of the census. Major structural weaknesses of the census include the lack of direct measures of income and relative deprivation. This results in the use of proxy variables being used as indirect measures of underlying social conditions.

Other countries ask directly the single most contentious question, that of household income levels. The Australian census has included a direct income measure classification question since 1976, this captures the gross household income, the question however has proven to be problematic generating the highest number of calls to the census completion hotline and has the highest levels of non-completion (9.4%) (Evans, J, 1996). The lack of a direct income question and issues of census ageing influenced the commissioning of the next data set to be considered, the Indices of Deprivation 2000 (Referred to as the IMD, although this is the composite of the six domain indices).

4.8 The Indices of Deprivation 2000

Commissioned by the DETR in 1998 the Indices of Deprivation 2000 was a response to growing criticisms of the 1991 Index of Local Conditions and its replacement the Index of Local Deprivation 1998, which were based upon both time decay and methodological arguments. At ward level the index is based upon the following six domains of deprivation:

- Income (25%)
- Employment (25%)
- Health deprivation and disability (15%)
- Education, skills and training (15%)

- Housing (10%)
- Geographical access to services (10%)

Each domain is based upon a range of predominantly non census variables which can be regularly and frequently updated, overcoming the time decay issues associated with the census and census based products. A composite Index of Multiple Deprivation is derived from a weighted aggregation of the individual domain scores, the weightings are shown in brackets next to domains above.

A weighted exponential transformation was used to generate identical domain distributions prior to combining the scores based upon the weighting presented, making the interpretation of the resulting IMD particularly difficult, beyond a direct ranked comparison of wards. The IMD represents a composite and specific measure of deprivation that is an alternative to the census based measures previously available. It is freely available, nationally comprehensive and although it is not census based it utilises census geography making it compatible with census outputs, census based classifications and user generated data sets. The aim of the research is that it should be of significant use to the FRS in enhancing their understanding of the problem of AADF and the potential to more effectively target resources to those areas of highest risk, as such the IMD represent a freely available measure of relative deprivation and as such will be used within the research.

As an alternative to the ward based and deprivation specific measure of the IMD, the ED based and area classification of the geodemographic typology system, SuperProfiles is now considered for use within the research.

4.9 Geodemographics

The term *geodemographics* refers to the development and application of spatially-referenced residential neighbourhood classifications based primarily, but not exclusively, on census data. Geodemographic classifications are generated using cluster analysis techniques to group together areas which are similar in terms of their demographic, socio-economic and housing composition. The classifications are usually produced at small area level, such as ED level. In a geodemographic classification, each area is assigned to a particular category out of a finite (and usually fairly small) number of possibilities (Brown and Batey, 1994).

The current version of Super Profiles at the date of the research was derived using information from the 1991 Population Census at ED level. Description of the resulting clusters was enhanced using data from the Electoral Roll and the Target Group Index (a consumer and lifestyle index derived by the British Market Research Bureau).

The stages involved in deriving the classification are discussed in more detail elsewhere (Brown and Batey, 1994). Broadly, some 120 variables were used to collapse Britain's 146,000 EDs into 160 neighbourhood types (or 'Super Profiles'). These were then re-grouped to form 40 'Target Markets' and 10 broader 'Lifestyle' categories. Hence, the classification is hierarchical and each ED has a Super Profile, Target Market and Lifestyle code (for example, a particular ED might be in the 'very high income professionals in exclusive areas' Target Market and the 'Affluent Achievers' Lifestyle). Table 4.2 sets out some of the characteristics of the 10 Lifestyle categories.

The table quantifies just some of the census variables that have gone into the derivation of the Super Profiles Lifestyles classification. It is apparent from the table

that the EDs that fall into the "Affluent Achievers" Lifestyle category has very low numbers of households without a car and males unemployed compared to the mean for EDs across the whole of Great Britain. By contrast the EDs falling into the "Have Nots" Lifestyle have significantly below average levels of owner occupation.

Table 4.2 Selected Characteristics of Each Superprofiles Lifestyle

Lifestyle	Households No Car	Males Unemployed	Lone Parent Families	Persons 65+	Owner Occupiers
1. Affluent Achievers	34	44	41	90	132
2. Thriving Greys	58	57	43	137	124
3. Settled Suburbans	59	59	57	84	131
4. Nest Builders	67	69	89	59	120
5. Urban Venturers	124	129	102	79	92
6. Country Life	34	50	43	91	104
7. Senior Citizens	139	111	67	205	89
8. Producers	125	113	87	131	84
9. Hard Pressed Families	138	154	167	75	75
10. Have Nots	192	249	285	78	34
G.B.mean (%)	33.3	11.1	4.1	7.0	66.3

(Brown and Batey, 1994,[2])

Notes: The figures are Location Quotients, comparing each variable to the G.B. Mean which has the value of 100. The variables were taken from the 1991 Population Census.

Detailed 'pen picture' descriptions of the demographic and social characteristics of the 10 clusters comprising the 'Lifestyle' level of the classification appear in Appendix 2. The most affluent lifestyle is the 'Affluent Achievers' and the least affluent is the 'Have Nots'.

Area classifications can enable researchers to gain a better understanding of geographical variations in the occurrence of victimisation and offending, social problems, medical conditions, lifestyle characteristics and consumer behaviour (e.g. Brown et al, 1991; Brown et al, 1995; Batey and Brown, 1995; Hirschfield et al, 1995). Geodemographic discriminators have been used in the British Crime Survey (BCS) since the mid 1980s and have been effective in discriminating between high and low crime areas. The types of residential neighbourhood with the greatest crime risks have been identified by tabulating victimisation rates from the BCS by neighbourhood cluster derived from the ACORN 'geodemographic' classification produced by CACI a marketing and policy analysis consultancy. In terms of residential burglary, for example, the areas of highest risk include the poorest council estates (i.e. public housing), multi-racial areas, and high status areas with an over-representation of single people. Burglary rates in these areas were between 2 and 3 times the national average (Mayhew et al, 1993).

Geodemographic classifications also provide a rich contextual description of areas which can give the researcher indicators as to why particular types of area are highly victimised. The classifications do not just define levels of deprivation but also reflect different housing stock, different employment patterns and different social behaviour. Such factors might have a significant impact on the criminogenics of an area that would not be highlighted by a measure that concentrated solely on deprivation, such as the IMD. Such factors apply also to the study of fire.

However, it is important to acknowledge that there are a number of drawbacks associated with the use of geodemographic classifications. One of these is the temptation to infer that the characteristics at area level also coincide at household level, in short the 'ecological fallacy', which is discussed in the following section of this chapter. A further problem is that the classification contains information from the 1991 Census of Population. The Census is only conducted every 10 years and so, by the late nineties the information is becoming out-of-date. The residential population of an area and indeed the land use of an area could have changed substantially in this period. For instance, a new residential estate could have been built, or the local authority could make changes in the allocation of housing in an area. However, this problem will affect any analysis that uses Census data.

Table 4.3 presents a breakdown of the population of Greater Manchester by SuperProfile Lifestyle.

Table 4.3 Greater Manchester by SuperProfile Lifestyle

	Lifestyle	hhlds	pop	Data as % Population	Index score Nat. average = 100
Affluent Achievers	1	72300	201361	8.1	89.7 Affluent Achievers
Thriving Greys	2	63668	156897	6.3	56.2 Thriving Greys
Settled Suburbans	3	138870	368859	14.8	130.9 Settled Suburbans
Nest Builders	4	179685	472465	18.9	128.9 Nest Builders
Urban Venturers	5	69815	183091	7.3	71.3 Urban Venturers
Country Life	6	1643	4468	0.2	6.4 Country Life
Senior Citizens	7	62551	128742	5.2	64.5 Senior Citizens
Producers	8	157378	357293	14.3	93.6 Producers
Hard-Pressed Families	9	98394	249344	10.0	138.9 Hard-Pressed Families
Have-Nots	10	154061	371304	14.9	146.0 Have-Nots
Total		998365	2493824	100.0	

The use of SuperProfiles within this research provides an additional and alternative classification of areas beyond that of the IMD. SuperProfiles does however have an underlying associated affluence scale which allows a certain level of alignment when considering both sets of data. The issues relating to spatial analysis are now considered and the methodology to be undertaken presented.

4.10 Spatial Analysis Issues and Data

In conducting any type of spatial analysis of data there are numerous issues that that the researcher and end user must be aware of. Some of these issues have already been alluded to in the text and are briefly elaborated upon here to ensure clarity.

Ecological fallacy – described in 'Ecological correlations and the behaviour of individuals' (Robinson, W.S., 1950). US census data was used to consider the association between area level illiteracy rates and % population who were black. The correlation coefficient between the two variables was 0.773. Individual level data for the same areas produced a correlation value of 0.203. It is clear that assumptions can not be made about the characteristics of individuals or groups of individuals from the aggregate data an area.

The individualistic fallacy relates to the misinterpretation of variables occurring in conjunction with one another that may or may not interact. Assuming that the whole is no more than the sum of its constituent parts may well be incorrect, individual variables may be inert in terms of a given hypothesis, yet may prove highly significant in combination with one or more other variables. Research in the area of natural disaster vulnerability at the household level, (Betty Hearn Morrow,

1999), shows that far from being mutually exclusive, risk factors tend to occur in combinations (or may arise from combinations) and can intensify risk exponentially. Failure to explicitly recognise and control for the limitations of your data may lead to spurious results. Community variation is often more than mere aggregations of their individual members.

Modifiable Areal Unit Problem - Aggregation of data in areal units for geographical analysis has been shown to be particularly problematic. Aggregate data defined by areal units is dependant upon the definition of those units. 'A Million or so correlation coefficients' (Openshaw and Taylor, 1981) showed that 500,000 residents of the city of Sheffield could be grouped by 29 wards in a variety of ward like contiguous territories, such as that when considering two variables across the territories a range of correlation coefficients from +1.00 to -1.00 could be acheived. Figure 4.7 demonstrates the effect with the rotation of the 500m grid square through an angle of 90^{o} resulting in the previously equal distribution of incidents (denoted by the black dots) now being enumerated in alternate pairs and absences. An alternative to this is when a cluster of incidents or area characteristics is split by the imposition of a boundary diluting the effect between two or more areal units, which may result in a significant concentration of the variable of interest falling below a set threshold and going unnoticed in the analysis. Figure 4.8 illustrates the phenomenon. The result is that two areas of the same area and shape present entirely different frequency profiles based upon the choice of positioning.

Figure 4.7

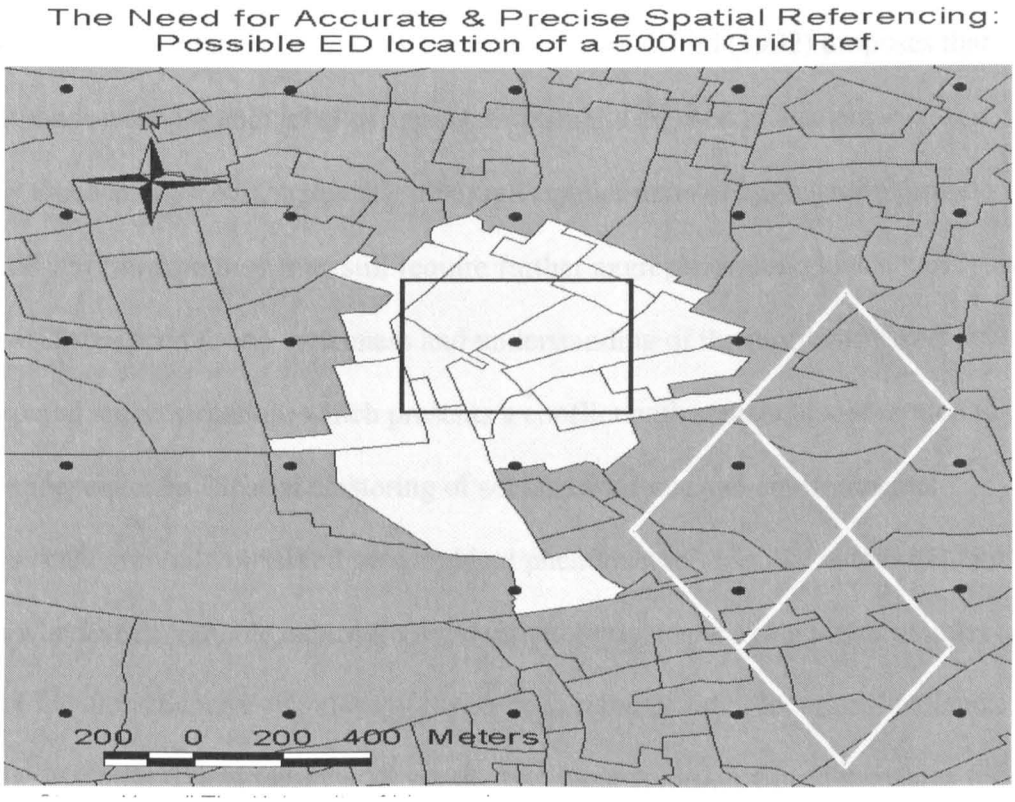
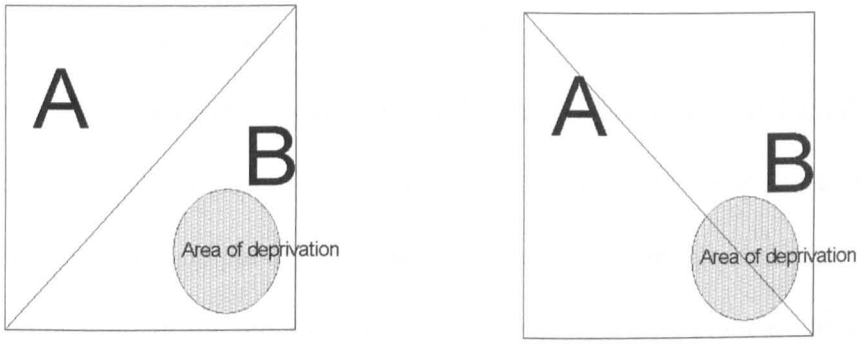


Figure 4.8 Modifiable Areal Unit Problem



A further factor to be considered is the 'Scale Effect' as described by Openshaw (1977), who reports that the larger the unit of aggregation the larger, on average, is the correlation between two variables. Goodchild (1992) proposes that data at the lowest possible level of aggregation should be used in analysis.

Openshaw (1996), states that although smaller units of aggregation provide more design freedom they may still require further aggregation for adequate analysis. There is also a need for an awareness and understanding of the problems associated with spatial autocorrelation, which presents a conflict with statistical assumption of serial independence. Spatial clustering of social, economic and environmental factors is a commonly observed geographical phenomenon. 'Spatial autocorrelation exists whenever a variable exhibits a regular pattern over space in which its values at a set of locations depend on values of the same variable at other locations' Odland, (1988). Moran's 'I' and Geary's 'c' are the two most commonly used measures for spatial autocorrelation of continuous variables.

Having identified the potential data sources for use within the research and given consideration to the peculiarities of spatial analysis it is also worth noting that some of these issues also relate to the temporal analysis of data, in terms of the choice of temporal subdivision divisions of the day, which when conducted in conjunction with an area based analysis presents the potential for spatio-temporal modifiable areal unit complexities to have influence of the results achieved.

The benefits of the predefined typologies presented by the ward level IMD and ED level Superprofiles classifications present both clear methodological derivation and spatial unit consistency in associative area characteristic data sources for use within the research. The census based Superprofiles provides a predefined, sophisticated use of the ED level census variables with additional non census inputs.

The nature of the methodology used captures those areas that are most alike based upon the range of variables used and useful pen pictures and descriptors are provided for the user, presenting a generalised but detailed typology of each area group. This provides an excellent data source for the research into AADF and it spatio-temporal distribution profile.

The theoretical model presented identifies the interaction of domestic routine activities and the behavioural trigger events which act to increase risk; the aim is to identify area characteristics that are associated with varying AADF profiles, that although not to be assumed as causally related, may act as useful indicators of risk. The choice of two pre-exiting measures of area characteristics is made over the use of individual census variables as the ability to derive causative relationships is not possible from the data available. As such we are seeking to identify the characteristics of the areas not the individual households and for this purpose a generalised measure of deprivation such as the IMD or a classification areas of similar characteristics such as SuperProfiles are well suited to the task.

It does not however indicate that the author considers individual or groups of census variables to be less worthy of inclusion or of a lower likelihood to prove a useful discriminatory tool in terms of differential AADF risk, but that the level of access to and analytical skills required to replicate the likely use of the individual variables would act to limit the potential replication and development of the research by the intended users, the FRS. Predefined and relatively user-friendly classification systems present the most accessible source of area discriminators available to the FRS.

With the basic data structure in place, the manipulation and analysis of the fire incident data now becomes the subject of further detailed analysis. In the context

of the proposed theoretical model of AADF we are able to consider the area characteristics that may be associated with increased incidence levels and further consider what the relationship may exist between the levels of the potential domestic routine activities that have an inherent level of risk, and the lack of due care and attention in the execution of those activities that acts as a trigger event to substantially increase that risk.

Initial data manipulation, subsequent to the extensive work to improve the locational referencing of the incident data base and sourcing of additional data, was to bring those data sets together through the unifying factor of geography. With the use of ArcView GIS software the individual incidents were plotted and intersected with the ward and enumeration boundary data sets for the Greater Manchester area. The area level characteristics in the form of the IMD and SuperProfile typology classes were also incorporated into the data set through the same process and census ward and ED population and household counts were appended to individual records. It was decided to make use of the 1991 ED boundary set and population figures for the research. The decision was made based upon the fact that the data set to be utilised commences on the date of the 1991 census and so starts from a validated point in time at which the census captured a snapshot of the ED level area characteristics. Further to this the ED based SuperProfiles typology was generated at this level using this boundary set, and as with the census is subject to a time decay effect upon its validity and representativeness.

The research by necessity will use a single aggregate time period of AADF incidents due to the relatively low frequency of AADF, this acts also to minimise the effect of boundary changes upon the analysis. This is due to the fact the data is being

treated as having occurred across a fixed period in time within which temporal variation of the aggregate incidents is to be conducted, with the reported outcomes based upon the fixed geography, census and geodemographic data sets. The resulting file produced from the GIS processing, brings together the range of data sets to be used within the empirical research analysis. The master data files provide individual incident level, and aggregate ward and ED level data sets which contain the combined incident record details and area characteristics to specific those wards and EDs within which they occurred.

The enhanced data sets produced, were then subjected to a range of exploratory data analysis and statistical testing, utilising both GIS and SPSS software. These tests were conducted both at the ward and ED levels and the resulting outputs compared and contrasted. The following chapter presents the detailed methodology and results.

4.11 Summary

This chapter has placed the research in the wider context of the fire and rescue service, as the organisation charged with the reduction of and response to AADF. The case study selection criteria were stated and the GMFRS was introduced as the participating FRS. The issues relating to the sourcing and manipulation of the extensive GMFRS incident data were presented along with the significant problems of successfully geographically recoding the incident data to meet the required standards for the research. Illustrative examples of the problems were provided and the issues relating to spatial and temporal analysis were addressed. The choice of Wards and EDs as the spatial units of analysis was also explored and justified in the context of the spatial analysis issues already presented. The availability and

suitability of the additional contextual and associative data sources in the form of the IMD and SuperProfiles was presented and assessed in relation to the aim of the research and the utility to the FRS of the theoretical model of AADF and associated analytical methodology developed.

The following chapter presents the detailed methodology, analysis and results.

Chapter 5

Methodology Development and Incident Data Analysis

5.1 Introduction

The previous chapters have identified and presented the need for a greater understanding of the spatial and temporal distributions of AADF, and specifically the potential discriminatory potential of measures of deprivation and geodemographic typologies. This chapter addresses those issues and the research questions set in Chapter 3 by processing, querying and analysing the enhanced AADF incident data set. The stages methodology development and spatial, temporal, and spatio-temporal analysis are presented and the results and their statistical significance are discussed. The analysis aims to address the problem of AADF in terms of providing empirical evidence about the relationships between causes of ignition, spatial and temporal, and spatio-temporal distributions of incidents, and the association of area characteristics with differential fire incident profiles.

5.2 Methodology Development and Analysis

The enhanced dwelling fire incident data set contained 23435 individual incident records covering the period from the date of the 1991 census of population, the 21st of April 1991 through to the 10th of September 1999. The data contained all dwelling fire incidents including those that were the result of malicious or deliberate acts of ignition. These accounted for 19% of the sample population roughly in line with the GMCFS and national rates for deliberate ignition dwelling fire incidents. The decision was made to exclude incidents of deliberate ignition as the focus of the research is on anthropogenic accidental dwelling fires. The factors involved in the

relationship between the offender and victim of arson, although of interest, fall outside the model of AADF, and is more akin to the environmental criminology model of routine activities as proposed by Cohen and Felson, (1979), which details the relationship between offender, victim and location.

The theoretical model proposed and tested in this thesis is specific to those incidents classed as accidental anthropogenic dwelling fire. The cases of deliberate ignition dwelling fire were selected and removed from the data set. The resulting file of incident data contained 19015 addressed and geographically coded incidents. The source of the verified and standardised address and national grid reference was Address Point Data. Address Point Data is a standard and widely used address gazetteer that is specific to locations of postal addresses. The gazetteer is well suited to the matching of data on residential properties; it is acknowledged that there are some questions as to the level of accuracy of some of the data held, however it is a nationally comprehensive and standardised data set which is widely available and used by both private and public sector bodies, as such with the utility of any proposed methodology and findings in mind, Address Point represents a satisfactory source of address verification.

5.2.1 AADF Incident Rate Concentrations

In order to answer the research question as to whether accidental dwelling fire is randomly distributed across the population an initial aggregation of all dwelling fire incidents was conducted at electoral Ward and Enumeration District level, the resulting aggregate AADF incident files were and ranked incident frequency tables were produced. These tables used household incident rates for AADF at the ED and Ward level, the rates were calculated from total fire incident counts and total household counts. The choice of household as a denominator for the

rates was made as this is the common unit of targeting and resource allocation when dealing with community fire safety and fire service targeting for dwelling fires.

Table 5.1 Targeting Table: All Accidental Dwelling Fires by Ward

% OF FIRES	NUMBER OF FIRES	% OF HOUSEHOLDS	NUMBER OF WARDs
5.85%	1113	1.99%	4
10.54%	2005	4.08%	8
24.95%	4744	12.50%	25
50.28%	9656	32.25%	67

From the basic summary targeting table, Targeting Table: All Accidental Dwelling Fires by Ward, Table 5.1, it can be seen that the ward level distribution of accidental dwelling fires is far from equal with the four highest fire incident level wards accounting for almost six percent of the total number of dwelling fires in the study population, whilst containing less than two percent of the households. The respective numbers for 10, 25 and 50% continue to show a trend of concentration of incidents with diminishing concentrations of fires as we move down the rows.

The methodology was repeated at the Enumeration District level, a finer level of geography with Manchester being comprised of over 5000 of these spatial units with average of about 200 households. The ED level table, Targeting Table: All Accidental Dwelling Fires by Enumeration District, Table 5.2, shows that there is an even greater concentration of incidents at this finer level of geography, indicating that there are areas of higher and lower concentration of fire incidents within individual wards. If this were not the case the proportional distribution of fires to households would be the same at both ward and ED level, this is clearly not the case.

Table 5.2 Targeting Table: All Accidental Dwelling Fires by Enumeration District

% OF FIRES	NUMBER OF FIRES	% OF HOUSEHOLDS	NUMBER OF EDs
5%	950	0.68%	35
10%	1900	1.91%	96
25%	4753	7.27%	361
50%	9503	20.80%	1041

The initial analysis of AADF incident rate distribution by both ward and ED shows a high level of concentration of incidents in a relatively low number of areas.

5.2.2 AADF Correlation with Deprivation and Geodemographic Classes

A preliminary test of correlation was then conducted to assess the level and direction of association between AADF incident frequencies and the ED level SuperProfiles and then again for the ward level IMD. Correlation coefficients were calculated at the ED level for all accidental dwelling fires across a range of SuperProfile classifications. The output is shown as ED Level SuperProfile Classification Correlations with AADF, Table 5.3

Table 5.3 ED Level SuperProfile Classification Correlations with AADF

Correlations					
		AADF	SP Lifestyle	SP Target Market	SP CLUSTER
AADF	Correlation	1	0.37	0.37	0.44
	Sig. (2-tailed)	.	0.00	0.00	0.00
	N	4573	4570	4570	4570
**	sig at the 0.01 level				

There is a significant and positive correlation between increased fire rate and each of the SuperProfile sub classification levels. The 10 class Lifestyle and 40 class

Target market categories perform equally well whilst the 160 class SuperProfile Cluster classification demonstrates a greater association with increased fire incidence with a correlation coefficient of 0.44. However with the relatively low frequency of AADF incidents, about 4 per 1000 households per year, the decision was made to use the more general 'Lifestyle' classification to ensure that there were sufficient observations in each class to generate robust statistical output. This is not to say the discriminatory power of the higher level classifications is redundant, the fine level of information on area similarity and dissimilarity may well prove extremely useful in discriminating between areas once a general association has been established. However, for the purposes of this research we will concentrate on the Lifestyle classification only.

At the ward level the Indices of Deprivation 2000 was tested in a bivariate correlation using a Spearman's rank test which resulted in a strong positive correlation being reported across all of the domain scores and the composite Index of Multiple Deprivation, shown in the table Indices of Deprivation Correlation Coefficients with AADF Incidents, Table 5.4. The fact that higher levels of correlation were observed at the ward level using the IMD as opposed to ED level SuperProfiles may well be influenced by the change in spatial area of aggregation with larger units of aggregation reporting on average higher levels of correlation between two variables, this is known as the scale effect with varying sizes of spatial unit resulting in differing statistical outputs for the same data set. Larger areal units of aggregation could conceal important smaller area patterns, smaller areal units may provide greater internal homogeneity, but rates become less reliable and correlation coefficients are generally smaller (Openshaw, 1977, 1981)

Table 5.4 Indices of Deprivation Correlation Coefficients with AADF Incidents

Correlations		FIRES
FIRES	Correlation	1.00
	Sig. (2-tailed)	.
	N	214.00
INDEX OF MULTIPLE DEP	Correlation	0.74
	Sig. (2-tailed)	0.00
	N	214.00
INCOME DOMAIN	Correlation	0.75
	Sig. (2-tailed)	0.00
	N	214.00
EMPLOYMENT DOMAIN	Correlation	0.76
	Sig. (2-tailed)	0.00
	N	214.00
HEALTH DOMAIN	Correlation	0.65
	Sig. (2-tailed)	0.00
	N	214.00
EDUCATION DOMAIN	Correlation	0.59
	Sig. (2-tailed)	0.00
	N	214.00
HOUSING DOMAIN	Correlation	0.59
	Sig. (2-tailed)	0.00
	N	214.00
ACCESS DOMAIN	Correlation	-0.48
	Sig. (2-tailed)	0.00
	N	214.00
CHILD POVERTY DOMAIN	Correlation	0.70
	Sig. (2-tailed)	0.00
	N	214.00
**	sig at the 0.01 level	

It is interesting to note that the correlation coefficients for each of the domain scores are generally proportionally in line with the relative weightings attributed to them for the generation of the composite IMD score.

The greater discriminatory power of the enumeration district as shown by the targeting tables indicates that there is merit in both use of the ED alongside the ward which achieved significantly higher correlation coefficient scores when used in conjunction with the IMD which is not available at the ED level.

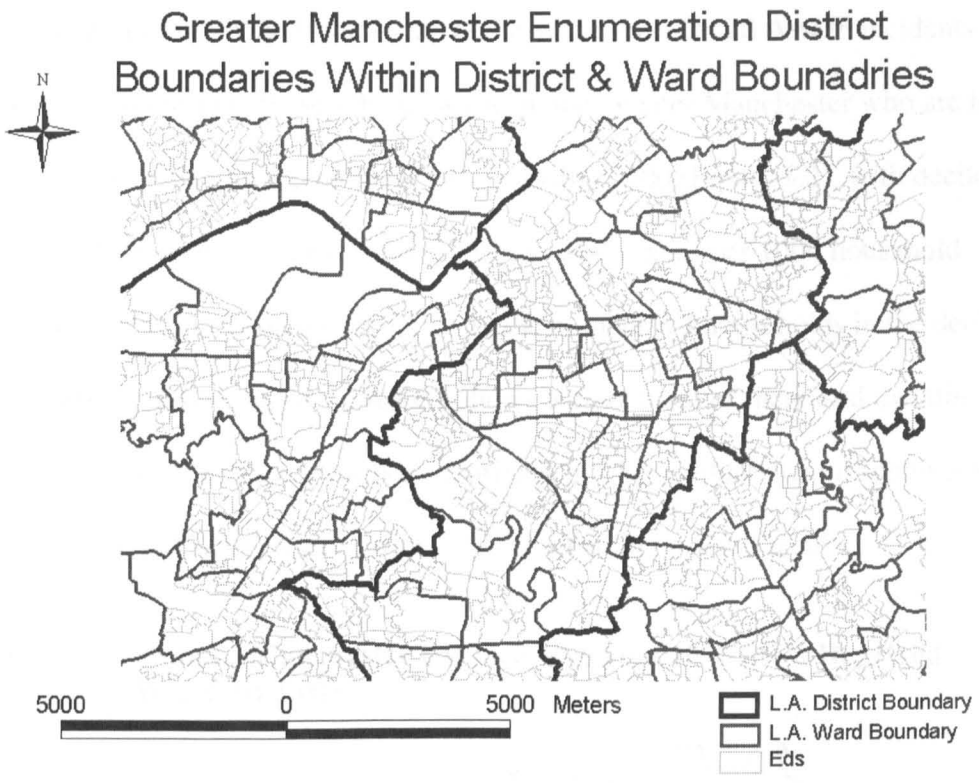
5.2.3 Areal Units of Analysis

The decision was made to concentrate on both the smallest level of aggregation and social data available to the study, the enumeration district and the larger aggregate unit of the ward (figure 5.1). This enabled the use of both the geodemographic typology of SuperProfiles to be used in profiling the areas and examining the association of AADF rates and area characteristics based upon the sophisticated cluster analysis of both census and non census variables, and also the ward level government standard and freely available Indices of Deprivation 2000. Both data sets represent potential discriminatory tools for placing the AADF profile of an area in a social, economic and environmental context which can be analysed without the need to conduct complex aggregations and modelling using multiple census variables from scratch. This is a considerable benefit to the FRS as an organisation as a whole who would benefit from comprehensive and standardised methodology and data sources for the analysis and interpretation AADF incident distribution and potential risk.

5.2.4 IMD Deciles AADF Distribution

The ward level analysis was then developed to incorporate not only the locational differential distribution but the contextual backcloth that the IMD provides. Details of the derivation of the IMD have previously been presented in chapter 4. The ward level index score provides a predefined, comprehensive and consistent composite measure of deprivation that is freely available and widely utilised. The results of the correlation coefficient test shown in table 5.4 indicated that there were several domain scores that were highly correlated with AADF incident rates, however there was little between the IMD and the best performing domains.

Figure 5.1



As the study is based upon data from a single large case study area the IMD, as a composite measure of multiple deprivation, represents the most likely nationally applicable indicator and as such will be used as the ward level socio-economic discriminator.

Ward decile groups were defined based upon equal numbers of cases (of wards) within the research case study data set. The decision to utilise equal number of cases as a subdivision methodology rather than a sub division of IMD score itself is based upon the complex derivation of the index and problems of interpreting the values beyond ranking them. The IMD 2000 score is the combined sum of the weighted, exponentially transformed domain rank of the domain score. Again, the bigger the IMD 2000 score, the more deprived the ward. However, because of the exponential distribution, it is not possible to say, for example, that a ward with a score of 40 is twice as deprived as a ward with a score of 20 (DETR, 2000).

The table IMD Deciles AADF Distribution, Table 5.5 shows the frequencies and incident rates by IMD decile group at the Ward level for all AADF incidents. IMD decile 1 represents those 10% 0f wards in the Greater Manchester who are least deprived as classified by the Indices of Deprivation 2000 (Figure 5.2), with decile 10 consisting of the most deprived wards. The use of the rates per 1000 household controls for the slight observed variation in the numbers of households in the decile groups. Visual inspection of the results shows a clear trend of increased dwelling fire incidence with increased levels of deprivation. This is illustrated in figure 5.3, IMD Decile AADF Distribution, which shows a bar chart of the results.

Figure 5.2 Greater Manchester Districts Showing 10% Most Deprived Wards by IMD

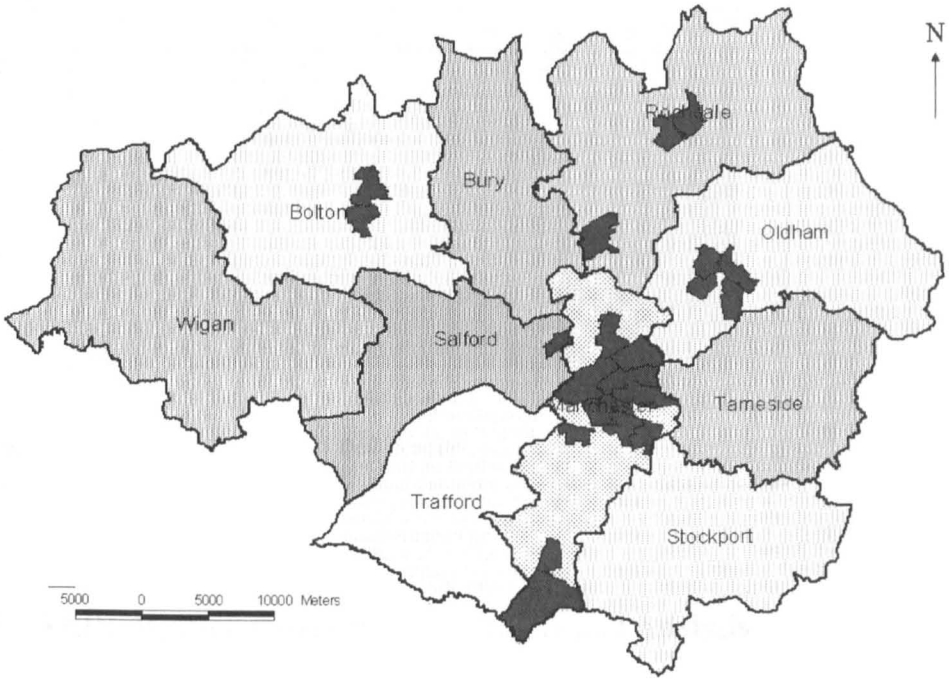
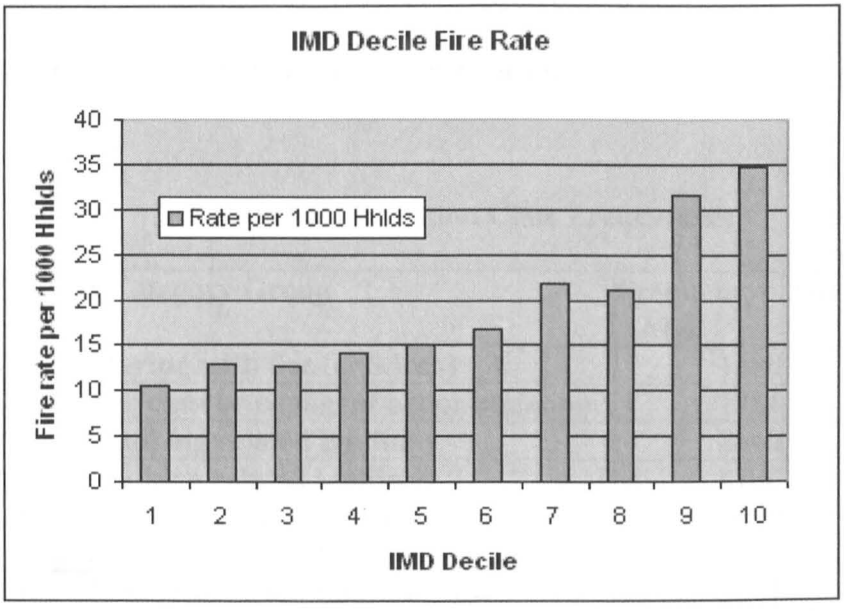


Table 5.5 IMD Deciles AADF Distribution

IMD Deciles	Households	Fires	Rate per 1000 Hhlds
1	101398	1057	10.42
2	97487	1250	12.82
3	108088	1383	12.8
4	98023	1379	14.07
5	98543	1484	15.06
6	98132	1649	16.8
7	103879	2253	21.69
8	96458	2030	21.05
9	99089	3142	31.71
10	97268	3388	34.83

Figure 5.3 IMD Decile AADF Distribution



5.2.5 AADF Ignition Category Classification and Analysis

In order to explore the detail of the relationship between the chosen socio-economic indicators and the potential variation across the IMD and Superprofiles groups, 6 Ignition categories were created which collapsed the wider range of categories capturing 91% of all AADF incidents in the sample population. Table 5.6,

AADF Act of Ignition Class Frequencies, shows the distribution of incidents across the ignition act categories.

For the purposes of the research from this point onwards the data analysis will be based upon those incidents in the ignition categories 1 through 6, category descriptions are listed below:

Category 1 = Playing with fire (children)

Category 2 = Accident or negligent act or omission

Category 3 = Smoking related ignitions

Category 4 = Cooking related ignitions

Category 5 = Article too close or dropped onto a heat source

Category 6 = Electrical or appliance misuse

Table 5.6 AADF Act of Ignition Class Frequencies

Ignition Category Group		Frequency AADF	Percent %	Cumulative Percentage
1 =	Playing with fire (children)	1590	8.4	8.4
2 =	Accident or negligent act or omission	1784	9.4	17.7
3 =	Smoking related ignitions	2440	12.8	30.6
4 =	Cooking related ignitions	8706	45.8	76.4
5 =	Article too close or dropped onto a heat source	691	3.6	80.0
6 =	Electrical or appliance misuse	2174	11.4	91.4
7 =	Other	1630	8.6	100.0
Total		19015	100.0	

The resulting sample of incident data (17385 cases) now fits the requirements of the proposed model of accidental anthropogenic dwelling fire, with the data reporting those incidents that are the result of the inappropriate behaviour, acts or omission by the dwelling occupants, the 'Trigger Event'.

It has been shown that there is a disproportionate distribution of incidents at the electoral ward level (table 5.1) and that the introduction of a ward level classification by IMD score deciles also reports a distinct increase in the frequency rate of AADF with increased levels of deprivation. In order to explore the inter-relationships of the IMD decile groups and the sub classification of incidents by the nature of the act of ignition of AADF, a cross tabulation of the variables has been conducted and a chi square statistic produced, testing the statistical probability and significance of the observed distribution. The results are shown in table 5.7, IMD Decile by Act of Ignition Recoded Cross tabulation (Counts), with the chi square statistic reporting that there is a significant difference in the observed distribution of act of ignition frequency distribution by IMD decile group.

Table 5.7 IMD Decile by Act of Ignition Recoded Cross Tabulation (Counts)

IMD DECILE		Ignition Category						Total
		1 Children	2 Accident	3 Smoking	4 Cooking	5 Too Close	6 Electrical	
1	Count	19	144	85	446	47	211	952
1	Expected Count	87.1	97.7	133.6	476.7	37.8	119.0	952.0
2	Count	43	149	102	589	44	206	1133
2	Expected Count	103.6	116.3	159.0	567.4	45.0	141.7	1133.0
3	Count	65	151	112	680	43	201	1252
3	Expected Count	114.5	128.5	175.7	627.0	49.8	156.6	1252.0
4	Count	52	165	119	638	70	205	1249
4	Expected Count	114.2	128.2	175.3	625.5	49.6	156.2	1249.0
5	Count	83	149	131	737	56	188	1344
5	Expected Count	122.9	137.9	188.6	673.0	53.4	168.1	1344.0
6	Count	98	149	166	848	48	214	1523
6	Expected Count	139.3	156.3	213.8	762.7	60.5	190.5	1523.0
7	Count	139	208	304	1077	96	246	2070
7	Expected Count	189.3	212.4	290.5	1036.6	82.3	258.9	2070.0
8	Count	133	165	269	961	72	232	1832
8	Expected Count	167.6	188.0	257.1	917.4	72.8	229.1	1832.0
9	Count	446	250	639	1281	94	220	2930
9	Expected Count	268.0	300.7	411.2	1467.3	116.5	366.4	2930.0
10	Count	512	254	513	1449	121	251	3100
10	Expected Count	283.5	318.1	435.1	1552.4	123.2	387.7	3100.0
Total	Count	1590	1784	2440	8706	691	2174	17385
Total	Expected Count	1590.0	1784.0	2440.0	8706.0	691.0	2174.0	17385.0

Chi-Square Test

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	1131.209	45	.000
N of Valid Cases	17385		

0 cells (.0%) have expected count less than 5. The minimum expected count is 37.84.

5.2.6 Standardised Residuals of AADF Frequencies by IMD Decile and Ignition Category

For the IMD Decile / Ignition category table of frequencies, the expected count for each cell was calculated utilising marginal row and column totals. An adjusted residual 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).

The residual scores measure how many standard deviations the observed frequency is from the expected. Approximately 95 percent of adjusted residuals lie two standard deviations either side of zero and over 99 percent of adjusted residuals are contained within three standard deviations of zero. Clearly, positive residuals reflect a higher than expected AADF incidents within the ignition category compared to the number expected by chance. Cells with a significantly greater number of observed than expected incidents will be those with the highest residuals.

It was decided to only look at the pattern of residuals greater that two, equating to a 5% likelihood of these values occurring by chance, whilst cells with a residual value of 3 or more have only a 1% likelihood of occurring by chance. Thus in a matrix of 60 cells, as represented here, it would be expected that 3 cells with residuals of greater than 2 would occur by chance and for the at the 1% level this would equate to 0.6 with a residual score of over 3 occurring by chance. According to Agresti and Finlay (1997) "a large adjusted residual provides evidence against

independence in that cell; a cell value exceeding about 3 provides strong evidence" (p 262).

The resulting standardised residuals table for IMD Decile by Ignition Category AADF incident frequencies is shown as table 5.8. For ease of interpretation cells with a high positive standardised residual score of >2 and therefore representing a greater than expected frequency of AADF incidents are coloured Red, whilst cells with a high negative standardised residual score of <2 and therefore representing a lower than expected frequency of AADF incidents are coloured Green, this applies to all standardised residual tables in this chapter.

The standardised residuals table 5.8 shows that there is highly significant and varied distribution of incidents both across and within IMD deciles and Ignition categories. If we examine the results by ignition category, those incidents due to children playing with fire are dominated by the most deprived, 9th and 10th deciles which exhibit highly significant variation above the expected incident frequency, with all other deciles being significantly lower than expected.

Table 5.8 Standardised Residuals of AADF Frequencies by IMD Decile, Ignition Category

IMD DECILE	IGNITION CATEGORY					
	1 Children	2 Accident	3 Smoking	4 Cooking	5 Too Close	6 Electrical
1	-15.87	4.37	-5.62	-2.05	1.42	7.55
2	-9.56	3.01	-6.05	1.33	-0.16	5.21
3	-6.44	2.04	-6.46	3.13	-1.08	3.59
4	-8.96	3.23	-5.56	0.74	2.64	3.92
5	-4.65	1.01	-5.45	3.66	0.37	1.64
6	-4.45	-0.66	-4.07	4.63	-1.91	1.83
7	-4.63	-0.34	0.89	1.90	1.55	-0.93
8	-3.25	-1.97	0.83	2.16	-0.10	0.22
9	10.79	-3.61	11.86	-7.51	-2.53	-10.83
10	13.42	-4.53	4.24	-4.08	-0.23	-9.57

The category for accidental ignition or neglect (not smoking or cooking related), shows that the relatively less deprived wards in deciles 1 to 4 have significantly higher than expected incidence in that category, and the 9th and 10th deciles significantly less than expected frequencies.

Smoking related ignitions are again significantly over represented in the 9th and 10th deciles, with deciles 1 through 6 having a significantly lower than expected incident frequency.

Cooking related incidents show both the most deprived and least deprived deciles having significantly lower than expected incidence with 3, 5, 6 and 8 having significantly higher levels of cooking related ignitions than expected.

The least varied of the ignition categories is those incidents resulting for articles being placed too close to a heat source or dropped onto a heat source. Decile 4 was significantly over represented in this category and decile 9 under represented. Finally electrical and appliance misuse related incidence showed that the most deprived deciles 9 and 10 were again significantly under the expected frequency level whilst the less deprived areas in deciles 1 through 4 had significantly higher level of incidence than expected.

The table shows that contained within the Chi square statistic that reports that there is significant variation between and across IMD deciles and Ignition categories, the individual cell frequencies can provide information as to the statistical significance of the residuals. The statistically significant variation in the ignition category profiles of IMD groups provides important and useful information for FRS use in targeting education and prevention resources by ward in line with the highest significant standardised residual scores.

5.2.7 Development of a Domestic Routine Activities Time Classification

Having established that there is a significant variation from the expected distribution of AADF incidents when analysing AADF ignition categories by ward IMD deciles we now introduce the temporal distribution of those incidents testing again for variation from the expected distribution of AADF incidents by time of the day within IMD deciles.

The proposition of the AADF theoretical model is that it is the domestic routine activities that are undertaken in the dwellings that have a potential fire risk in combination with the other stated factors. The functional tempo, rhythm and timing (Hawley, 1950) are integral parts of the domestic community structure and as such it is important to capture the generalised patterns of activity within domestic dwellings as well as we can. It is proposed that there may be discernable differences in the patterns of activity across areas due to factors such as unemployment and demographics which may influence the classification of time periods and their function. This is described by LeBeau and Coulson (1996), who use the categories discretionary and obligatory to describe the differences in activity characteristics of different time periods, with obligatory time periods generating less demand for service from the police as people are at work and so less susceptible to personal crime and perhaps unaware of property crime.

The time periods used in the analysis are 4 hour blocks which have been specified so as to capture functional nature of domestic routine activities throughout the day. The time divisions chosen cover the full 24 hour period of a single day.

The first period selected as a transition period from one day to the next, covering 2300hrs through to 0259hrs. This period has been specified so as to capture the late night household activity that may be associated with retiring for the night and

returning from external entertainment activities including public houses and clubs closing times.

The next period covers 0300hrs to 0659hrs, encompassing the block of time during which the majority of people will be sleeping, and perhaps beginning to wake and begin the day's activities. There is likely to be little AADF risk activity during this period, however there may be cases of slower developing fires caused primarily by smokers materials discarded at an earlier point in the evening.

0700hrs through until 1059hrs captures the beginning of household activities for the majority of people. Cooking of breakfast, cigarette smoking and the work and school rush which is likely to subside as we move through this period.

From 1100hrs to 1459hrs people are likely to be at work and children at school, however the lunchtime period is also contained in this block and as such there this is likely to be associated with an increase in the routine domestic activities undertaken.

1500hrs through until 1859hrs covers the period of schools closing, work ending and the main evening meal for households. This is likely to be a period of intense household activity across the full time period.

Finally 1900hrs through until 2259hrs covers the end of the day and the general winding down of domestic activity. Risk activity in the form of smoking related incidents is however likely to be high during this period as active household occupation levels are likely to be at there highest during this period.

Table 5.9, Functional Activity Time Period Classification, Description and Incident Frequency, provides a summary of AADF incident frequencies for each of the defined time periods.

Table 5.9 Domestic Routine Activities Time Classification, Description and Incident Frequency

Time Period	Description	Incident Frequency
1 = 23.00 – 02.59	Night / early morning, public houses and clubs closing times.	2000 11.5%
2 = 03.00 – 6.59	Early hours of the morning, little activity, most people asleep.	888 5.1%
3 = 07.00 – 10.59	Breakfast period, start of work, school rush.	1896 10.9%
4 = 11.00 – 14.59	Lunch period.	3478 20%
5 = 15.00 – 18.59	End of school, work, and main evening meal period.	5409 31.1%
6 = 19.00 – 22.59	Late evening highest active occupation levels	3714 21.4%
	Total	17385

The table itself shows that the observed distribution fits the proposed theoretical model of AADF with the generalised domestic routine patterns of activity mirrored in the observed frequencies of AADF incidents. The significant peak of AADF occurs within the period in which the evening meal is cooked and there is a build up of activity as juveniles finish school and people finish work. The lunch and late evening periods also show high levels of AADF incidents which again fit the proposed AADF model in terms of the activity patterns proposed. The night / early morning time period shows a slowing down of activity and demand for service from the FRS accounting for 11.5% of all incidents by time block. The lowest level of AADF incidents (5.1%) is evident for the early hours of the morning between 0300hrs and 0659hrs which correlates with the lowest expected domestic routine activities level as people are likely to be sleeping.

5.2.8 Standardised Residuals of AADF Frequencies by IMD Decile and Domestic Routine Activities Time Classification

A cross tabulation analysis and chi square test was conducted on the AADF incident data examining the observed variation by IMD deciles and hour block groups. The reported chi square statistic shows significant variation between the observed and expected frequencies of IMD group hour blocks. Table 5.10, AADF Standardised Residuals for IMD Deciles by Domestic Routine Activities Time Classification, shows the standardised residuals, calculated in the same way as for the IMD / ignition variable. Although the Chi square value reports significant variation it is clear from examination of the standardised residuals that there is far less significant variation in individual cells than was observed for the IMD deciles by ignition category frequencies. There are however 3 cells of significantly high AADF incident frequencies which again will inform FRS targeting.

Table 5.10 AADF Standardised Residuals for IMD Deciles by Domestic Routine Activities Time Classification

	Hour Block					
IMD Group	**23.00–02.591**	**03.00 – 06.59**	**07.00 – 10.59**	**11.00 – 14.59**	**15.00 – 18.59**	**19.00 – 22.59**
1	-5.82	0.91	1.25	0.21	0.63	1.16
2	-1.66	-0.71	1.27	1.37	0.30	-1.15
3	-0.19	0.78	1.39	-0.26	-0.29	-0.83
4	-1.82	-1.56	-0.40	1.02	1.34	-0.13
5	-0.88	-1.04	1.27	1.26	0.30	-1.43
6	-2.16	-1.97	0.33	-0.52	2.85	-0.49
7	0.93	-0.51	0.46	-0.24	1.10	-1.88
8	-0.37	0.05	0.95	0.09	-1.29	0.87
9	5.20	0.49	-1.71	-2.39	-2.28	1.47
10	1.18	2.11	-3.22	0.34	-1.36	1.37

Chi-Square Test

	Value	df	p. Sig. (2-sided)
Pearson Chi-Square	108.78	45	.000

5.2.9 Temporal Variation of AADF Incidents by Ignition Category Class

In order to assess if the observed AADF temporal variation is related to the ignition class categories a frequency table was produced. Again this is conducted by undertaking a cross tabulation of the data and conducting a chi square test. The resulting chi square statistic and frequency table is shown as table 5.11, AADF Incident Frequency by Temporal Variation of Ignition Class and Domestic Routine Activities Time Classification.

Table 5.11 AADF Incident Frequency by Temporal Variation of Ignition Class and Domestic Routine Activities Time Classification

	Ignition Category						Total
Hour groups	1 Children	2 Accident	3 Smoking	4 Cooking	5 Too Close	6 Electrical	
23.00–02.59	88	175	558	826	94	259	2000
03.00–06.59	35	103	272	296	51	131	888
07.00–10.59	258	235	271	674	93	365	1896
11.00–14.59	333	394	361	1788	126	476	3478
15.00–18.59	512	498	431	3317	171	480	5409
19.00–22.59	364	379	547	1805	156	463	3714
Total	1590	1784	2440	8706	691	2174	17385

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	735.4	25	0.000

The frequency distribution table 5.11 shows that pattern of incident distribution by ignition category fits the theoretically based model of AADF with the all ignition categories conforming to the domestic routine activities levels expected for the time blocks through out the day and night. Cooking related incidents rise from lunch time peaking during the evening meal time block and then slowly reducing in

the later evening and night time blocks with the lowest levels in the early hours of the morning. Each ignition category follows the same pattern with the exception of smoking related incidents. Smoking exhibits a less pronounced variation across the day and has a later and sustained peak ignition period through the hours 7pm to 3am. This remains in line with the proposed theory as the routine activity of smoking is a regular waking hours activity which maintains its peak during the periods of highest levels of household occupancy and activity.

5.2.10 AADF Temporal Variation by Ignition Class Standardised Residuals

As previous discussed, a standardised residuals table was generated for time versus ignition category and is shown as table 5.12, AADF Incident Standardised Residuals by Ignition Class and Domestic Routine Activities Time Classification.

Table 5.12 AADF Incident Standardised Residuals by Ignition Class and Domestic Routine Activities Time Classification

	Ignition categories					
Hour groups	**1 Children**	**2 Accident**	**3 Smoking**	**4 Cooking**	**5 Too Close**	**6 Electrical**
23.00–02.59	-10.64	-2.51	15.74	-8.38	1.64	0.63
03.00 – 06.59	-8.05	1.28	11.38	-10.76	2.35	1.94
07.00 – 10.59	6.19	3.02	0.34	-13.76	2.01	8.16
11.00 – 14.59	0.96	2.24	-7.65	1.76	-1.22	2.29
15.00 – 18.59	0.97	-3.16	-18.15	21.58	-3.94	-10.63
19.00 – 22.59	1.52	-0.12	1.35	-2.02	0.77	-0.08

Table 5.12 shows that there is significant variation across ignition categories and hour groups, the significantly lower than expected frequencies of children

playing with fire in the hour groups 1 and two are consistent with children, especially younger children sleeping during these hours, whilst the significantly higher than expected incident frequency in hour block 3 is consistent with unsupervised children in the morning, whilst the guardians are in bed. This is supported by anecdotal evidence from fire fighters.

Anecdotal evidence also the significant standardised residual values in the hour blocks 2 and 3 for ignition category 5, incidents resulting from articles too close to heat sources, in which items are left to dry in front of a heat source overnight and there is a lack of supervision which can result in a fire.

The cooking related evening meal peak is clearly visible along with the smoking related late night fire incidents. The interesting smoking related cell is activity block 2, 03.00 – 06.59, in which although the incidence of fires starts to drop off during this time period of least household activity, the time delay in the development of smoking related fires is clearly visible and significantly in excess of the expected AADF incident frequency.

5.2.11 AADF Domestic Routine Activities Time Classification by AADF Ignition Class and IMD Groups

We now consider the variation within 4 hour time AADF Domestic Routine Activities Time Classification in relation to AADF Ignition class by IMD groups. In order to secure the statistical validity of the chi square results obtained from this three way cross tabulation the IMD deciles were collapsed into two classes, higher deprivation and lower deprivation. This effectively reduces the number of cells increasing the observed frequencies populating them. The resulting tables of frequencies for the lower deprivation group and the higher deprivation group are

shown as table 5.13 and 5.14. The reported chi square is significant for both higher and lower deprivation groups for each time and ignition combination.

Tables 5.13 & 5.14 again show that there is a clear frequency distribution concentration of incidents within the more deprived wards of Greater Manchester. It appears that the temporal and ignition category distributions are proportionately similar to the overall distributions presented earlier.

Table 5.13 AADF Ignition Class by Hour Group Lower Deprivation

Hour groups	Ignition						Total
	1 Children	2 Accident	3 Smoking	4 Cooking	5 Too Close	6 Electrical	
23.00–02.59	6	71	127	248	33	106	591
03.00 – 06.59	7	47	80	84	14	60	292
07.00 – 10.59	63	111	63	247	37	177	698
11.00 – 14.59	52	160	79	664	49	232	1236
15.00 – 18.59	82	215	84	1216	64	219	1880
19.00 – 22.59	52	154	116	631	63	217	1233
Total	262	758	549	3090	260	1011	5930

Chi-Square Tests					
	Value	df	Asymp. Sig. (2-sided)		
Pearson Chi-Square	531.9098	25	0.000		
N of Valid Cases	5930				
0 cells (.0%) have expected count less than 5. The minimum expected count is 12.80.					

In order to compare these two higher and lower deprivation groups with the previous non grouped distribution, standardised residuals tables for both high and low IMD groups were then produced, table 5.15 & 5.16, to identify the pattern of significant variation within and across the AADF ignition and time block groups. These can then be compared against each other and for the previous table 5.12 of the non-IMD grouped residuals.

Table 5.14 AADF Ignition Class by Hour Group Higher Deprivation

Hour groups	Ignition						Total
	1 Children	2 Accident	3 Smoking	4 Cooking	5 Too Close	6 Electrical	
23.00–02.59	82	104	431	578	61	153	1409
03.00 – 06.59	28	56	192	212	37	71	596
07.00 – 10.59	195	124	208	427	56	188	1198
11.00 – 14.59	281	234	282	1124	77	244	2242
15.00 – 18.59	430	283	347	2101	107	261	3529
19.00 – 22.59	312	225	431	1174	93	246	2481
Total	1328	1026	1891	5616	431	1163	11455

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	735.4189	25	0.000
N of Valid Cases	11455		

0 cells (.0%) have expected count less than 5. The minimum expected count is 22.42.

It is significant that in the comparison of the AADF Domestic Routine Activities temporal ignition category it remains relatively constant across the higher and lower deprivation IMD groups and remains in line with the observed distribution of the non grouped sample. This implies that whilst the frequency of incidents resulting from anthropogenic trigger events is higher in the more deprived wards, the pattern of domestic routine activities involving potential fire risk appears to be common to both groups.

One significant variation observed was that for the significant higher than expected frequency of 'items too close to a source of heat', observed in hour block 2, 03.00hrs – 06.59hrs, of the non grouped sample, this was found to be significant only in the more deprived sub group of incidents. Again this is supported by anecdotal evidence from fire fighters who report clothing being dried overnight in front of fires

in households without central heating or the money to use relatively expensive tumble dryers.

Table 5.15 Lower Deprivation Group AADF Incident Standardised Residuals by Ignition Class and Domestic Routine Activities Time Classification

Hour Groups	Ignition categories					
	1 Children	2 Accident	3 Smoking	4 Cooking	5 Too Close	6 Electrical
23.00–02.59	-8.35	-0.60	8.26	-5.21	1.36	0.59
03.00 – 06.59	-2.29	1.59	7.52	-8.93	0.34	1.53
07.00 – 10.59	4.87	2.44	-0.23	-9.63	1.17	5.56
11.00 – 14.59	-0.41	0.19	-4.45	1.28	-0.84	1.77
15.00 – 18.59	-0.14	-2.17	-10.92	14.65	-2.70	-8.25
19.00 – 22.59	-0.39	-0.35	0.20	-0.73	1.33	0.57

Table 5.16 Higher Deprivation Group AADF Incident Standardised Residuals by Ignition Class and Domestic Routine Activities Time Classification

Hour Groups	Ignition categories					
	1 Children	2 Accident	3 Smoking	4 Cooking	5 Too Close	6 Electrical
23.00–02.59	-9.56	-2.39	13.05	-6.45	1.13	0.91
03.00 – 06.59	-8.04	0.38	8.66	-7.00	2.59	1.37
07.00 – 10.59	4.75	1.69	0.83	-10.06	1.60	5.76
11.00 – 14.59	1.51	2.61	-6.08	1.17	-0.94	1.25
15.00 – 18.59	1.31	-2.41	-14.74	16.08	-2.92	-7.11
19.00 – 22.59	1.69	0.22	1.29	-1.91	-0.04	-0.45

5.2.12 Enumeration District Geodemographic Analysis

Having established the ward level temporal variation of AADF incidents by IMD decile and ignition category in line with the proposed theoretical model and research questions the same methodology was employed for the ED level analysis. SuperProfiles geodemographic typology lifestyle groups were generated with incidents aggregated to the ED level and then classified via the 10 Lifestyle typologies. The aggregate AADF incident distribution pattern was again examined in terms of the ignition categories of AADF and the temporal distribution of those incidents. It is proposed that the differing nature of the SuperProfiles geodemographic typology, both in terms of derivation of the classification and spatial scale, will result in a different distribution profile than the Ward based IMD, but the underlying influence of domestic routines will be evident within the observed distributions.

The smaller spatial area of the ED based geography employed by the SuperProfiles classification provides a higher level of discriminatory power than the ward based IMD. The sophistication of the cluster analysis process used in the derivation of the Lifestyle classifications provides a powerful and detailed area based typology which has the potential to provide valuable contextual risk information in terms of AADF. Again it should be stated that association is not indicative of a causal link only that there is a level of coincidence of factors at a given spatial level that can be used to inform FRS policy and management. The following analysis explores the extent to which the basic SuperProfile Lifestyle level descriptors are associated with the observed spatial and temporal distribution and AADF incidents.

The initial task was to aggregate all AADF incidents to the ED level and then aggregate the AADF incidents by the Superprofile Lifestyles. Rates of fire were then

calculated per 1000 population. The results, shown in table 5.17, AADF Incident Rates by SuperProfiles Lifestyle, show a range of incident rates which is similar to the IMD decile range, will the 'Thriving Greys' and 'Affluent Achievers' having the lowest rates of AADF and the 'Have Nots' the highest rates.

Although the Lifestyle classification is not an affluence scale there is an underlying association of affluence running from 'Affluent Achievers' down through the Lifestyles to the 'Have Nots'. The typology is significantly more sophisticated than a basic affluence rank and aims to cluster areas of similar characteristics.

The interesting variation observed is the high AADF incident rate for those areas described as 'Urban Venturers', with an AADF rate of 28.69 per 1000 households. These areas are described as 'cosmopolitan, multi-racial groups residing within areas of major cities undergoing gentrification but retaining a significant proportion of poorer quality housing' (Brown & Batey, 1994). Areas such as this may not be identified by the IMD classification in relation to AADF, as they have relatively high levels of disposable income and good access to services; they are also likely to have lower than average levels of unemployment. This represents a distinct difference from the ward based IMD classification which focuses solely on deprivation indicators.

The country life category, group 6, has only a very few incidents and households within the sample population and as such creates difficulties for the chi square and standardised residuals interpretation. Due to this the category was selected and removed from the AADF data set for the remaining analysis.

Table 5.17 AADF Incident Rates by SuperProfiles Lifestyle

SPLS	AADF	HHLDS	RATE 1000 hhlds
1 – Affluent Achievers	703	72300	9.72
2 – Thriving Greys	573	63668	9.00
3 – Settled Greys	1518	138870	10.93
4 – Nest Builders	2423	179685	13.48
5 – Urban Venturers	2003	69815	28.69
6 – Country Life	18	1643	10.96
7 – Senior Citizens	1141	62551	18.24
8- Producers	2904	157378	18.45
9 – Hard Pressed Families	2083	98394	21.17
10 – Have Nots	5645	154061	36.64

5.2.13 AADF Incident Frequency and Standardised Residuals by Ignition Class and SuperProfiles Lifestyles

In order to examine the AADF ignition profile of incidents by SuperProfiles Lifestyle the data was cross tabulated and a chi square statistic produced. Table 5.18, AADF Frequency Distribution by Ignition Category and SuperProfiles Lifestyle shows the frequency distribution of ignition categories by Lifestyle, the chi square statistic attached shows that there is significant variation in the difference between the expected and observed frequency distribution.

As with the IMD deciles the standardised residual for each cell was calculated, the results are shown as table 5.19, AADF Incidents Standardised Residuals by Ignition Category and Super Profile Lifestyle. The results show that there is highly significant variation of incidents within the matrix. When compared with the IMD decile table 5.12, the results are very similar indeed. The biggest difference is in the Urban Venturer category, which shows significantly higher than expected frequencies of Children playing with fire, Smoking related incidents, and articles to close to a heat source. This represents a combination of statistically significant higher than expected levels of frequencies not recorded by any of the

ward level IMD classes. It is distinct from all other IMD and SuperProfile categories, in relation to ignition profile. This is a category of area characteristics that appears to have a relatively high AADF incident risk yet is unsuited to capture by a simplistic deprivation measure.

Table 5.18 AADF Frequency Distribution by Ignition Category and SuperProfiles Lifestyle

SPLS	Ignition Categories						Totals
	1 Children	2 Accident	3 Smoking	4 Cooking	5 Too Close	6 Electrical	
1	15	112	48	241	34	173	623
2	10	67	49	254	25	112	517
3	38	175	106	701	66	280	1366
4	100	252	198	1138	102	379	2169
5	228	176	315	816	91	203	1829
7	57	109	150	564	31	136	1047
8	149	283	334	1514	102	263	2645
9	178	181	223	1031	80	238	1931
10	815	423	1014	2438	160	387	5237
Totals	1590	1778	2437	8697	691	2171	17364

Chi-Square Test

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	1286.04	40	0.00
N of Valid Cases	17364		

Table 5.19 AADF Incidents Standardised Residuals by Ignition Category and Super Profile Lifestyle

SPLS	Ignition Categories					
	1 Children	2 Accident	3 Smoking	4 Cooking	5 Too Close	6 Electrical
1	-11.04	5.20	-5.98	-5.93	1.67	8.87
2	-11.96	1.88	-3.57	-0.44	0.92	5.19
3	-14.50	2.99	-8.86	0.95	1.54	7.84
4	-10.43	2.16	-8.28	2.38	1.72	6.71
5	4.63	-0.94	3.87	-4.95	2.10	-2.01
7	-5.39	0.19	0.28	2.54	-1.99	0.48
8	-8.26	0.83	-2.35	8.18	-0.36	-4.69
9	0.10	-1.38	-3.59	3.10	0.38	-0.25
10	18.32	-6.58	12.77	-6.04	-4.43	-15.60

The temporal distribution of incidents by the Domestic Routine Activities Time Classification used for the IMD analysis, was examined. The chi square statistic again reported significant variation across the groups, and again the standardised residuals, Table 5.20, Standardised Residuals of AADF Incidents by Super Profile Lifestyle and Domestic Routine Activities Time Classification for temporal distribution show less variation than is observed for the Lifestyles ignition category distribution, which was the case for the IMD deciles. SuperProfile Lifestyle 10 shows significantly higher than expected observed AADF incidents in the 23.00hrs to 02.59hrs period whilst the Affluent Achievers significantly higher incident frequency than expected in the 07.00hrs to 10.59hrs period, which is indicative of varying risk activity profiles between the two groups within those time periods.

Table 5.20 Standardised Residuals of AADF Incidents by Super Profile Lifestyle and Domestic Routine Activities Time Classification

	Hour Blocks					
SPLS	23.00–02.591	03.00 – 06.59	07.00 – 10.59	11.00 – 14.59	15.00 – 18.59	19.00 – 22.59
1	-5.46	-2.14	2.68	0.53	0.88	0.39
2	-0.65	1.05	0.37	1.24	-1.07	-0.49
3	-3.44	-4.44	1.65	0.18	2.50	-0.05
4	-1.45	-0.27	1.19	1.29	0.20	-1.21
5	1.75	1.06	-2.30	-1.52	-0.76	1.90
7	-2.21	0.78	-0.86	0.43	-0.61	1.98
8	-1.45	-0.87	0.45	2.65	-0.55	-0.83
9	1.31	1.61	1.61	-0.52	-0.36	-2.40
10	4.66	0.90	-2.93	-2.77	-0.13	0.78

It was not possible to consider the AADF ignition category by Domestic Routine Activities Time Classification and SuperProfile Lifestyle as the observed cell frequencies were not sufficiently large for a chi square test to be conducted. This was possible with the IMD as we were able to collapse the deciles into 2 classes of

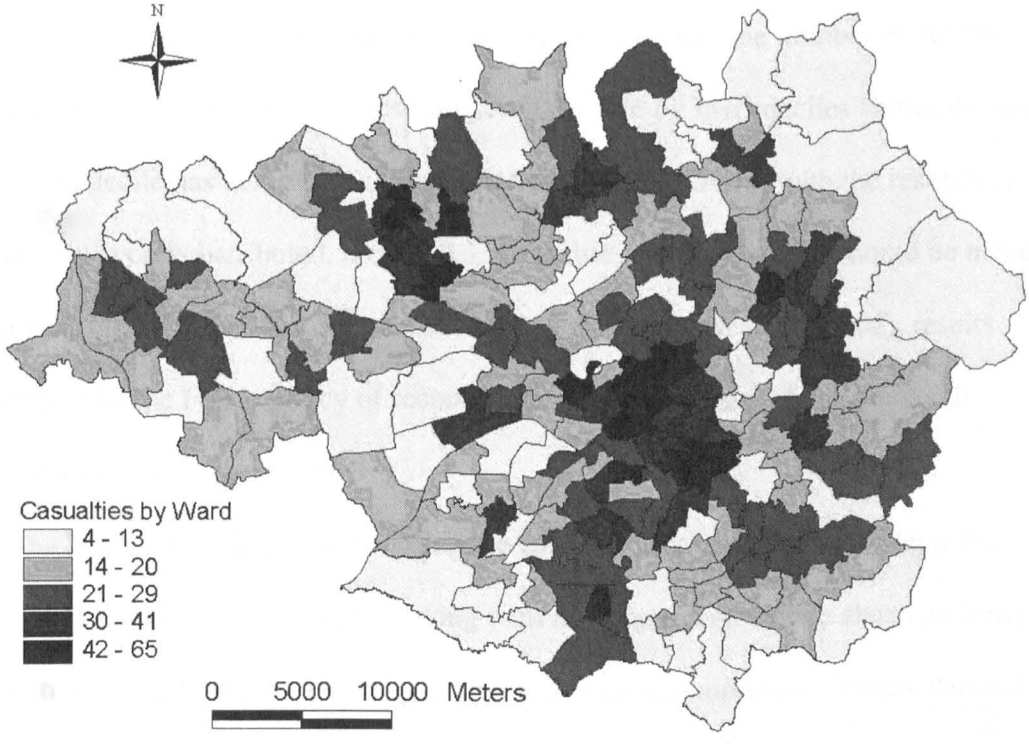
higher and lower deprivation. This is not possible with SuperProfiles as each lifestyle is a discrete class unrelated to any other.

5.2.14 AADF Casualties, Smoke Alarm Ownership and Operation

The analysis now moves on to examine the AADF incident data base in relation of the principle aim of the FRS, that of reducing casualties and fatalities. The incidence of AADF Fatalities is relatively very low and as such of limited analytical potential in relation to this research, however AADF Casualty data was made available and is examined using the IMD at ward level deciles previously defined.

The incidents were mapped using a choropleth shading scale. Raw counts were used and concentrations of casualties in the areas of the cities and major towns are evident, Figure 5.4, AADF Casualties by Ward.

Figure 5.4 AADF Casualties by Ward



The AADF casualty data was aggregated by ED and then classified by IMD decile. A rate per AADF incident was calculated for each of the deciles and the results are shown in table 5.21, IMD Deciles Casualty Frequency and Rate per AADF.

Table 5.21 IMD Deciles Casualty Frequency and Rate per AADF

IMD Decile	Casualties	AADF	Casualty Rate per AADF
1	265	1057	0.25
2	376	1250	0.30
3	478	1383	0.35
4	452	1379	0.33
5	554	1484	0.37
6	523	1649	0.32
7	735	2253	0.33
8	749	2030	0.37
9	945	3142	0.30
10	1106	3388	0.33
Total	6183	19015	0.33

The distribution of casualties shows a general trend of increased casualties with increasing relative deprivation levels. However when the number of AADF incidents is controlled for , the resulting casualty rate by IMD deciles shows the least deprived decile has the lowest casualty rate of 0.25 per AADF, with the rest being relatively evenly distributed, around 0.33 casualties per incident. It should be noted that the high levels of casualties recorded in the GMCFS (Watson, 2002), results mainly from the FRS's policy of recommending precautionary check ups to all persons present at the incident.

The methodology for recording the casualty data has now been adapted to incorporate a measure of severity, along with information on smoke alarm presence, condition and activation. Preliminary findings from the improved casualty data set are shown in tables 5.22 and 5.23 which show the number of smoke alarms present

or not present at AADF which resulted in one or more casualties.

Table 5.22 Smoke Detector Present at AADF Incidents Resulting in a Casualty by IMD Quintiles

Smoke Detector	IMD Quintile				
	1	2	3	4	5
YES	47	56	72	116	165
NO	92	115	135	239	252

Table 5.23 % of Operational Smoke Detectors (where fitted) at AADF Incidents by IMD Quintiles

Smoke Detector Working	IMD Quintile				
	1	2	3	4	5
YES	66%	66%	66%	51%	66%
NO	34%	34%	34%	49%	34%

The tables show that across all IMD quintile groups the level of smoke alarm presence in fires resulting in casualties was significantly lower than the 83% ownership levels reported in the national fire statistics for the year 2000 (Watson, 2002), with a maximum of 40% of incidents, in the most deprived areas having a smoke alarm present at the time of the fire, whilst the in the least deprived areas the figure was as low as 33%. Details captured on the operational status of the smoke alarms at the time of the fires are also captured and showed that in quintiles 1,2,3 and 5 only 64 % of those households with smoke alarms present had maintained them in working order, quintile 4 recorded even less working alarms with 49% not working at the time of the fire. Narrative reports from the fire fighters reveal that most of the non operational alarms have either had their batteries removed or they have run out and not been replaced. This information along with historical risk profiles is being used immediately by GMCFS to target community safety initiatives.

5.3 Analysis Summary

The methodological framework developed for the analysis of AADF has delivered highly significant results with major policy and operational benefit implications for the FRS. To summarise the results, the research has shown that:

- The distribution of Anthropogenic Accidental Dwelling Fire is not random and can be shown to be disproportionately concentrated in wards with relatively higher levels of deprivation, as measured by the IMD and in EDs both at the lower end of the SuperProfiles Lifestyle classification and in areas of young adults, with high levels of disposable income living in multiracial areas of major cities. Distinct spatial distribution profiles for AADF incidents were generated for each classification used.
- The incidence of AADF has been shown to vary significantly throughout the course of the day. Four hour time periods were defined to capture routine domestic activity patterns that conformed to the theory of AADF and the inherent potential fire risk associated with specific routine activities in the home.
- AADF Ignition Category frequencies have also been shown to vary significantly throughout the day, supporting the proposed Domestic Routine Activities Time Classification.
- The AADF ignition category profile has also been demonstrated to vary by area characteristics, both the IMD and SuperProfiles classifications. Significant variation was reported by Chi square tests and the use of standardised residual values.
- The temporal profile of AADF incidents has been shown to vary significantly by area characteristic classification, both IMD and SuperProfiles, although

this has proven to be the least pronounced variation observed, indicating lower levels of observed variation in domestic routine activities across area types.

- Areas classified as being either more or less deprived both exhibit significant variation in temporal ignition class profiles. Both sets of areas had significantly different frequency profiles, with the more deprived areas experiencing many more incidents across all categories of ignition; however both temporal profiles followed the proposed AADF Domestic Routine Activities Time Classification.

In relation to the policy direction of a modernising FRS the findings of the empirical analysis provide evidence in support of the significant value not only of FRS incident data sets, but also the importance of use additional external datasets to provide a contextual backcloth for analysis. The use of the IMD and SuperProfiles has clearly demonstrated the statistically significant association that can be observed between the distribution of AADF incidents and areas with common levels of deprivation or similar geodemographic profiles.

The methodology developed is replicable by FRS and will enable spatial, temporal and spatio-temporal AADF risk profiles to be developed for a range of ignition categories which will inform the development, tailoring and targeting of incident and area risk specific interventions, education and operational response resource allocation. The use of standard, consistent and comprehensive spatial, deprivation and geodemographic data sets again aids the replication of the research by individual FRS and other researchers.

It is clear that the quantified and statistically significant associations between AADF and area types provides specific small area profiles classified by 3 key

parameters of location, time and ignition category, effective utilisation of this level of operational intelligence provides the potential for the FRS to achieve significant reductions in AADF and associated fatalities and casualties.

The ability of the FRS to adopt and utilise an empirical evidence lead approach to FRS policy development and management is dependant upon a range of factors relating to the organisation, personnel, data, systems and processes. The following chapter presents a comprehensive national survey of FRSs examining the use of information technology and statistics for community fire safety planning. The results are presented and the capacity of the FRSs to adapt an evidence lead approach is discussed.

Chapter Six

Operational Intelligence a National Survey:

The Importance of Data, Information and Evidence

6.1 Introduction

The previous chapter tested and validated the principles of the proposed theoretical model of AADF. This was achieved by developing an AADF Domestic Routine Activities Time Classification and a methodology that was used to derive empirical evidence in support of the model, providing a standardised analysis framework for FRS use. The temporal distribution frequency levels of AADF were shown to exhibit statistically significant variation across area type and by ignition category, and the application of the AADF Routine Activities Time Classification achieved strong and clear associations between domestic routine activity periods and AADF ignition category classes.

The applied potential for this research lies in the capacity of the FRS to make use of the theoretical and methodological developments along with the empirical evidence presented, adapting and further developing their systems and methodologies over time to better understand and address the problem of AADF.

This chapter deals with the capacity of the FRS to utilise their own incident records, along with supplementary data sources, to inform policy decisions and operational management, directing resources to areas of greatest need. To this end a comprehensive national survey of the FRS was developed and undertaken to assess the capabilities and practices of the FRS in terms of operational intelligence. The findings from the national survey of FRS are presented along with detailed additional

information on internal FRS systems and process obtained through research interviews and audits.

Data, information and evidence are essential for informed Fire and Rescue Service management. FRSs and their individual commands, stations and departments generate large amounts of valuable data. The potential utility of this wealth of data is a key factor in the ability of a FRS to achieve better informed planning, policy, management, resource allocation and best value service delivery. The ability to harness the potential of the data is dependent upon the structures, processes, systems and analytical skills of the FRS.

The collective term describing the desired outputs from the data is 'Operational Intelligence', this term refers to the end product of a process that involves the collection, capture, collation, cleaning, sharing, linking, analysis, interpretation and presentation of data. In order to assess the operational intelligence capacity of the Fire and Rescue Service a national survey of FRSs was conducted examining 'The use of information technology and statistics in Community Fire Safety planning'. The survey was sent out to 58 FRSs in England, Wales, Scotland and Northern Ireland. The Channel Islands and the Isle of Mann services were not included (due to data recording procedures incompatible with the structure of the survey). A high response rate of 53 out of the 58 FRSs was achieved and there were no significant variations between the characteristics of the respondent and the non-respondent groups of FRSs. The survey was designed to provide a national position statement in terms of operational intelligence capacity, specifically relating to data, software, skills, priorities and current practice with reference to Community Fire Safety planning within the Fire and Rescue Services of the UK.

6.2 National Survey Results

This section presents the results of the collated and analysed national FRS survey data and information. In terms of practicality of access to the wealth of data recorded for each incident by a FRS on the form FDR1 (Appendix 1), the FRSs were asked if they stored this data in electronic format. Of the 53 respondents 39 FRSs, representing 73% of the sample, stated that they kept computerised incident records, with only 29 FRSs capturing 100% of those incident records. Although not questioned directly, experience and communication with FRSs reveals that amongst those who do record FDR1 data in a digital format, there is great variation in what data is captured and the quality and structure of the records. The research conducted (chapter 4) has shown some of the difficulties in working with fire incident data and the issues relating to data standards and spatial analysis. Table 6.1 shows the variation reported in the recording of the location in the form of a geocode for FDR1 incidents.

Table 6.1 The Variation in the Geocode Scale Recorded for FDR1 Incidents

FDR1 Geocode Scale:	Frequency
None	8
1KM	5
500m	9
100m	6
50m	1
10m	1
1m	13
Post Code	9
Other	1

The explanations for choice of geocode recorded showed that 60% of FRSs stated that their choice reflected recognition of the utility of a geocode whilst the remainder stated their method was a reflection of historical precedent or Home Office requirements. The reported level of variation in terms of the geocode scale is indicative of a lack of clear guidance and understanding of the importance of the content and structure of the data collected as well as the potential applied uses of that data. This has since been addressed with the issue of recommended data standards for the geographic referencing of data in anticipation of FRSs adopting a risk based approach to fire cover.

In terms of the analysis of incident data, 31 FRSs reported having a statistics department whilst only 19 FRSs had a GIS department and 17 FRSs stated that they did not use any GIS for fire data analysis. A comparative 1997 survey of United States law enforcement agencies reported that only 14% were undertaking crime mapping, with larger agencies employing over 100 sworn officers reported at 35% (Mamalian and La Vigne, 1998), no directly comparable data for the UK Police is available. In comparison the FRS survey reported that 77% of respondents made some use of GIS and computer mapping even without a dedicated GIS officer. Existing GIS departments were found to be predominately under the command of Operations with little or no use made of GIS for Community Fire Safety (CFS) purposes. However this was not a universal finding and there are examples of FRSs making increasingly effective use of GIS within the field of CFS (e.g. Manchester and Merseyside FRSs).

The use of supplementary data sources to provide a context within which the fire incident data may be analysed was questioned. The results are shown in table 6.2.

Table 6.2 Use of Contextual Data for Fire Incident Analysis

Other Data Sources	Number of FRSs Using data sources	Percentage of FRSs
Other data sources used? YES	21	40
Census data	14	26
Unemployment data	4	8
Housing benefits data	1	2
Index of local conditions	2	4
Index of local deprivation	6	11
Property gazetteers	3	6
Area classifications	4	8
Insurance claim records	2	4
OS digital data products	6	11
Other digital map products	1	2
Other social economic or environmental data sets	4	8

The survey reports that only 40% of FRSs use any additional source of data to provide a context for the fire incident data analysis. Yet as part of Local Government FRSs have access to a wide range of contextual data sources under numerous local government service level agreements and licenses.

The use of data within FRSs was questioned in terms of resource allocation and setting quantifiable performance related targets. The results are shown in table 6.3.

Table 6.3 Use of Information Derived from Analysis for Target Setting

Data used for:	Number of FRSs
Data used for resource targeting	33
Data used for target setting	40
Targets set for FRS as a whole	34
Targets set for command areas	9
Targets set for station grounds	18
Targets set for other areas	2

Although there were no targets set by the Home Office for the reduction of fire incidents, casualties and fatalities (CFSTF, 1997, para. 4.2), three quarters of FRSs used data to set some form of targets for the reduction of fire incidents. Whilst this is encouraging, only one third of FRSs set targets at station ground level and only 2 FRSs at finer levels of geography for targeting resources and local accountability.

In terms of how the data analysis was used to inform resource targeting, FRSs were asked to provide details of initiatives undertaken resulting from some form of data analysis. The results are shown in table 6.4 and are accompanied by comparative figures showing the % of all FRS incidents reported in 1998 attributable to the incident type targeted by the individual initiatives.

Table 6.4 Data and Geographical Analysis for Resource Targeting Purposes

Initiative	Number of FRSs Reporting Initiatives	% of Initiatives	Cumulative % Initiatives	% of all Incidents 1998 (Fire Stats UK 1998)
Malicious calls	26	40.00	40.00	9.68
False Alarm Due to App.	10	15.38	55.38	26.99
Community Fire Safety	6	9.23	64.62	
Arson	4	6.15	70.77	3.71
Chimney Fires	3	4.62	75.38	2.18
Vehicle Arson	3	4.62	80.00	5.78
Residential Fires	3	4.62	84.62	8.17
Hot Spot Analysis	3	4.62	89.23	
Rubbish Fires	2	3.08	92.31	15.18
Chip Pan Fires	2	3.08	95.38	1.42
Station Trends	1	1.54	96.92	
Fire Cover Model	1	1.54	98.46	
Smoke Alarms	1	1.54	100.00	

The results of the comparisons made in table 6.4 highlight major disparities between the focus of the initiatives and the respective proportions of workload generated by those specific incident types and importantly the associated rates and absolute numbers of casualties and fatalities.

Official government fire statistics report that 'Dwelling fires were responsible for about three-quarters of the total number of non-fatal casualties, similar to deaths' (Home Office Statistical Bulletin, Fire Statistics United Kingdom 1998, p23, para 2.14). The report of the Community Fire Safety Task Force 'Safe as Houses' states that in terms of dwelling fire numbers 'We believe that significant in-roads can be made and estimate reductions of 8% a year should be possible, delivering a reduction

of 33% over a 5 year period' (Community Fire Safety Task Force, Safe as Houses, 1998, p26). Even with this focus and recommendation only 3 FRSs reported a targeted campaign aimed at the specific reduction of residential fires. Only 2 FRSs reported targeted initiatives for the reduction of the incidence of chip pan fires, yet 'the majority of injuries were caused by chip/fat pan fires which accounted for over one third of all non-fatal casualties' in accidental dwelling fires in 1998 (Home Office Statistical Bulletin, Fire Statistics United Kingdom 1998, p23, para 2.15). It was also significant that no FRS reported targeted initiatives aimed at reducing the number of dwelling fires caused by smokers' materials, when 'Smoking related materials and matches were the most frequent source of ignition causing accidental dwelling fire deaths' (Home Office Statistical Bulletin, Fire Statistics United Kingdom 1998, p23, para 2.10).

'Both Ministers who set overall policy for the Fire Service and the Fire Authorities who run it need to make the reduction of the number of fires and fire casualties the principle targets which drive fire service activity', (Community Fire Safety Task Force, Safe as Houses, 1998, p7, para 1.8). The survey reports that over 55% of the targeted initiatives undertaken by FRSs do not directly involve fire or casualties/fatalities. In terms of current thinking and policy initiatives within the Government and the Fire and Rescue Service these figures appear to represent a focus upon targets outside the primary aim to reduce casualties and fatalities through Community Fire Safety fire prevention initiatives.

An important additional component that individual FRSs must consider is the proportion of their response workload that malicious false alarms and false alarms due to apparatus account for, as these incidents divert resources from life threatening incident response. The national figures for 1998 report that malicious false alarms

and false alarms due to apparatus accounted for 37% of all incidents responded to (a rise of 2% on figures from 1997). Rubbish fires accounted for 15.18% of all incidents attended by the Fire Service in 1998, yet only 3.08% of initiatives reported focused on this area. There would appear to be a clear case for specialisation of response in relation to specific incident types, by response time standards and also dispatched vehicle type, equipment levels and staffing. Specialisation presents significant potential operational benefits freeing up fully staffed pumping and rescue vehicles, saving lives and saving money through improved efficiency.

The findings provide evidence for significant conflicts between resource allocation in terms of reducing the numbers of casualties and fatalities through driving down incidents of dwelling fires (dwelling fires accounted for 8.17% of all incidents 1998 and 82% of all non fatal casualties and 76.05% of fatalities, Home Office Statistical Bulletin, Fire Statistics United Kingdom 1998), and the disproportionate demand for resources resulting from incidents involving a very low casualty/fatality rate.

The financial strictures within which Fire and Rescue Authorities and FRSs must work, and in light of the CFSTF's assertion that 'the Fire Service's re-focused role need not increase the total budget of individual FRSs.... We believe that most of the budget for these teams (CFS) can come from a reallocation of resources' (Community Fire Safety Task Force, Safe as Houses, 1998, p17, para 5.11 and 5.12) mean that the FRS will require an informed, balanced and dynamic approach to resource allocation. The achievement of this level of informed and enabled management and service delivery is to a great extent dependant upon the ability of the FRS to provide high quality, timely and relevant information to its managers.

The survey asked the FRSs to consider their skill levels in five key areas; a summary of the results is shown in table 6.5.

Table 6.5 Key Area Skill Levels Within FRSs

Skill Level	Not At All Skilled	Not Skilled	Skilled	Very Skilled	Priority YES	Priority NO
Statistics	3	15	20	15	49	3
Mapping and G.I.S.	19	15	10	9	46	7
Delineation of Priority Areas	26	15	7	5	31	22
Risk Factor Identification	17	16	12	8	36	17
Monitoring and Evaluation	23	14	9	7	45	8

The category of 'Statistics' was the only skill area in which the majority of FRSs considered themselves either skilled or very skilled. A previous question established that analysis was reported only at the FRS level for the majority of FRSs. This severely limits the utility of the information in terms of FRS management, providing only an overview of incidents and associated risk. Effective use of the wealth of information available within FRS records would require at a minimum that "each Fire Service should look to provide the station with the impetus necessary to drive the process across their Fire Service, together with monthly statistics on the number of fires and casualties in their area." (Community Fire Safety Task Force, 1997, P18, para. 5.23).

The ability to 'map' incidents and make use of even the most elementary functions of a Geographic Information System, linking incident data with other data sets through geographical location, enables the incidents to be aggregated by a specified spatial unit and contextual attribute data appended to incident records.

"Special targeting...is needed...However, many FRSs are still attempting to develop their own approaches upon no harder evidence then a gut feeling" (Community Fire Safety Task Force, 1997, p10, para2.19). Mapping and GIS use is able to produce data from which information can be extracted. However, whilst 77% of FRSs stated that the made use of mapping and GIS, 65% of FRSs consider they are either not skilled or not at all skilled in these areas.

The use of the data produced via statistics and GIS would enable historical analysis of the spatial and temporal distribution of incidents at an appropriate level of geography and time intervals. The ability to produce this level of information provides baseline statistics, the use of which (in conjunction with other factors) enables the expectation of the Community Fire Safety Team to "... identify and target special local campaigns" (Community Fire Safety Task Force, 1997, P15, para. 4.9), to be based upon 'harder evidence than a gut feeling'. The skills needed to produce baseline statistics via the use of GIS returned the lowest levels of self assessed skill base within the FRSs, with 79% not skilled in this area. This lack of skill is reflected and to a greater or lesser degree may be in some part responsible for only 34% of FRSs producing reports below FRS level.

The identification of risk factors directly from analysis of fire incident data captured from the FDR1 form requires the combination of the previous three skill areas to provide the base data for further analysis. .'FRSs should tailor local activity to their own area to reach those "at risk" groups as this is where local input can have the most effect.' (Community Fire Safety Task Force, 1997, P21 para. 5.44). In order to achieve these levels of discrimination a higher level and wider range of data manipulation, analytical skills and understanding of spatial and statistical analysis is required than in the previous three areas. 'Evaluation is crucial to demonstrate the

value of CFS activity in an environment of budgetary constraint. We recommend that all future CFS work must be evaluated so that resources can be effectively deployed and continuous improvements achieved.' (Community Fire Safety Task Force, 1997, P15, para. 4.14). With only 29% of FRSs considering themselves skilled in this area and the validity of any monitoring and evaluation to a great extent being dependent upon the other skill areas to produce the information required, the survey results indicate that there is a pressing and wide ranging need for the acquisition of these skills within FRSs.

Whether or not each of the five skill areas was considered a priority was questioned. The two areas which are perhaps the most complex in terms of the whole process were 'delineation of priority areas' and 'risk factor identification', and were least commonly considered priorities with 39% and 33% respectively of respondents stating that these areas were not current priorities within their FRSs. Without these key areas being addressed, failure to identify, quantify and profile the fire risk faced and often generated by the communities served by the FRS will continue, with the unacceptable associated costs in terms of loss of life and injury. The ability to identify risk, define its characteristics and differentiate by risk type and level are crucial in reducing fires and fire related deaths and injuries.

The results from this survey were presented at a national Fire and Rescue Service conference organised by the author jointly with the GMFRS and held at Old Trafford in June 1999. The aim was to promote the use of data analysis and its value to informed risk identification and resource allocation. The survey identified that there was wide range of capacity across and within the FRSs. A principal recommendation resulting from the survey was that in order to achieve an understanding of, and report on, the processes of production and collection of data

within the FRS, an internal FRS data audit should be conducted nationally and at the individual FRS level.

6.3 Fire and Rescue Service Audit Recommendations and Initial Findings

The objective of a FRS data audit would be to identify what data is held by the FRS, by whom and in what format. The reasons for the collection of the individual data variables should also be questioned and justified, identifying core, business critical FRS data and other additional data that may be specific to non core or temporary activities or initiatives. It is also important that the methods of collection and storage are understood, with a view to standardise and ensure maximum levels of intra and inter organisation compatibility. Beyond the basics of compatibility it is also important to verify the extent to which the existence of data and its potential utility is known within the organisation, shared and utilised. In relation to this the FRS should maintain an accessible and up to date index of data and information available within and to the FRS and its partner organisations.

Any report produced should provide critical assessment of the use of information systems within the FRS, along with an overview of the levels of understanding and skills relating to operational intelligence generation and its utility. In order to improve the data and operational intelligence awareness of the FRS and its partners, an organisation structure and information systems overview should be generated and maintained. It is essential that any such document is subject to a process of continuous development, ensuring that an up to date and accurate record is available at all times.

An audit the FRS will need to consider a range of key issues that are fundamental to the essential processes of modernisation facing the organisation as a

whole. These areas would include data specific issues in relation to: policy, standards, quality, capture, storage, manipulation, sources, sharing, and utilisation. A further essential component relates to computing and would involve the assessment of suitability and availability of: hardware, software, skill levels, budget levels and distribution by command. In order to maximise the utility of any data and data related tools the skills of the FRS personnel are critical and should be assessed both in terms of absolute level in relation to core business objectives and their distribution by command unit, lines of communication and importantly the capacity of key staff to undertake operational intelligence development work which may be additional to their existing workload. This is associated with the organisational structure of both the FRS as a whole and the individual FRSs, whose operational intelligence policies may vary significantly. The information generation, dissemination and communications policy and practice are fundamental components of the FRS's adoption and implementation of informed modernisation and management practices. This impacts not only upon the service delivery responsibilities of the FRS but also upon the important internal and external partnership working practices that are essential if the FRS is to fulfil its potential role in securing a safer community.

In order to meet the demands of the continuing modernisation agenda faced by the FRS another key area to the examined by any audit is that of training budgets. It is important that the financial position is clearly stated in relation to the ability of departments, commands and the FRS to provide training within the audit under current budgets, and the extent to which training may need to reprioritised to meet the demands of any identified Operational Intelligence focused training programmes required. This leads into the requirement for the audit to assess the current priorities within the FRS and the extent to which these may require amendment and refocusing

as key areas within which Operational Intelligence will benefit Best Value service delivery are identified.

Having stated the key components of an operational intelligence audit and having completed the comprehensive national survey of the FRS, arrangements were made with Merseyside Fire FRS and Mid and West Wales along with the case study area of Greater Manchester, to conduct further survey work (Appendix 3) and to undertake site visits to supplement the information gathered in the surveys. Examination of the organisational structures of the FRSs', data holdings, systems and processes was undertaken.

The overall findings and consensus of opinion from the survey, FRS visits and interviews with senior officers, fire fighters and civilians, was that data issues lie at the centre of the FRS's operational intelligence capability. It is the raw material from which the analytical outputs are derived. Failures in the capture, storage and manipulation of the data can seriously undermine the functionality and validity of any data dependant information systems within the FRS.

Common failings within FRSs with respect to operational intelligence capacity include a lack of a named and clearly identifiable person or post with overall responsibility for data related issues is often cited as a problem, with disparate data sets, systems and departments all acting independently of each other. Such a post or person would provide clearer direction within the organisation and facilitate the standardisation and linking of systems.

It is essential that there is a written data policy for the whole of the FRS and that is comprehensive in its coverage and is well publicised and strictly adhered to. This policy should include standards for the structure and storage of data that are common to all the FRS's data sets. The policy should also be reviewed on a regular

and frequent basis (at least annually) and be flexible enough to accommodate any changes in the operational intelligence requirements of the FRS or advances in the technology employed / available. The survey and interviews identified that there was often no written FRS policy on internal or external data sharing and information dissemination. The lack of written policies on internal data sharing is often seen to some extent to be a result of the problems of incompatible systems and what are perceived as insurmountable technical problems. However many departments hold data and information in isolation from others, and whilst recognising the value of sharing and linking data sets the practice of doing so was found to be infrequent.. Beyond the technical and data compatibility problems, a lack of a clearly defined policy failed to provide the internal procedures and impetus for improved communications. Again where policy, guidance or good practice was found there was limited knowledge of its existence, and it was not seen as a compulsory reference for all data sharing and partnership development.

The research found that monitoring and evaluation of operational activities has often been neglected, however with an increasing emphasis on Best Value and Key Performance Indicators, FRSs are now gaining in experience in this area and becoming more competent in this skill area. Currently the variation in the quality of data sets, storage mediums, systems in use and analytical skills available limits the ability to practically and effectively apply any policy on monitoring and evaluation of performance across all areas of FRS activity.

6.4 Systems Issues

The reality of finite resources to be provided from within the budgetary strictures imposed upon FRSs, and the requirements of Local and National Government objectives increasingly demand robust, effective and accessible data systems, capable of providing meaningful and timeous operational intelligence to inform the decision making process. Well designed Information Systems can provide a centralised and standardised coherent structure for the capture, storage and dissemination of data, along with the functionality to manipulate, query, analyse, link and export data in a range of standard formats. They can enable the value of an organisation's data holdings to be maximised in a resource efficient manner. Not all information systems within FRSs are computerised, linked or compatible. This creates problems in terms of access to the data and limits the potential to link the data held with other information held restricting the analytical possibilities related to that data. The individual command structure of FRSs often results in a large number of disparate systems that operate in various departments, with little or no compatibility and a lack of data standards. This results in difficulties in linking the systems and extracting information. It is also very difficult to track information through the FRSs departments. The wide range of unlinked data sets results in a significant duplication of effort in the recording of data, generation of information and the production of operational intelligence. The variation in systems also acts as a barrier to access to the information held within them and innovation built upon them, as each system requires specific training and skills to query and extract information from them.

There is little linking of systems due to the technical incompatibilities of many of the disparate systems and also a lack of data standards across the databases

to provide key variables through which records could be linked. This results in the inability to bring together information from different systems specific to a common theme. For example an integrated operational intelligence system would enable all incidents attended by a specific fire-fighter to be identified for a given time period, any injuries sustained, casualties or fatalities dealt with by the fire-fighter, which incidents involved the use of Breathing Apparatus (BA), the fire-fighters training record, scheduled training programme, sickness record, salary costs, training costs and previous annual review records. This could form part of the fire-fighters annual review process and identify any specific health and safety issues, training needs and generate an activity / operational experience record for each employee, etc. This to a great extent would be possible now but would involve several different systems and the extensive use of paper records.

Overall the FRS staff are often all too aware of the restrictions that their systems currently place upon them and that there is greater potential to use their data and that of others if effective systems and organisational structures were put in place. There is evidence across commands / departments of FRSs that staff use their skills to develop ad hoc database solutions in systems such as access or spreadsheets in excel to add to or circumvent inadequacies or difficulties in existing systems.

6.5 Analytical Skills and Training Issues

The human factor is a key component in the success of operational intelligence systems. It is not only the knowledge required to operate the systems that is important, as much of this can be built into the user interface, but more significantly it is the ability to understand the nature of the data used, the analytical

methodologies employed, and the ability to interpret and utilise the outputs that are dependant to a great extent upon the user. Even at a basic level of data manipulation and analysis, a failure to understand the principles of spatial, temporal and statistical analysis can result in well presented, convincing but erroneous information being produced. Failure to ensure that the appropriate training is provided for personnel who are producing and using operational intelligence would severely restrict the potential benefits of any investment in this area and may result in costly mistakes being made.

Results from the interviews and discussions with FRS staff report that although there was a general awareness of the value of data and the importance of information systems, staff felt that the systems available to them were difficult to query beyond the day to day maintenance and standard reports generated, and that the training required to remedy this would often be complex and disproportionate to the potential benefits. A range of statistical analysis outputs and operational intelligence skills were observed that had been developed to meet the demands of the FRS for operational intelligence, utilising the various systems and data available currently within the FRS. However, again it is the systems, data formats and inconsistencies that were identified as limiting the outputs obtainable and inhibiting the development of a better understanding of the issues and appropriate operational responses.

The range of courses provided by FRSs and their availability to staff was found to be good, but it was the systems and current data structure weaknesses that inhibited their use of the data to produce meaningful operational intelligence. Again skills in using common proprietary 'Windows' based spreadsheets and databases such as Excel and Access were seen as more valuable and transferable amongst many

of the staff. To a great extent the analytical methodologies required to produce meaningful operational intelligence can be built into a computer system, minimising the skill level required to conduct the analysis. The focus of training can then be tailored to the understanding of the methodologies employed, educating the user to ask relevant questions of the data and how to interpret the outputs.

Generally it was felt that the FRSs were capable of providing the training and support needed and is forward thinking and progressive in its attitudes in relation to operational intelligence. However the limitations of the current systems and databases restrict the development of effective operational intelligence and its dissemination. The following section of the report examines the FRSs functional structure in terms of the generation and capture of data, access, and information dissemination.

6.6 Functional Structure: Data Generation, Capture, Access and Dissemination

The functional structure of the fire and rescue service is clearly defined and task orientated. Each command and department is designed to undertake specific functions and provide a range of services and outputs contributing to the core business of the FRS. Each of these separate departments is relied upon to contribute to the functioning of the FRS and to the generation of the overall operational intelligence information. It is the links between the departments' data sets, processes and systems that are essential in providing relevant and timely data to enable the production of operational intelligence to inform effective strategic planning and service delivery.

Results from the questionnaires and interviews report that the legacy of historical data systems and processes of FRSs and their respective organisations and

information systems was seen as a significant contributory factor in the lack of effective data sharing and access to data across the FRSs. The number of stand-alone systems and compartmentalised data flows that exist within FRSs were often delivering what was required at an individual department level, but they were thought to restrict development and innovation. Although many FRSs have updated their information systems few have undertaken a comprehensive review of current operational capacity and operational intelligence requirements.

Many FRS departments have limited access to the data and information held throughout the wider FRS. The lack of a single coherent data structure and centralised data warehousing facility creates significant barriers to access, analysis and dissemination of the data held. The greater value of the data generated and captured by the FRS lies in the ability to view, query, analyse and interpret the data held in its entirety and ideally from a single point of access. The infrastructure provided by FRS intranets are generally was seen as a key tool for the development of communications and operational intelligence capabilities within the FRSs. The networks provide a potential route for access to any information and analysis systems made available within the FRS and could act as an effective vehicle for information dissemination. The basic structures exist within the FRSs to provide effective communications, access to data, information and operational intelligence. What is required, are tailored information and operational intelligence solutions to the current process and system inadequacies found to be endemic within the FRS. Without addressing the fundamental problems that are embedded within the processes and systems of the FRSs, development of operational intelligence facilities will be limited to short term fixes rather than long term solutions.

6.7 Recommendations

It is evident from the research and continuing working relationship with the Fire and Rescue Service that the FRSs currently hold and generate a significant volume of valuable information. This data is held in various formats, across all commands and departments and often in different, non-compatible systems. FRS staff members are required to produce operational intelligence from these disparate data sources and systems. The lack of linkage between these databases and systems imposes severe limitations upon the scope of the analysis that can be practically conducted. Improvements in the quality of the data captured, information systems utilised and data accessibility are essential for significant and sustainable improvements to the operational intelligence capacity of the FRSs.

The following recommendations are made:

There is an immediate imperative to ensure that there is an identified head of operational intelligence issues within the individual FRSs who has the support of the FRS management and the seniority to ensure that all parties comply with the specifications of the policies, protocols and systems to be developed. Operational Intelligence policy documents and protocols should be developed in consultation with internal FRS commands and departments, and also in consultation with external Crime and Disorder and Community Safety partners to ensure compatibility of systems and data standards. These documents should incorporate data standards, minimum system specifications and training and support issues.

A full and comprehensive review of the data and operational intelligence requirements of the FRSs should be undertaken. This should identify the current and

anticipated future data requirements of the FRSs as a whole. Consideration should be given to the development of a Central Data Warehousing and Operational Intelligence System providing a single coherent structure for operational intelligence production and access. This process should be conducted in partnership with the system developers but also with the aid of a consultant acting with and on behalf of the FRS to ensure maximum functionality, ease of use, flexibility, development potential, compatibility and best value from the system and suppliers.

All policies, protocols and operational intelligence systems should be developed to be accessed and used through the FRS's intranet. This would include password protected levels of access to data, reports, information, analysis tools, mapping etc. and have the capacity for electronic FDR1 completion and capture. Any operational intelligence protocol should include the requirement for unique identification codes for all incident records, and key variables through which related records could may be linked and tracked through the system. Unique property reference numbers for all buildings, residential, commercial, public etc. should be generated or obtained and used to generate and maintain a fire history for each property, including all incidents, risk assessments, certification (if applicable), intervention initiatives undertaken in the area and other relevant information. Records of incident reduction initiatives should be kept with geographical boundaries created to identify and map their locations. These can be stored as coverages / layers in a Geographic Information System enabling these to be linked with incident records, property histories, and social, economic and environmental contextual data.

External data should be used to provide a wider context within which the FRS's operational intelligence can be viewed and interpreted. Sources of external data include the Governments Neighbourhood statistics, Local Authority data sets,

Recorded Crime data, the British Crime Survey, other initiatives in the area and funding opportunities.

Community Fire Safety staff '...have often worked on the margins of FRS activity, yet the results of their work is central to how a FRS's performance ought to be considered' (CFSTF, P8, para. 2.2). If FRSs are to rise to the challenge of the increasing focus on CFS, it is through the development and implementation of the systems, processes and skills to capture, analyse, interpret, develop, implement, monitor and evaluate both the differential demand for Fire Service educational programmes and response options, as well with the effectiveness of any CFS initiative undertaken.

The findings presented, form the basis of an agenda for change in terms of business process and systems development within the Fire and Rescue Service that have the potential to deliver the operational intelligence required to meet the demands of what should be a continuum of development and modernisation.

6.8 Summary

This chapter has explored the operational intelligence position and requirements of a modernising Fire and Rescue Service through the presentation of the results of a comprehensive national FRS survey and additional in depth data, systems and process audits of FRSs. The results have been presented, discussed and recommendations made. The utility of the theoretical model of AADF, AADF Domestic Routine Activities Time Classification, proposed analytical methodology and empirical research findings is based upon the ability of the FRSs to take the work forward and consider the findings in the local area context in which they operate. The policy implications both at a national and local level are significant and appear

to be clear and immediate if the FRS is to successfully manage the ongoing process of modernisation. There is a need for strong national guidance and framework documentation to be made developed and made available to the FRS, with a focus on the value of data, analysis and evidence to inform policy, strategic and operational FRS management and delivery.

The following chapter presents a potential application of the IMD as a fire risk discriminator, in the form of a proxy for demand for the Fire and Rescue Service, addressing the current perverse incentive issue within the FRS standard spending assessment which penalises FRS for successfully reducing fires and demand for service.

Chapter Seven

The Fire Calls SSA Indicator:

Options for Replacement with a Measure of Deprivation

7.1 Introduction

The theoretical model of AADF provides us with a framework within which research can be conducted to improve our understanding of the components of risk, their interaction and manifestation. Based upon this model the research conducted within this thesis has identified differential fire incidence rates across varying spatial scales and socio-economic area characteristics. The demonstrated associative relationship between deprivation indicators and fire incidence levels of AADF are now considered in terms of potential application within the fire service funding methodology.

The need for the fire service to be able to capture, analyse, monitor and evaluate fire incidence and its own effectiveness in both prevention and response to the fire problem has been shown to be essential for a more efficient and effective service delivery. The theoretical model of AADF, AADF Domestic Routine Activities Time Classification, analytical methodology, empirical analysis results, and the comprehensive national survey of FRS organisational structure and capacity presented in this thesis have demonstrated that there is a clear and essential requirement for individual FRS to better understand the fire incident distribution profile of their area. In order to improve their service delivery capacity they must achieve greater levels of sophistication in their operational intelligence capacity, which can be informed by analysis of the contextual backcloth of the fire incident

distribution, the discernable associations between differing incident types and social and demographic area characteristics, and the components and interaction processes of fire risk not only as presented in the theoretical model of AADF but across the complete workload profile of the service.

The wholesale change of emphasis from response to prevention and the focus on incident reduction that has occurred over the past decade since the publication of the audit commissions report 'In the line of fire' (1995), has seen a positive reaction from FRS who have committed themselves to driving down the incidence of fire with a clear focus on AADF and the high levels of casualties and fatalities that these fires generate. This has by necessity resulted in the focus of attention turning to the funding model for fire service, the standard spending assessment (SSA) which contains a perverse incentive for the fire service, in that fire service funding is in part dependant upon the number of incidents that they are called to attend. A reduction in fires results in a reduction in funding. This chapter utilises the findings of this research, through the principles set out in the theoretical model of AADF, using the association of a measure of deprivation with areas of higher levels of fire incidence, and the capacity to quantify the differential risk through historical data analysis, to consider the use of a measure of the IMD as a proxy for demand for service from the brigades which is not dependant upon calls. The chapter demonstrates an application of the research findings in modelling IMD area scores, based upon the GMCFS data, into the SSA calculation in order to address the existing perverse incentive.

7.2 The Standard Spending Assessment

The Fire SSA incorporates an activity measure, 'Fire Calls', as a sub-component of the 'Fire Cover' section of the SSA. This acts as a direct measure of the demand for the service and is used in the calculation of the resources required to respond to calls for assistance from the brigades. Although a direct measure of the demand for service, the indicator has been criticised in recent years partly because of its instability and also due to the 'perverse incentive' it creates for brigades. The primary aim of Fire Authorities is to reduce fire incidents and the number of related casualties and fatalities. However an SSA that is heavily dependant upon fire calls as a funding generator creates the situation where Fire Authorities whose fire safety and prevention intervention initiatives are successful, and reduce the measured fire calls, are then penalised by a subsequent reduction in funding. The decrease in the resources made available for those Authorities with effective prevention policies then undermines the sustainability of any progress made.

The majority of SSA methodologies use a proxy for demand rather than a direct measure in order to avoid such perverse incentives, this study looks at how such a proxy indicator might be identified, quantified and incorporated within the Fire SSA model utilising the principles outlined by the DTLR for SSA formulae.

- Formulae should be fair
- Formulae should not be treated as an infallible guide to how much local authorities should spend
- Formulae should be based on factual evidence
- Formulae should be intelligible to stakeholders

- Formulae should not create perverse incentives or penalise authorities for improving efficiency
- Data should be fair and appropriate

In Formula Review group FR(01)1 (DTLR, 2001), the DTLR wrote in relation to perverse incentives that;

"The present indicator within the Fire block which gives more grant to authorities that receive more fire calls is often given as an example of a perverse incentive. We need to find a replacement for fire calls, but also be sure that old or new indicators in any block do not give rise to similar problems. Under the present system, authorities keep any gains they make through efficiency savings. That is a feature that needs to be preserved"

This study considers the options for the replacement of the 'Fire Calls' component based upon evidence that Fire is not a random phenomenon and can be shown to be disproportionately concentrated in areas exhibiting similarities in social, economic and environmental composition, characterised by high levels of relative deprivation and social exclusion.

7.3 SSA Background and Approach

The research findings presented in this thesis have shown that the incident data for the GMCFS exhibits a strong link between social, economic and environmental factors and demand for the services of the brigade. This chapter makes an initial attempt to identify the potential utility of a suitable and effective

proxy for fire calls within the SSA based upon such an indicator or group of indicators.

The model is based upon the analysis of Fire calls data aggregated to the Ward level in the Greater Manchester area for the years 1995/96 – 1999/2000 in line with the current Fire SSA (2002). To place the model in the context of the data upon which it is based some basic descriptors of the case study area are restated. Greater Manchester itself has a population of some 2.577 million people, around 1 million households and contains 214 electoral wards. It is a predominantly urban area although it includes a range of rural wards, sparsely populated areas with high elevation, a major city centre and an international airport. There are no coastline areas (a component of the fire service SSA calculation), although a major shipping canal exists within the authority.

The Fire SSA is comprised of 4 components: Fire Cover, Fire Safety Enforcement, Fire Safety Education and Fire Pensions. The Fire Cover component accounts for around 74% of the total SSA funding figure and includes a measure of demand for assistance from the fire brigade that is based upon a rolling 5 year average of annual calls per head of population for each individual brigade. Within the Greater Manchester SSA calculation, Fire Calls accounted for 43% of the Fire Cover component. This equates to 31.82% of the total Fire SSA for GMCFS being dependant upon Fire Calls. The proportion of the Fire SSA that Fire Calls contributes will vary for each brigade dependant upon the other Fire Cover components.

With Fire Calls contributing almost a third of the funding provided by the SSA the use of this measure of demand as a funding generator is called into question. The perverse incentive created may result in brigades being penalised for achieving

one of their primary purposes of reducing the number of incidents that they are called to attend whilst conversely being rewarded for having an increased number of incidents.

The GMCFS incident database was used to quantify and classify the distribution of incidents at the electoral ward level and to analyse the relationship of fire incidence with a range of potential proxy indicators for demand for service. Consideration was given to a range of indicators for use as a proxy based upon factors such as relevance and relationship to the underlying causes of fire incidence, availability, consistency and comprehensive coverage of the indicators and the time period of updating of the source data for the proxy.

The best performing proxy within the parameters, identified from the initial work conducted, was the Indices of Deprivation 2000 (IMD) (*DETR, 2000*). The IMD being derived mainly from none census data provided a nationally comprehensive and consistent database that was to be updated annually, was readily available, and an accepted measure of deprivation used by government departments. The IMD 2000 itself is a detailed ward level Index. It is based on six separate 'domains' of deprivation:

- Income,
- Employment,
- Health Deprivation and Disability,
- Education Skills and Training,
- Housing,
- Geographical Access to Services.

The six domain scores are combined to produce an overall ward level Index of Multiple Deprivation 2000 (IMD 2000).

The IMD constitutes a single comprehensive and consistent measure of relative deprivation at the ward level. It uses up-to-date information from 33 indicators to describe deprivation. This includes information from previously untapped data sources, such as Department of Social Security (DSS) benefits data and University and Colleges Admissions Service (UCAS) data. Most of the indicators can be updated regularly at periods of significantly less time than the decennial census data widely used in previous indices, and so form the basis for a dynamic index. In addition to the Domain Indices, the overall ward level Index of Multiple Deprivation brings this substantial amount of knowledge and information together in a single index.

Drawing together these indicators for the first time gives the IMD 2000 a major advantage over previous indices; the range of indicators at ward level enables a focus on deprivation at a small geographical level which was not possible before. This is an improvement on the 1998 ILD which was able to present relatively little information at ward level, and the information that was included was based on the 1991 census, a rich and widely used source of social and demographic information, but one that suffers from the potential effects of time decay as areas change over the 10 year period from one census to the next, with the potential for data for specific areas becoming increasingly misrepresentative of the general circumstances. This is particularly problematic as without detailed local knowledge you are unable to identify which areas have changed and which have not.

The Index is based on the premise that multiple deprivation is made up of separate dimensions, or 'domains' of deprivation. These domains reflect different

aspects of deprivation. Each domain is made up of a number of indicators which cover aspects of this deprivation as comprehensively as possible. Combining domains to form an overall ward level Index involved weighting to ensure that weights for each domain are explicit. From the outset it was proposed that the Income and Employment Domains should carry more weight than the other domains, a position supported by academic literature and by respondents to the consultation. It was therefore inappropriate to simply sum the Domain Indices because this would have given each Domain Index equal weight in the procedure. It was also proposed that the most robust domains should carry the most weight. This means that the contribution of each domain to the overall Index varies. As a result of these two criteria the weights selected are as follows:

- Income 25%
- Employment 25%
- Health Deprivation and Disability 15%
- Education, Skills and Training 15%
- Geographical Access to Services 10%
- Housing 10%

These weights are applied to the domains accordingly and the weighted domains summed to generate the overall Index of Multiple Deprivation (DETR, 2000). It is against this background that the study was undertaken examining the potential for the inclusion of a measure of the drivers of demand rather than the measure of response generated by demand.

7.4 An IMD Based SSA Alternative Methodology

The Five Year data set (1995/96 – 1999/2000), required to match the data used in the current SSA was obtained from the GMC brigade and was manipulation and re-coded in order to be compatible with SSA calculation. The data was then plotted in a Geographic Information System and linked with the appropriate ward code and IMD scores.

In order to consider the potential use of the DETR's Indices of Deprivation 2000 as a possible proxy indicator for fire service demand levels, correlation analysis was conducted at the ward level. The use of correlation analysis was used to explore the direction and strength of the relationship between fire calls and the IMD. A non-parametric test was used on the IMD ward rankings, as differences in IMD scores are meaningless (a score of 20 is not twice as deprived as a score of 10, but simply more deprived). The number of all fire calls in wards of Greater Manchester County (GMC) was calculated. The Spearman rank correlation test returned a score of 0.735. This is considered to be a strong and statistically significant score indicating that the more fire calls observed in a ward, the more deprived it tended to be.

The methodology used to produce IMD weightings for population demand for service is based upon the known demand within GMCFS. The proposal is to test the ability to derive deprivation weighted ward groups that will replicate the known demand for service within GMCFS and apply those population demand weightings to the known population distribution of all other brigades within the ward groups created.

The GMC wards were ranked according to deprivation and then partitioned into a number of IMD national rank based groupings. National ranks were used in the partitioning, enabling the application of the derived information to be used in a national framework for SSA. Wards were classified by IMD rank into 4, 5, 10, 20, 25, 50 and 100 groups of equal numbers of wards. 'Equal numbers' was used rather than any division based upon IMD scores, as the differences in IMD scores do not represent any meaningful interval. The population and historical call demand distribution for each grouping was calculated from the GMCFS data.

The calculation of fire call population weightings for each IMD group was based upon a series of plots of the distribution of demand relative to the levels of deprivation as described by the IMD. A line of best fit was calculated and the regression equation describing the line used to calculate deprivation demand weightings for all classes of IMD including those not populated by the GMC data. The historical GMC demand data was used to produce the IMD demand proxy regression equation, and as such the line of best fit was generated to maintain the principle of the basis of the use of the IMD as a proxy, namely that increased levels of deprivation result in increased levels of demand for service.

Each ward was weighted according to the regression equation for the group within which it was classified. The equation produces weightings in line with the result of the correlation coefficient, wards with ranks indicating a large volume of fire calls will have greater weightings applied than wards with lower ranks. The ward group weights were calculated proportional to demand, scaled so that the ward group with highest deprivation was weighted proportionally greater than those groups with a lower deprivation rank.

The weightings, calculated from the power curve regression equation used, enabled an adjusted demand distribution to be produced that maintained the principle of the relationship between deprivation and demand as indicated by the initial correlation coefficient. The derived population demand weightings for each of the IMD ward groups was then used as a proxy for fire calls in the SSA by multiplying the population of the group by the group weighting.

In order to test the robustness of the proxy derived from the IMD association with demand for service observed in GMC, a list of Wards within each Fire Authority nationally was compiled. This list enabled the relative proportion, and numbers of each brigade's population to be calculated for the series of the IMD classes generated in the GMC series of models. The weightings derived from the GMC models were then applied to the population statistics for each brigade and the SSA recalculated for all individual brigades.

7.5 Results

Working from the original proposition that deprivation as measured by the IMD is positively related to the observed demand distribution of Fire Calls, based upon the research findings presented in previous chapters and the reported positive correlation coefficient of 0.735, a further set of correlation tests were conducted for the range of ward groupings constructed. The results of which are shown in Table 7.1. All the groups report a high level of positive correlation between deprivation (IMD) and demand for service (Fire Calls).

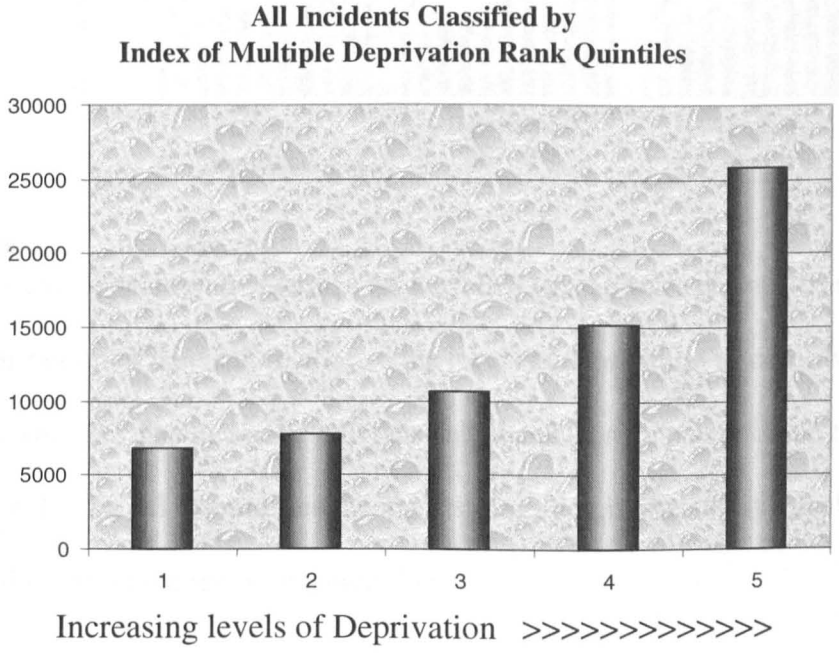
As a general trend the higher the level of deprivation the greater the number of Fire Calls. This is illustrated in Table 7.1, which shows the distribution of all

incidents occurring within a single year classified by IMD ranks into 5 groups of equal numbers of wards.

Table 7. 1 Non Parametric Correlations. Incident Rate Per Head of Population with Deprivation as Measured by IMD Classes

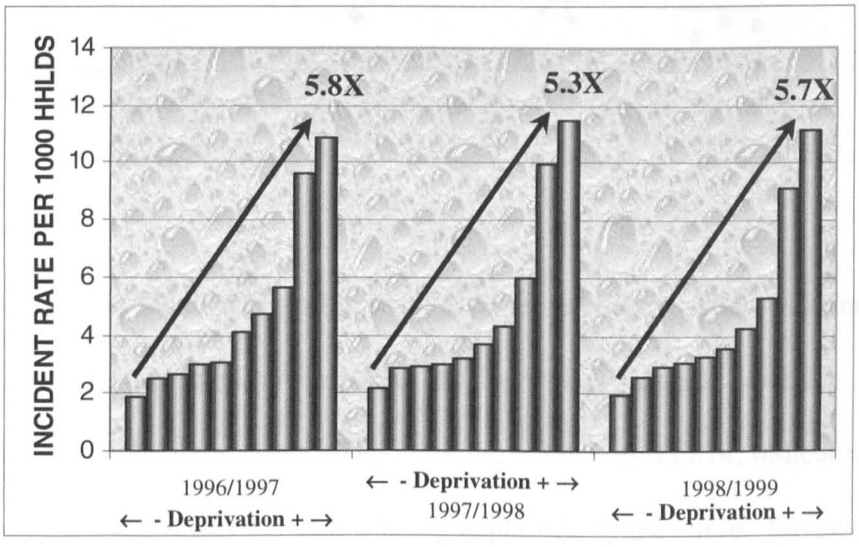
National IMD Rank Classes	Correlation Coefficient	Number of Classes Populated by GMCFS Data	Significance Level
4	1.0	4	.01 (2 tailed)
5	1.0	5	.01 (2 tailed)
10	0.855	10	.01 (2 tailed)
20	0.874	18	.01 (2 tailed)
25	0.783	24	.01 (2 tailed)
50	0.752	42	.01 (2 tailed)
100	0.755	70	.01 (2 tailed)

Figure 7.1



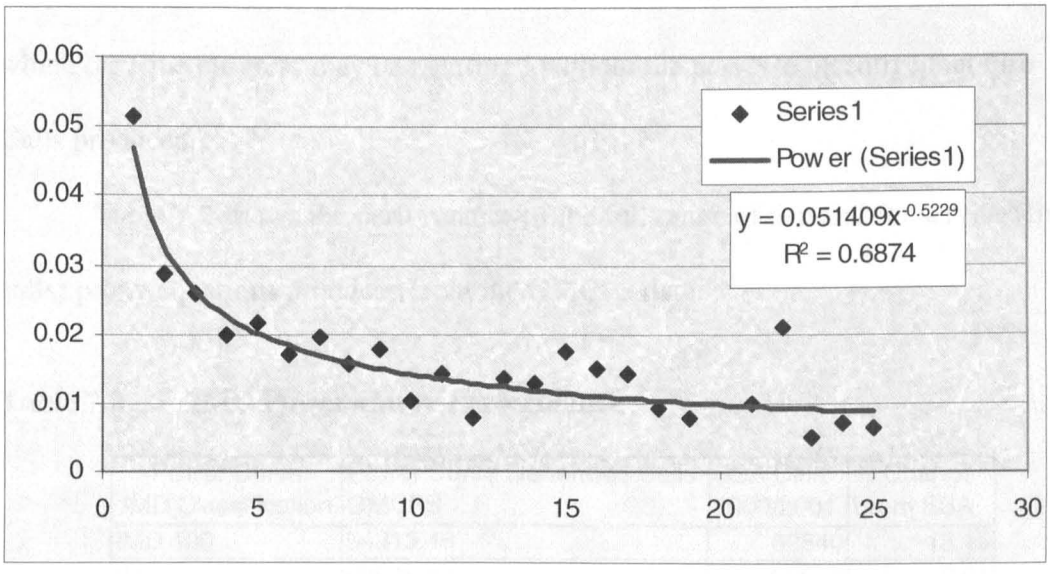
The relative concentration of residential dwelling fire, which account for the majority of all casualties and fatalities resulting from fire incidents, can also be considered in this way. Figure 7.2 shows the annual distribution of such incidents over a three year period classified by IMD decile groups. The figure illustrates that the most deprived areas of Greater Manchester are experiencing over 5 times the rate of the least deprived areas.

Figure 7.2 Non-Malicious Ignition Dwelling Fires: Ward Level Distribution Within Index of Multiple Deprivation Deciles



The fire call population weightings for each IMD group were derived from plots of the distribution of demand, relative to the levels of deprivation as described by the IMD groupings. The line of best fit was calculated using a power curve regression equation. Figure 7.3 exemplifies the methodology and illustrates the results of the plot and power curve regression equation.

Figure 7.3 Fire Calls Demand Distribution by IMD Ward Level Grouping (25 classes)



The trend in the data is similar to an exponential decay. There is some variation about the predicted power curve, but the residuals appear normally distributed either side of the curve. The r^2 for the curve was 0.6874, indicating that a great deal of the variation in the data is being explained by the curve. Given the well-documented relationship between deprivation and fire service demand, this is to be expected. The full set of figures (including equations) for all 7 classifications tested are provided as Appendix 4.

From the analysis the best performing IMD ward classification regression equations were identified as the 25 and 50 class groupings. These distributions had correlation coefficients of 0.783 and 0.752 respectively. The lines of best fit reported r^2 values of 0.6874 and 0.6664. As would be expected the over fitted model for the GMCFS produced a demand for service value almost exactly equal to the 2000/2001

SSA Fire Calls component. It needs to be stressed that the methodological approach taken here is based upon a known demand and the aim to produce a proxy based upon the relationship of the known demand with a measure of deprivation. This is an exercise in replacing a component of the SSA model with new component, from which baseline progress may be measured without the perverse incentive that Fire Calls produced.

Table 7.2 shows the performance of the full range of demand for service (fire calls) proxy equations produced from the GMCFS data.

Table 7.2 IMD Power Curve Performance

Power Curve IMD Classification	Power Curve Generated Calls GMCFS	SSA Calls 2000/2001	% Change From SSA
IMD 100	54313.46	62540	-13.15
IMD 50	62546.87	62540	0.01
IMD 25	62540.09	62540	0.00
IMD 20	64561.53	62540	3.23
IMD 10	66817.16	62540	6.84
IMD 5	65282.82	62540	4.39
IMD 4	63710.69	62540	1.87

The weightings obtained from the GMCFS model, being based upon a national classification of wards using the IMD, were then applied to each ward in England and aggregated to the 47 Fire Authorities. Table 7.3 shows the overall average performance of the GMCFS Fire Calls Proxy for each of the 7 IMD based groupings of wards. Again the 25 and 50 class groupings perform best, with overall increases in the demand for service component of 3.8 and 4% respectively. However the individual Fire Authority level performance of the proxy as shown in Table 7.4 shows a wide range of % change from the Fire Calls component of the SSA. These levels of variation are observed across all 7 groupings tested. The full weighting tables for each of the 7 groupings created are provided in Appendix 4.

Table 7.3 Fire Calls Proxy Performance: % Change From National SSA Fire Calls Component

National Power Curve IMD Classification	Fire Calls Proxy Performance: % Change From National SSA Fire Calls Component
IMD 100	-10.7
IMD 50	4.0
IMD 25	3.8
IMD 20	9.5
IMD 10	18.7
IMD 5	19.5
IMD 4	17.4

Table 7.4 Fire Calls Proxy Performance: By IMD Ward Level Grouping (25 classes)

Fire Authority Name	Power Curve 25 Weighted Calls	SSA Calls 2000/2001	% Change From SSA
Avon	14067	15880	-11.42
Bedfordshire	7703	7097	8.54
Berkshire	8403	12419	-32.34
Buckinghamshire	7533	9638	-21.84
Cambridgeshire	8777	11015	-20.31
Cheshire	14252	14557	-2.09
Cleveland	15589	14952	4.26
Cornwall County fire Authority	8539	5513	54.89
Cumbria County fire Authority	8486	7621	11.35
Derbyshire	16075	13563	18.52
Devon	16876	14727	14.59
Dorset	8729	8894	-1.86
Durham	15301	11281	35.64
East Sussex	11474	11137	3.03
Essex	21542	20862	3.26
Gloucestershire County Fire Authority	6583	6596	-0.20
Greater Manchester Fire and CD Authority	62540	62540	0.00
Hampshire	19806	20594	-3.83
Hereford and Worcester	8709	8545	1.92
Hertfordshire County Fire Authority	10486	12788	-18.00
Humberside	17415	16258	7.12
Isle of Wight Fire Authority	2216	1479	49.82
Isle of Scilly Fire Authority	18	17	6.18
Kent	21630	21833	-0.93
Lancashire	28900	26656	8.42
Leicestershire	14280	13681	4.38
Lincolnshire County Fire Authority	9546	6673	43.06
London Fire Authority	139018	127835	8.75
Merseyside Fire and Civil Defence Authority	44306	39909	11.02
Norfolk County Fire Authority	12202	9113	33.90

North Yorkshire	8612	8624	-0.13
Northamptonshire County Fire Authority	7748	9105	-14.90
Northumberland County Fire Authority	5631	5000	12.61
Nottinghamshire	20929	17512	19.51
Oxfordshire County Fire Authority	6309	9828	-35.81
Shropshire	6057	6225	-2.70
Somerset County Fire Authority	6219	6434	-3.34
South Yorkshire Fire and Civil Defence Authority	31933	24456	30.57
Staffordshire	22324	14474	54.24
Suffolk County Fire Authority	7645	7233	5.70
Surrey County Fire Authority	10520	14022	-24.97
Tyne and Wear Fire and Civil Defence Authority	24117	28659	-15.85
Warwickshire County Fire Authority	6099	7493	-18.60
West Midlands Fire and Civil Defence Authority	63818	57269	11.44
West Sussex County Fire Authority	8201	12549	-34.65
West Yorkshire Fire and Civil Defence Authority	43652	45736	-4.56
Wiltshire	6672	7588	-12.07
Total Calls and Overall % Change From SSA Fire Calls	867489	835880	3.78

It is important to restate that the % change from the SSA Fire Calls component shown in Table 7.4 affects on average one third of the overall SSA generated funding for brigades. Therefore a 30% increase in the % Change column equates to a 10% overall increase in the final SSA figure.

7.6 Discussion and Recommendations

The use of deprivation as a proxy for fire calls introduces the inclusion of a measure of the drivers of demand rather than the measure of response generated by demand. It has been demonstrated that within Greater Manchester the IMD has a high level of correlation with fire incidence and as such has the potential to serve as an effective demand driver measure. It should however be recognised that the broad brush approach of using an aggregate general measure of deprivation such as the IMD will not account for all variation observed in demand distribution. It will however provide a baseline profile of an areas deprivation characteristics which can

be related to demand, against which brigades' performance can be measured free of perverse incentive.

For Greater Manchester Fire and Rescue Authority a FRS level deprivation based proxy can be effectively modelled to the known distribution of incidents and used to provide a baseline for demand for service. . However the derivation of a nationally effective deprivation based proxy for demand in relation to the SSA formula would require further and wider ranging analysis than is possible with a single FRS's data. Further longitudinal studies of the stability of the relationship between deprivation and fire calls would also need to be conducted. Work would also need to be undertaken to quantify the proportion of the workload that is not related to deprivation e.g. land use and functional space factors as these demand generators would not be reflected in a deprivation based demand proxy.

The use of the non-census based IMD indicator as a proxy for demand provides a greater flexibility in the potential to update the demand distribution proxy equation over time than would a census-based proxy. It also enables the analysis of demand variation via a nationally comprehensive and consistent measure at the sub authority level of the ward. This ties in with the need for locally targeted initiatives in response to locally manifested problems.

The fact that this study has had access to a high quality source of digitally held incident data has enabled the analysis to be conducted using all of the data that contributed to the 5 year annual average calls used in the SSA. In order to develop the potential application of the use of the IMD or another measure or set of measures of deprivation, the study would need to include a wider sample of FRSs. Data from other FRSs should be sought and used to generate a wider evidence base on the demand for the fire and rescue service in relation to deprivation. The availability and

quality of that data at this point in time, has been called into question by the result of the national survey presented in chapter six. The use of a single FRS's data to generate a deprivation-based proxy may prove unrepresentative of the wider relationship between demand and deprivation. This appears to be the case from the results, with the GMC weighted data producing a high level of volatility across FRSs.

A wider data sample may enable the national performance of a proxy to be improved reducing the variation between the demand as generated by the use of Fire Calls and the deprivation demand weightings. A national model derived from data for the whole country may decrease the observed volatility of the deprivation based proxy.

Calls would however still play a part in measuring the effectiveness of FRSs in driving down fire incidents. The use of a weighted deprivation based proxy alongside fire calls measure could also be considered, which would address both the underlying relationship between demand and deprivation whilst including the direct measure of activity/demand for services as reported by fire calls. This may involve the use of positive weightings for achieving reductions in fire calls and negative weightings for increased fire calls. The weightings may be generated using demand variation measured against deprivation levels within brigades and/or against national call level trends.

To date there has been no research that fully quantifies the demand drivers for the Fire and Rescue Service. This research has shown that deprivation has significant discriminatory power in relation to AADF and previous research has indicated a wider association across incident types (Chandler, 1984), but its associative relationship at the aggregate area level is not the sole answer to the observed distribution of all fire incidents. The use of fire calls in the SSA takes no account of

the underlying demand drivers and the effectiveness of individual brigades in their service delivery and prevention initiatives. As such it can be argued that that the current Fire SSA lacks a credible evidence based approach to resource allocation and is not sophisticated enough to discriminate between high and low risk populations, but only responds to historical incident levels.

7.7 Summary

This chapter has built upon the development of the theoretical model of AADF and the established associative links between AADF and area based measures of deprivation and characteristics and attempted to apply the findings to the organisational funding issues central to the ability of the service to pursue an evidence lead, prevention based resource allocation and service delivery. It represents the first attempt to develop a theoretically and evidence based alternative or addition to the funding method for the fire service, exemplifying the potential adaptation of theory and empirical research findings to the management and funding of the fire service through the use of a measure of deprivation as a proxy for the underlying fire risk. The resulting funding mechanism presented represents a development in the approach to identifying a risk based funding and service delivery methodology. Further research would be required to refine and perhaps identify more effective models and risk based proxies for demand and mechanisms within which they may be incorporated.

The following, and final, chapter summarises and critically assess the research conducted. It states the principle developments presented in this thesis, bringing together the multiple strands of the work conducted, stating the current level of our knowledge in respect of AADF and the wider field of fire incidence research.

Conclusions are drawn, policy implications discussed and recommendations for further research are made.

Chapter 8

Conclusions and Recommendations

8.1 Introduction

This thesis builds upon the existing literature to develop a new theoretical model of Anthropogenic Accidental Dwelling Fire which provides a framework both for the empirical core of the research and for future work to be undertaken. The adaptation and development of existing theory and models from the fields of ecology and criminology resulted in the specification of a new AADF Domestic Routine Activities Time Classification that was used in the production of an AADF differential risk profile evidence base.

The chapter brings together the major components of the research into a unified coherent argument for the adoption of a theory based analysis of Anthropogenic Accidental Dwelling Fire (AADF), to inform Fire and Rescue Service policy, management and the operational targeting of resources and tailoring of initiatives deal with the problem of AADF.

The findings demonstrate the development of the knowledge within the field and have the potential to contribute to the direction of further research, policy development and management of a modernising Fire and Rescue Service.

8.2 Building Upon the Existing Literature: Developments and Findings

The stated aim of the research was to 'develop an understanding of the non-random spatial and temporal distribution of anthropogenic accidental dwelling fire incidents in relation to social, economic and environmental factors, and to exemplify the

potential utility of such knowledge to inform evidence based Fire Service policy and management'.

The literature review identified five clear, distinct and inter-related areas that represented significant gaps in the field and related to; a lack of theoretical basis for any of the existing research undertaken, the applicability of the existing literature outside of the specific case study areas, a failure to recognise the importance of variation in ignition cause of AADF, little research into or evidence of the role of temporal patterns in the distribution of dwelling fires, and the lack of incorporation of the role of the fire service.

The literature did provide evidence of association between income levels fire incident rates, and the ability to 'enumerate a set of community characteristics that are likely to go hand in hand with high fire incidence rate'(Munson & Oates, 1983,p72). It also introduced the idea that incident ignition categories were likely to show variations in patterns of distribution, and the proposition that fire ignition type was likely to be 'people dependant' and specifically area characteristic associated (Ducic, 1980 and Gilliam, 1985), although there was limited supporting evidence presented.

Building upon the evidence of association between dwelling fire incidents, income and a range of community characteristics, as well as existing theory and methodology from other fields, the component parts of AADF were identified a theoretical model developed. The model, draws upon the Routine Activities work of Hawley (1950) and components of environmental criminology theory, it identifies the inherent risk in domestic routine activities and the critical role of the 'trigger event' in increasing that risk significantly. The incorporation of location and time has enabled the dynamics of the observed distributions to be investigated and area characteristics to be

used to provide a contextual backcloth to inform the interpretation of the observed patterns.

The specification of the new Domestic Routine Activities Time Classification was developed based upon the theoretical premise that the routine domestic activity diurnal profile was the underlying driver of the AADF incident profiles. The classification identifies those periods of the day within which differing domestic routine activities are concentrated and enables comparative statistical analysis to be conducted and the associated risk parameters of both activity and time period to be identified. The routine activities are associated with specific ignition categories which were used define and examine fire profiles in relation to spatio-temporal incident distributions.

The existing literature identified the need to find suitable variables which could be used for the purposes of differentiating fire risk by area type. Both the Index of Multiple Deprivation and the geodemographic classification Superprofiles were selected for use within the research offering pre-existing, consistent and nationally comprehensive data sets to classify area types.

The research results clearly demonstrated that the distribution of AADF incidents was highly spatially concentrated both at the electoral ward level and increasingly so at the enumeration district finer level of geography. A significant correlation was identified between increased levels of deprivation (IMD) and higher AADF incident rates, a similar correlation relationship was observed within the Superprofiles classification, which although not a measure of deprivation can to some extent be assumed to have an underlying scale of affluence associated with the Lifestyle classification.

The analysis provided evidence that there was significant variation in the fire incident profile of areas by ignition category, with the most deprived areas having a predominance of ignition causes associated with children and with smoking, whilst the less deprived areas were more likely to have fires associated with electrical appliance misuse or a range of accidental causes.

The introduction of the Domestic Routine Activities Time Classification into the analysis enabled the pattern of AADF to be considered in relation to temporal variation. The results showed that there were clear temporal patterns of AADF associated with the patterns of domestic routine activities within the households as reported by the frequency of ignition categories. A unique profile was obtained for each ignition category. Using standardised residuals, statistically significant concentrations of AADF were calculated and quantified for each ignition category and also by deprivation group. It was interesting to observe that although unique AADF profiles were obtained in each set of analysis, that the routine activities profile was similar across the deprivation groups, supporting the applicability of the classification in relation to fire ignition causes.

The empirical analysis findings develop the existing body of evidence, identifying clear associations between AADF and two separate area classification typologies, the IMD and Superprofiles. However it is the incorporation of the ignition and time categorisations that provide significant new evidence of the utility of area based AADF risk profiling.

Another failing of the existing literature was that to consider the issues affecting the Fire Service in relation to their ability to adopt research findings within their organisational structure. The consideration of data issues and standards within the fire

service formed a significant part of the early research as data quality problems proved difficult to overcome. The early interest was developed through the partnership with the GMCFS, and lead to a comprehensive national survey of brigades being undertaken to establish the potential for the applied use of the research. This was supplemented by a national conference on data and analysis being organised as part of the Ph.D. research, for the fire service in June 1999, which was followed up by further detailed survey and site visits. The reported survey results (chapter 6) and detailed additional information collated provide the most comprehensive report on the capabilities of the fire service to adopt theory lead research and evidence based resource targeting conducted to date. The results reported that that there was a significant need for the development of skills, systems and processes within the organisation and a lack of clear legislative and policy guidance in relation to risk based fire cover.

The final component of the research was to test the application of a risk based proxy for demand for the fire service against the existing fire service standard spending assessment (SSA). The SSA contained a perverse incentive within the funding formula which resulted in fire services that were successful in reducing the incidence of fire, their primary aim, having their funding reduced as a result. In order to test the potential application of the analytical component of the research findings, area based fire risk indicators were introduced, for the first time, into the fire service funding methodology (SSA). The applied use of the IMD as a proxy for fire service demand, in the over fitted weightings model, demonstrates that although the outcome of the model proved volatile, there is potential for the national application of a funding model based upon theoretically grounded research and the empirical evidence derived.

8.3 Discussion: Research Limitations and Statements of Applicability

The empirical core of the research was conducted between 1998 and 2002, utilising data sets which were current to that period of time.

The theoretical model developed identifies the key components of AADF, and provides a theory based framework within which continuing research can be conducted. The components of risk and processes of interaction place people at the centre of the model, it is their domestic routine activity patterns and variation in behavioural risk profiles that act to create trigger events and influence outcomes. The model is not time or location dependant and therefore has local, national and international applicability.

The development of the AADF Routine Activities Time Classification was to a great extent data driven and therefore will be subject to adaptation based upon local analysis to define the time period boundaries and associated activity classes in relation to ignition categories. Although variation over time may be observed in the frequency of AADF within time periods the classification can be adjusted accordingly and is not restricted or devalued by the passage of time. The date period of the data is likely to be less important than cultural variations in lifestyle patterns which may be very pronounced in specific communities or indeed for international utilisation.

Within a dynamic policy and service delivery environment the demands made upon the FRS will vary. The results of the AADF data analysis have specifically focused on producing results which provide information on the core components of the problem. The methodological framework developed and use of standard areal units of analysis, a measure of multiple deprivation and a sophisticated geodemographic lifestyle area classification combine to both deliver a statistically significant and robust evidence base

for the AADF risk profiles presented and associated area characteristics, but also enable the same methodology to be repeated using the same or similar data sets to continually test, monitor and evaluate the patterns of distribution. The observed patterns are likely to change over time, whilst the fundamental AADF associations with specific area risk profiles are the focus of the policy makers and service providers who aim to achieve change through better understanding of the issue and targeted intervention.

The results from any single survey represent a snapshot of circumstances at a given point in time. The National Survey conducted within this research identified the baseline position for the Fire Services at that time, it informed the development of policy and process within both GMCFS in relation to data, analysis and information use, at the time, and to some extent all other participating Fire Services. The information gathered formed the basis of a National Conference of Fire Services which was attended by FRS, Local, Regional and Central Government, feeding into the ongoing FRS modernisation agenda and national policy development. The passage of time since the survey and conference have not diminished the validity and value of the results obtained, rather it has served to validate the findings and increase the value of the information gained through contribution to policy formation and operational processes and management.

The research conducted was limited to a single UK Fire Service, GMCFS, due to the lack of suitable and willing participants at the time of the empirical data analysis. Although the Greater Manchester area provided a wide range of socio-economic variation the patterns of incident distribution reported are specific to the case study area only and further analysis will be required to test the robustness of the results and the wider applicability of the findings. This was to some extent demonstrated in the performance of

the proxy for demand used in the recalculation of the SSA in chapter 7, with good overall performance but a relatively high level of volatility within the results obtained.

The access to only a single case study Fire Service also dictated that due to the relatively low frequency of anthropogenic accidental dwelling fire the data analysed had to be aggregated to a single time period to overcome problems of small numbers. This aggregation, although representative of the overall demand for service in relation to area characteristics, limited the research in relation to analysis of change over time. This however is to some extent mitigated by the fact that the primary source of contextual data for the research, and available to the Fire Service for ongoing analysis, was the fixed data point of the census.

Area level characteristics were selected based upon availability and national applicability. At the time of the empirical analysis the current census data available was that of the 1991 census. Census variables since released at the output area level may well prove a more flexible and powerful areal unit of analysis based upon their smaller size and increased levels of homogeneity.

A wide range of spatio-temporal statistics were potentially available for utilisation within the empirical core of this thesis when examining the distribution of AADF and the association with area based characteristics, however the use of area based analysis and pre-defined measures of deprivation and area classification system were found to be well suited to the scope of the research, testing the theoretical model proposed and demonstrating the non-random nature of the problem. There is additional scope to take the research on and more closely investigate the spatial distribution patterns of AADF

and the use of alternative individual and groups of variables to derive new measures of relative risk.

The limitations identified within the critical review of the research begin to form the foundations for recommendations for further research. They identify the need for additional data to be obtained from a representative sample of FRS in order to develop the evidence base and establish the wider applicability of the empirical analysis results obtained in relation to the area based risk profiles for AADF. The following section draws the thesis to a conclusion, and considers the policy implications of the research developments and findings, the potential organisational impact and makes a series of recommendations for further research.

8.4 Policy Implications and Recommendations for Further Research

This research has focuses on the very specific sub categorisation of fires identified as Anthropogenic Accidental Dwelling Fires. This classification is not a Government or Fire and Rescue Service classification, but is created within this research to identify a distinct class of fires which can be attributed to the behavioural interaction between people and their domestic dwelling environment. The research has provided evidence for the significant differential in levels of risk that can be associated with specific area types as defined by either deprivation (IMD) or lifestyle (Superprofiles). The theoretical model of AADF places people at the center of the model and identifies the role of domestic routine activities and behavioural trigger events that act to increase the risk of ignition. The research has demonstrated the ability to identify spatio-temporal specific area based risk profiles across a range of routine activity associated ignition categories, the

combination of the research findings has significant associated implications both in terms of policy and FRS management.

The issue of AADF is inherently complex due to the pivotal role of the person as both the responsible agent and victim of the fire event. The increasing legislative and policy focus on prevention as the primary aim of the FRS, through the introduction of the Fire Services Act 2004, the National Framework for FRS, Fire Comprehensive Performance Assessment (CPA) and the Fire Service Emergency Cover (FSEC) toolkit, data, information and evidence have become more widely used and valued within the modernizing FRS. AADF remains a significant challenge for the FRS, accounting for the vast majority of fire deaths and casualties in the UK (Watson, 2000). The current data sets, tools and methodologies utilised by the FRS have significant gaps relating to AADF and gaining an increased understanding of the problem. This research has developed a theoretical model which introduces the theory of routine activities to the field, along with the temporal classification developed and the behavioural trigger event; this provides a framework to guide policy development, research and operational planning and delivery.

Whilst the research provides a new framework, methodology and supporting evidence for the identification and profiling of relative risk, it also identifies a significant gap in the knowledge base associated with the risk related patterns of behaviour influencing the frequency of the trigger event. There is little or no data collected by the FRS specifically dealing with the circumstances directly leading to the AADF incident other than to record the class of ignition and room of origin of the fire. This information has been shown to be of value in producing AADF risk profiles but lacks information on the specific behavioural patterns of risk, and the range and nature of the trigger event.

For example in relation to an AADF caused by an ignition classified as cooking related, it would be valuable to know the level of occupancy in the dwelling at the time, the activities of those occupants, the act or omission that triggered the ignition, was it related to a lack of due care and attention, distraction from the task by children or other factors, inappropriate use of appliances etc. Information such as this would inform the way in which FRS developed education and intervention policy and targeted resources.

The aspect of risk related behavioural patterns associated with domestic routine activities is an important area for further academic research. Individual level data relating to AADF trigger events would enable the development of the theoretical model of AADF to incorporate sub-classifications of activities, behaviours and household composition related to risk, all contributing new information and contributing to the better understanding of the nature of the problem, and informing potential interventions.

The research findings associated with the use of the Domestic Routine Activities Time Classification to produce and provide evidence for unique area based AADF profiles represents an important incremental step for the FRS. This provides an impetus for policy development prioritising specialisation within the FRS, with a tailored approach to highly specific risk within communities based upon theoretically justified methodologies and evidence. The current high profile focuses on Integrated Risk Management Planning (IRMP) and risk based fire cover, have provided a national foundation for the research findings to be adopted and operationalised within the FRS. Area profiles are now routinely produced by FRS, using the FSEC toolkit, and the logical next step is for more specific analysis of sub classifications of fire incidents to be utilised.

Specialisation not only in respect of AADF but across the whole service provision is essential if the FRS are to achieve the highest standards of service provision. Understanding the detailed nature of the key components of AADF will enable national guidance and local initiatives to be developed specifically tailored to those at highest risk. Continued monitoring and evaluation of such initiatives will provide feedback to refine both the theoretical model of AADF and also the classifications and methodologies developed.

Beyond the immediate reporting of the results of the comprehensive national survey of Fire Services, which provides an important baseline position statement, the issues raised relating to the value and utilisation of additional data sets are key to both the better understanding of AADF and also the ability of the FRS to contribute to its reduction. With the national network of regional control centers providing improved and validated data sets from within the FRS, the organisation needs to look outside to potential partners and sources of additional data sets, information and evidence that can be used to address the immediate manifestation of the problem, the fires, but also to contribute to addressing some of the associated causes. The availability of improved spatial referencing achieved through regional control, the validated incident records and the analytical tools available increases the internal value of the FRS's own data. Historically the FRS were often unable to provide supporting empirical evidence in relation to major issues faced by them or to contribute evidence of risk to the wider community safety field, the ability to do so now and the increasing potential to be achieved, through adopting research finding such as presented in this thesis, strengthens their position politically and as an organisation as a whole.

The use of the IMD as a proxy for demand for the fire service within the SSA provides an example of the strengthened political position to be gained from being better informed about the core business of the FRS. The research demonstrated the utility of the IMD as an area based discriminator for AADF frequency. The ability to address the perverse incentive that was contained within the SSA and present a strong case for the replacement of fire calls as a funding component was demonstrated within this thesis. GMCFS used the findings of the research to lobby for a review and change in the funding methodology which was going to reduce their income due to the success that they had achieved in reducing fire incidents through proactive CFS activities. The findings of the SSA model presented in the thesis contributed towards securing a full review of the calls component of the fire standard spending assessment.

Building upon the findings presented, additional research into the role of domestic routine activity patterns and associated risk behaviours is a priority in relation to AADF. The development of risk probability profiles, methodologies for dynamic risk management and associated cost-influence matrices are all logical considerations for further research.

There is a clear need to get to detail of trigger event circumstances to better understand how to educate those at risk, when to intervene and to what extent response may be the most effective option. Researchers and the FRS will need to draw from wider research communities, embrace new technologies, and value a wide range data sets, skills, external expertise and partnership development, if they are to achieve what is an exciting potential within this field.

Proposals are currently in development working with US universities to approach ESRI and Fire Departments in both the US and UK to conduct an international comparison study developing the findings presented and pursuing the recommendations made.

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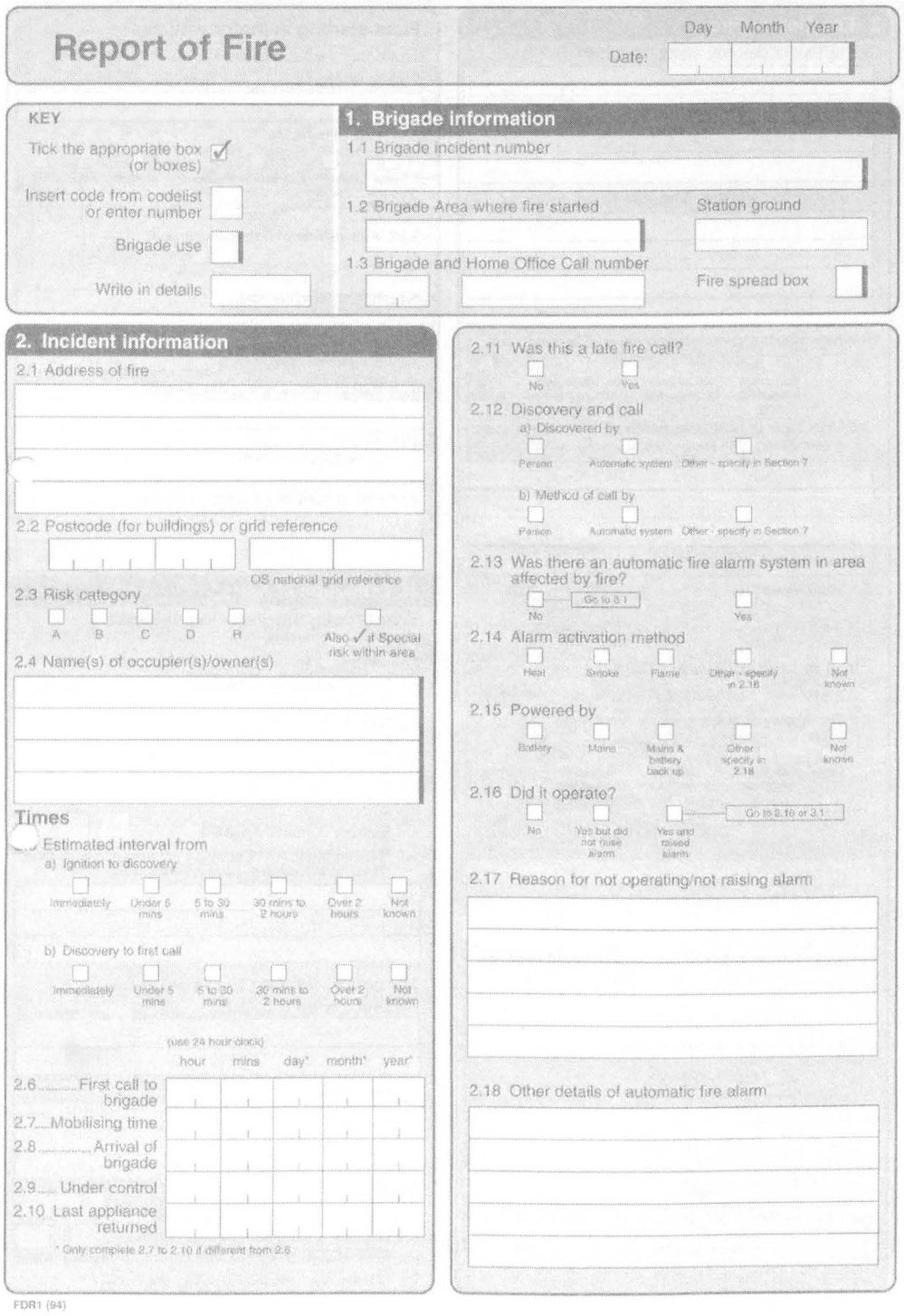
Appendices

Appendix 1: Form FDR1



Report of Fire

Date: Day Month Year

KEY

Tick the appropriate box (or boxes) ☑

Insert code from codelist or enter number

Brigade use

Write in details

1. Brigade information

1.1 Brigade incident number

1.2 Brigade Area where fire started

Station ground

1.3 Brigade and Home Office Call number

Fire spread box

2. Incident information

2.1 Address of fire

2.2 Postcode (for buildings) or grid reference

OS national grid reference

2.3 Risk category

A B C D R

Also ✓ if Special risk within area

2.4 Name(s) of occupier(s)/owner(s)

Times

Estimated interval from

a) Ignition to discovery

Immediately | Under 5 mins | 5 to 30 mins | 30 mins to 2 hours | Over 2 hours | Not known

b) Discovery to first call

Immediately | Under 5 mins | 5 to 30 mins | 30 mins to 2 hours | Over 2 hours | Not known

(use 24 hour clock)

	hour	mins	day*	month*	year*
2.6 First call to brigade					
2.7 Mobilising time					
2.8 Arrival of brigade					
2.9 Under control					
2.10 Last appliance returned					

* Only complete 2.7 to 2.10 if different from 2.6

2.11 Was this a late fire call?

No Yes

2.12 Discovery and call

a) Discovered by

Person | Automatic system | Other - specify in Section 7

b) Method of call by

Person | Automatic system | Other - specify in Section 7

2.13 Was there an automatic fire alarm system in area affected by fire?

No — Go to 3.1 | Yes

2.14 Alarm activation method

Heat | Smoke | Flame | Other - specify in 2.18 | Not known

2.15 Powered by

Battery | Mains | Mains & battery back up | Other - specify in 2.18 | Not known

2.16 Did it operate?

No | Yes but did not raise alarm | Yes and raised alarm — Go to 2.18 or 3.1

2.17 Reason for not operating/not raising alarm

2.18 Other details of automatic fire alarm

FDR1 (94)

3. Location of Fire

3.1 a) Type of property where fire started

b) If mobile property, give location

3.2 Residential accommodation affected by fire?

☐ No ☐ Yes, where fire started only ☐ Yes, spread to residential ☐ Yes, where both started and spread to residential ☐ Not known

3.3 Main trade or business carried on where fire started

If none ✓ box ☐ eg wholly residential, and go to 3.4

3.4 Multiseated fire

☐ No ☐ Yes

Fires in buildings and ships

If not ✓ box ☐ and go to 3.10

3.5 Occupancy of building where fire started (leave blank for ship)

☐ Single ☐ Multiple same use ☐ Multiple different use ☐ Under construction ☐ Under demolition

☐ Derelict ☐ Unoccupied ☐ Other - specify below eg - under refurbishment ☐ Not known

3.6 Place where fire started

3.7 Use of room, cabin or roof space where fire started

3.8 Floor, deck of origin

Number ☐ if above ground/main deck

✓☐ if ground/main deck

Number ☐ if below ground/main deck

✓☐ if other, specify below

3.9 Total number of floors in building where fire started

☐ (leave blank for ship)

Fires starting in motor vehicles

If not ✓ box ☐ and go to Section 4

3.10 Make/Model

3.11 Fuel of vehicle

☐ Petrol (not fuel injected) ☐ Petrol fuel injected ☐ Petrol (not known) ☐ Diesel/ other oil ☐ Electric ☐ LPG ☐ Other - specify in 3.17

3.12 Was vehicle turbo/supercharged?

☐ No ☐ Yes ☐ Not known

3.13 Registration number (if available)

3.14 Year of manufacture (if available)

3.15 Part of vehicle where fire started

3.16 Was engine running? (immediately before fire)

☐ No ☐ Yes ☐ Not known

3.17 Other information available eg VIN No,Chassis No etc

4. Extinction of fire

Fixed firefighting/venting systems

(in area where fire started)

If none ✓ box ☐ and go to 4.6

	Type 1	Type 2	Type 3
4.1 Type of system (code up to 3) See Code list 4.1			
4.2 Manual or automatic M = Manual A = Automatic Z = Not known			
4.3 Did it operate A = Yes and extinguished fire B = Yes and contained (controlled) fire C = Yes but did not contain, (control) fire N = No			
4.4 Number of heads actuated			

4.5 Reason(s) for not operating/containing/controlling (Leave blank if answer to question 4.3 is A or B)

Type
1
2
3

Method of fighting the fire

4.6 Before arrival of brigade

4.7 By brigade up to stop

4.8 Number of main jets used

4.9 Number of local authority appliances attending up to time of stop — Pumping — Other

(If further details required by brigade - use Section 7

5. Supposed cause, damage and other fire details

5.1 Most likely cause

a) ☐ Accidental ☐ Malicious ☐ Deliberate ☐ Doubtful ☐ Not known

b) caused by:

☐ Child ☐ Youth ☐ Adult ☐ Animal ☐ Other (not a person or animal) ☐ Not known

Give additional details of person (if known)

c) Defect, act or omission giving rise to ignition

5.2 Source of ignition

a) Appliance/installation and other sources

b) Powered by

c) If source is an appliance, enter the make or model, if known below

5.3 Material or item ignited first

a) Description

b) Composition

5.4 Material or item mainly responsible for development of fire

a) Description

b) Composition

5.5 Dangerous substances affecting firefighting or development of fire (Specify up to 2 in order of priority)

If none ✓ box ☐ and go to 5.6

	a) Material	b) Circs.
1		
2		

Circumstance codes: M = being Made S = in Storage T = in Transit U = being Used W = combination of circumstances Z = not known

c) Main effect of substance on fire and/or firefighting

5.6 Explosion

a) ☐ No → go to 5.7 ☐ Yes, occurred ☐ First ☐ During fire ☐ First and during fire ☐ Not known

b) Materials involved in explosion (Specify up to 2)

1

2

c) Containers involved in explosion (Specify up to 2)

1

2

5.7 Abnormal rapid fire development

No ☐ Give additional details (if known)

Yes ☐

5.8 Damage caused to:

i) item ignited first

ii) room, cabin, compartment etc of origin (buildings, ships & vehicles only)

iii) elsewhere on floor, deck, other compartments of origin (buildings, ships & vehicles only)

iv) elsewhere in/on property of origin

v) outdoors beyond property; beyond building, ship, plant, vehicle etc

a) %: enter percentage of item/room etc damaged eg. 25 = quarter, 50 = half etc

b) Severity: enter code to show severity of damage L = Light, M = Moderate, S = Severe

Damage caused by	to i) a % b	to ii) a % b	to iii) a % b	to iv) a % b	to v) box(es) if affected
fire					☐
heat					☐
smoke					☐
other					☐
Total not to exceed 100%					buildings
% of structure damaged	%	%	%	%	vehicles
Number of additional: damaged		room, cabin, compartment etc	floors		other locations
Number of additional: total					

If further description required by Brigade use Section 7.

5.9 Estimate of horizontal area damaged

a) Area damaged by direct burning

Area = sq m
under 1 sq m
1-2
3-4
5-9
10-19
20-49
50-99
100-199
200 +

If over 200 write in to nearest 50 sq m.

b) Total area damaged by fire heat smoke etc.

5.10 Animals killed

If none ✓ box ☐ and go to Section 6

If yes record up to 3 main species

	Species	Number
1		
2		
3		

6. Life Risk

Involvement of persons (as known to brigade)

If none ✓ box ☐ and go to Section 7

6.1 Number of non-fatal casualties (including those who were rescued)

6.2 Number of fatal casualties

6.3 Number of rescues only (exclude those who were casualties)

6.4 Approximate number of persons at discovery of fire in room, cabin, compartment, etc., of origin

6.5 Approximate number of persons at discovery of fire in other parts of building, vehicle, etc.

6.6 Approximate number who left the affected property (including any who were casualties)

6.7 Fatalities, other casualties and rescues:
Complete one line for each person
Refer to guidance notes for codes
Use single code in each column 2 to 7

	Name of person	Age Yrs	Sex	Location	Main Circumstance	Status	if no injury leave blank: Nature of injury	if not rescued leave blank: Rescued by	if not rescued leave blank: Rescue methods up to 2	Brigade use
A										
B										
C										
D										
E										
F										
G										
H										
		1	2	3	4	5	6	7	8	9

7. More detailed description of fire/further information (if applicable)

Section/question	

7.1 Further investigation to be carried out

☐ No ☐ Yes by ☐ Fire brigade ☐ Police ☐ Others ☐ Fire of special interest

7.2 Further information to follow

☐ No/Not known ☐ Yes

Special study boxes

7.3 | 7.4 | 7.5 | 7.6 | 7.7

Name & rank of person in charge at first attendance (IN CAPITALS)

Name & rank of person in charge of the fire (if different from above) (IN CAPITALS)

Signature

Form completed by (IN CAPITALS)

Rank

Date

The Stationery Office (FM) Ref. 602745 Feb 97

Appendix 2
Super Profile Lifestyle Pen Pictures

A short description of each provides some idea of the likely characteristics of these geodemographic groups. Taken from Brown and Batey (1994).

Lifestyle 1: 'Affluent Achievers'

High income families, living predominantly in detached houses. The Affluent Achiever typically lives in the stockbroker belts of the major cities, and is likely to own two or more cars, which are top of the range recent purchases and much relied on for the pursuit of an active social and family life.
This type of person has sophisticated tastes. They eat out regularly, go to the theatre and opera and take an active interest in sports (e.g. cricket, rugby union and golf). In addition they can afford several expensive holidays every year.
Financially aware, with a high disposable income, Affluent Achievers often invest in company shares and/or specialised accounts. They use credit and charge cards frequently, and are likely to have private health insurance. Investments are followed closely in broadsheets such as the Financial Times, The Times and the Telegraph. Other magazines bought may include Hello, Harpers & Queen, and Vogue.

2: 'Thriving Greys'

Generally older than Affluent Achievers, possibly taking early retirement, the Thriving Greys are also prosperous. Their detached or semi-detached homes have been completely paid for, and children have grown up and left home. Therefore the greys have money to spare for investments or spending, on items such as a superior car. They eat out regularly, take one or two holidays a year, and are likely to play golf and enjoy going to
the theatre.
This group also are financially aware and may invest in the stock exchange, and/or purchase health insurance. The Thriving Greys read the broadsheets as well as more traditional magazines, such as Woman's Realm and Woman and Home.

3: 'Settled Suburbans'

Well-established families in generally semi-detached suburban homes. Settled Suburbans are employed in white collar and middle management positions, while in addition many wives work part-time. The lifestyle is fairly affluent, in that one or two package holidays a year may be taken, and the family can afford to purchase newer cars.
They have taken advantage of government share offers in the past and often use credit cards. Many are mail order agents. Typical publications read include the Daily Mail, The Express, Ideal Home and Family Circle.
4: 'Nest Builders'

'Thirtysomethings' who have recently started a family, the Nest Builders are middle management, white collar workers. Although there are often two incomes, the mortgage on the house consumes a large portion of the money. With young children and a relatively small amount of money for luxuries, Nest Builders rely on home-based entertainment, such as watching sport on television, or subscribing to satellite/cable TV. Socialising is usually done at home, while many also shop via catalogues. They may have more than one car, though frequently these are older, cheaper models.
Tabloids, and in particular Today, are the Nest Builders' chosen papers. They also read Home PC and Mother & Baby in significantly high numbers.

5: 'Urban Venturers'

This cosmopolitan, multiracial group reside in areas of major cities that are undergoing gentrification but retain a significant proportion of poorer quality housing.
These young adults live in terraced houses or flats and have a high level of disposable income, which is spent on eating out, expensive holidays, keeping fit, going to pubs, clubs, concerts and the cinema. Close to busy areas, there is little need for a car, so forms of public transport (bus, train, and the tube) are preferred.
Urban Venturers read about their interests in magazines such as Time Out and Cosmopolitan and keep up to date with current affairs in the more liberal broadsheets, The Guardian and The Independent.

6: 'Country Life'

Rural in nature, this group lives, works and plays in the countryside. Many live on farms or in tied cottages, which are concentrated in East Anglia, Scotland, Wales and the South West.
Given the relatively low numbers of retail outlets and the distances to them, car ownership and the utilisation of direct mail are both high.
Popular reading includes the Field and Country Living magazines, and broadsheet newspaper The Telegraph. As might be expected, they like to relax outdoors, and one preferred leisure pursuit is watching horse racing.

7: 'Senior Citizens'

An elderly group living in small, possibly sheltered accommodation. Many have moved into retirement areas and there are many "little old ladies" -lone single female pensioners.
The Senior Citizens will live within their means, however limited, with their key recreational activities being passive, such as the pub and television. They also prefer to shop at convenience stores in their own neighbourhood.
This group have always been financially aware and saving for a rainy day has been a way of life. Of all the lifestyle groups the Senior Citizens are the least likely to read newspapers and the popular magazines.
8: 'Producers'

These more affluent blue collar workers live in terraced or semi-detached housing. Many are middle aged or older and their children have left home. The Producers work in traditional occupations and manufacturing industries, where unemployment has risen to a significant level.
Most are well settled in their homes, which are either purchased or rented from the council. Leisure pursuits include going to the pub and betting on horse races. On TV, football and rugby league are the preferred sports.
They do not spend money on cars and there is little planning for the future by way of financial investments. The Sun, The Mirror, and The News of the World are the most popular newspapers.

9: 'Hard-Pressed Families'

Living in council estates, in reasonably good accommodation, unemployment is a key issue for these families. Most work is found in unskilled manufacturing jobs, if available, or on Government schemes. The parochial nature of this group is emphasised by an unwillingness or inability to either move home or go on holiday.
The most popular leisure activities are betting and going to pubs and clubs. On TV, sports such as football and rugby league are watched. Tabloids, particularly The Sun, The Mirror and The Daily Record are their chosen daily papers.

10: 'Have Nots'

Single parent families composed of young adults and large numbers of young children, living in cramped flats.
These are the underprivileged who move frequently in search of a break. However, with two and a half times the national rate of unemployment, and with low qualifications, there seems little hope for the future.
Most are on Income Support, and those who can find work are in low paid, unskilled jobs. There are very few cars and little chance of getting away on holidays. Recreation comes mainly from the television and the take up of satellite and cable TV is high. Betting is also popular, particularly on greyhound racing. The Sun and The Mirror are the most popular newspapers.

Appendix 3a
Operational Intelligence Questionnaire Part 1

SECTION ONE - General Data Recording Procedures

1.1 Does your Brigade store individual FDR1 incident records in computer files?

Yes ☝ No ☝

1.1a If 'Yes', approximately what proportion of FDR1 incident record forms are captured in computer files?

< 10% ☝ 11 - 25% ☝ 26 - 50% ☝ 51 - 75% ☝ 76 - 100% ☝ 100% ☝

If less than 100% please specify the reasons - _____

_____

1.1b Does your brigade capture all variables recorded on the FDR1 form for each incident?

Yes ☝ No ☝

If NO please specify the reasons if known - _____

_____

1.1c Does your Brigade store a unique identification code for each FDR1 incident record stored on in computer file?

Yes ☝ No ☝

1.1d In what format or software system do you capture and store your FDR1 incident records?

Please specify - _____

_____

1.2 Does your Brigade store individual FDR3 incident records in computer files?

Yes ☝ No ☝

1.2a If 'Yes', what proportion of FDR3 records are captured in computer files?

< 10% ☝ 11 - 25% ☝ 26 - 50% ☝ 51 - 75% ☝ 76 - 100% ☝ 100% ☝

If less than 100% please specify the reasons - _____

_____

1.2b Does your Brigade store a unique identification code for each FDR3 incident record stored on in computer file?

Yes ☝ No ☝

1.1d In what format or software system do you capture and store your FDR1 incident records?

Please specify - _____

_____

1.3 If you generate computer records from the FDR forms, how many years of incident data do you currently hold in computer files?

Please specify the number (tick):	**FDR1**	**FDR3**
	Less than 1 Year ☝	Less than 1 Year ☝
	1 Year ☝	1 Year ☝
	2 Years ☝	2 Years ☝
	3 Years ☝	3 Years ☝
	4 Years ☝	4 Years ☝
	5 Years ☝	5 Years ☝
	6 Years ☝	6 Years ☝
	7 Years ☝	7 Years ☝
	8 Years ☝	8 Years ☝
	9 Years ☝	9 Years ☝
	10 Years ☝	10 Years ☝

Other please state - _____

1.3a If you have computer files containing coded FDR incident data have there been any changes in how and what you have captured since you started generating these computer records?

Yes ☝ No ☝

If 'Yes' please state the dates and nature of these changes and how they affect data compatibility.

_____

_____

1.4 Do you use British Standard 7666 'Spatial Data-Sets for Geographic Referencing' (BS7666) when recording the fire incident data?

Yes ☝ No ☝ Don't know ☝

SECTION TWO

Incident Record Geographical Referencing

2.1 Which of the data sets held as computer files are geocoded?
(i.e. put a code on each incident record denoting the place where the incident occurred)

None of the data ☝ FDR1 data ☝ FDR3 data ☝ Other data sets ☝

If 'Other', please specify _____

2.2 What level of geographical referencing is recorded for each incident?

	FDR1	FDR3	
1Km grid reference	☝	☝	
500m grid reference	☝	☝	
100m grid reference	☝	☝	
50m grid reference	☝	☝	
10m grid reference	☝	☝	
1m grid reference	☝	☝	
Full Unit Post Code	☝	☝	
Other	☝	☝	- please specify _____

2.3 How does your Brigade generate its geographical referencing?

(Tick all that apply)

Ordnance Survey paper maps	☝
Ordnance Survey digital maps	☝
Ordnance Survey Address Point	☝
Quick Address	☝
A-Z based maps	☝
Post Code books	☝
Digital Post code directory	☝
Other	☝ please specify - _____

2.4 Does your Brigades choice of geographical referencing system reflect:

(Tick all that apply)

Historical precedent (it has always been this way); ☝

Home office requirements (FDR1 fields); ☝

A recognised utility, within the Brigade; ☝ please specify

_____

SECTION THREE

Statistics, Analysis and Resource Targeting

3.1 Does your brigade have a statistics department?

Yes ☝ No ☝

3.2 Does your brigade have a Geographical Information Systems (GIS) department?

Yes ☝ No ☝

3.3 If you have both statistics and G.I.S. sections are they combined or separate?

Combined ☝ Separate ☝

3.4 Under which command / commands are the GIS and statistics departments?
(E.g. Fire safety, Operations etc.)

GIS - _____

Statistics - _____

3.5 Which types of incident information do reports produced by your Brigade currently contain?

Fire numbers (*counts of fires*) ☝

Fire rates (*e.g. per 1000 pop)* ☝

Geographical distribution of fire ☝

Historic analysis of fire incidents ☝

Temporal variation in fire incidents ☝
(e.g. time of day / season of year)

Pattern identification ☝
(e.g. school holidays & school arsons)

Case studies ☝

Computer mapping ☝

Casualty demographic data ☝
(e.g. casualty rates by age & sex)

Other ☝

Please specify other _____

_____

_____

3.6 **Does your Brigade use other data sources to provide a context for the fire data?**
(E.g. high levels of malicious false alarm calls recorded in areas of relative deprivation)

	Yes ☝	No ☝
(If 'yes', please indicate which data sources are used)		
Census data	☝	
Unemployment data	☝	
Housing Benefits data	☝	
Index of Local Conditions	☝	
Index of Local Deprivation	☝	
Index of Deprivation 2000	☝	
Property Gazetteers	☝	
Area Classifications (e.g. ACORN, Superprofiles)	☝	
Insurance claim records	☝	
Ordnance Survey digital data products	☝	
Other digital map products	☝	
please specify –		
Other social, economic or environmental data sets	☝	
please specify –		

3.7 **For which geographical areas are your reports produced?**
(Tick all options that apply)

Brigade level	☝	L.A. District level	☝
Division level	☝	Ward level	☝
Station ground level	☝	Enumeration district level	☝
Other	☝ please specify _____		

3.8 **Has your Brigade used data and geographical analysis for resource targeting purposes?**
(E.g. identification of public telephone boxes used to make high numbers of malicious false alarm calls, followed by a programme of placing posters in those boxes discouraging malicious calls)
Please list, date and give brief details:

1.

2.

3.

3.9 Are data analysis results used in setting fire reduction targets within your Brigade?

Yes at:		No ☝
Brigade level	☝	
Command area level	☝	
Station Ground level	☝	
Other	☝ please specify _____	

SECTION FOUR

Software, Skills and Training Needs

4.1 Which statistical software or database packages does your Brigade use to analyse fire incident data?

None	☝
SPSS	☝
Microsoft ACCESS	☝
Microsoft EXCEL	☝
SAS	☝
LOTUS 123/Approach	☝
Other	☝ please specify _____

_____

_____

4.2 Which mapping or GIS software does your Brigade use to analyse fire incidence data?

None	☝	Mapbase	☝
ArcView	☝	Atlas GIS	☝
ArcInfo	☝	IDRISI	☝
Mapinfo	☝	Other	☝ please specify _____

_____

_____

4.3 **Please indicate the current levels of skills and expertise of your staff with respect to the following:**
(Circle the most appropriate response and indicate which skills you see as a particular priority within the Brigade)

	Very Skilled			Not at all Skilled	Priority?
Statistical analysis of fire data		1	2	3 4	Y / N
Fire mapping and GIS	1	2	3	4	Y / N
Targeting of priority areas	1	2	3	4	Y / N
Risk factor identification	1	2	3	4	Y / N
Monitoring & Evaluation techniques	1	2	3	4	Y / N

Appendix 3b

PART TWO:

PAGE ONE

Operational Intelligence: Brigade Policy.

Please provide full and frank answers to the questions posed. Please feel free to add any further information that is relevant or has been omitted from the range of topics covered. If you are constrained by the space provided please make use of additional sheets. Thank you.

Do you have a written data policy?

When was this policy written?

Is there a system for review of this policy in place?

When was this last reviewed?

When is this due for review?

Does your brigade have stated standards for the format and storage of data?

When was this policy written?

Is there a system for review of this policy in place?

When was this last reviewed?

When is this due for review?

Are data standards uniform across the brigade?

Are data standards / policy adhered to across the brigade?

PAGE TWO

Does your brigade have a written data sharing policy for both internal and external data exchange?
When was this policy written?
Is there a system for review of this policy in place?
When was this last reviewed?
When is this due for review?
Is data and information collated and disseminated through a formal and widely recognised framework/system?
Does your brigade have a written policy on partnership working and the data sharing implications that that may present?
When was this policy written?
Is there a system for review of this policy in place?
When was this last reviewed?
When is this due for review?
Is this policy a compulsory reference for all partnership formation, development and working?

PAGE THREE:

Does your brigade have a written policy on monitoring and evaluation?

When was this policy written?

Is there a system for review of this policy in place?

When was this last reviewed?

When is this due for review?

Does your brigade have a written policy on Crime and Disorder issues?

When was this policy written?

Is there a system for review of this policy in place?

When was this last reviewed?

When is this due for review?

Does your brigade have a nominated member of staff with overall responsibility for data and information?

Operational Intelligence: Information Systems

PAGE FOUR

Are all information systems within the brigade computerised?

Which departments within the brigade generate and store data and information on (please give brief details):

Incidents;

Personnel;

Health and Safety;

Fire Investigations;

Inspections;

Education;

Intervention programmes;

Others – please specify

Are all computerised information systems within the brigade linked and available via the intra net?

Operational Intelligence: Data Links

PAGE FIVE

Do all computer stored incident records have a unique identification code stored?

Are records kept of the individual appliances that attended individual incidents?

Are details of officers assigned to those appliances kept on computer records?

Do the current data capture and storage systems enable the identification of all incidents attended by individual personnel?

Is data held in computer records of injury to fire fighters?

If held does the data contain a link to the incident at which the injury was sustained?

Is the data held for injury to fire fighters linked by a unique identification code to the full incident data at which the injury occurred?

Is the training record of individual members of staff held on computer?

Are Fire safety data about individual premises held on computer files?

PAGE SIX

Does this data contain records of previous visits to the premises and details of the risk assessment carried out?

Are records of previous incidents at the premises recorded in the data held?

Is the data system for Inspections linked directly to command and control and / or to the incident data base.

If risks are identified is the nature of the risk flagged up when command and control receive a call for assistance?

Operational Intelligence: Data Analysis

Does your brigade have a dedicated statistics department?

How many staff are employed specifically within that department, full time, part time?

What software systems are commonly used to store, manipulate and analyse data within the department?

Does the statistics department use Geographic Information Systems (GIS) to analyse fire incident and related data sets?

If used, are GIS operated by statistics department staff or by another department's staff?

PAGE SEVEN

Are GIS used elsewhere in the brigade and if so by which departments/sections?

What geographic boundary data sets are held by the brigade?

What geographic boundary sets are used by the brigade to analyse data and produce information and evidence for reports?

Does your brigade use other sources of data to provide context for the incident data, this may involve the use of census data or other environmental, economic and demographic data sets?

Does your brigade make use of individual or aggregate level crime data for the identification of areas and issues of common concern?

Are community profiles produced for targeting purposes?

What if any data and information sharing partnerships exist between statistics and both internal and external departments/organisations?

PAGE EIGHT

Does the department have the capacity to conduct research and development work to inform evidence based strategic planning and service delivery?

How is the information produced by the statistics department currently used within the brigade?

Which areas of work performed within the statistics department currently account for the majority of staff time?

Does the department control its own budget?

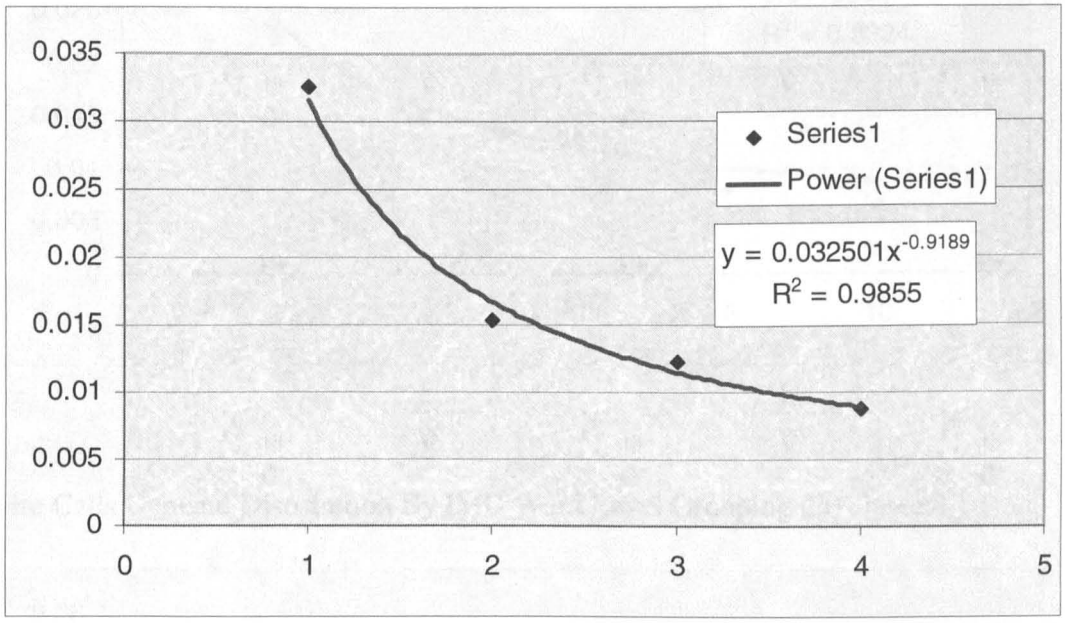
Are there any specific areas in which staff would benefit from further training?

Does the current funding of the department enable sufficient training to be purchased for staff?

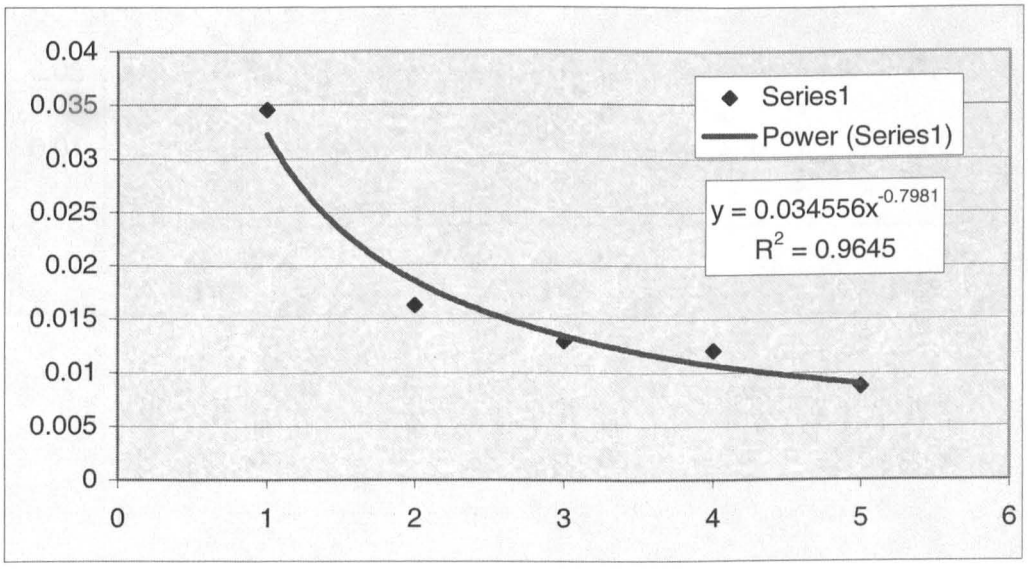
Appendix 4

Fire Calls Demand Distribution By IMD Ward Level Grouping Plots

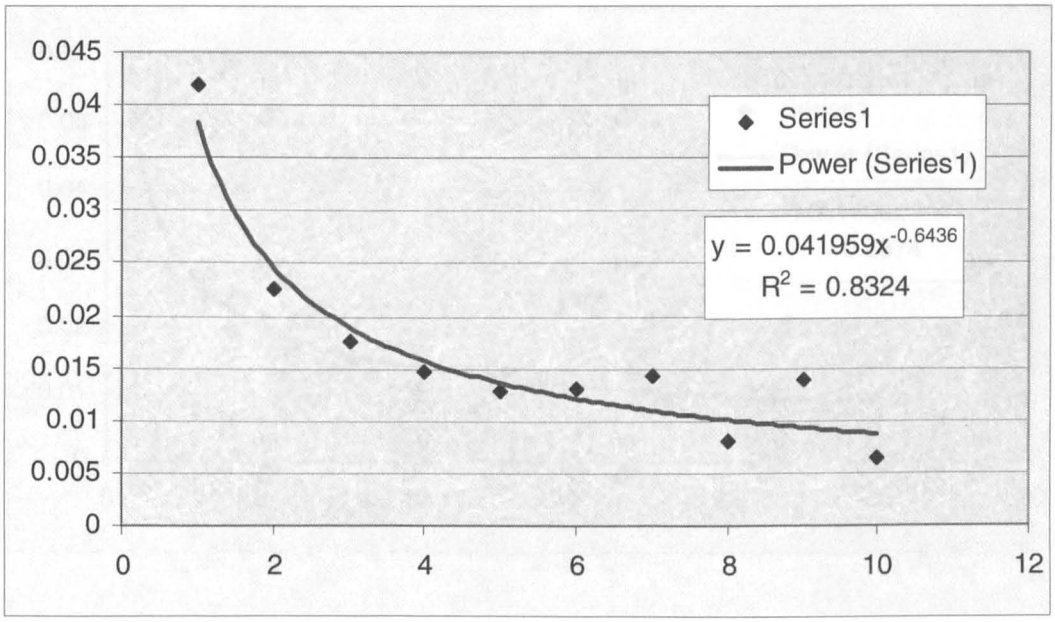
Fire Calls Demand Distribution By IMD Ward Level Grouping (4 classes)



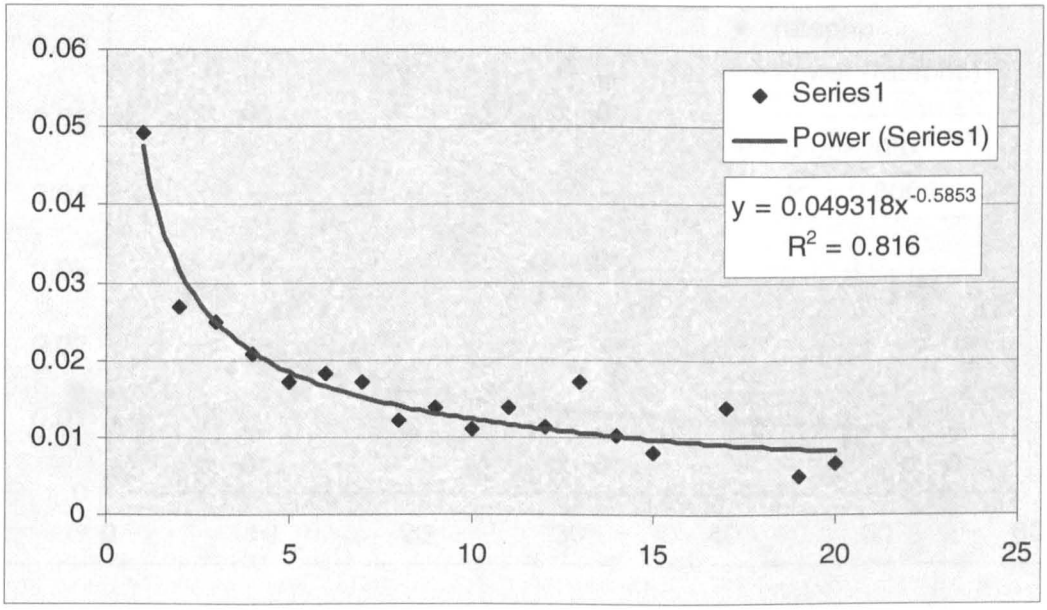
Fire Calls Demand Distribution By IMD Ward Level Grouping (5 classes)



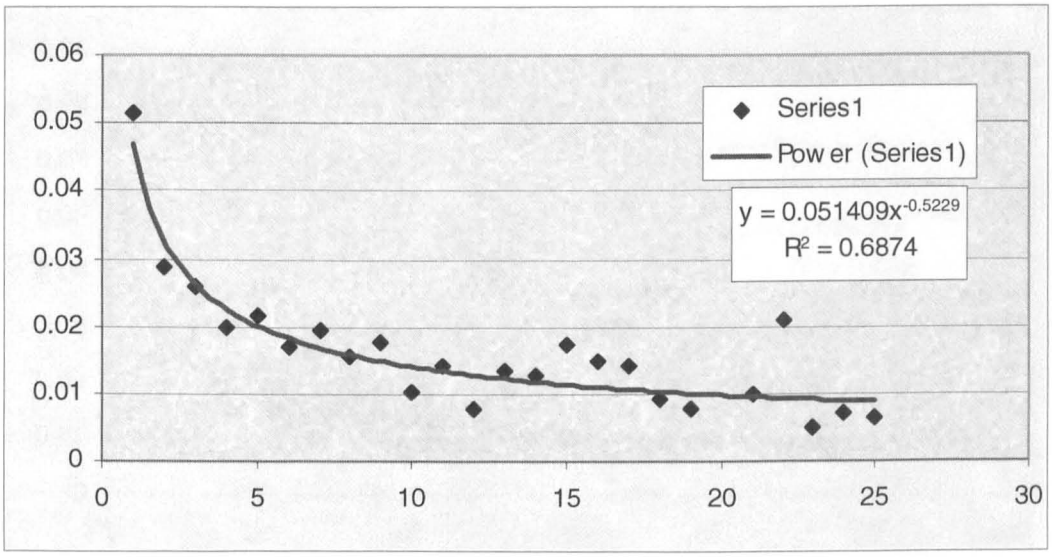
Fire Calls Demand Distribution By IMD Ward Level Grouping (10 classes)



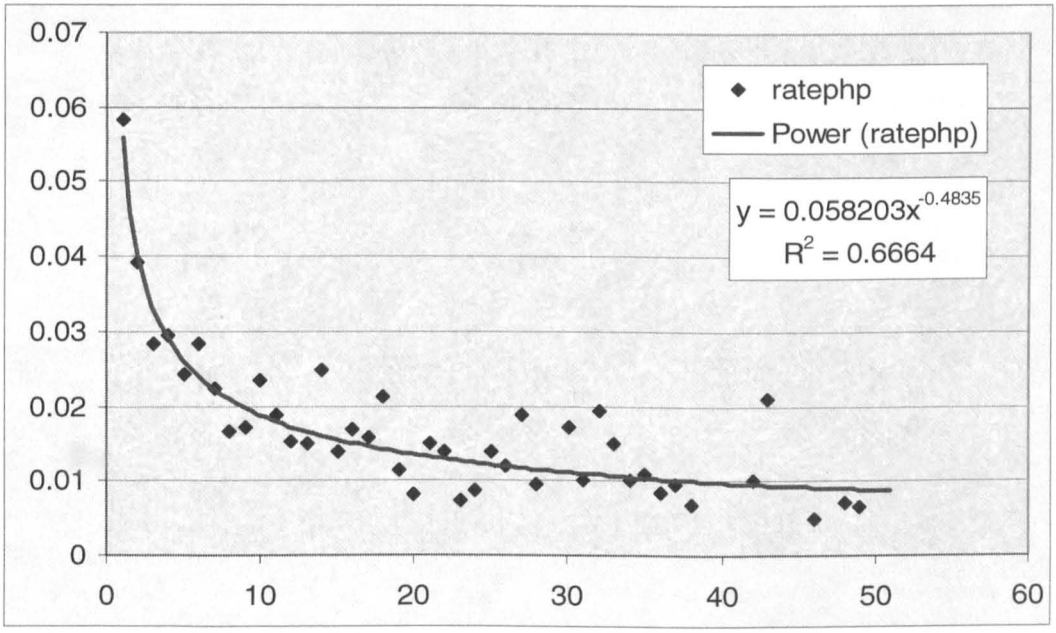
Fire Calls Demand Distribution By IMD Ward Level Grouping (20 classes)



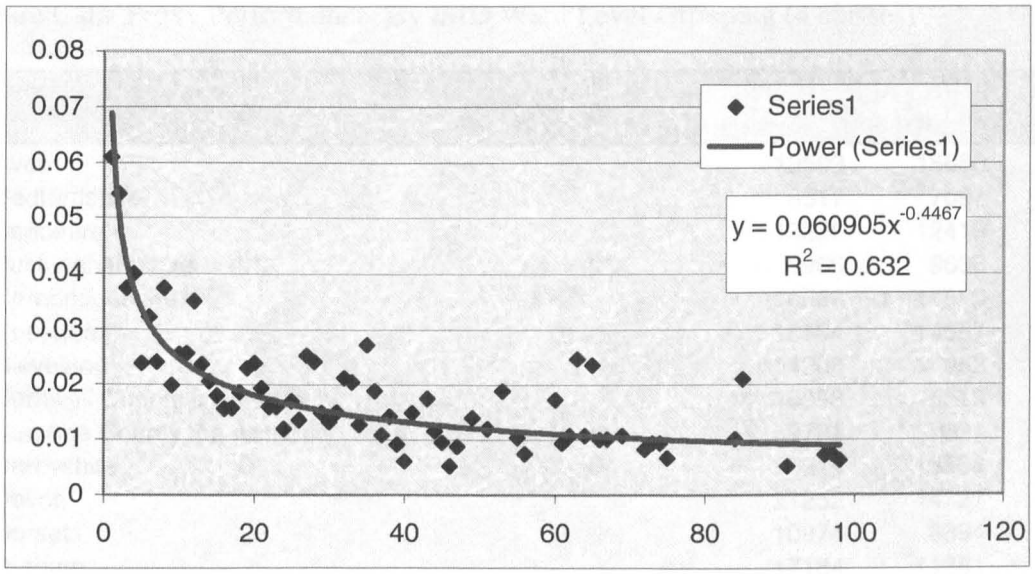
Fire Calls Demand Distribution By IMD Ward Level Grouping (25 classes)



Fire Calls Demand Distribution By IMD Ward Level Grouping (50 classes)



Fire Calls Demand Distribution By IMD Ward Level Grouping (100 classes)



Fire Calls Proxy: Fire Authority Level Performance Tables

Fire Calls Proxy Performance: By IMD Ward Level Grouping (4 classes)

Fire Authority Name	Power Curve 4 Weighted calls	SSA Calls 2000/2001	% Change From SSA
Avon	16593	15880	4.49
Bedfordshire	9517	7097	34.10
Berkshire	10226	12419	-17.66
Buckinghamshire	8966	9638	-6.97
Cambridgeshire	10569	11015	-4.05
Cheshire	16584	14557	13.92
Cleveland	14205	14952	-5.00
Cornwall County fire Authority	10998	5513	99.50
Cumbria County fire Authority	9791	7621	28.47
Derbyshire	18914	13563	39.45
Devon	21252	14727	44.31
Dorset	10976	8894	23.41
Durham	17184	11281	52.33
East Sussex	14498	11137	30.18
Essex	26707	20862	28.02
Gloucestershire County Fire Authority	8227	6596	24.73
Greater Manchester Fire and CD Authority	63711	62540	1.87
Hampshire	23880	20594	15.95
Hereford and Worcester	10996	8545	28.69
Hertfordshire County Fire Authority	12396	12788	-3.07
Humberside	19592	16258	20.50
Isle of Wight Fire Authority	3157	1479	113.45
Isle of Scilly Fire Authority	18	17	6.94
Kent	27199	21833	24.58
Lancashire	31618	26656	18.61
Leicestershire	16007	13681	17.00
Lincolnshire County Fire Authority	11406	6673	70.92
London Fire Authority	157183	127835	22.96
Merseyside Fire and Civil Defence Authority	38647	39909	-3.16
Norfolk County Fire Authority	14905	9113	63.56
North Yorkshire	10508	8624	21.85
Northamptonshire County Fire Authority	9885	9105	8.57
Northumberland County Fire Authority	6871	5000	37.42
Nottinghamshire	23596	17512	34.74
Oxfordshire County Fire Authority	7348	9828	-25.23
Shropshire	7974	6225	28.09
Somerset County Fire Authority	7964	6434	23.78
South Yorkshire Fire and Civil Defence Authority	34999	24456	43.11
Staffordshire	25683	14474	77.44
Suffolk County Fire Authority	9513	7233	31.52
Surrey County Fire Authority	12293	14022	-12.33
Tyne and Wear Fire and Civil Defence Authority	26558	28659	-7.33
Warwickshire County Fire Authority	7671	7493	2.37
West Midlands Fire and Civil Defence Authority	67404	57269	17.70
West Sussex County Fire Authority	10075	12549	-19.72
West Yorkshire Fire and Civil Defence Authority	49471	45736	8.17
Wiltshire	7975	7588	5.10
Total Calls and Overall % Change From SSA Fire Calls	981708	835880	17.45

Fire Calls Proxy Performance: By IMD Ward Level Grouping (5 classes)

Fire Authority Name	Power Curve 5 Weighted calls	SSA Calls 2000/2001	% Change From SSA
Avon	17025	15880	7.21
Bedfordshire	9496	7097	33.80
Berkshire	10599	12419	-14.65
Buckinghamshire	9042	9638	-6.18
Cambridgeshire	10603	11015	-3.74
Cheshire	17380	14557	19.39
Cleveland	14530	14952	-2.82
Cornwall County fire Authority	10968	5513	98.94
Cumbria County fire Authority	9911	7621	30.05
Derbyshire	18845	13563	38.94
Devon	21460	14727	45.72
Dorset	10694	8894	20.24
Durham	17016	11281	50.84
East Sussex	14099	11137	26.60
Essex	27206	20862	30.41
Gloucestershire County Fire Authority	8271	6596	25.39
Greater Manchester Fire and CD Authority	65283	62540	4.39
Hampshire	24382	20594	18.39
Hereford and Worcester	11101	8545	29.91
Hertfordshire County Fire Authority	12776	12788	-0.09
Humberside	19307	16258	18.76
Isle of Wight Fire Authority	3063	1479	107.11
Isle of Scilly Fire Authority	23	17	34.47
Kent	27844	21833	27.53
Lancashire	32410	26656	21.59
Leicestershire	16568	13681	21.10
Lincolnshire County Fire Authority	11644	6673	74.49
London Fire Authority	161287	127835	26.17
Merseyside Fire and Civil Defence Authority	40135	39909	0.57
Norfolk County Fire Authority	14843	9113	62.88
North Yorkshire	10649	8624	23.49
Northamptonshire County Fire Authority	10107	9105	11.00
Northumberland County Fire Authority	6604	5000	32.09
Nottinghamshire	24146	17512	37.88
Oxfordshire County Fire Authority	7700	9828	-21.65
Shropshire	7787	6225	25.09
Somerset County Fire Authority	7960	6434	23.71
South Yorkshire Fire and Civil Defence Authority	34480	24456	40.99
Staffordshire	26497	14474	83.06
Suffolk County Fire Authority	9557	7233	32.14
Surrey County Fire Authority	12639	14022	-9.86
Tyne and Wear Fire and Civil Defence Authority	26825	28659	-6.40
Warwickshire County Fire Authority	7887	7493	5.25
West Midlands Fire and Civil Defence Authority	69748	57269	21.79
West Sussex County Fire Authority	10124	12549	-19.32
West Yorkshire Fire and Civil Defence Authority	50316	45736	10.01
Wiltshire	8118	7588	6.98
Total Calls and Overall % Change From SSA Fire Calls	998954	835880	19.51

Fire Calls Proxy Performance: By IMD Ward Level Grouping (10 classes)

Fire Authority Name	Power Curve 10 Weighted calls	SSA Calls 2000/2001	% Change From SSA
Avon	16561	15880	4.29
Bedfordshire	9246	7097	30.28
Berkshire	10191	12419	-17.94
Buckinghamshire	8978	9638	-6.85
Cambridgeshire	10566	11015	-4.08
Cheshire	17119	14557	17.60
Cleveland	16047	14952	7.32
Cornwall County fire Authority	10555	5513	91.46
Cumbria County fire Authority	9753	7621	27.98
Derbyshire	18675	13563	37.69
Devon	20074	14727	36.31
Dorset	10518	8894	18.26
Durham	16950	11281	50.25
East Sussex	13619	11137	22.29
Essex	25986	20862	24.56
Gloucestershire County Fire Authority	8052	6596	22.07
Greater Manchester Fire and CD Authority	66817	62540	6.84
Hampshire	23539	20594	14.30
Hereford and Worcester	10571	8545	23.71
Hertfordshire County Fire Authority	12592	12788	-1.53
Humberside	19464	16258	19.72
Isle of Wight Fire Authority	2770	1479	87.29
Isle of Scilly Fire Authority	22	17	29.47
Kent	26433	21833	21.07
Lancashire	32207	26656	20.83
Leicestershire	16932	13681	23.76
Lincolnshire County Fire Authority	11215	6673	68.06
London Fire Authority	159290	127835	24.61
Merseyside Fire and Civil Defence Authority	43304	39909	8.51
Norfolk County Fire Authority	14448	9113	58.54
North Yorkshire	10417	8624	20.80
Northamptonshire County Fire Authority	9264	9105	1.75
Northumberland County Fire Authority	6597	5000	31.95
Nottinghamshire	24204	17512	38.21
Oxfordshire County Fire Authority	7665	9828	-22.01
Shropshire	7567	6225	21.56
Somerset County Fire Authority	7555	6434	17.43
South Yorkshire Fire and Civil Defence Authority	35754	24456	46.20
Staffordshire	25890	14474	78.88
Suffolk County Fire Authority	9151	7233	26.52
Surrey County Fire Authority	12711	14022	-9.35
Tyne and Wear Fire and Civil Defence Authority	27359	28659	-4.53
Warwickshire County Fire Authority	7552	7493	0.79
West Midlands Fire and Civil Defence Authority	70790	57269	23.61
West Sussex County Fire Authority	9795	12549	-21.95
West Yorkshire Fire and Civil Defence Authority	49453	45736	8.13
Wiltshire	8132	7588	7.17
Total Calls and Overall % Change From SSA Fire Calls	992351	835880	18.72

Fire Calls Proxy Performance: By IMD Ward Level Grouping (20 classes)

Fire Authority Name	Power Curve 20 Weighted calls	SSA Calls 2000/2001	% Change From SSA
Avon	14896	15880	-6.20
Bedfordshire	8066	7097	13.66
Berkshire	9051	12419	-27.12
Buckinghamshire	7982	9638	-17.18
Cambridgeshire	9395	11015	-14.71
Cheshire	15367	14557	5.56
Cleveland	15850	14952	6.01
Cornwall County fire Authority	9107	5513	65.19
Cumbria County fire Authority	8951	7621	17.45
Derbyshire	17012	13563	25.43
Devon	17849	14727	21.20
Dorset	9442	8894	6.16
Durham	16228	11281	43.85
East Sussex	12007	11137	7.82
Essex	22985	20862	10.18
Gloucestershire County Fire Authority	7099	6596	7.62
Greater Manchester Fire and CD Authority	64562	62540	3.23
Hampshire	20999	20594	1.97
Hereford and Worcester	9371	8545	9.66
Hertfordshire County Fire Authority	11272	12788	-11.85
Humberside	18247	16258	12.24
Isle of Wight Fire Authority	2385	1479	61.28
Isle of Scilly Fire Authority	19	17	14.53
Kent	23277	21833	6.62
Lancashire	30320	26656	13.74
Leicestershire	15316	13681	11.95
Lincolnshire County Fire Authority	10009	6673	49.99
London Fire Authority	146312	127835	14.45
Merseyside Fire and Civil Defence Authority	44696	39909	12.00
Norfolk County Fire Authority	12907	9113	41.63
North Yorkshire	9261	8624	7.39
Northamptonshire County Fire Authority	8306	9105	-8.77
Northumberland County Fire Authority	5922	5000	18.44
Nottinghamshire	22203	17512	26.79
Oxfordshire County Fire Authority	6815	9828	-30.66
Shropshire	6607	6225	6.13
Somerset County Fire Authority	6700	6434	4.13
South Yorkshire Fire and Civil Defence Authority	33450	24456	36.78
Staffordshire	23544	14474	62.67
Suffolk County Fire Authority	8174	7233	13.01
Surrey County Fire Authority	11380	14022	-18.84
Tyne and Wear Fire and Civil Defence Authority	25680	28659	-10.39
Warwickshire County Fire Authority	6594	7493	-12.00
West Midlands Fire and Civil Defence Authority	68170	57269	19.03
West Sussex County Fire Authority	8788	12549	-29.97
West Yorkshire Fire and Civil Defence Authority	45929	45736	0.42
Wiltshire	7220	7588	-4.85
Total Calls and Overall % Change From SSA Fire Calls	915723	835880	9.55

Fire Calls Proxy Performance: By IMD Ward Level Grouping (25 classes)

Fire Authority Name	Power Curve 25 Weighted calls	SSA Calls 2000/2001	% Change From SSA
Avon	14067	15880	-11.42
Bedfordshire	7703	7097	8.54
Berkshire	8403	12419	-32.34
Buckinghamshire	7533	9638	-21.84
Cambridgeshire	8777	11015	-20.31
Cheshire	14252	14557	-2.09
Cleveland	15589	14952	4.26
Cornwall County fire Authority	8539	5513	54.89
Cumbria County fire Authority	8486	7621	11.35
Derbyshire	16075	13563	18.52
Devon	16876	14727	14.59
Dorset	8729	8894	-1.86
Durham	15301	11281	35.64
East Sussex	11474	11137	3.03
Essex	21542	20862	3.26
Gloucestershire County Fire Authority	6583	6596	-0.20
Greater Manchester Fire and CD Authority	62540	62540	0.00
Hampshire	19806	20594	-3.83
Hereford and Worcester	8709	8545	1.92
Hertfordshire County Fire Authority	10486	12788	-18.00
Humberside	17415	16258	7.12
Isle of Wight Fire Authority	2216	1479	49.82
Isle of Scilly Fire Authority	18	17	6.18
Kent	21630	21833	-0.93
Lancashire	28900	26656	8.42
Leicestershire	14280	13681	4.38
Lincolnshire County Fire Authority	9546	6673	43.06
London Fire Authority	139018	127835	8.75
Merseyside Fire and Civil Defence Authority	44306	39909	11.02
Norfolk County Fire Authority	12202	9113	33.90
North Yorkshire	8612	8624	-0.13
Northamptonshire County Fire Authority	7748	9105	-14.90
Northumberland County Fire Authority	5631	5000	12.61
Nottinghamshire	20929	17512	19.51
Oxfordshire County Fire Authority	6309	9828	-35.81
Shropshire	6057	6225	-2.70
Somerset County Fire Authority	6219	6434	-3.34
South Yorkshire Fire and Civil Defence Authority	31933	24456	30.57
Staffordshire	22324	14474	54.24
Suffolk County Fire Authority	7645	7233	5.70
Surrey County Fire Authority	10520	14022	-24.97
Tyne and Wear Fire and Civil Defence Authority	24117	28659	-15.85
Warwickshire County Fire Authority	6099	7493	-18.60
West Midlands Fire and Civil Defence Authority	63818	57269	11.44
West Sussex County Fire Authority	8201	12549	-34.65
West Yorkshire Fire and Civil Defence Authority	43652	45736	-4.56
Wiltshire	6672	7588	-12.07
Total Calls and Overall % Change From SSA Fire Calls	867489	835880	3.78

Fire Calls Proxy Performance: By IMD Ward Level Grouping (50 classes)

Fire Authority Name	Power Curve 50 Weighted calls	SSA Calls 2000/2001	% Change From SSA
Avon	14384	15880	-9.42
Bedfordshire	7817	7097	10.15
Berkshire	8954	12419	-27.90
Buckinghamshire	7897	9638	-18.07
Cambridgeshire	9229	11015	-16.22
Cheshire	14333	14557	-1.54
Cleveland	15540	14952	3.93
Cornwall County fire Authority	8410	5513	52.56
Cumbria County fire Authority	8458	7621	10.99
Derbyshire	16066	13563	18.46
Devon	16788	14727	14.00
Dorset	9049	8894	1.74
Durham	14757	11281	30.82
East Sussex	11516	11137	3.40
Essex	22066	20862	5.77
Gloucestershire County Fire Authority	6875	6596	4.23
Greater Manchester Fire and CD Authority	62547	62540	0.01
Hampshire	20479	20594	-0.56
Hereford and Worcester	9047	8545	5.87
Hertfordshire County Fire Authority	11236	12788	-12.14
Humberside	17691	16258	8.82
Isle of Wight Fire Authority	2200	1479	48.77
Isle of Scilly Fire Authority	20	17	15.47
Kent	22115	21833	1.29
Lancashire	28502	26656	6.93
Leicestershire	14575	13681	6.54
Lincolnshire County Fire Authority	9540	6673	42.97
London Fire Authority	135476	127835	5.98
Merseyside Fire and Civil Defence Authority	44112	39909	10.53
Norfolk County Fire Authority	12373	9113	35.77
North Yorkshire	9025	8624	4.65
Northamptonshire County Fire Authority	7987	9105	-12.28
Northumberland County Fire Authority	5572	5000	11.45
Nottinghamshire	20664	17512	18.00
Oxfordshire County Fire Authority	6758	9828	-31.24
Shropshire	6211	6225	-0.22
Somerset County Fire Authority	6436	6434	0.03
South Yorkshire Fire and Civil Defence Authority	31589	24456	29.17
Staffordshire	22569	14474	55.93
Suffolk County Fire Authority	8027	7233	10.98
Surrey County Fire Authority	11295	14022	-19.45
Tyne and Wear Fire and Civil Defence Authority	23297	28659	-18.71
Warwickshire County Fire Authority	6382	7493	-14.83
West Midlands Fire and Civil Defence Authority	62472	57269	9.09
West Sussex County Fire Authority	8669	12549	-30.92
West Yorkshire Fire and Civil Defence Authority	43427	45736	-5.05
Wiltshire	7060	7588	-6.96
Total Calls and Overall % Change From SSA Fire Calls	869494	835880	4.02

Fire Calls Proxy Performance: By IMD Ward Level Grouping (100 classes)

Fire Authority Name	Power Curve 100 Weighted calls	SSA Calls 2000/2001	% Change From SSA
Avon	12293	15880	-22.59
Bedfordshire	6689	7097	-5.75
Berkshire	7782	12419	-37.34
Buckinghamshire	6858	9638	-28.85
Cambridgeshire	7933	11015	-27.98
Cheshire	12173	14557	-16.38
Cleveland	13614	14952	-8.95
Cornwall County fire Authority	7118	5513	29.11
Cumbria County fire Authority	7213	7621	-5.36
Derbyshire	13628	13563	0.48
Devon	14321	14727	-2.76
Dorset	7798	8894	-12.32
Durham	12499	11281	10.80
East Sussex	9813	11137	-11.88
Essex	18944	20862	-9.19
Gloucestershire County Fire Authority	5957	6596	-9.68
Greater Manchester Fire and CD Authority	54313	62540	-13.15
Hampshire	17644	20594	-14.33
Hereford and Worcester	7815	8545	-8.55
Hertfordshire County Fire Authority	9802	12788	-23.35
Humberside	15227	16258	-6.34
Isle of Wight Fire Authority	1868	1479	26.29
Isle of Scilly Fire Authority	17	17	1.18
Kent	18987	21833	-13.04
Lancashire	24343	26656	-8.68
Leicestershire	12490	13681	-8.71
Lincolnshire County Fire Authority	8128	6673	21.81
London Fire Authority	115567	127835	-9.60
Merseyside Fire and Civil Defence Authority	39535	39909	-0.94
Norfolk County Fire Authority	10635	9113	16.70
North Yorkshire	7813	8624	-9.41
Northamptonshire County Fire Authority	6880	9105	-24.44
Northumberland County Fire Authority	4687	5000	-6.25
Nottinghamshire	17488	17512	-0.14
Oxfordshire County Fire Authority	5890	9828	-40.07
Shropshire	5316	6225	-14.60
Somerset County Fire Authority	5544	6434	-13.83
South Yorkshire Fire and Civil Defence Authority	26891	24456	9.96
Staffordshire	19619	14474	35.55
Suffolk County Fire Authority	6961	7233	-3.76
Surrey County Fire Authority	9846	14022	-29.78
Tyne and Wear Fire and Civil Defence Authority	19671	28659	-31.36
Warwickshire County Fire Authority	5503	7493	-26.56
West Midlands Fire and Civil Defence Authority	52943	57269	-7.55
West Sussex County Fire Authority	7531	12549	-39.99
West Yorkshire Fire and Civil Defence Authority	36792	45736	-19.55
Wiltshire	6123	7588	-19.31
Total Calls and Overall % Change From SSA Fire Calls	746503	835880	-10.69