Towards a Comprehensive Understanding of Human Behaviour in Dwelling Fires

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DECLARATION

I certify that the work contained in this thesis or any part of it, has not been accepted in substance for any previous degree awarded to me, and is not currently being submitted for any degree other than that of Doctor of Philosophy being studied at the University of Greenwich. I also declare that this work is the result of my own investigations, except where otherwise identified by references and that the contents are not the outcome of any forms of research misconduct.

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ABSTRACT

This thesis looks at human behaviour in accidental dwelling fires (ADFs), specifically the behaviours and motivations of those who survive fires in low-rise dwellings. Human behaviour in fire is a well-established subject area, but the primary research focus has been on behaviour in public, commercial and industrial spaces. With the exception of the identification of occupant-related risk-factors for fire fatalities, there has been very limited research undertaken to understand human behaviour in ADFs. This lack of understanding means that the frameworks, models, and other tools used to understand, explain and predict behaviours in fires are currently of limited relevance to dwellings.

A range of descriptive and inferential statistical analysis was undertaken on 419 occupant surveys collected as part of the LIFEBID project. This analysis has developed an understanding of people's behaviours and motivations, associations between behaviours and select variables (e.g. gender, smoke alarms), as well as advanced understanding of risk factors for ADF injuries. A total of nine research questions were proposed. The study was able to answer eight of these; a lack of available data from high-rise dwellings prevented investigation of the other. The research findings have been distilled into five highlights and have led to the development of the Domestic Appraisal Response (DAR), a shorthand way to contextualise occupant behaviour during an ADF.

As well as contributing to clear gaps in the knowledge, this work has a range of practical and theoretical outcomes for both practitioners and academics. For evacuation modellers, the findings offer a resource to assist in the development of behavioural itineraries for evacuation modelling. For fire and rescue services, the findings are relevant to: fire safety messaging, fire prevention activity, incident command training and operational response, and emergency call handling. Importantly, this work has already resulted in changes to fire and rescue policy and practice.

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FIGURES AND TABLES

LIST OF INITIALISMS

ADF – Accidental Dwelling Fire

CFOA – Chief Fire Officers' Association

DAR – Domestic Appraisal Response

DCLG – Department for Communities and Local Government

FDR1 – Fire Damage Report

FRS – Fire and Rescue Service

HMO – A house in multiple occupation

IRS – Incident Recording System

MHCLG – Ministry of Housing, Communities and Local Government

NFCC – National Fire Chiefs Council

NIFRS – Northern Ireland Fire and Rescue Service

PCI spaces – Public, commercial and industrial spaces

RFO – Room of fire origin

ROO – Room of origin

"Life is the sum of all your choices" (Albert Camus)

1. INTRODUCTION

1.1 OVERVIEW

This PhD is concerned with developing an understanding of how people (occupants) behave during accidental dwelling fires (ADFs) and considering that against what is already known about behaviour during fires in public, commercial and industrial spaces. This is more than just a point of academic interest as ADFs are, and continue to be, the single largest cause of all fire-related injuries and deaths in multiple countries including the UK, USA, Canada, Japan, New Zealand and Australia (Barnett et al., 2007; Fire and Disaster Management Agency Japan, 2019; Home Office, 2019; New Zealand Fire Service Commission, 2005; Sekizawa, 2005; Sekizawa, 2015; Statistics Canada, 2019; U.S. Fire Administration, 2019). Yet since the initial work of Wood (1972), Bryan (1977), and Canter et al. (cited in Canter, 1990) in the late 1970s and early 1980s there has not been a focus upon developing an understanding of the behaviours and underlying motivations of those who survive dwelling fires, either with or without injury. Since this time the majority of the work on human behaviour in fires has been concerned with studying behaviour during fires occurring in public, commercial and industrial spaces, while the work that has looked at the domestic environment has been focussed upon identifying occupant-related risks surrounding fatal fires. This is undoubtedly valuable, but it would seem that something of a consensus has been reached in this regard, as the various studies in this area have tended to highlight recurrent and similar factors that place people at increased risk of fire mortality. Consequently there is a clear gap in the knowledge – manifesting itself as limited formal understanding and available empirical data – on the behaviour and motivations of those who survive dwelling fires. The lack of understanding of people's actions and movement during dwelling fires, the goals of that behaviour, and the decision making and other cognitions driving that behaviour mean that the main frameworks, models, and other tools that people use to understand, explain and predict behaviours in fires are currently of limited relevance to dwellings and thereby in need of development.

1.2 WHAT THE THESIS INVESTIGATES

This thesis looks at the human factors involved in ADFs. Not the risk factors associated with deaths from these fires, as broad agreement has (for the current time) been reached about this issue, but rather the behaviours and motivations of those who survive ADFs, in order to identify what are the key behaviours, the circumstances in which they occur, and assess behaviour's impact on fire outcomes, i.e. occupant was injured vs. not injured. To date, the concentration of the field upon human behaviour in non-domestic spaces raises a number of important questions: can what is known from these contexts be applied directly to human behaviour in ADFs, or are the behaviours in domestic spaces likely to be different? And if so, in what ways and why do these differences exist? Furthermore, there is a need for a better understanding of what drives behaviour – going beyond the frequent assumption that all movement in a fire is simply part of a process in which the end point is evacuation from a building.

1.3 THE METHODOLOGY

Although fire and rescue services routinely collect data from the dwelling fires they attend, the focus of data collection from such incidents is on building characteristics, fire and smoke spread, the associated damage, the firefighting media used and tactics employed. However, data on the actions occupants undertake are not collected and recorded in detail – usually only being done so when there have been fatalities during the fire. But even during a fire investigation the focus will be on the origin and cause of the fire rather than specifically seeking to understand occupant behaviour during the course of the event – a focus best described at looking at how the fire affected the occupant rather than the reverse. Where occupant behaviour is considered it will be where it is seen as relevant to the cause of the fire, as opposed to attempting to provide a narrative account of a person's actions throughout the duration of the fire. Therefore this thesis presents an analysis of detailed first-hand accounts of behaviour from survivors, collected through survey methods, which allow for an investigation not just of what people do, but the reasons underpinning that behaviour. Networks were created with UK fire and rescue services to help collect this survey data.

1.4 WHO THIS WORK PROVIDES INSIGHTS FOR AND THE BENEFITS

This work provides insight into what behaviours to expect in an ADF and into instances where behaviour will contribute to injuries being sustained. It also provides insight into whether and how other human factors (occupant gender, age) relate to behaviour and injuries. This increased understanding will assist UK fire and rescue services in their operational response, emergency call handling procedures, and fire prevention and community safety services. It will also benefit fire safety professionals, for example evacuation and fire modellers who seek to predict fire outcomes and help make buildings safer, by providing information on behavioural responses to hazards (smoke, flames) and to safety devices (smoke alarms). A greater understanding of people's behaviour (and the associated motivations for that behaviour) during dwelling fires, offers an opportunity to improve technical and academic knowledge, plus improve evacuation modelling and assist fire and rescue services, all of which are factors that will help to reduce further the numbers of casualties and the disproportionate human cost of dwelling fires.

1.5 PUBLICATIONS NOTE

Parts of the literature review that are presented in chapter two are also available in the following peer-reviewed publication:

> Thompson, O.F., Galea, E.R. and Hulse, L., 2018. A review of the literature on human behaviour in dwelling fires. Safety Science, 109, 303-312.

The journal this paper appears in is a Quartile-1 journal in the subject areas of Social Sciences ('Safety Research'), Engineering ('Safety, Risk, Reliability and Quality'), and Medicine ('Public Health, Environmental and Occupational Health'), and commands an international and multidisciplinary audience (Scimago, 2019). In addition, sections of the analysis that are presented in chapter 4 have been written up as a journal paper which will be submitted to Safety Science:

> Thompson, O.F., Galea, E.R. and Hulse, L., *in preparation*. An analysis of human behaviour and injury in accidental dwelling fires.

2. LITERATURE REVIEW

2.1 STRUCTURE

Having set out what this thesis seeks to achieve, consideration will now be given to providing an overview of the structure that this literature review adopts. The starting point is an examination of fire statistics, taking in the current situation and changes over time in the numbers of fires (in both dwellings and non-dwellings) and the injuries and deaths associated with these fires. Fortunately, the UK maintains fairly comprehensive and detailed records on the numbers of fires going back several decades (Home Office, 2018; Home Office, 2019; Marriott, 1993; MHCLG, 2019). In keeping with the focus upon these necessary issues of background, the section following on from this considers current rules regarding fire safety within the UK. It presents an overview of the primary and secondary legislation (i.e. laws and regulations) that cover fire safety in public, commercial and industrial spaces and the legislation that pertains to dwellings.

Given that this PhD is concerned with developing an understanding of how people behave during fires in dwellings, and considering that against what is already known about behaviour in the public, commercial and industrial space, there is a section devoted to discussing the various theories that have been developed to understand decision making during fires. These have arisen from work undertaken to understand the cognitive processes that occur in a specific, high pressure environment where access to information is frequently incomplete or imperfect and where most individuals are not able to draw upon any prior experience to assist them in that decision making.

Following this, the earliest work specifically on human behaviour in fire (as opposed to human movement) is then presented and discussed. The 1970s was the decade when human behaviour in fire emerged as an academic discipline. By undertaking the first dedicated wide-scale study of actions undertaken by people during a range of fires in different physical environments occurring in different geographical locations, the work of Wood in the UK in 1972 (Wood, 1972), and then Bryan in the USA in 1977 (Bryan, 1977), created a dedicated area of study in this field. In the late 1970s and early 1980s further work in the UK by Canter, Breaux and Sime (cited in Canter, 1990, and referred to from here on as Canter et al.) moved the field forward by attempting to refine understanding of the actions undertaken as they pertained to different environments and the various sequences of those actions.

The subsequent development of the discipline is then presented through an overview of what is known about human behaviour in fire, the key themes and intellectual concepts that have come to underpin and define the area. This section presents what is currently known about human behaviour in fires and includes such aspects as: the rise of evacuation modelling; the work supporting the move away from the idea of panic as a default response and the rejection of the irrationalist tradition in favour of the theory of emergent behaviour; research on movement through smoke; and studies of evacuation of the functionally impaired. By presenting what are felt to be the central tenets of the subject, the aim is to convey the development and key milestones of the past forty years.

Having summarised what is currently known and accepted about human behaviour in fire, an overview is presented of what is known about human behaviour in fire within the domestic environment. As the majority of work has been concerned with studying human behaviour during fires occurring in public, commercial and industrial spaces, there is not a comparable volume of work looking at behaviour in fires in the home. The majority of work that has been undertaken in this area has been dominated by a focus on identifying risks in relation to fire deaths in the home; an area about which there is now a broad consensus. This means that there is an area – namely the behaviour and motivations of those who survive dwelling fires – for which there is limited formal understanding and empirical data available.

2.2 KEY DEFINITIONS

Where appropriate, pre-existing definitions are used, which are mainly drawn from three sources: existing academic literature on the subject; fire and rescue service operational guidance and generic risk assessments; and the Home Office (the UK government department responsible for fire and rescue, security, law and order, and immigration). Moreover, due to the length of several of the terms employed throughout, in order to avoid usage becoming unnecessarily cumbersome, wherever possible initialisms will be used. For ease of reference a list of these has been provided on page x.

2.2.1 Incident reporting

Since 2009, across the fire and rescue services in Great Britain (and since 2011 in Northern Ireland) an electronic, web enabled system for recording incident data was implemented. Called the ‘Incident Recording System’ (IRS), this replaced the previous paper-based system known as the FDR1 (Fire Damage Report) and expanded upon the information collected.

Upon returning from an incident, the leading fire officer has responsibility for completing and submitting the IRS incident report. Utilising a branching system of check boxes and free text fields, the IRS allows detailed information to be collected on the whole range of incidents attended. These IRS data are submitted to the Home Office for fire statistics reporting.

In recent years there have been some changes in the way that the annual fire statistics are published. From 2010/11 to 2013/14, the annual fire statistics were produced for Great Britain only (i.e. excluding Northern Ireland), prior to this they were for the UK. The statistics covering the financial year 2014/15 onwards (published 20/08/2015) are produced for England only with the other home nations producing their own fire statistics. In addition, on 05/01/2016, responsibility for fire and rescue policy transferred from the Department for Communities and Local Government (DCLG)[1] to the Home Office. However, key definitions, and processes have remained unaffected by this.

2.2.2 Fire and rescue services in the UK

There is no single fire service for the UK. What exists is a collection of fifty fire and rescue services which, allowing for differences in legislative frameworks and administrative structures, share a collective identity and rank structure, have similar statutory duties and employ broadly consistent terminology, definitions and reporting standards. The term 'fire and rescue service' (abbreviated as FRS) is freely used within the sector to refer to the UK's fire and rescues service as a collective entity. When discussing several fire and rescue services, the abbreviation 'FRSs' is used.

There are currently 45 FRSs in England, three in Wales and one each in Scotland and Northern Ireland. The two principal pieces of legislation governing the statutory duties of FRSs in England and Wales are the Fire and Rescue Services Act 2004 and the Regulatory Reform (Fire Safety) Order 2005 (Legislation.gov.uk, 2004; Legislation.gov.uk, 2005). Scotland and Northern Ireland both have their own legislative framework: the Fire (Scotland) Act 2005 and the Fire and Rescue Services (Northern Ireland) Order 2006 respectively (Legislation.gov.uk, 2005a; Legislation.gov.uk, 2006).

The definitions, standards and practices adopted in this thesis are those set out by the Home

[1] In January 2018, DCLG was changed to a ministry and renamed the Ministry of Housing, Communities and Local Government (MHCLG).

Office (the ministerial department responsible for FRSs in England and Wales). This approach is justified on the grounds that the equivalents within Scotland and Northern Ireland – including the range of definitions used in incident reporting – are broadly similar, if not identical. Moreover, the Home Office is the largest of the governmental departments across the United Kingdom that has a responsibility for emergency fire and rescue service cover and in doing so serves the largest area of the UK, both in population and geographical area. Consequently, unless otherwise stated, any terminology used may be regarded as being applicable to, or in common usage, across the UK as a whole.

2.2.3 Human behaviour

A key definition is that of the term 'human behaviour in fire'. A useful definition is offered by Interscience Communications, who describe it as:

"Human Behaviour in Fire is the study of human response when exposed to fire and other similar emergencies in buildings, structures and transportation systems. It includes an understanding of people's awareness, beliefs, attitudes, motivations, decisions, behaviours and coping strategies and the factors that influence them." (Interscience Communications, 2017)

2.2.4 Accidental dwelling fires, dwellings and non-dwellings

Accidental dwelling fire (abbreviated to ADF) is the term used by FRSs to describe fires believed to be non-deliberate or of unknown origin and occurring in a dwelling. For these purposes a dwelling is defined by the Home Office as follows:

"Buildings occupied by households, excluding residential institutions and short stay accommodation e.g. hotels/motels and hostels. From 1988 mobile homes have been specifically included in the dwelling count. In 2000, the definition of a dwelling (for the purposes of recording fires) was widened to include any non-permanent structures used solely as a dwelling, such as caravans, houseboats etc." (DCLG, 2015, p53)

Within the IRS, the main categories for dwelling type are bungalow, house, purpose built flat/maisonette, and HMO (a house in multiple occupation). One point to note is that flats (apartment blocks) are divided into three sub categories according to the number of floors present in the building: up to three storeys, four to nine storeys, and ten or more storeys, the latter of which makes the building a 'high rise' in the UK. To describe buildings that are not dwellings, this work adopts the phrase 'public, commercial and industrial spaces', abbreviated from here on as 'PCI spaces' (Wales and Thompson, 2012).

2.2.5 Casualties and fatalities

Two other terms that require explanation are 'fatal casualty' (also referred to as 'fatality' or 'fire-related death') and 'non-fatal casualty' (also referred to as 'injury'). Although the term fire fatality may appear self-explanatory, there are some specific conditions attached by the Home Office to the definition. A fire fatality is defined as:

"*…any fatal casualty which is the direct or indirect result of injuries caused by a fire incident even if death occurred weeks or months later.*" (DCLG, 2015, p54)

In this case a direct result would be a person being overcome and dying from exposure to the smoke and products of combustion, or through burns from the flames. An example of indirect result would be of a person jumping from a building to escape a fire and subsequently dying of the injuries sustained as a result of the fall. Although not injured by the fire itself, the actions they undertook were in response to the fire and so the fire is considered to have led to their death. The timescale extends for 364 days after the date of the fire, thus giving a cut-off date of one year.

With 'non-fatal casualties' the four following groups are defined by the Home Office for incident reporting standards: those given first aid at the scene of the fire; those taken to hospital to see a doctor for slight injuries; those taken to hospital to see a doctor for serious injuries; and those for whom there does not appear to be any obvious sign or injury or shock, but who are advised to attend hospital or see a doctor as a precautionary measure (DCLG, 2015, p55).

2.2.6 Room of fire origin and room of origin

FRSs use the term 'room of origin' (ROO) to denote the room or space within a building where the fire is believed to have originated, while within the academic literature on human behaviour in fire the term 'room of fire origin' (RFO) is used. In order to ensure clarity and consistency with the existing convention for the academic literature, the term RFO will be adopted throughout.

2.2.7 Summary

Consequently, having set out the direction this literature review takes and also outlined the key definitions that have been used it is now appropriate to look at the prevalence of fires within the UK and the changes that have been taking place with fire-related deaths and injuries.

2.3 FIRE, FATALITY AND INJURY TRENDS IN THE UK

2.3.1 Introduction and overview

The most striking aspect about the numbers of reported fires in the UK is the scale of the decline that has taken place since the millennium. Total recorded fires of all types have more than halved, falling 54% from 445,000 in 2000/01 to 204,000 in 2017/18 (the peak of 572,000 fires occurred in 2003/04), while ADFs fell 37%, from 54,000 to just under 34,000 (Figure 1) (Home Office, 2018; Home Office, 2019; Scottish Fire and Rescue Service, 2019; Welsh Government, 2019). A similar picture is evident for fire-related fatalities and injuries (Table 1). The number of all fire fatalities fell 29% (from 554 in 2000/01 to 393 in 2017/18), while ADF fatalities declined 21%, from 363 to 288 for the same year period (Home Office, 2018; Home Office, 2019; Scottish Fire and Rescue Service, 2019; Welsh Government, 2019). Consequently, the overall trend has been one of steady decline.

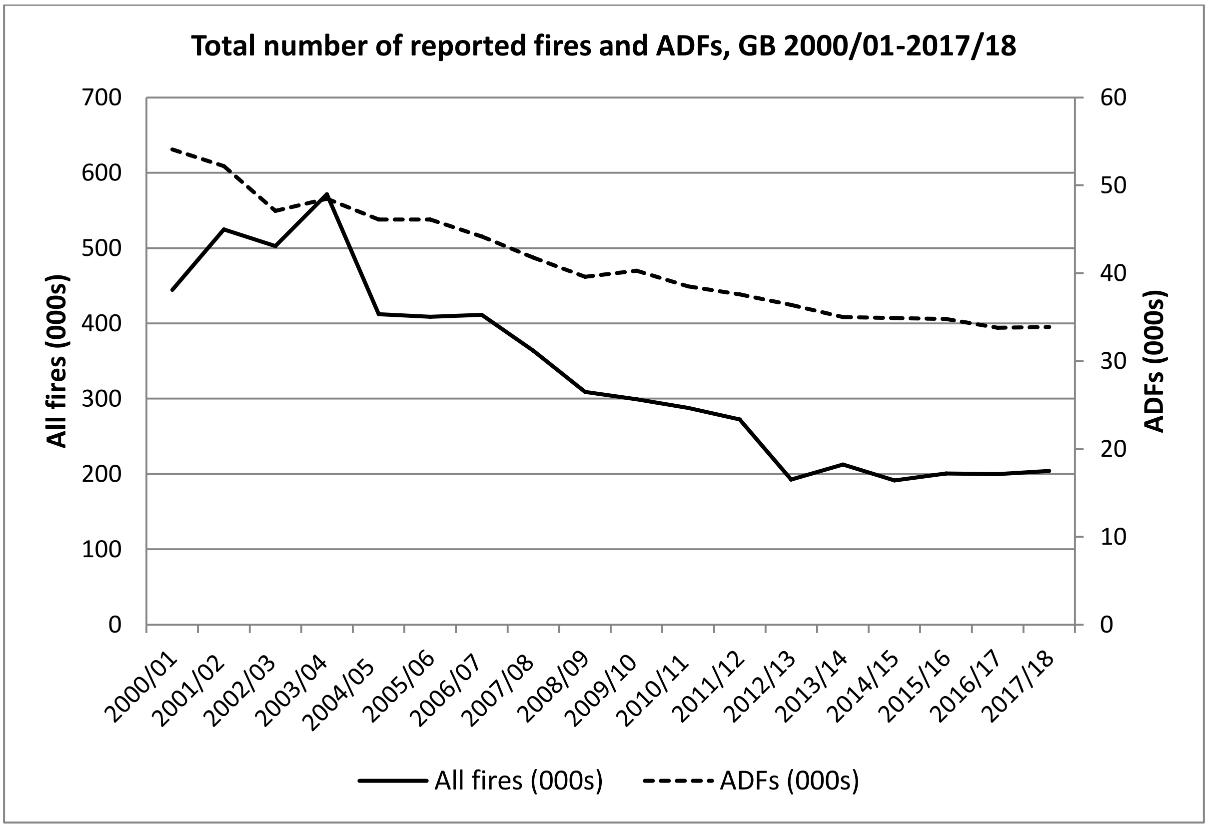

Figure 1: Numbers of fires (000s) and ADFs (000s), 2000/01 to 2017/18.
Source: Home Office, 2018; Home Office, 2019; Scottish Fire and Rescue Service, 2019; Welsh Government, 2019. NB: from 2009 data collected changed from the UK to GB.

However, any discussion of fire-related deaths (and injuries) must consider the obvious increase in fire fatalities that has occurred as a result of the Grenfell Tower fire of 2017. With 72 deaths attributed to this fire, there has been a large increase in the number of ADF fatalities recorded in the UK for the reporting period 2017/18 (Table 1). If this is removed then the figures follow the trend of previous years, as for 2017/18 the total number of fire fatalities would be 321 and ADF fatalities would be 216. The Grenfell fire was a unique event in size and scale and cannot be said to be part of, or indicative of, a wider trend (see Section 2.4.2 for further discussion of Grenfell). Overall, since the year 2000, fire deaths and injuries have undergone a significant decline.

Fire-related injuries displayed a strong downward trend, declining by 46%, from over 16,000 per year in 2000/01 to fewer than 9,000 for 2017/18. This was similar for injuries occurring in ADFs, which fell 47%, from 11,200 to just under 6,000 (Table 1) (Home Office, 2018; Home Office, 2019; Scottish Fire and Rescue Service, 2019; Welsh Government, 2019).

Table 1: Fatalities and injuries for all fires and ADFs, 2000/01 to 2017/18

Year	All fire fatalities	ADF fatalities	All fire injuries	ADF injuries
2000/01	554	363	16,542	11,263
2001/02	583	404	16,907	11,348
2002/03	522	341	15,055	10,200
2003/04	576	359	15,228	10,226
2004/05	483	322	13,672	9,476
2005/06	470	286	13,578	9,323
2006/07	430	249	13,088	8,902
2007/08	458	291	12,669	8,714
2008/09	404	268	11,533	7,987
2009/10	416	275	10,652	7,244
2010/11	388	268	11,134	7,776
2011/12	380	244	11,300	7,729
2012/13	350	217	10,300	7,354
2013/14	322	219	9,748	6,872
2014/15	324	209	9,232	6,495
2015/16	368	237	9,512	6,521
2016/17	326	229	8,979	6,046
2017/18	393	288	8,938	5,987

Source: Home Office, 2018; Home Office, 2019; Scottish Fire and Rescue Service, 2019; Welsh Government, 2019. NB: From 2009, data collected changed from the UK to Great Britain.

2.3.2 Northern Ireland

Because fire statistics from 2010/11 were produced for GB only (i.e. excluding Northern Ireland), it is useful to look separately at the picture for Northern Ireland since this period. Overall the total number of reported fires occurring in Northern Ireland fell from 21,000 in 2000/01 to 9,390 in 2017/18. Consequently, as with the rest of the UK, the overall trend is of a declining number of fires (Table 2). However, the rest of the picture is slightly more complicated as although the number of ADFs fell to a low of 750 in 2011/12, it actually rose thereafter to reach 896 in 2017/18 (NIFRS, 2019; NIFRS, 2019a). Moreover, both fire deaths and ADF deaths have fluctuated over this period, between a range of 17 and 10 for the former and between 12 and 4 for the latter (NIFRS, 2019; NIFRS, 2019a). All fire injuries have also fluctuated along with ADF injuries: the latter peaking at 137 in 2010/11, falling to a low of 60 in 2012/13, then rising and falling in the period since. Nonetheless, these are all increases that, when combined with the data for the rest of the UK, would be too small to offset the overall decline in absolute numbers of fires, injuries and deaths.

Table 2: Fires in Northern Ireland, 2009/10 to 2017/18

Year	**All fires**	**ADFs**	**All fire deaths**	**ADF deaths**	**All fire injuries**	**ADF injuries**
2009/10	14,276	819	14	8	585	131
2010/11	15,392	806	17	11	652	137
2011/12	12,404	750	15	10	504*	**
2012/13	9,140	811	15	11	486	60
2013/14	9,749	898	10	8	581	101
2014/15	9,414	923	11	8	533	104
2015/16	9,065	843	16	12	429	75
2016/17	9,174	826	10	9	411	95
2017/18	9,390	896	11	4	416	93

Source: Northern Ireland Fire & Rescue Service (NIFRS), 2019; NIFRS, 2019a
* Figure is for all primary fire casualties only and does not include ADF injuries
** 2011/12 figure not available due to transition to Incident Recording System across NIFRS

2.3.3 Long term trends

Dwelling fires. The number of dwelling fires recorded in 2017/18 is nearly double the figure for 1950/51, a trend that may appear to correlate with the growth in the number of UK dwellings since 1950. Based on the last available data for the UK, there are now twice as many dwellings – approximately 28 million, while at around 66 million, the population is also a third greater than in 1950 (DCLG, 2016; ONS, 2018). The number of dwelling fires underwent a steady increase since 1950, slowing somewhat through the 1980s and 1990s before starting to fall at the start of the millennium, from which point the number dropped by 47% up to 2017/18 (Figure 2). The fall in reported dwelling fires means that the current figure has fallen to approximately the same level as in the late 1960s. Moreover, this decline since the millennium has occurred against a 12% increase in the population of the UK over the same period.

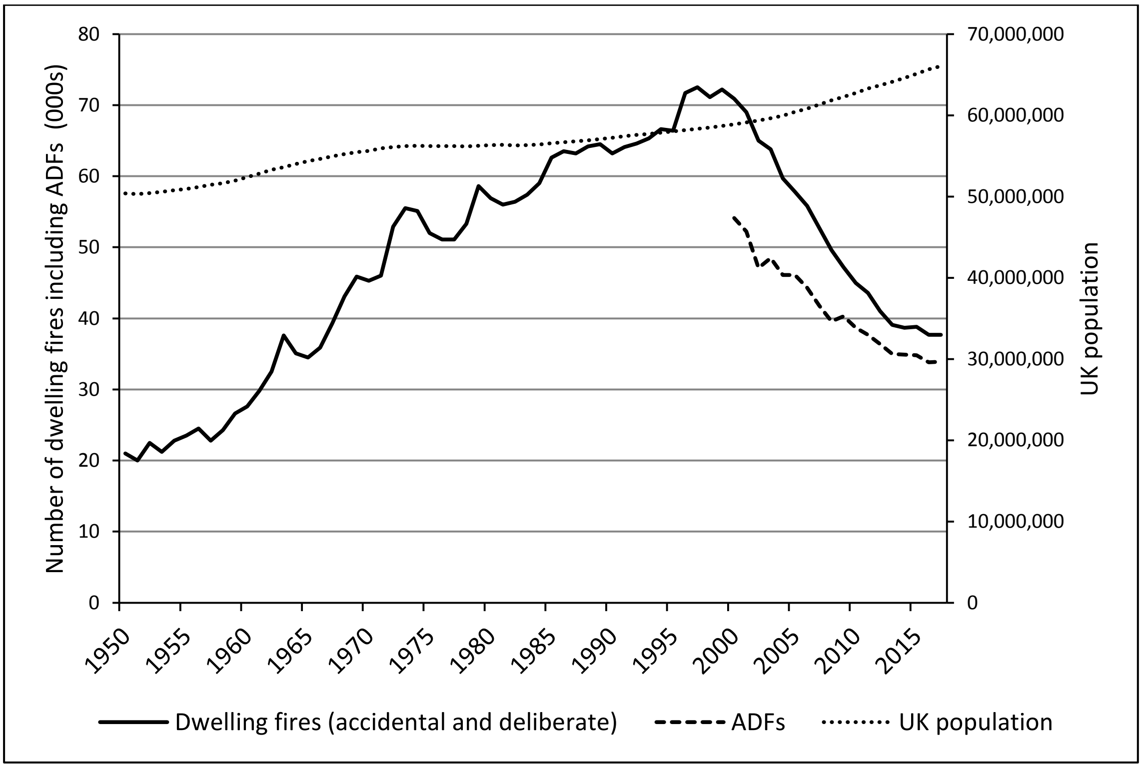

Figure 2: Dwelling fires and ADFs (ADFs recorded from 2000) and the UK population, 1950/51 to 2017/18.

Source: Home Office, 2018; Home Office, 2019; ONS, 2018; Scottish Fire and Rescue Service, 2019; Welsh Government, 2019. NB. From 2009, data collected changed from the UK to Great Britain.

Dwelling fire fatalities. It may be reasonable to assume that these figures will be subject to historical limitations imposed by the varied data collection and reporting standards of different FRSs. However, the UK has employed a standardised and nation-wide method of fire incident reporting for almost 70 years. An overview of dwelling fire fatalities since 1960/61 shows that the fall in their number started at the end of the 1970s, when the number of fatalities fell by 47% between 1979/80 and 2000/01 and then by a further 32% in the period since the millennium (Home Office, 2018; Home Office, 2019; Scottish Fire and Rescue Service, 2019; Welsh Government, 2019) (Figure 3). The visible increase in 2017/18 is the result of the Grenfell Tower fire (see also Table 1).

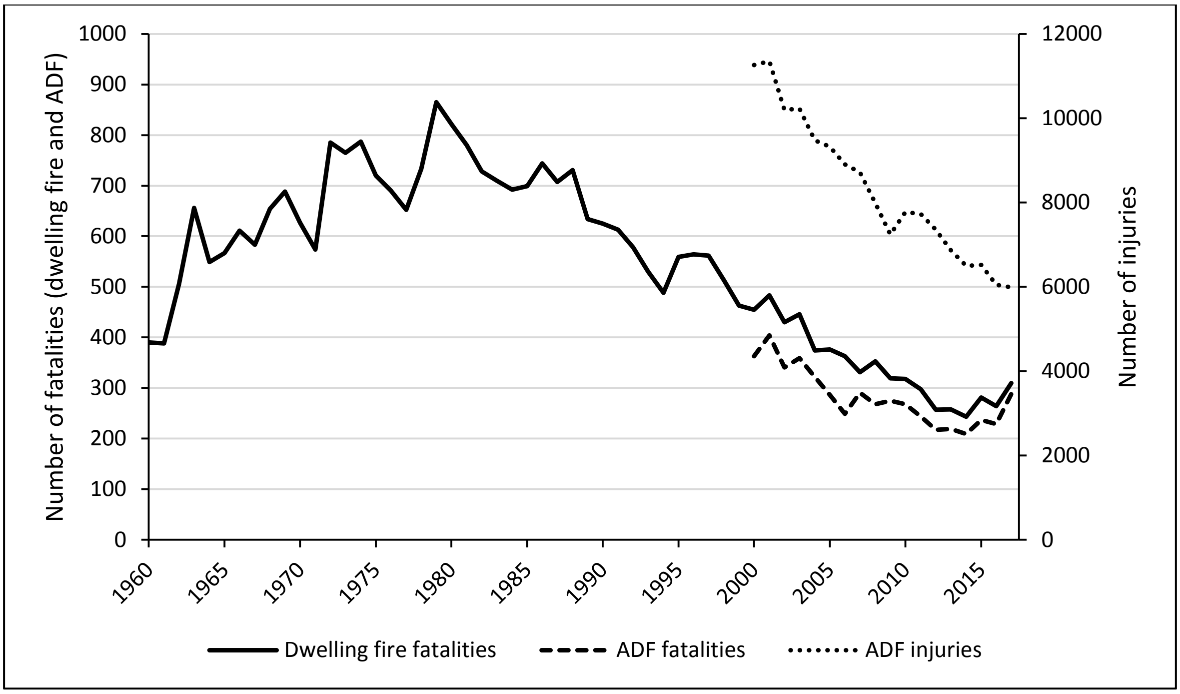

Figure 3: Fatalities and injuries in dwelling fires, 1960/61 to 2017/18.

Source: Home Office, 2018; Home Office, 2019; Scottish Fire and Rescue Service, 2019; Welsh Government, 2019. NB. From 2009, data collected changed from the UK to Great Britain.

2.3.4 Reasons for the decline in fires and injuries

The decline in fires, ADFs, deaths and injuries are clearly considerable. However, what is not so clear is the reason for such a rapid, consistent and widespread fall in these numbers, particularly as no definitive study has been undertaken into, nor conclusive evidence presented for, these reductions (Thompson, Galea and Hulse, 2018). Consequently, in the absence of this, the explanations that are presented by government, FRS and academia are anecdotal and based upon factors that, although clearly correlated, have not had their causality demonstrated. These factors may be grouped into two main areas: legislative and lifestyle-related. Although the exact nature of the relationship, the degree of influence and their cumulative effect of these factors is unclear, they are nonetheless frequently cited as contributing towards the large decline in reported fires and associated injuries and deaths. As a result it is worth examining each of these in turn.

<u>Legislative reasons</u>. Legislative approaches to improving fire safety in the home have sought to address the promotion of smoke alarms, sprinklers and the requirement for fire retardant furnishings. It is only recently that legislation has been introduced on a limited basis to

address the issue of smoke alarms. In England, since October 2015 it has been a legal requirement for landlords to install working smoke and carbon monoxide alarms in their properties (CFOA, 2015; GOV.UK, 2015b). With sprinkler systems, the Welsh assembly introduced legislation in October 2013 and January 2016 for automatic sprinkler systems to be made compulsory for all new and later converted residential properties (the 'Domestic Fire Safety (Wales) Measure 2011), (Gough, 2015; Legislation.gov.uk, 2013). However, the piece of legislation currently credited with contributing to the decline in the frequency of fires is the Furniture and Furnishings (Fire Safety) Regulations Act 1988 (Legislation.gov.uk, 1988), which required the upholstery and composites used in furniture supplied in the UK to meet specified ignition resistance levels and be labelled as such, thereby leading to greater numbers of fire retardant materials in more homes. The regulations were then extended to the covering and upholstery on bedding and in 1993 to second hand furniture offered for retail sale.

There is a body of evidence that argues there is a clear link between the introduction of the Furniture Safety Regulations and the reduction in fire-related injuries and deaths that have taken place over the past 25 years (Emsley et al., 2002; Emsley et al, 2005; Stevens and Mann, 1999; Stevens and Mann, 1999a; Stevens, 2000; Stevens et al., 2006). It is argued that the introduction of the furniture fire safety regulations in the UK has in fact led directly to a decline in the number of total deaths, the number of deaths related to smoke inhalation, and the number of non-fatal injuries where upholstery was the item first ignited (Emsley et al., 2002; Stevens et al., 2006).

The other piece of legislation most frequently credited with having the greatest effect in reducing the frequency of fires is that mandating a focus by FRSs on fire prevention and community safety work and the associated promotion and distribution of smoke alarms (CFOA, 2012; Fire, 2014; Fire, 2015; Fire, 2015a; Knight, 2013; Local Government Association, 2012; Ridley, 2013; The Parliamentary Review, 2014). This focus on prevention and community safety work was a direct consequence of the Fire and Rescue Services Act 2004 (England and Wales) and its legislative equivalents in Scotland and Northern Ireland (the Fire (Scotland) Act 2005 and the Fire and Rescue Services (Northern Ireland) Order 2006) (Legislation.gov.uk, 2004; Legislation.gov.uk, 2005a; Legislation.gov.uk, 2006). Although many FRSs had begun to recognise the need for, and indeed implemented community safety initiatives prior to this, it was Section 6 of the Fire and Rescue Services

Act 2004 that specified that a fire and rescue authority must make provision for the promotion of fire safety within its area, including publicity and information about how to prevent fires and fire-related death and injury through active strategies targeted at all sections of the population. This resulted in a significant change in the work and outlook of the FRS from a focus purely on operational response to include an equal importance to fire prevention through direct involvement with the public.

Consequently, the focus on public education resulted in UK FRSs developing 'community safety' departments dedicated to providing fire prevention and safety advice to the public through a range of initiatives and public safety campaigns. Key components of this are school visits and what are generally called 'home safety visits', where, following a referral or direct request, FRS staff visit people in their own homes to carry out a fire safety check, offer fire safety advice and, where appropriate, supply and fit a free smoke alarm. The provision of smoke alarms has been a key feature of the FRS's aim to reduce fire-related deaths and injuries (DCLG, 2014).

It has been claimed that the focus by FRSs upon prevention activity has directly reduced the number of dwelling fire related injuries and deaths and the overall number of dwelling fires (CFOA, 2012; Knight, 2013; LGA, 2012). Smoke alarm ownership rates increased from under 10% in 1988 to 90% in 2016 (Figure 10) (Home Office, 2019). A report from 2009 commissioned by DCLG to evaluate the 'Home Fire Risk Check Initiative' and the 'Fire Prevention Grant' (two 'pump priming' grants from central government provided to support FRSs in their fire prevention activities) stated that for the period 2005-2007 the home fire risk checks undertaken by FRSs, and the smoke alarms that were installed as part of these checks, accounted for 57% of the fall in ADF-related fatalities, 53 fewer deaths per year, 888 fewer casualties per year, and 13,670 fewer fires per year (DCLG, 2009; Wiredgov, 2009). Indeed, so certain is this conviction within the fire sector that it has become adopted as something of a mantra:

"A few years ago, the Fire and Rescue Service rewrote the rule book on community fire safety initiatives, hence the marked reduction in operational incidents, deaths and injuries." (Fire, 2015, p3)

Despite the widespread claims made for the effect of home fire risk checks, would a programme of fire safety visits and installing smoke alarms really result in fewer fires? One could perhaps argue that the fire safety advice that accompanied the alarm installation made people more aware of the risks and therefore reduced the likelihood and frequency of them having a fire. However, the evidence from numerous studies on public safety advice and public health campaigns has demonstrated that limited numbers of people actually listen to the advice they are given, fewer act on it and, even when they do, the effects are frequently short-lived, as people fairly quickly resort to their former habits and lifestyles (Aschemann-Hornik and Kelly, 2007; Jepson et al., 2010; Maibach et al., 2007; Walls et al., 2011; Witzel et al., 2012).

In fact the period which saw the greatest uptake in smoke alarm ownership actually predates the widespread introduction of home fire risk checks and associated smoke alarm installation arising from the statutory duty created by the Fire and Rescue Services Act (2004). As shown in Figure 4, the most rapid increase took place between 1988 and 1993, a period which saw smoke alarm ownership rates jump from 8% to 66% of all households. This growth coincided with the introduction, in 1988, of a national TV campaign to promote smoke alarm ownership – which, along with a fall in the cost of smoke alarms, has been credited by DCLG as being responsible for this rapid rise in ownership rates since 1988 (DCLG, 2008; DCLG, 2014; Home Office, 1998; Home Office, 2019; MHCLG, 2019; MHCLG, 2019a). It could be argued though that the fitting of smoke alarms by FRSs following the 2004 Act has increased their ownership among the section of the population who would not have been motivated to purchase and fit smoke alarms themselves. In addition, the legal requirement in England since October 2015 for landlords to install working smoke and carbon monoxide alarms in their properties and ensure that the alarms are in working order at the start of each new tenancy (The Smoke and Carbon Monoxide Alarm [England] Regulations 2015) may have also helped to protect a segment of society who would otherwise not have had smoke alarms (CFOA, 2015; GOV.UK, 2015b; MHCLG, 2019b).

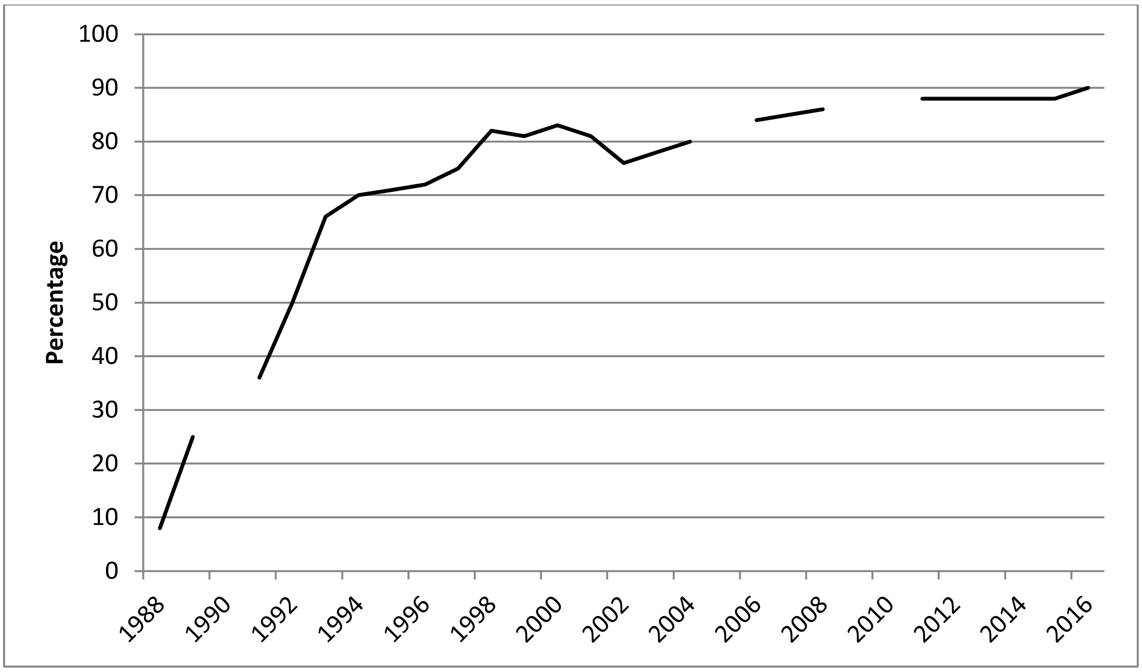

Figure 4: Smoke alarm ownership rate in England and Wales 1988 to 2016 (England only from 2004).

Source: Home Office, 2019 (note: missing areas denote years for which data are absent).

Despite the seemingly high level of smoke alarm ownership, the situation is further complicated by questions about the veracity of the public's reporting of smoke alarm ownership and issues concerning their maintenance and removal (Levin, 2014). Statistics on smoke alarms demonstrate that despite a reported ownership rate of almost 90% for England, no smoke alarm was present in almost a third (31%) of all dwelling fires (Home Office, 2019). Of battery powered alarms, 39% failed to operate, while 20% of mains powered alarms failed to operate (Home Office, 2019). In the majority of cases (44%) this was simply because the fire and smoke products did not reach the alarm, however in a quarter of the instances where a battery powered alarm did not operate it was due to missing or flat batteries (Home Office, 2019). This has led some to question the accuracy of the reported levels of smoke alarm ownership across the UK (Levin, 2014) and speculation that the high levels of reported smoke alarm ownership may obscure the fact that many of these alarms may not be in a working condition (Merseyside Fire & Rescue Service, 2015).

The claims made about the effects of the 'Home Fire Risk Check Initiative' and the 'Fire Prevention Grant' being single-handedly responsible for the decline in fires, fire-related injuries and deaths are clearly open to debate. A report from the National Audit Office (the UK's independent parliamentary body responsible for auditing government departments, agencies and non-departmental public bodies) identified that, for the period between 2010-11 and 2014-15, the downward trend in the numbers of fires and associated fatalities and casualties continued despite a general reduction (due to austerity) in prevention activities and fewer hours being spent on home safety visits (National Audit Office, 2015).

To credit safe and well visits and the installation of smoke alarms for such a large contribution towards the fall in fires and reduction in fire risk, overlooks the contribution from advances within the medical sector; specifically the enormous improvements made over the past four decades in the clinical treatment and management of burns and the resultant effects upon patient survival, and recovery (DiGuiseppi et al., 1998; Herndon, 2014; Kamolz, 2010; Pruitt, 1980; Pruitt and Wolf, 2009; Rowan et al, 2015). Moreover, these medical advancements are not simply limited to burns; the understanding and treatment of smoke inhalation injuries has also undergone improvement (Fraser and Venkatesh, 2005; Sen et al., 2014).

These developments are largely the result of the increase in research that has been undertaken into burns care, leading to a much better understanding of the pathophysiology of burn injuries and the resultant means by which they can be treated (Stylianou et al., 2015). There has been an expansion in the number of academic burns publications and papers on the subject (Sen et al., 2014). The areas where treatment and management of burns has improved are wide ranging, encompassing a variety of aspects such as: critical care; the prevention of infection and toxicosis; surgical procedures, including grafting and reconstruction; nutritional care; and rehabilitation programmes (Rowan et al., 2015).

<u>Lifestyle-related reasons</u>. With lifestyle changes, the most apparent has been the decline in smoking among the adult population of Great Britain. The smoking rate has fallen from 46% of all adults in 1974 to 15% in 2017 (ONS, 2018a). In conjunction with this decline, fires where the source of ignition was attributed to smokers' materials fell by 41% between 2001/02 and 2013/14 (DCLG, 2015). By 2017/18, in England, smokers' materials were the source of ignition in just 7% of accidental dwelling fires (Home Office, 2019). However, the category described as 'careless handling of fire or hot substances (mostly cigarettes)' remains the leading cause of fatal ADFs (DCLG, 2015; Home Office, 2019).

From the early 1970s, central heating systems began to replace solid fuel fires or three-bar electric fires as the most common method of heating homes, thereby reducing another potential source of domestic fires. So widespread is its installation that central heating is now present in over 90% of all dwellings (DCLG, 2014a).

In the late 1970s the Canadian frozen food producer McCain was the first to introduce ‘oven chips’ to the UK, the subsequent popularity of frozen oven chips is held as contributing to the decline in the traditional method of cooking chips through oil filled chip pans and a consequent reduction in fires resulting from this method of cooking. In 2000/01 chip pan fires were the cause of one in five of all ADFs. However, by 2013/14 this figure had fallen to less than one in fifteen (DCLG, 2015).

Despite the undoubted correlation between all of the above listed factors and the decline in fires, no conclusive explanation has yet been offered to account for the declines since the millennium. Based upon the evidence presented in this section, it seems reasonable to assume that a combination of all the above listed factors is the most likely explanation for the decline.

2.3.5 Static injury and fatality rates

Despite the large declines that have occurred, the fall in the incidence of dwelling fires and associated fatalities has not been accompanied by a reduction of the likelihood of dying or being injured should a dwelling fire occur. The late 1970s was the period which saw the start of the marked falls in the dwelling fire fatality rate (Figure 5). From a high of 1.74 fatalities per 100 fires in 1963, this continued to fall throughout the following decades, dropping below 1 person per 100 fires in 1989 and then continuing to fall slightly during the 1990s. However, since 1999 the fire fatality rate in dwelling fires has plateaued, fluctuating between 0.63 and 0.83 deaths per 100 fires. Consequently, in the event of a fire the overall risk of dying in a dwelling fire has not changed over this period.

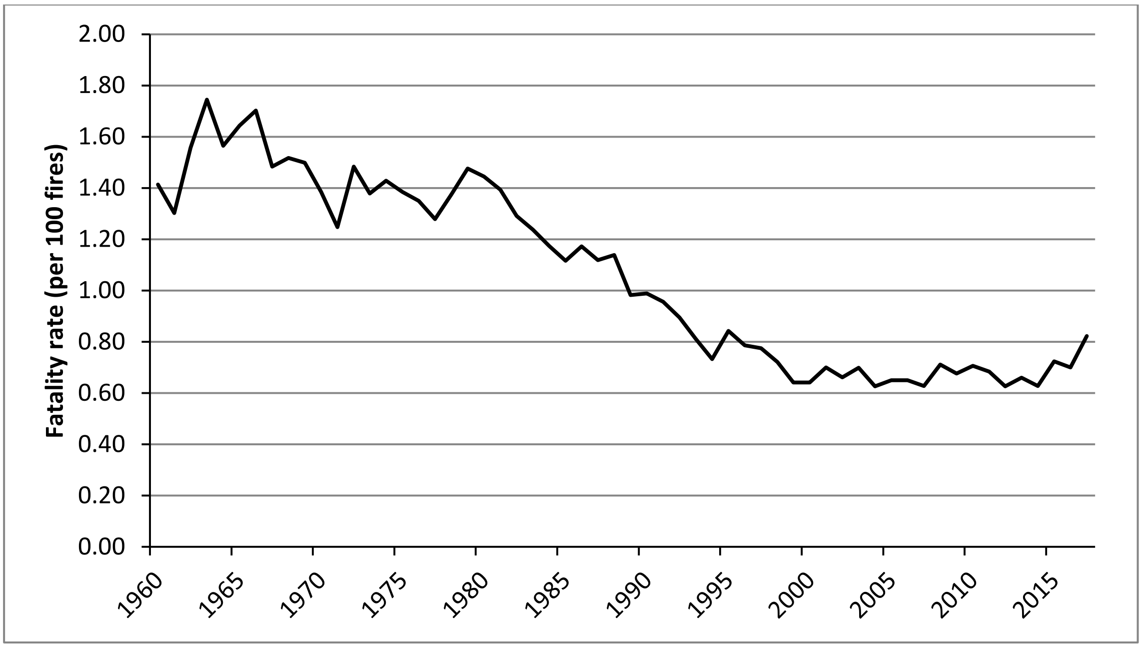

Figure 5: Dwelling fire fatality rate (per 100 fires), 1960/61 to 2017/18.

Source: Home Office, 2018; Home Office, 2019; Scottish Fire and Rescue Service, 2019; Welsh Government, 2019.

The same is also true with the risk of being injured in a fire, as since the millennium the dwelling fire injury rate has also remained fairly constant at between 17.6 and 20.6 non-fatal casualties per 100 dwelling fires, with a median of 19.3 (Figure 6).

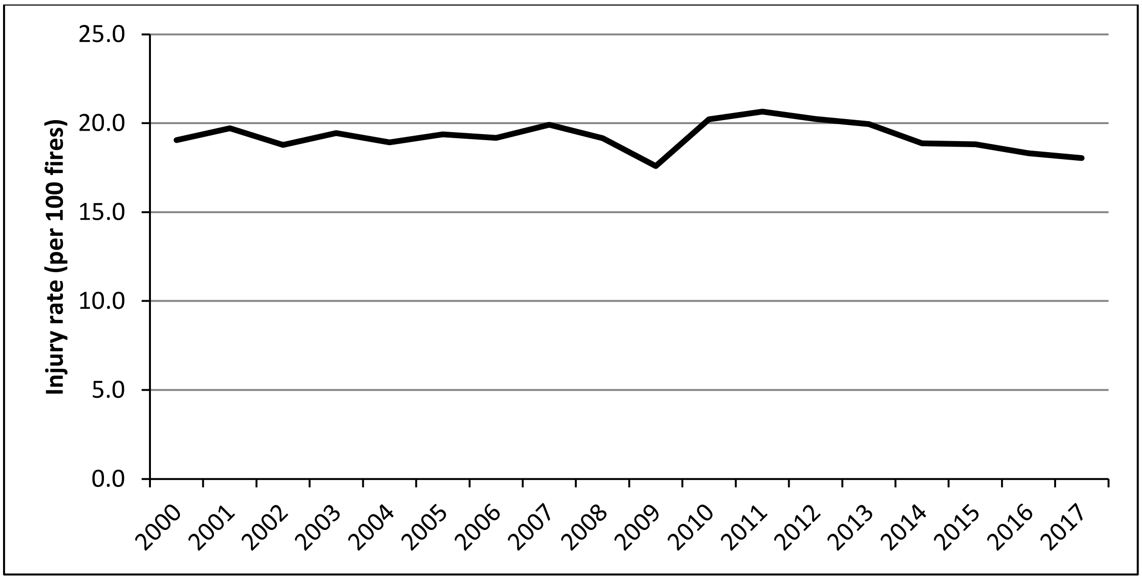

Figure 6: Dwelling fire injury rate (per 100 fires), 2000/01 to 2017/18.

Source: Home Office, 2018; Home Office, 2019; Scottish Fire and Rescue Service, 2019; Welsh Government, 2019.

ADFs account for between only 8% and 20% of all fires by type, yet they continue to be the cause of between 58% and 73% of all fire-related injuries and fatalities (Figure 7) (Home Office, 2018; Home Office, 2019; Scottish Fire and Rescue Service, 2019; Welsh Government, 2019). As a result, it can be seen that the reductions in overall numbers of fires, fatalities and injuries conceal an important point, which is that while the risk of having an ADF has reduced, the overall risk of dying or being injured in an ADF has not. Consequently, as accidental fires in the home continue to be the leading cause of all fire-related fatalities and injuries they are an area about which a greater understanding needs to be developed.

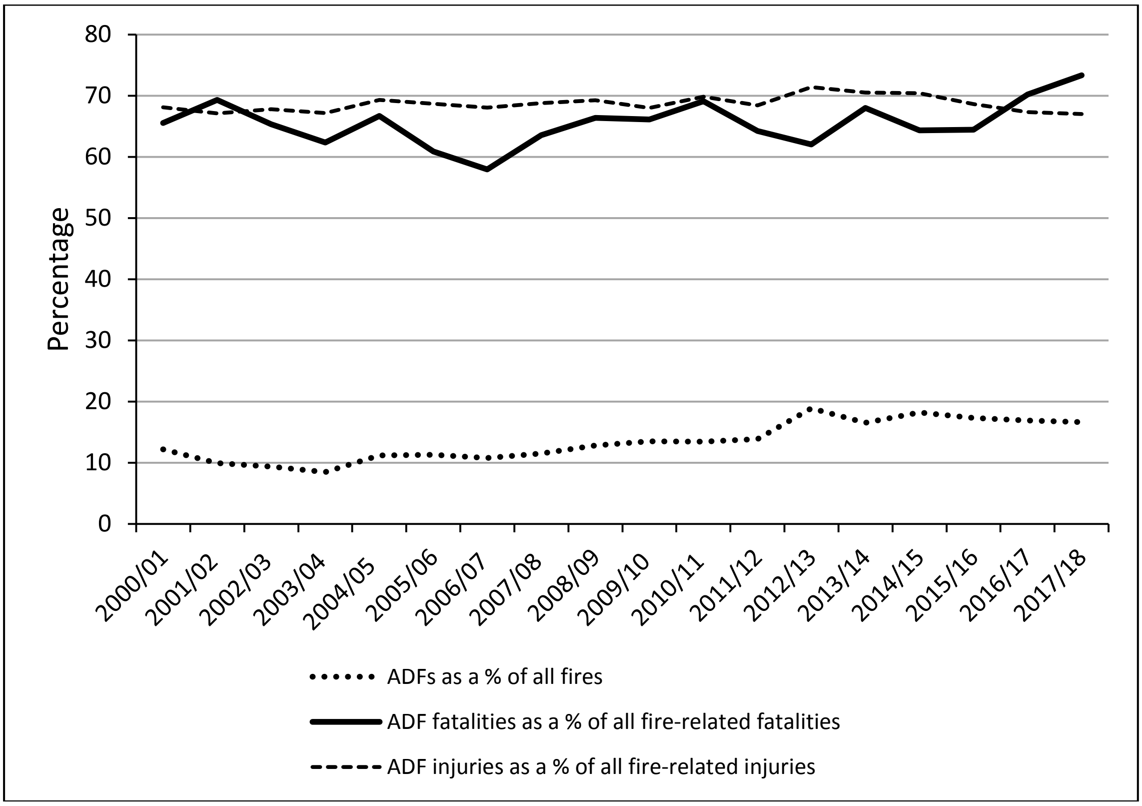

Figure 7: ADFs as a proportion of all fires, fire-related fatalities and fire-related injuries, 2000/01 to 2017/18.

Source: Home Office, 2018; Home Office, 2019; Scottish Fire and Rescue Service, 2019; Welsh Government, 2019. NB. From 2009, data collected changed from the UK to Great Britain.

2.3.6 Summary

Since the millennium, with the exception of the Grenfell Tower fire, there have been large and sustained falls in fires, and fire-related deaths and injuries. While this is clearly something to be welcomed, the causes for this decline should be studied particularly against a backdrop of concerns about increased fire safety risks posed by an ageing population and the continued reductions in FRS budgets since 2010. However, this highlights the key point about the fall in fires: it has yet to be studied in any detail and, until it is, the reasons given for why there are fewer fires lack a clear empirical basis. This is important because if these declines reach a plateau, or begin to undertake a reversal, there will be no understanding of the causes. Furthermore, the welcome reductions in fires, deaths and injuries conceal an important point: that the proportion of injuries and deaths in the type of fire which is their single largest cause has not changed. The risk of having an ADF has reduced, however the risk of dying or being injured in an ADF has not. Consequently, accidental fires in the home continue to be the leading cause of all fire-related deaths and injuries.

2.4 FIRE SAFETY

2.4.1 Introduction

The relevance of human behaviour in fire to building design and the adoption of prescriptive building codes (particularly in the UK and the US) meant that a large amount of research has been undertaken in this area (Bryan, 2002; Fruin, 1971; Jin 1978, 1982, 1997, 2002; Jin and Yamada, 1985, 1989; Pauls 1977, 1990, 1996, 2003; SPFE 2003). As such there is a wide body of literature on, and understanding of, movement speeds and flow rates under a range of conditions – information that has fed into fire safety legislation and codes of practice for building design (Bryan, 1998, 1999).

Within fire safety engineering one of the concepts that is commonly used to evaluate occupant safety is the RSET/ASET calculation (LWF, 2015, Purser, 2003). RSET (Required Safe Egress Time) is an estimation of the amount of time that would be required for an occupant to move to a place of safety, and combines the time from ignition to becoming aware that something is happening (e.g. when an alarm sounds), pre-movement time (i.e. from becoming aware to the commencement of movement to a place of safety; a.k.a. recognition + response time), and movement time (i.e. time spent moving to a place of safety; a.k.a. travel time). ASET (Available Safe Egress Time) is a measure of the time needed for the fire to reach untenable conditions following ignition (often expressed as the time to reach an unacceptable level of vision, a certain depth of hot smoke layer, or a certain CO level within cold air) (De Smet, 2015). Based upon these calculations if ASET exceeds RSET then it is assumed that occupants will be able to evacuate with some margin of safety (Figure 8).

However, there has also been criticism about the degree to which the foundations of prescriptive fire safety codes and regulations are based upon inaccurate or over-simplistic assumptions, which do not take into account an empirical understanding of how people really behave during a fire or the wide variation in different people's capabilities (Babrauskas et al., 2010; MacLennan, 1985; Proulx et al., 2006). In particular, the assumption that after becoming aware of a fire occupants will simply begin to undertake a process of evacuation and move towards the closest exit has been criticised as not being representative of what has been observed from studies of real fires (Kuligowski, 2008; Proulx and Richardson, 2002).

In response to this, there has been an increasing focus on, and incorporation of, a behavioural perspective into building design (O'Connor, 2005), marked by the development of the

ORSET model (Occupant Response Shelter Escape Time) by Sime (Sime, 2001), which seeks to integrate aspects of building fire safety and human behaviour during an evacuation. In doing so the ORSET model asserts that people's behaviour is influenced by their physical location, occupancy risk criteria, building type and prevailing social structure present at that particular time and as such consciously seeks to move away from a deterministic approach.

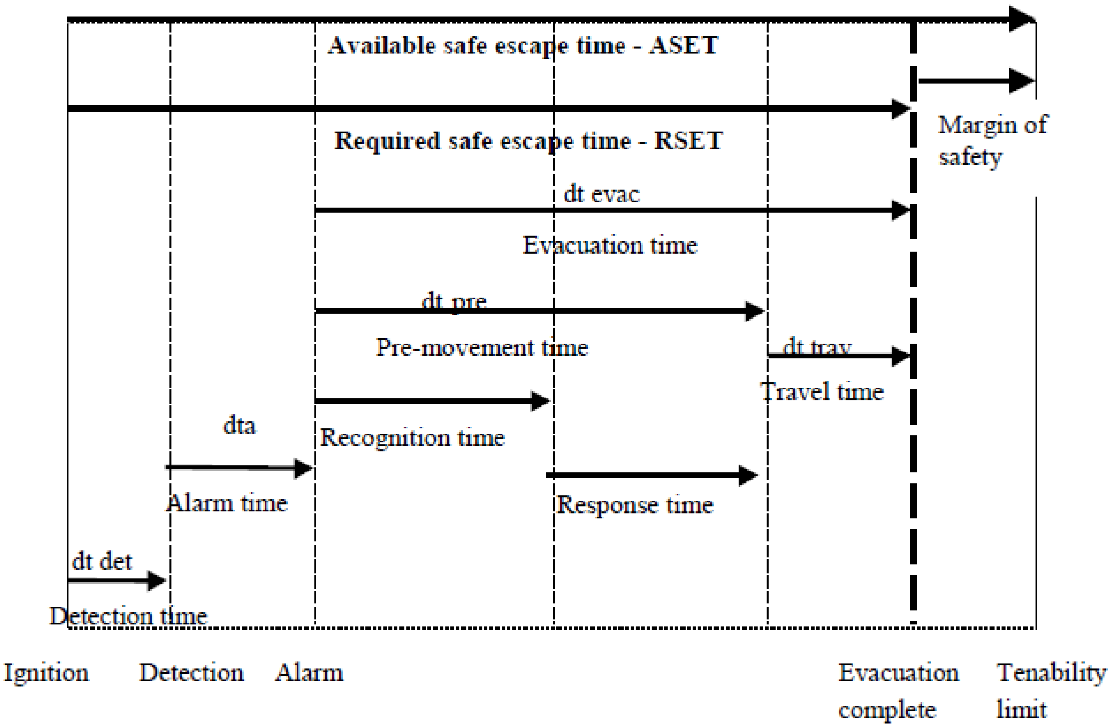

Figure 8: The egress time model.

Source: Proulx et al., 2006.

The awareness since the 1990s of the need to recognise and incorporate different capabilities into the understanding of evacuation has led to an increased focus on the egress capability of those with functional impairments and disabilities (Boyce et al., 1999, 1999a, 1999b, 1999c; Sime 2001; Proulx, 2002; Shields et al. 1996). In recent years there have also been moves to understand and incorporate the effect of cultural factors on evacuation behaviour and movement, something that was a key principle of the BeSeCu (Behaviour, Security, Culture) project (for a further discussion of this, see Section 6) (Galea, 2009a; Galea et al., 2013; Schmidt and Galea, 2013). There has also been a focus on understanding the effects of traditional forms of dress – such as the abaya and chardor – upon walking speed and evacuation rates (Almejmaj et al., 2015).

2.4.2 The Grenfell Tower fire

An examination of the current regulatory framework cannot take place without reference to the Grenfell Tower fire. Although, at the time of writing, the existing regulatory framework has yet to change in response to the events that occurred at Grenfell, the effects of this fire have been far reaching and, as a consequence, it is highly likely that at some point in the near future the UK government will enact legislative changes to the current regulatory framework.

Within the UK, the Grenfell Tower fire was unique both in the size of the fire and the large number of deaths that resulted. The fire occurred in the 24 storey Grenfell Tower block of flats in London on 14th June 2017, and caused 72 deaths, at least 18 of whom were children. This makes it the worst building fire in the UK since the start of the twentieth century (Grenfell Tower Inquiry, 2019; Wikipedia, 2018). Grenfell Tower contained 127 flats and 293 people were believed to be present in the building at the time. The fire is believed to have started in a fridge freezer in a flat on the fourth floor which, despite being quickly extinguished by London Fire Brigade, spread to exterior cladding on the building from where it moved up and around the tower. The cladding used on the building is believed to be the reason why the fire spread so quickly (BBC News, 2019; Grenfell Tower Inquiry, 2018; Wikipedia, 2018).

Such was the scale and severity of this fire (and outpouring of public anger) that the government commissioned a wide-ranging review of building fire safety regulations (titled the Independent Review of Building Regulations and Fire Safety, informally referred to as the Hackitt Review) (GOV.UK, 2018). The final report was published on 17th May 2018 and set out a series of recommendations for improvements to the system of fire safety regulations in the UK (GOV.UK, 2018). In response to the publication of the Hackitt Review, the government issued a statement outlining its intention to consult on proposed changes to the system of building fire safety regulations and then, following this, to bring forward legislation that: *"delivers meaningful and lasting change and gives residents a much stronger voice in an improved system of fire safety."* (GOV.UK, 2018a). In addition, a public inquiry (the Grenfell Tower Inquiry) was set up to *"examine the circumstances leading up to and surrounding the fire at Grenfell Tower"* (Grenfell Tower Inquiry, 2018). This formally opened on the 14th September 2017 and began the evidential hearings in June 2018.

Consequently, as a result of the Grenfell Tower fire, it is highly likely that there will be a number of wide-ranging amendments to the regulatory framework. However, at the time of writing, such changes have yet to be enacted, so an overview will be presented of the system as it currently stands.

2.4.3 Current legislation

Non-domestic premises. Within England and Wales fire safety in non-domestic premises is covered by the Regulatory Reform (Fire Safety) Order 2005 (RRO), which came into force in October 2006 (Legislation.gov.uk, 2005; DCLG, 2007; GOV.UK, 2015a). This replaced the method of fire certification that was in place with the previous Fire Precautions Act 1971 with an approach that places a duty upon the 'responsible person' for the building to undertake a risk assessment and reduce any fire risks (firenet, 2015). Although the RRO is not applicable to domestic premises, it can be applied in circumstances where the potential risk to communal areas of a residential building is increased due to changes being made to one of the flats within that building (Lacors, 2008).

Non-domestic premises are defined as: all workplaces and commercial premises; all premises the public have access to; and the common areas of multi-occupied residential buildings. Responsibility for fire safety in non-domestic premises will rest with a 'responsible person', defined as "*the person who has control of the premises in connection with the carrying on of a trade business or other undertaking*." (Lacors, 2008, p4). In practical terms this will generally be an employer, owner, managing agent, landlord or occupier (HSE, 2015). In most premises local FRSs are responsible for the enforcement of this legislation, while the Health and Safety Executive (HSE) is responsible for enforcement on building sites, nuclear premises, and ships undergoing repair or construction.

Domestic premises. The RRO does not apply to private homes, which includes the individual flats within a block of flats or residential areas within houses in multiple occupation (HMOs). With dwellings, new building work or amendments or alterations to existing dwellings are governed by the fire safety requirements of the 'Building Regulations 2000', which specify the requirements for their design, layout and construction. The provisions set out within this aim to cover the relevant areas of fire safety that relate to a building (DCLG, 2007a, 2007b). With smoke alarms, the Building Regulations provide guidance on the placement of fire detection and alarm systems and state that all new 'dwellinghouses' are required to have a fire detection and fire alarm system which should be powered by mains electricity (DCLG, 2007a, 2007b). The 'Smoke and Carbon Monoxide Alarm (England) Regulations 2015' require private sector landlords to have at least one smoke alarm fitted on every storey of a property and a carbon monoxide alarm in any room containing a solid fuel burning appliance (e.g. a coal fire, wood burning stove). The landlord is then required to ensure that the alarms are in working order at the start of each new tenancy (MHCLG, 2019b).

However, unlike PCI spaces or privately rented properties, there is no requirement for smoke detection systems in privately owned domestic buildings to undergo any periodic checks or maintenance (DCLG, 2007a). As a result, these differences in legislative requirements around smoke alarms mean a potentially greater risk exists in privately owned dwellings compared to PCI buildings.

2.4.4 Changes in housing structure and tenure

Currently, no requirement exists for older, unmodified dwellings to meet any of the provisions set out in the Building Regulations, which also includes the fitment of smoke alarms. Within England it is estimated that there are 22.7 million dwellings, with age of housing stock varying greatly by tenure (DCLG, 2015a). The majority of all dwellings (80%) are houses and over a third of all of housing stock was built before 1945, while just 14% was built after 1990. With the private rented sector, one third of properties were built before 1919, with only 18% built since 1990 – something indicative of the high proportion of converted flats in this sector (DCLG, 2015a). In fact the most significant change in tenure in recent years has been the doubling of the number of private rented homes from two to four million between 1996 and 2011 (DCLG, 2013). With local authority housing, the majority (72%) was built between 1945 and 1980 (DCLG, 2015a). Consequently a large proportion of the housing stock was built before the introduction of modern methods of fire safety engineering. Furthermore, the regulations covering alterations or amendments as set out in the Building Regulations only cover the amended portion of the property, not the entire property. As a result there are a large number of dwellings where the design, layout and materials used in construction may pose a greater fire safety risk than those built since the advent of recent fire safety regulations.

2.4.5 The increased fire safety risk in dwellings

There have been moves in certain areas to increase regulation around fire detection and suppression systems in residential locations. Legislation was implemented by the Welsh assembly in October 2013 and January 2016 for automatic fire sprinkler systems to be made compulsory for all new and converted residential properties (the 'Domestic Fire Safety (Wales) Measure 2011), (Gough, 2015; Legislation.gov.uk, 2013). The Scottish Government has undertaken work to update the cost-benefit analysis for sprinklers in residential buildings (in this case houses, flats, HMOs and student halls of residence) (Scottish Government, 2015). While in England, since October 2015 it has been a legal requirement for landlords to install working smoke and carbon monoxide alarms in their properties (CFOA, 2015; GOV.UK, 2015b).

However, the above examples notwithstanding, the fact remains that there are fewer regulations for domestic compared to non-domestic buildings – the most notable difference being the obvious absence of any domestic equivalent to the RRO. This means that there is no legal requirement for private households to conduct fire risk assessments and then make suitable safety provisions based upon those assessments. Consequently fire risks which may be identified and thereby reduced within PCI spaces may not be observed and acted upon when they exist within the domestic environment. These risks fall into the following areas: kitchens and cooking; electrical appliances and electrical safety; and smoking and associated materials.

The leading source of ignition in cases of ADF fatalities is smokers' materials (defined as cigarettes, cigars and pipes) which result in over a third of all fatalities (37%). This is followed by cooking appliances at 14% and space heating appliances at 9%. The three main sources of ignition in cases of ADF injuries are cooking appliances (which account for more than half of all fire-related injuries – 53%), followed by other electrical appliances and smokers' materials, both of which accounted for 10% of injuries (DCLG, 2015).

With regard to where within a property ADFs occur, the majority (62%) started within the kitchen, this was followed by the living room and bedroom, both at 9%. At 43%, most fires that resulted in a fatality occurred in the living room, followed by the bedroom (29%) and then the kitchen (18%). For non-fatal casualties the order was slightly different, with three fifths resulting from kitchen fires. Next was the bedroom (15%), followed by the living room (12%). It is clear that the majority of fatal and non-fatal casualties occurred in fires which started in the kitchen, living room or bedroom (DCLG, 2015).

2.4.6 Summary

The previous section highlighted that, despite their declining numbers, ADFs clearly remain a type of fire that poses serious and long-lasting costs to society in terms of fire-related injuries and deaths, not to mention property damage. Yet in spite of this, less attention is focussed and fewer rules placed on fire safety in the home – something that may perhaps act as a contributing factor to this situation.

Due to the absence of legislative fire safety requirements (outside of new and amended buildings), lack of compulsory risk assessments, formalised inspections and associated powers of enforcement, the risk profile within dwellings is greater than for PCI buildings. Clearly this situation is primarily the result of limitations upon the degree to which retrospective fire safety legislation may be applied to private dwellings (and also effectively enforced within that environment) but, nonetheless, there is not a comparable level of formalised legislative requirement around fire safety for domestic buildings, both in terms of the building and the requirements upon individuals within the building.

In looking at fire safety regulation, this section discussed some of the ways in which the actions of individuals within the building may be associated with a fire starting in a dwelling. However, what is known about individuals' behaviour once a fire has started, and how does this relate to the outcomes of the fire? Before going on to discuss the existing literature on the actions individuals take during fires, it is important to first consider the decision making process that a person will undertake that in turn results in the performance of an action.

2.5 DECISION MAKING DURING FIRES

2.5.1 Introduction

Key to the understanding of how people behave in a fire is an understanding of their decision making processes. However, decision making during a fire or other dynamic, time-pressured emergency is subject to a very different series of inputs and constraints from day-to-day situations.

The field of decision making developed originally as a way to understand managerial decision making within organisations (Buchanan and O'Connell, 2006; Gok and Atsan, 2016). These traditional 'normative' models of decision making focussed on identifying the best decision in a given situation, and were predicated upon the assumption that the decision maker will possess all the relevant knowledge about the situation and the situation itself is clearly defined and easily interpreted (Baron, 2004). Consequently such normative models are not applicable to situations in which there are severe constraints imposed by a rapidly changing and potentially life-threatening situation (Kahneman and Tversky, 1979).

The naturalistic decision making (NDM) framework emerged to address these limitations (Klein et al., 1986; Klein, 2008). NDM describes the process of rapid decision making in complex real world environments where information is often incomplete, ambiguous and subject to rapid change – situations which may frequently be found during a fire or other emergency (HM Fire Service Inspectorate, 2002; Klein, 2015; Klein et al., 1993). In these situations, there is no time to weigh different options and compare the likely outcomes of each. Instead the decision maker perceives and recognises the situation and then, on the basis of prior experience, quickly selects a satisfactory (rather than the optimal) response (Zsambok and Klein, 1997). In this context the NDM approach can be considered as an amalgamation of intuition and analysis, which broadly corresponds with the System 1 (faster and intuitive) System 2 (slower more analytic) approach (Kahneman, 2012). One of the most notable examples of this is the Recognition-Primed Decision (RPD) model (Klein, 1998).

The focus of NDM has been decision making by experienced decision makers, such as airline pilots, medical staff, military personnel and firefighters. (Klein, 1998; New Scientist, 2015). This has meant that although a framework existed for understanding decision making by 'experts' in complex, real-world, emergency situations, it does not offer an understanding of decision making by those who are not experts and who lack any or much prior experience upon which to draw. For this area one needs to turn to a slightly different field, specifically studies of responses to disasters and the disaster warnings that precede them.

2.5.2 Emergent understanding of decision making processes

The current understanding of this area has its origins in Prince's study of the response to and aftermath of the Halifax Explosion of 1917 in Canada (Prince, 1920). Following a collision with another ship, a fire broke out on board the French munitions ship *SS Mont-Blanc* causing it to explode. The resulting explosion killed almost 2,000 people, injured approximately 9,000, and destroyed large parts of the city and is believed to be the largest human-created explosion of the pre-atomic age (Kitz, 2000). Prince's work was, arguably, the first sociological study of response to a disaster and its aftermath. He outlined a number of what are now commonly accepted themes, notably emergent behaviour, stranger assistance, mutual aid, community resilience, and an absence of role abandonment (Cocking et al., 2007; Cocking et al., 2008; Drury et al., 2009; Gwynne, 2008; Provitolo et al., 2011; Quarantelli, 1983; Scanlon, 1988). This was the first structured study to advocate the idea that during an emergency or disaster, people do not act in a haphazard, random or animalistic manner; instead they engage in behaviour that results from decisions informed and based upon their perception of the environmental and social cues (Mileti and Beck 1975; Mileti and Sorensen 1990; Wolfenstein, 1957; Zajonc and Bernstein, 1961).

From the 1960s it became increasingly recognised that there were a number of psychological and physical processes that underpinned the decision making process during the stresses imposed by disasters and emergency warnings. In short, people behaved according to a process which could be mapped and articulated (Barton, 1963; Blumer; 1969; Withey, 1962). This led to the development of the idea that a warning or disaster response comprised a series of cognitive and behavioural stages, which included receiving cues (information about the threat), attempting to understand the nature of the threat, its likelihood of causing harm to the recipient and making a 'behavioural adaption' (defined as a response based upon the information received) (Withey, 1962; Withey, 1976).

2.5.3 Development of theories of decision making during fires

The first systematic research into human behaviour in fire began to be carried out from the 1950s (Bryan, 2002a). However it was not until the 1970s and the work of Wood in the UK (Wood, 1972) and later Bryan in the USA (Bryan, 1977) that large scale research was undertaken into human behaviour in fires in a range of building types (Bryan, 1999). These were the studies which laid the foundation for the development of human behaviour in fire as an academic discipline. As will be discussed in the next section, these large scale studies provided a successful methodological framework and a descriptive overview of the responses and the actions that 'non-specialist individuals' undertake when encountering a fire in a building. Other researchers were able to use these studies as a basis for developing an understanding of the behavioural and decision making processes that informed people's responses and actions during a fire. As a result, it was at this time that the early theories of human behaviour in fire and decision making models began to emerge.

2.5.4 The early models

One of the earliest examples of an attempt to develop a theory of human behaviour in fire was developed as a manual for fire investigators by Lerup (Lerup, 1977). In *People in Fires: A Manual for Mapping*, Lerup developed a methodology and procedure to describe how fire events can be conceptualised in relation to the behavioural actions of the building occupants. The source for this was data gathered from the Geiger Nursing Home fire in 1971 in Pennsylvania. This was examined in further detail in a subsequent piece of work by Lerup and a number of colleagues which, using the mapping procedures outlined in earlier work, applied these to ten case studies of fires in health care facilities (Lerup et al., 1977). This sequence of behaviour was considered against a three stage process comprising a situational cue, a behavioural response to that cue, and then a reason why that specific response was undertaken.

At a similar time Breaux et al. (1976) developed a model of cognitive decision processes during a fire that also comprised three distinct stages. The first of these is recognition and interpretation: perceiving the initial cues and then recognising that those cues are indicative of a fire. The second stage is behaviour: acting in response to the cue recognition. Importantly this may mean action or inaction as the authors recognised that the latter can also be a deliberate response to a fire. The third stage is the outcome of the action, which can then drive further decision making and behavioural processes. Breaux et al. also recognised the importance of cognitive inputs (prior experience, role within the setting and the current situation) in influencing the decision making process.

2.5.5 Further development

In the UK, the awareness among some researchers that building fire regulations were based upon assumptions, rather than empirical observations of human behaviour (Canter and Matthews, 1976), led to further study of behaviour in fires. From December 1977 the Fire Research Unit at the University of Surrey undertook a survey to collect data from fires across a range of occupancy and building types. This study focussed on three main areas: initial stages of occupant response and behaviour during a fire; actions undertaken during a fire in a building; and escape from a building in which there is a fire.

The decision making model that was subsequently developed (named the ‘general model of human behaviour in fires’, Figure 9) was based upon three stages (‘nodal points’) which represented a point of potential behavioural sequence change during a fire (Canter, 1996). The first is the interpretation and response to the initial cue. The second is a range of preparatory actions that will be undertaken (instruct, explore or withdraw). The final one is the actions and will lead to 'evacuate', 'fight', 'warn' or 'wait' act sequences (Canter, 1990; Canter, 1996).

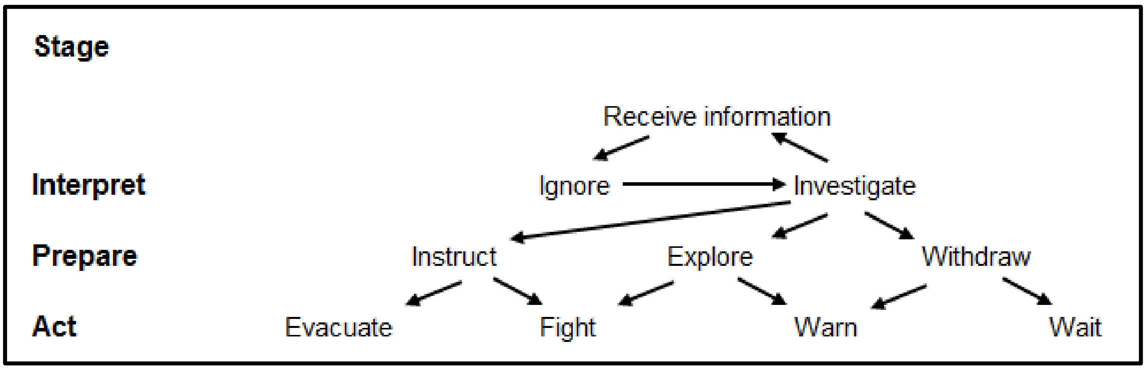

Figure 9: The general model of human behaviour in fire.

Source: Canter, 1996

Canter argues that decision making is governed by what he terms the 'Role/Rule Model', which asserts that people are goal-oriented and their motivations driven accordingly (Canter, 1996). These goals may be considered as a function of a person's role in that specific setting at that particular point in time. These roles in turn have a series of associated expectations and actions, which Canter terms 'rules'. Canter goes on to state that commonly occurring rules can be established for different classes of occupancy and types of fire. This is an interesting concept, however it may be argued that it hinges on what specifically is meant by 'type of fire' as although possibly able to offer an explanation for why certain actions occurred when reviewing an event, one criticism here is that the 'type of fire' would not be apparent until the event itself and as such could not be predicted.

Identifying that perception of the fire itself is key to driving the decision making processes during a fire (Latane and Darley, 1968; Wood, 1972), Bryan developed a model that sought to explain this. Combining Withey's (1962, 1976) work on perceptual processes with his own studies of behaviour in fire, Bryan was able to develop a model to express the decision processes of an individual during a fire (Figure 10).

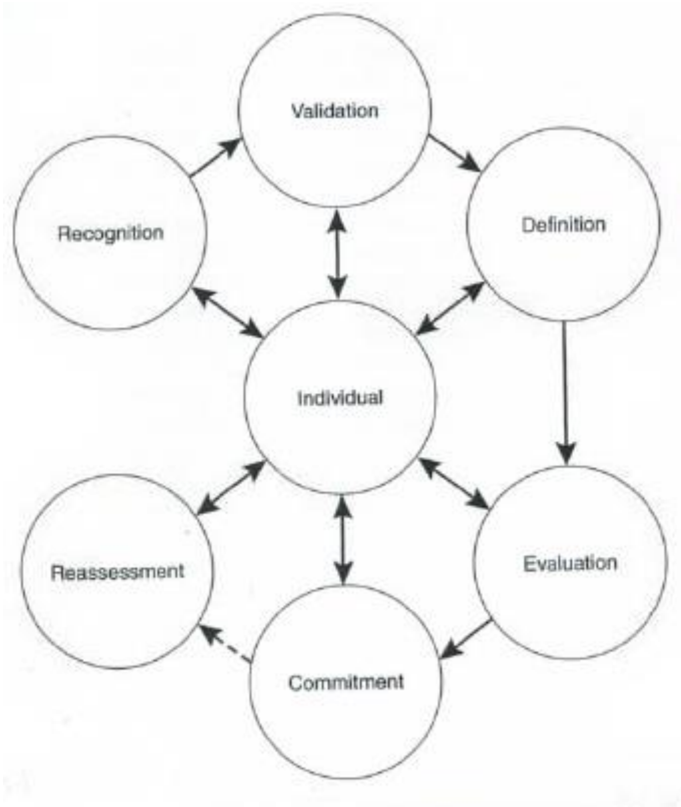

Figure 10: The decision process of the individual in a fire.

Source: Bryan, 2002

Bryan's decision process model employed six stages. The first, recognition, describes perceiving a change in the environment through the presence of fire cues, an automatic alarm or warning from another occupant. Validation of the fire cues takes the form of seeking additional information. With definition, the information received is processed in relation to the situational and environmental context of the fire, including its perceived threat. Evaluation is a process of cognitive and other psychological activities undertaken in order to allow an individual to respond to the threat identified. With the commitment process one sees the implementation of the behavioural responses. This response will in turn lead to one of three possible outcomes: completion; partial completion; or non-completion. If the response is partially completed or not completed, a further cognitive process of reassessment is undertaken which will again lead to commitment. (Bryan, 1977; Bryan, 2002).

2.5.6 A comprehensive theory of decision making

As a result of the extensive work undertaken, it is accepted that during a fire human actions are not random or predetermined, but are the result of a decision making process (Breaux et al., 1976; Mileti and Beck, 1975; Mileti and Sorensen, 1990). It is also evident that as part of this cognitive process people move through a series of distinct phases of recognition and interpretation with various cue and occupant-related factors influencing each constituent phase (Bryan, 2002; Canter, 1990; Mileti and Beck, 1975; Sime, 1984). However, despite this it has been argued that computer evacuation models continue to focus disproportionately on movement and still make a number of unvalidated assumptions about behaviour during a fire, including a failure to consider the decision making processes that are undertaken by those encountering a fire (Kuligowski, 2008). There has been a tendency for evacuation models and building procedures to focus almost exclusively on movement at the expense of seeking to understand behaviours (Kuligowski, 2008).

As a response to this, Kuligowski (2008) has proposed the development of a comprehensive theory on occupant behaviour for incorporation into evacuation models as a means of reinforcing the empirical foundation upon which the models themselves are developed. This model is predicated upon the basis that an action performed in a situation is the result of a decision making process, with an interpretation between stimulus and response (Figure 11). A cognitive process is undertaken, which although it may occur over a very short space of time (giving the impression of spontaneity), actually follows a number of identifiable stages. The model asserts that actions result from 'perceptions, interpretations and decisions' which are based upon a range of 'external and internal (occupant-based)' cues. This decision making process is initiated when an occupant becomes aware of a change in their environment.

As part of her work to develop a predictive behavioural model, Kuligowski identified four phases in the decision making process, each of which are subject to two sources of influence (occupant-based factors and cue-based factors) (Kuligowski, 2008). Phase 1 (perceive cues) may be compared to the recognition phase in Bryan's model (Figure 10) (Bryan, 2002). The 'validation' and 'definition' processes of Bryan's model are combined within a single phase (phase 2, interpret situation and risk) in Kuligowski's approach. Phase 3 (make a decision about an action) is comparable to Bryan's 'evaluation' phase, whereas phase 4, 'perform an action' and the attached feedback loop are broadly similar to the 'commitment' and 'reassessment' phases presented by Bryan. If new cues are presented then the action can be abandoned (irrespective of whether it has begun to be undertaken) and the behavioural process begins again.

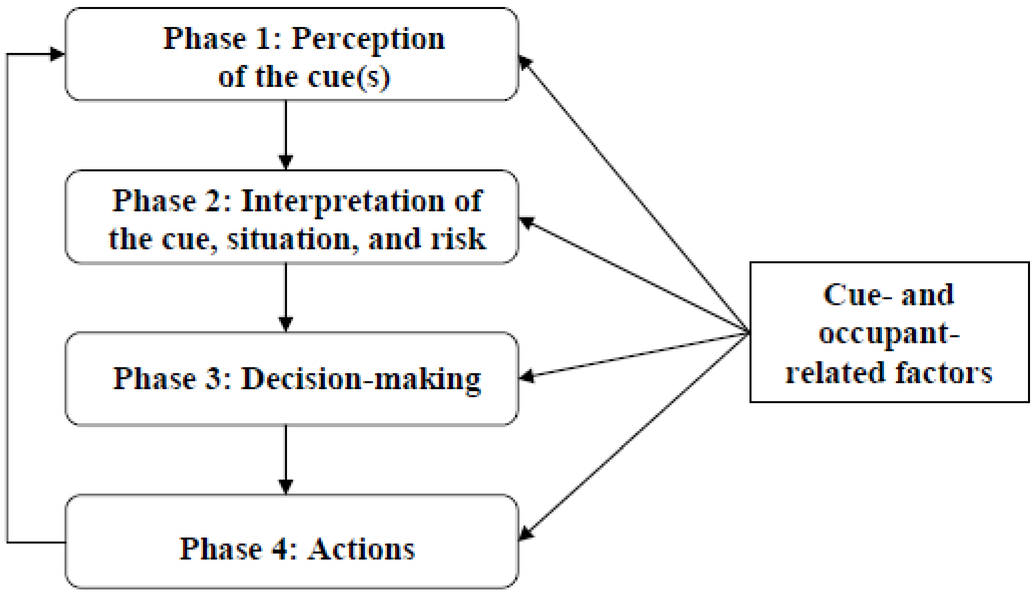

Figure 11: The conceptual model of the behavioural process for building fires.

Source: Kuligowski, 2008

2.5.7 Summary

The understanding of the decision making processes during a fire emerged initially from studies on people's responses to disaster warnings. Since the 1970s, as the focus on human behaviour in fire grew, there has been an accompanying focus on developing an understanding of the cognitive decision making processes that are undertaken by those experiencing a fire in a building. Creating a theory and associated decision making framework to map these processes has resulted in the development of several decision making models, leading to a robust understanding of this area. Individual variations between separate models aside, there is also general agreement that decision making during a fire is a flexible process comprising several stages, during which reassessment takes place in response to changes and alterations in the environmental conditions and the underlying occupant based factors. Because behaviour during a fire is the result of a decision making process, it follows that any attempt to understand human behaviour must be supported by an understanding of these underlying decision making processes. Through the cumulative efforts of researchers over the past 40 years, the field is now at a stage where this understanding can be said to be in place. However, as the next sections will demonstrate, despite the seminal work conducted in the 1970s and early 1980s, this same 40 year period has not witnessed a similar progression in the understanding of people's behavioural responses during dwelling fires.

2.6 THE EARLY STUDIES

2.6.1 Introduction

The origins of what would eventually become the subject recognised today as 'human behaviour in fire' can be traced back to the study of the movement of people through doors, on stairs and in corridors undertaken during the early 20th century with the aim of improving building design so as to aid evacuation during an emergency (Bryan, 1998, 1999; Kobes et al., 2010). In the 1950s initial research into human behaviour in fire began to be carried out in the form of case studies of large, particularly destructive building fires resulting in considerable loss of life (Bryan, 1957). However, these case studies were still predominantly focussed upon movement and driven by the aim of reconstructing aspects of a particular incident, rather than attempting to develop a theory and understanding of human behaviour in fire more widely.

It was not until the early 1970s with the work carried out by the UK's Fire Research Station (Wood, 1972) that the first formal study was undertaken dedicated to looking at the actions people undertake when encountering a fire in a building. The importance of the area and need for understanding more about it is outlined by Wood within the introduction to his study; the points he made being as relevant today as when they were first published over 40 years ago:

"The drawing up of legislation for fire protection, the design, planning and inspection of buildings for means of escape, the efficiency of fire protection measures and the life saving activities of the Fire Service are all dependent, in the actual event, upon knowledge of the human behavioural responses which are made by people involved in fires." (Wood, 1972, p1*)*

The focus on human behaviour that was initiated by the work of Wood (Wood, 1972), led in 1977 to the first international seminar devoted to what was then coalescing into a formalised academic discipline. Held at the University of Surrey, this was an event that marked a milestone in the emergence of the field as several of the papers presented were incorporated in the 1980 book 'Fire and Human Behaviour' (Canter, 1990), a text acknowledged as *"the first complete book on human behaviour in fire"* (Bryan, 2002a, p6) and one whose findings were regarded as being at the leading edge of knowledge in the field (Proulx, 2001).

2.6.2 The first of three pioneering studies: Wood, 1972, UK

This work undertaken by Wood (Wood, 1972) was the first of three separate studies carried out by different groups in the period between the 1970s and early 1980s that, arguably, marked the emergence and subsequent development of human behaviour in fire as a formal field of academic enquiry. The other two were the 'Project People' study that was carried out by the University of Maryland in the USA (Bryan, 1977) and the work of the Fire Research Unit at the University of Surrey (Canter, 1990). Their position as the first such studies in the field means it is appropriate to discuss each of these studies, their relationship to each other, and their wider influence upon the emergent field of human behaviour in fire.

Methods. Following two pilot studies, a full scale study was undertaken by Wood, for which 12 fire brigades participated. The survey comprised four main sections: 1. Fire variables; 2. Building variables; 3. Personal variables; 4. Behavioural variables. Data were collected from 952 fires across a range of building types. The majority (38.2%) of fires occurred in the afternoon (12.00hrs to 18.00hrs), and of these just over half (50.6%) were dwelling houses, 17% factories, 11% flats or other multi-occupancy dwellings, 7% shops and 4% institutions (schools, hospitals). A total of 2,193 people were interviewed, 56% were male (n=1239) and 44% (n=954) female, with a modal age group of 30-39 years. The proportion of injuries among the sample was quite small; only 6% involved non-fatal injuries, seven incidents involved a fatality (there were no multiple fatalities), and only 1.6% of incidents involved a rescue by the fire service.

Analysis and main findings. The analysis undertaken on the data used frequency counts and chi square analysis to test relationships between several variables. The three most frequently cited first actions were: fire-fighting, warning or alerting others, and investigating the fire. The most surprising result for Wood was the frequency with which people attempted to fight the fire; this was identified as being in inverse proportion to the perceived severity of the fire, with people being more likely to attempt to tackle the fire if thought not to be very serious. It is also important to highlight that, although data were not obtained about the point at which the fire service was called, Wood argued that for different people a certain level seriousness of the fire must be reached before people call the fire service (Wood, in Canter, 1990).

Wood found the more serious a person considered a fire to be, the more likely they would be to immediately leave the building. However, familiarity with a building's layout was found to have no relationship to whether a person attempted to immediately leave that building. With regard to fire safety training, Wood speculated that the more frequently a person had received fire safety training then the more frequently they would undertake 'correct' or 'appropriate' actions, such as contacting the fire service, or warning others. However, among the 29 first actions listed, only two – 'raise alarm' and 'organise evacuation' – demonstrated an increase in the proportion of people undertaking those actions in line with increased frequency of training. Beyond these the frequency of training did not affect the first action undertaken. Those who had previously been involved in a fire were more likely to fight the fire, or minimise the risk in some way and they were less likely to leave the building. However, compared to those who did not have previous experience of a fire, they were no more likely to contact the fire service.

Contrary to what was assumed at that time, Wood found that people were prepared to move through smoke; 60% of the sample attempted to do so, with men being more likely than women to move through smoke and also move greater distances. Importantly, movement was found not to be just associated with leaving the building, causing Wood to speculate that it was undertaken while performing some other activity, such as warning others or tackling the fire. The likelihood of attempting to move through smoke increased in line with familiarity with the layout of the building.

With evacuation behaviour, it was observed that males were less likely than females to leave the building, but more likely to re-enter if they did leave. As stated above, while those individuals who had previously been involved in a fire were less likely to leave the building, they were more likely to re-enter if they did leave. Regarding the relationship with fire safety training, Wood found that compared to those with some training, a greater proportion of those with no training left the building. The study highlights the importance of the presence of children, a fact that led to increased likelihood of immediate evacuation. Interestingly Wood also refers to young children being interviewed as part of the study. Noteworthy was the fact that 43% of respondents re-entered the building – the more familiar people were with a building, the more frequently they re-entered. The three main variables which led to increased re-entry were: being male; the fire occurring during the daytime; and incidents where smoke was present. Wood's study identified a number of behavioural differences between males and females. Females were more likely to warn others, request assistance, evacuate their family and evacuate themselves. Males, on the other hand, were found to be 'situation-oriented'; more likely to tackle the fire and re-enter the building.

An innovation was the use of decision trees (named 'question/response charts') to map out three important behaviours during a fire: exiting the building and re-entry ('returning in' as Wood terms it), and movement through smoke (Figure 12).

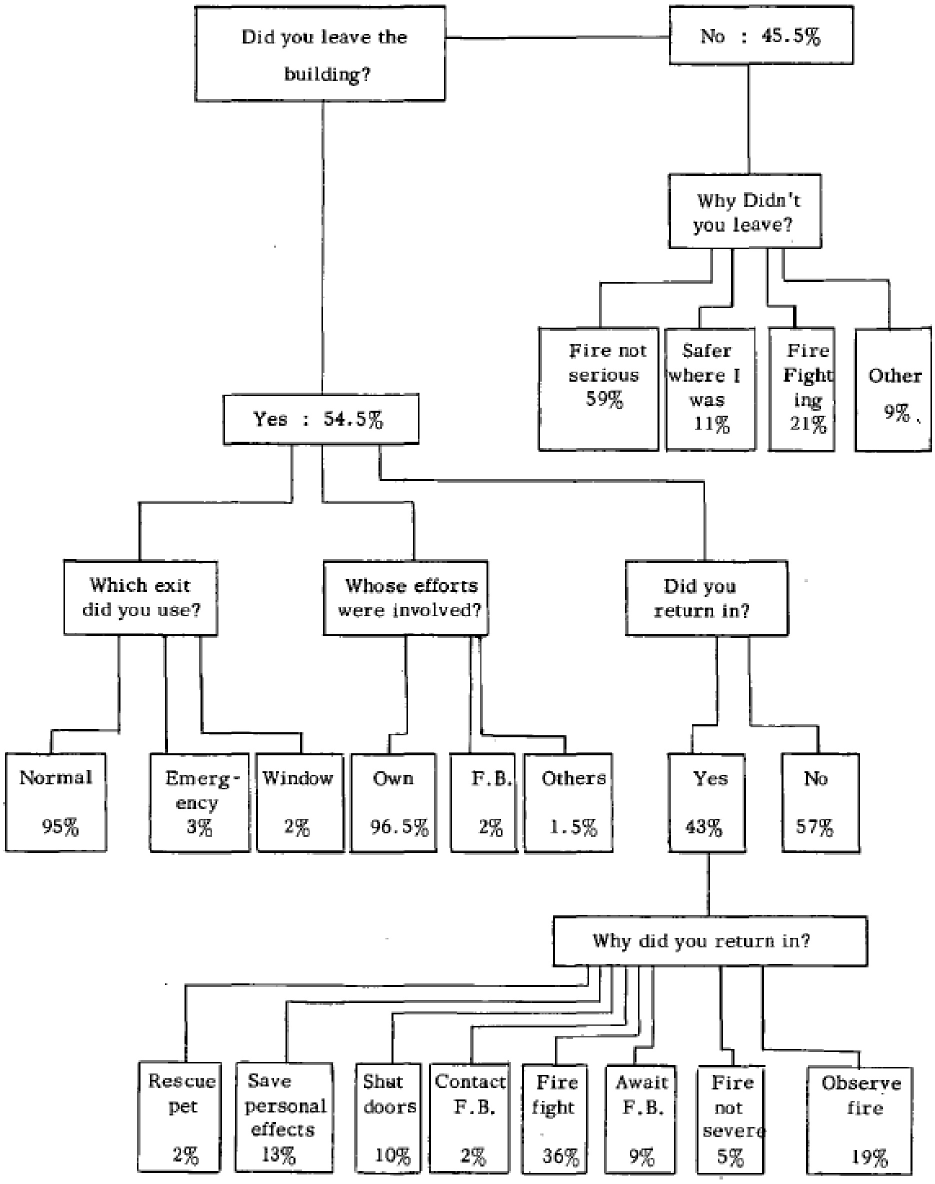

Figure 12: Question/response chart outlining exiting and re-entry behaviours.

Source: Wood, 1972

Even at this early stage in the study of the area, Wood argued that, when looking at behaviour in real fires, people generally behave in a rational and logical manner, given the information available to them at the time. This was an emergent idea that was gaining increased interest following earlier work challenging the idea of 'panic' (Quarantelli, 1954). Finally, particularly prescient is Wood's condemnation of approaches to fire safety messaging and advice that does not take into account how people are actually behaving:

"The high percentage of people who returned into the building must be a comment – not only upon the ineffectual nature of fire-safety propaganda which invariably preaches the folly of such behaviour, but also the difficulty many people experience in 'doing nothing' when their possessions and property are threatened." (Wood, in Canter, 1990, p92)

2.6.3 The second of three pioneering studies: Bryan, 1977, USA

Following the work undertaken by Wood, a study was commissioned by the U.S. Department of Commerce's National Bureau of Standards (Bryan, 1977). This American study set out to achieve five main objectives, chief among which was a verification of the data collected by Wood. The other stated objectives were: to identify and understand the relationships between demographic variables of those involved in the fires; to investigate the effect of the environmental features of a building upon evacuation behaviour; to assess effectiveness of evacuation signals; and the influence of smoke on evacuation behaviour.

Methods. The principal method of data collection was a questionnaire survey that was undertaken at the scene by fire department personnel based in and around Washington D.C. and Baltimore. A total of 11 fire department jurisdictions participated in the study, all of whom contributed to the development and design of the questionnaires. Peter Wood (the author of the study discussed previously in this section) also contributed to the development of the questionnaire. Comprising two parts, part 1 ("The Building and the Fire") concerned information about the building and the fire (e.g. building type, weather conditions and temperature, location of fire, fire detection and fire protection equipment [extinguishers, standpipe hoses, sprinklers]). Part 2 ("The Person and the Fire") gathered information on the individual, their actions and interactions with the fire/smoke.

In total 584 participants from 335 incidents were surveyed using a questionnaire that was distributed by FRS personnel between January 1975 and April 1976. Analysis was undertaken using SPSS and frequency distributions of each variable were produced. With dwelling type, the total of all residential dwellings was 84.5%, of which 59.4% were single family dwellings. Other types of building included in the study were restaurants, motels, schools, hospitals and offices. The majority of participants were female (54.8%) (319 female participants, 263 male, 2 not recorded). The age of participants ranged from 6 to 90; indeed, 2.6% of the study participants were reportedly aged between 6 and 10 years old, meaning that as with Wood's study data were collected from children.

Analysis and main findings. A range of 13 cues were identified as alerting people to the fire, of which the five most frequently cited were: 1. 'smelled smoke'; 2. 'notified by others'; 3. 'noise'; 4. 'notified by family'; 5. 'saw smoke'. At the time when they became aware of the fire the majority of participants (39.6%) were in the bedroom, followed by the living room (19.5%), then the kitchen (9.6%). The FRS personnel undertaking the survey at the scene recorded the first three actions of each participant in the order in which they were undertaken after that participant realised there was a fire. The most frequently cited first action was 'notified others' (15%), followed by 'searched for fire' (10.1%) and 'called the fire department' (9%). Expanding upon the work carried out by Wood, Bryan identified the importance of understanding whether certain actions may influence the decision to undertake any subsequent actions. To illustrate this, Bryan utilised a 'weighted diagraph' (Figure 13) – a flow diagram displaying sequences of actions, weighted by number of participants. The importance here is that it represents an early attempt to understand the relationships between different actions undertaken during a fire. This was a concept that was to receive further attention from the subsequent work of Canter et al. (Canter, 1990) (see Section 2.6.5).

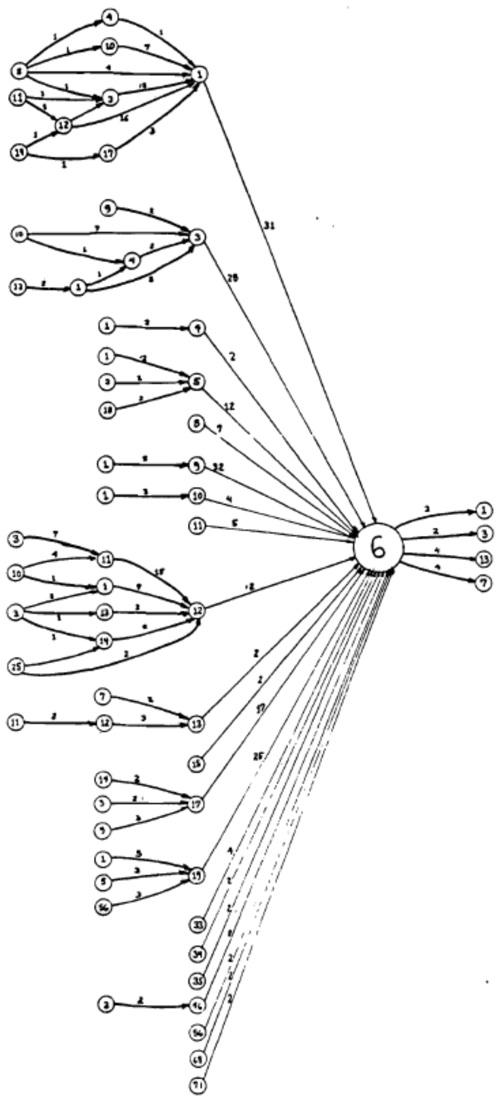

Figure 13: The weighted diagraph.

Source: Canter, 1990

Examining the differences between males and females, several areas were identified and, although the data showed no difference in the most frequently cited action ('notification of others'), applying chi square tests a statistically significant relationship was identified between males and the following actions: 'searched for the fire' and 'obtaining a fire extinguisher'. Among females, a relationship was found with the actions 'call the fire department', 'leave the building' and 'obtain other family members'. A key difference identified was the greater propensity of male participants to engage in behaviour related to fire-fighting, a relationship that was also found to be statistically significant. The fact this was predominantly a male activity is also clear from a comparison of the populations: 22.9%

(n=134) of the total participant population fought the fire, of which 62.7% were male and 37.3% female.

With training there were some, but not as many, differences as in Wood's study between participants who had received fire safety training and those who had not. Approximately 34% of the participants had received previous training. Importantly, Bryan looked at the types of training they had received, the organisations that had offered that training, the frequency of training, and the date of the last training course received – offering a more comprehensive overview of training than that provided by Wood. The non-trained population were statistically significantly more likely to undertake the actions 'obtained other family members' and 'went to the fire area'. For the trained population, the only statistically significant relationship was action 'got extinguisher'. No statistically significant differences were found in the first actions of those participants who had or had not previously experienced a fire.

Data gathered on re-entry behaviour showed that over a quarter of participants (27.9%, n=163) re-entered the building. The three most frequently cited reasons for this were 'fire fighting' (22.2%), 'obtain personal property' (17.2%), and 'check on fire' (11%). A gender breakdown of re-entry behaviour (males n=97, females n=66) shows that, although the top three reasons remain unchanged, among females the order altered to 'obtain personal property' (22.8%), 'fight fire' (18.3%) and 'check on fire' (10.6%).

The other important area which the study focussed upon was movement through smoke. The majority of respondents (62.7%) reported moving through smoke. No statistically significant relationships were found between distance moved through smoke and previous fire experience. However, a relationship was found between those who had previous fire safety training and being prepared to move greater distances through smoke. Of those who moved through smoke, 29.2% were forced to turn back due to the effects of smoke and or heat. As with Wood's findings, Bryan's early observations on movement through smoke played an important role in the understanding of this issue.

2.6.4 Comparison with Wood's study

That Bryan's study was undertaken a relatively short time after Wood's, made direct reference to it, and included Wood in the design and planning, naturally invites a comparison with the earlier study. However, it must be noted that any direct comparisons between Wood's and Bryan's studies are quite difficult due to the different composition of property types, occupancies and gender make ups between the two studies. These issues notwithstanding, it is useful to present an overview of some of the general similarities and differences.

Bryan's project people study had a lower number of fires and fewer participants than Wood's study (335 fires and 584 participants in Bryan's compared to 952 fires and 2,193 participants in Wood's). Bryan's study had a greater proportion of dwellings of all types compared to Wood's: 84.5% and 61.6% respectively. With single storey dwellings the respective proportions were 59.4% and 50.6%. For both studies, the greatest proportion of all incidents occurred in the period between 12.00 and 18.00 hrs, followed by 18.00 to 23.00 hrs. Wood's study contained more male participants (56.5%) and the sample tended to be slightly older (higher proportion in the 40-49 age group) than Bryan's sample which contained more females (54.8%) and was slightly younger (higher proportion in the 20 to 29 age group). In both studies the majority of participants were alerted to the fire by seeing smoke or being informed by others. The proportion of participants with previous fire experience was similar: 24.8% of Wood's participants; 28.3% of Bryan's participants.

The most frequently cited first action in Bryan's study was 'notified others' (15%), followed by the other communicative activities 'searched for fire' (10.1%) and 'called the fire department' (9%). This represented a difference with Wood's study where the most frequently cited first actions were 'some fire-fighting action', 'contact fire brigade', and 'investigate fire'. Bryan also choose to offer a comparison between the two studies related to five key behaviours: 'evacuation', 're-entry', 'fire-fighting', 'movement through smoke', and 'turned back'. In Wood's study a higher proportion of the sample undertook the behaviours 're-entry' and 'turned back', and in Bryan's study higher proportions undertook 'evacuation' and 'fire-fighting'. Both studies found very similar proportions of people who moved through smoke (60% for Wood's and 62.7% for Bryan's). Importantly, this validated Wood's findings that people will choose to move through smoke, something that at that time was not assumed to occur when people experienced a fire.

On the issue of re-entry into a building during a fire, the higher rates in Wood's study (44.1% compared to 27.9%) might be a consequence of the greater number of high-rise dwellings present in Bryan's study. Despite this, it is interesting to note that, although the order was slightly different, the three most frequently cited reasons for re-entry were identical. These were: ‘fight fire’ (Wood’s 36%, Bryan’s 22.2%); ‘observe fire’ (Wood’s 19%, Bryan’s 11%); ‘save personal effects’ (Wood’s 13%, Bryan’s 17.2%).

Lastly, both studies identified a number of differences in the behaviour between males and females, with males being more likely to exhibit firefighting behaviours whereas females were more likely to alert others and exit the property.

In general terms both studies found evidence of people tackling fires, movement through smoke, re-entry behaviour, and clear differences between males and females in behaviour and frequency of certain behaviours. Recognising Wood’s work, in summarising his own study, Bryan outlines the broad similarity between the two:

“The results of the two studies were in general agreement, with the differences in large part explainable by the larger percentage of residential fires in this study.” (Bryan, 1977, p289)

2.6.5 The third of three pioneering studies: Canter et al., 1980, UK

Although following slightly later than Wood’s and Bryan’s studies, the third piece of work that needs to be included in any retrospective of the first generation of dedicated research into human behaviour in fire is that of Breaux, Canter and Sime of the Fire Research Unit at the University of Surrey (cited in Canter, 1990, and referred to here on as ‘Canter et al.’). Building upon the work carried out previously, this study sought to look at the relationships between different actions during a fire.

<u>Methods</u>. A significant challenge that was identified was the difficulty in locating and gaining access to incidents and those who experienced them. Consequently, adopting the model used by Wood and Bryan, the study worked with five FRSs (London, West Midlands, West Yorkshire, Greater Manchester and Merseyside). A questionnaire was distributed by the participating FRSs at fire scenes between December 1977 and March 1980, a total of 578 questionnaires were returned, covering a range of occupancy and building types. A number of these participants were then contacted for follow up interviews which provided further supplementary information.

The majority of properties were dwellings 63%, specifically houses (51.4%), with the remaining building types comprising hospitals, hotels, factories and offices. There were more females than males among the respondents (53.6% and 46.4% respectively) and the modal age category was 16 to 35 years old.

Analysis and main findings. The study presents a picture of the early stages of a fire being characterised by ambiguity, as the awareness of a change in the environment brought about perception of the initial cues is not accompanied by a simultaneous recognition that there is a fire. The importance of early recognition of a fire is made clear:

"From the questionnaires it can be seen that when the early stages of investigation and clarification of ambiguous cues lead to early recognition of the presence of a fire, then people are able to cope effectively with that fire." (Canter, 1996, p175)

Although the certainty with which this is asserted is questionable (the phrase '*may* be able to cope effectively with that fire' would perhaps be more accurate), the underlying principle is clear: early recognition and confirmation of a fire is of vital importance in managing (although not necessarily reducing the risk of) that fire more effectively.

Survey responses were coded in order to build up a list of each of the actions (referred to as 'acts') undertaken by the participants. From these data a number of 'decomposition diagrams' were developed which display the sequence and attempt to show the strength of relationship between acts (Figure 14). Produced for settings including domestic, hospital and multiple occupancy (i.e. hotels), and also broken down by gender, these diagrams aim to present the strength of association between different acts, with a higher number indicating a greater strength of association and the increased likelihood of being followed by the specified act. This represented a desire to develop a more in-depth analytical understanding of behaviour during a fire, with the authors asserting their aim to move beyond the conceptual foundations for the study and understanding of human behaviour in fire that were laid down by Wood and Bryan.

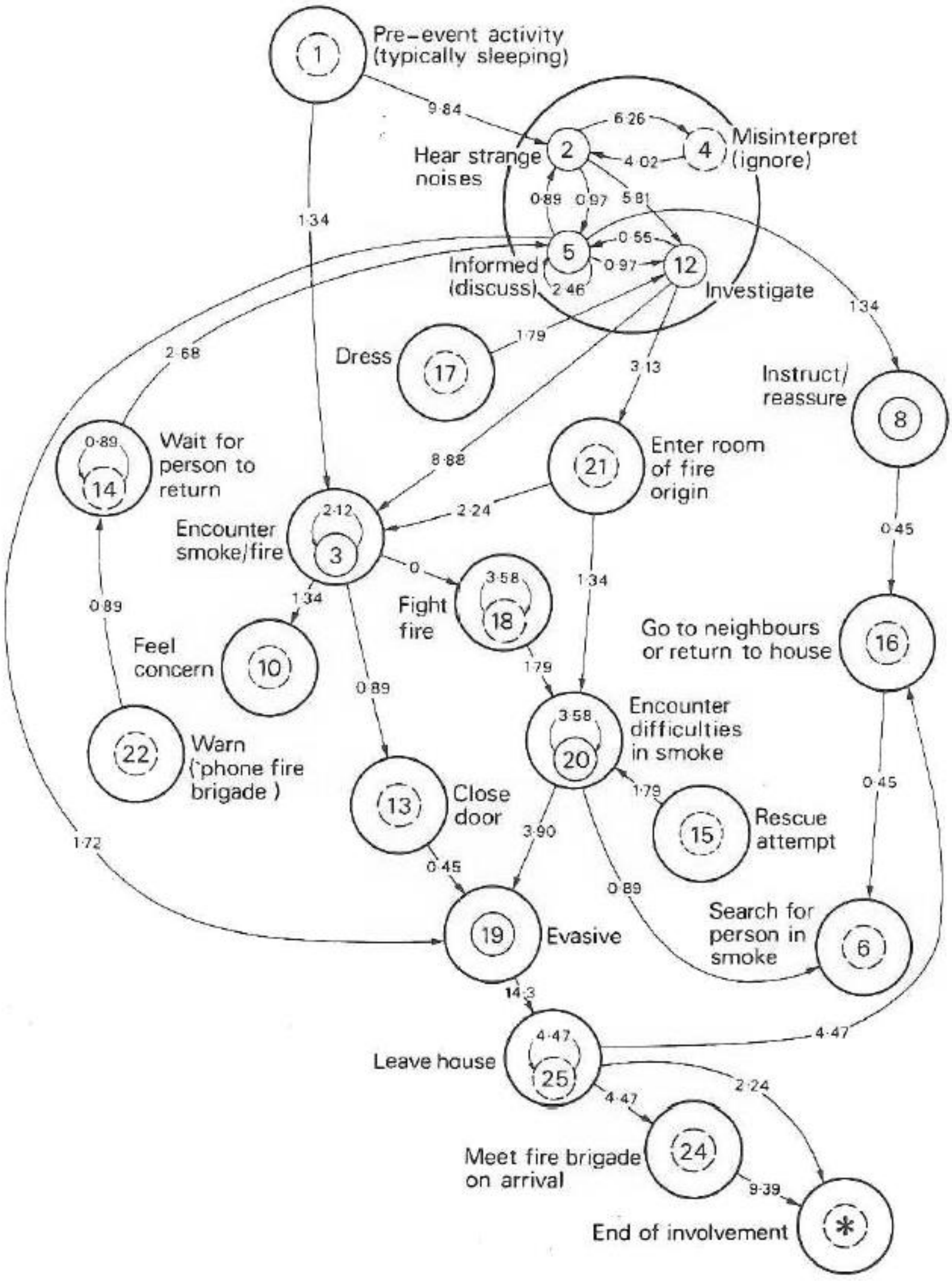

Figure 14: Decomposition diagram for domestic fires.

Source: Canter, 1990

The study found differences in behaviour between domestic and non-domestic settings and multiple occupancy fires. Additionally, an important distinction was the greater tendency of people in domestic fires to attempt to tackle the fire. For multiple occupancy fires, while there is frequently ambiguity about the initial fire cues, from this point there a greater complexity in the pattern of behaviour was observed. It was speculated this may be due to the range of potential sources of information and uncertainty by individuals about whether they are the first to discover the fire or not.

Arguably the key determinant of behaviour during a fire for Canter et al. is a person's gender, with the study reporting clear differences in behaviour between males and females – an area upon which there was a far greater focus than in Wood's and Bryan's studies. Canter et al. stated that during fires in dwellings there will be a "*maintenance of husband and wife roles*" (Canter et al., in Canter, 1990, p11). Given that the study was undertaken in the 1970s, if one chooses to follow popular gender-based stereotypes then the assumption from this statement is that males were dominant, and acted as the 'head' of the household. Nonetheless, the findings in relation to occupants' gender are similar to those of the two preceding studies. Gender differences were identified among behaviours undertaken during the early stages of the fire, with females more likely to warn others, close the door to the room of fire origin and exit the property. In contrast, males were more likely to fight the fire and take action to try to control or mitigate it.

"The active role for males is characterized by firefighting or rescue, or females by warning others. Where males and females are present the latter's role tends to be more passive and/or supportive. The role and rules followed may be determined both by who is present, as well as socially determined pre-existing sex roles." (Canter et al., in Canter, 1990, p122)

2.6.6 Comparison of the three studies

Table 3 presents a summary of the findings between pre-event and peri-event variables that were identified in the studies undertaken by Wood, Bryan and Canter et al.:

Table 3: Summary of findings of Wood, Bryan and Canter.

Study	Gender	Fire safety knowledge	Prior experience
Wood	Females: Less likely to fight fire; more likely warn others, immediately leave building, request assistance, evacuate family, request assistance Males: Less likely to evacuate; more likely to re-enter	Lower incidence of evacuation among those with knowledge/training If no training/knowledge, greater proportion left the building	With prior experience, less likely to leave building, but more likely to re-enter if they did leave though
Bryan	Females: More likely to call fire department, leave building, obtain family members Males: More likely to fight fire	No differences found	With experience more likely to get fire extinguisher If no experience, then more likely to get family members, go to fire area
Canter et al.	Females: More likely to warn others, leave building Males: More likely to tackle fire and do associated behaviours	No relationships found between training and frequency of firefighting.	Prior experience associated with people being less likely to leave immediately; more likely to tackle fire and re-enter property Also not any more likely to act in a way that follows established fire safety advice, e.g. calling 999

From this it can be seen that there was a consistency across all three studies to the relationship between one pre-event variable, gender, and peri-event (behaviour) variables: i.e. males were more likely to tackle the fire and less likely to evacuate, while females were more likely to warn others, call for assistance, evacuate family, and exit the building. With fire safety knowledge/training, some similarities were observed between Wood and Bryan;

namely that those with fire safety knowledge/training were more likely to engage with the fire, while those with no with fire safety knowledge/training were more likely to evacuate. However, no such relationships were found with the work of Canter et al. Finally among those with prior experience of a fire, Wood and Canter et al. found that people were less likely to leave immediately and more likely to engage with the fire. On the other hand, Bryan found no behavioural differences on the basis of whether people had prior fire experience or not.

2.6.7 Societal developments since these studies

Since these studies were undertaken considerable changes have occurred in the structure of households and families within the UK including the notion of 'traditional' gender roles and hierarchies. Among the changes that have taken place there are four in particular which stand out: the decline in the proportion of the married population and the increase in the proportion of people who are co-habiting (Beaujouan and Bhrolcháin, 2011; ONS, 2012; ONS, 2014).; the growth in the proportion of one parent families (ONS, 2013a); the increase in the proportion of people living alone (ONS, 2013a); and the mainstream societal acceptance of same sex relationships and ensuing formalisation in law.

Over the period from 1979 to 2011 the proportion of women aged 18 to 49 who were married fell from 74% to 47%, while the proportion of women who were cohabiting rose from 11% to 34% (ONS, 2013a). In addition, women have continued to achieve greater economic independence; female participation in the labour market has increased from 53% of women aged 16 to 64 in 1971 to 67% in 2013. In contrast, for men the proportion fell from 92% to 76% over the same period (ONS, 2013b). In 1971 some 92% of families with dependent children were headed by a married or cohabiting couple, however, by 2011 this had fallen to 78% (ONS, 2013a). Overall, more people now live alone, the proportion of adults living alone having almost doubled over the past 40 years, from 9% in 1973 to 16% in 2011 (ONS, 2013a). Finally, one of the most significant changes since the 1970s has been the widespread societal acceptance of same sex relationships, formally recognised with the introduction of civil partnerships in 2005 and the Marriages (Same Sex Couples) Act in 2013. This has effectively introduced a form of household composition that did not exist (or more accurately, would not have been formally recognised) when the studies undertaken by Wood, Bryan, and Canter et al. were first published. Consequently, these considerable changes that have occurred to the structure of households and families raise questions about the continued relevance and applicability of Wood's, Bryan's and Canter's conclusions regarding the influence of occupant gender as a determinant of behavioural response during a dwelling fire.

2.6.8 Summary

These early studies by Wood, Bryan and Canter et al. were of central importance in laying a foundation for the study of human behaviour. Not only did they seek to develop an understanding of what was a neglected area, they also set out to do so with admirable scale and ambition, a feat that is even more impressive when one considers the absence of any preceding work in the field. It is interesting to reflect upon how these three studies dealt in a similar way with the primary challenge of gathering data from those members of the public who had experienced a fire in a building. Each of them demonstrated the value in working with FRSs when seeking to undertake a large scale survey of fires. Furthermore, these three studies identified and focussed attention upon a number of important themes, including: the influence exerted by a person's role and or gender; the ambiguity that often accompanies initial cues of a fire; that people are prepared to move through smoke; and the fact that people will attempt to re-enter a building on fire after having successfully evacuated. However the passing of forty years, in which there have been societal changes, merits an examination of the themes' relevance in today's world. Moreover, the indication that different behaviours are observed in different building types supports this thesis' argument that dwellings need specific attention. Before analysing the situation today, in dwellings specifically, it is important to acknowledge some other important work on emergencies, work that has consolidated and extended what is known and accepted about human behaviour in fire.

2.7 WHAT IS KNOWN ABOUT HUMAN BEHAVIOUR IN FIRE?

2.7.1 Introduction

In the period since the three original studies (Wood, 1972; Bryan, 1977; Canter, 1990), individual areas of human behaviour in fire have been explored, albeit in isolation and across different areas. This section will offer a summary of these areas, breaking them down into the following eight key themes:

1. Panic
2. Decision making
3. Task attachment and inertia
4. The influence of role

5. Optimism bias
6. Movement through smoke
7. Exit choice
8. Re-entry behaviour

2.7.2 Panic

When looking at what is known about human behaviour in fire, it is appropriate to start with the persistent and inaccurate idea that people's natural reaction during a fire will be panic. In this context, panic may be understood as maladaptive, irrational and aggressively competitive individualistic behaviour for which social mores and structures exert no influence upon the individual other than as possible obstacles to self-preservation. Within popular culture, entertainment and the news media, the notion of panic continues to be perpetuated as a description of how people will respond during a fire. Its frequent reference in news reporting – including it must be said within accounts and magazines targeting those working in fire safety and prevention (FIRE, 2014a; FIRE, 2014b; Ross, 2005) – has served to create something of an automatic association between the words 'fire' and 'panic'. The risk of this goes beyond mere semantics, it is a concept that leads to inaccurate, and thereby potentially dangerous, stereotypes in the minds of fire professionals, perpetuating a paradigm of disaster management that is both exclusionary and paternalistic and utilising emergency procedures that are ultimately predicated upon false assumptions (Drury et al., 2009; Thompson and Wales, 2012).

While people certainly experience a heightened state of stress and or fear, the idea of panic commonly occurring during a fire has been rejected by experts since the 1950s. Starting with the work undertaken by Quarantelli, numerous studies and interviews undertaken with those who have experienced fires (and other disasters) have consistently demonstrated that people rarely engage in what may be considered panic behaviour (Bryan, 1999; Bryan, 2002, 2002a; Canter, 1990; Connell, 2001; Dombrosky et al., 2006; Drury, 2011; Fahy et al., 2009; Fahy et al., 2012; Gwynne, 2008; Johnson, 1988; Keating, 1982; Paulsen, 1984; Proulx, 1993, 1997, 2001, 2003; Quarantelli, 1954, 1975, 1979, 2001; Ramachandran, 1990; Sime, 1990). What in fact occurs is that people make rational decisions, but do so in situations where the circumstances are prone to rapid or sudden change, and where access to information is imperfect or limited. It is only with hindsight, when there is access to a far greater range of information, that it may be seen that those decisions were flawed (Canter, 1990; Proulx, 2001; Sime, et al., 1992). This is not to say that such behaviour never occurs, but where maladaptive behaviour has been observed – generally in the form of aggressively competitive behaviour for exits as the fire, smoke and or heat has overtaken people or reached a point that is unambiguously frightening, uncomfortable and life threatening – (Fahy et al., 2009; Johnson, 1988;), it remains relatively uncommon (Drury et al., 2009; Galea, 2005).

Because panic has been so extensively explored and discussed within the literature on human behaviour in fire, there is a well-established consensus regarding the infrequency with which what may be considered as true panic actually occurs. Consequently, panic is not a subject that will be explored further within this thesis as there is little that is new or of particular value that can be added to what is already known and accepted.

2.7.3 Decision making

It is known that people undertake a behavioural process during a fire that comprises several stages, which broadly run as follows: becoming aware of the cues of a fire, recognising that those cues represent a fire and that the fire poses a risk; making a decision about what action to undertake; then undertaking that action (see Section 2.5 for a discussion of this in greater detail) (Bryan, 2002a; Canter, 1996; Mileti and Beck, 1975; Mileti and Sorensen, 1990; Sime, 1984). During this individuals will constantly be receiving both environmental, and possibly social, inputs which may cause the behavioural process to be amended or repeated. However, this process is not an instantaneous one – individuals do not hear a fire alarm or smell smoke and then immediately evacuate. The period between a building occupant becoming aware of the initial fire cues and then consciously responding to those cues is frequently characterised by a lack of initial response and a high degree of ambiguity (Canter, 1990; Canter, 1996; Levin, 1984; McConnell et al., 2009; Paulsen, 1981; Proulx, 1997; Proulx and Richardson, 2002; Spearpoint, 2008). Fire and smoke alarms are frequently ignored, often due to an assumption that rather than indicating a fire, the alarm is being tested or has a fault, will soon stop and thereby allow the situation to return to its normal pre-alarm state (Brennan, 1998; Proulx, 2000). While it has been shown that individuals are more responsive to social over environmental cues (Bryan, 2002; Proulx, 2003; Proulx and Fahy, 1997), even upon being informed by another person of a fire, initial responses – certainly among males – tend to be dominated by investigation in order to seek confirmation of the information they have received (Bryan, 1977; Canter, 1990; Proulx, 2000a; Wood, 1972).

2.7.4 Task attachment and inertia

Task attachment describes people continuing to undertake an action or task that preceded their awareness of the fire cues, even when smoke and flames are visible. This continues until the cues reach a stage where their ambiguity reduces to a point that those cues are of sufficient magnitude to induce a behavioural response in that individual (Canter, 1996; Fire, 2014a; Proulx, 2001; Thompson, 2011). Examples of task attachment are evident through people continuing to eat meals, shop, enjoy concerts or undertake other leisure, or work-related activities. This has been observed in numerous high profile fires including Cocoanut Grove (Boston, 1942), Summerland (Isle of Man, 1973), Woolworths (Manchester, 1979), and Villaggio Mall (Doha, 2012).

Contrary to the assumptions inherent within emergency evacuation procedures for buildings, it has been established that there is in most instances a greatly varied delay between an alarm and the evacuation process – if indeed an evacuation occurs at all (Galea, 2009, 2009a; Gwynne et al., 1999; Kuligowski, 2008; Kuligowski, 2009; Shields and Proulx, 2000). Upon hearing an alarm or becoming aware of a fire people do not begin an instantaneous process of movement towards a building's exits (Canter, 1990; Galea, 2009; Proulx, 2009; Sime, 1984; Sime, 2001). Studies of the evacuation during the 1993 and 2001 attacks on the World Trade Center highlighted this and provided further data on pre-movement times and pre-movement actions, which included information receipt and relay, locating colleagues, and collecting and securing items within the building (Averill et al., 2012; Galea et al., 2006; Galea et al., 2008; Galea et al., 2012; Gershon et al., 2012).

2.7.5 The influence of role

Occupant response, including non-evacuation tasks, is subject to the sometimes powerful influence exerted by role – both an individual's own role and their role in relation to those around them (Canter, 1990; Galea, 2009, 2009a; Kobes et al., 2010; Paulsen, 1984). By role, it is meant the socio-environmental construct in which individuals operate. The influence of role is such that the pre-fire organisational framework is used as a form of reference by individuals during a fire (Canter, 1996). During a fire, guests in a restaurant or visitors in a shopping centre will frequently look to the staff to provide direction and guidance. The staff in turn will frequently – although of course not always – attempt to fulfil those roles, by undertaking tasks such as assisting members of the public to evacuate (Galea et al., 2007; Galea et al., 2013; Proulx, 2001).

Two further observed phenomena that are known to exert an influence during a fire are 'normative social influence' and 'informational social influence' Asch, 1956; Cialdini and Goldstein, 2004; Myers, 2008; Perry, 2010). Although they can be considered distinct from the idea of 'role', there is nonetheless an overlap with these two forms of social influence. Normative social influence describes the desire to conform publically to the behaviours, and attitudes of a particular reference group (Asch, 1956; Cialdini and Goldstein, 2004). This has important ramifications during a fire as the presence of individuals who display inactivity in the face of fire cues has been demonstrated to exert an inhibiting effect upon others who are also present (Latane and Darley, 1968).

Informational social influence describes the belief that others' knowledge, information and access to relevant information is more accurate and timely than one's own (Myers, 2008). This is particularly the case in circumstances where information is incomplete or ambiguous (Perry, 2010). This was observed in responses to the September 2001 attacks on the World Trade Center, where building occupants sought further information and guidance from supervisors and managers on the understanding that those individuals possessed access to more accurately and timely information about the situation (Day et al., 2013; Kuligowski, 2011).

2.7.6 Optimism bias

Optimism bias describes the predisposition of most people to assume that compared to others they will be less likely to be involved in negative events (e.g. financial exposure, car accident, disease, or a fire). Consequently, there is a tendency to dismiss, ignore or misinterpret the initial cues of a negative event, or fail to take behaviour that reduces the risk of that event being realised (Klein and Helweg-Larsen, 2002; McKenna, 1993). Optimism bias has received considerable attention in the literature on emergency or disaster preparedness – particularly in relation to hurricanes and earthquakes (Koshiba and Ohtani, 2015; Kung and Cheng, 2012; Spittal et al., 2005; Trumbo et al., 2014). In the case of a fire this was a phenomenon first highlighted by Wood (1972), applying the (then) contemporary term of 'The Personal Invulnerability Factor' (Wood, 1972, p9). It is now recognised that optimism bias is an influencing factor upon the delayed response between cue receipt and cue recognition (Helweg-Larsen and Shepperd, 2001; Shepperd et al., 2002). The understanding of this in relation to fire has been enhanced through the work of the BeSeCu (Behaviour, Security, Culture) project (EU Cordis, 2019); a large-scale project that collected data from a sample of over 1,000 individuals who had experienced a range of emergencies from eight countries across Europe (the Czech Republic, Italy, Germany, Poland, Sweden, Spain, Turkey and the UK). Among the many work streams and findings to come out of BeSeCu was the identification of differences in the perceived and objective risk of the likelihood of experiencing a range of emergencies – something which specifically included domestic fires (Knuth et al., 2015; Schmidt and Galea, 2013). Results from BeSeCu also showed that perceived risk for emergency events was heightened in cases when the participant had previously experienced the same type of emergency; again, domestic fires featured within this (Knuth et al., 2014).

2.7.7 Movement through smoke

With emergency response and building safety it was originally assumed that people would be reluctant to move through smoke (Dowling, 1994; Proulx, 1997; Stiff, 1980). However, the original studies undertaken on human behaviour in fire demonstrated that people were willing to, and indeed did, move through smoke of varying degrees of thickness (Bryan, 1977; Canter, 1980; Wood, 1972). Importantly, this was not simply limited to the process of evacuation. Approximately 60% of the sample in Wood's study attempted to move through smoke, and this increased in line with familiarity with the layout of the building. Similar results were recorded by Bryan, in which 62.7% of the sample reported moving through smoke (Bryan, 1977). Further detailed work on this area demonstrated that during a fire people are indeed prepared to move through smoke (moving alongside walls for guidance when visibility is reduced) and, for those familiar with a building's escape routes, there is a tendency to turn back when visibility is less than 3 to 5 metres, and 15 to 20 metres for those who are unfamiliar (Bryan, 2002; Jin, 1978, 1982, 1997, 2002; Jin and Yamada, 1985; Proulx, 1993; Sime et al., 1992). Moreover, the inhibiting effects of exposure to smoke upon cognitive ability have also been established: walking speed and ability to undertake mental processes (arithmetic) decrease with an increase in smoke density and radiant heat exposure (Jin and Yamada, 1989) and that the physiological effects caused by passing through smoke result in people needing to change direction or retrace steps (Gwynne et al., 2001). Furthermore, the propensity of people to move through smoke has been found across a range of occupancy and building types which include high-rise offices, tunnels, hotels, high-rise dwellings and single occupancy dwellings (Bryan, 1977; Bryan, 2002; Fahy and Proulx, 1995; Fridolf et al., 2013; Proulx, 1998; Proulx et al., 2006; Purser, 2003; Purser, 1996; Sime et al., 1992; Wood, 1972).

2.7.8 Exit choice

During a fire, familiarity has also been demonstrated to exert a stronger influence than distance in exit choice (Gwynne et al., 2001; Kobes et al., 2010; Levin, 1984; Pauls, 1990; Pauls, 1996; Sime, 1985). The tendency to use a familiar exit rather than a closer, emergency exit, has been observed in evacuation studies where people seek to exit via the same door in which they entered, even where that is further away than an emergency exit (Benthorn and Frantzich, 1996; Kimura and Sime, 1989). Explanations for this relate to the fact that such doors are rarely used, which generates a sense of uncertainty towards them and an inherent bias towards using familiar rather than unknown routes in a building, particularly during a period of high stress as would be found in an emergency (Levin, 1984; Proulx, 2001).

2.7.9 Re-entry behaviour

Once people do evacuate, it has been observed since the initial work undertaken by Bryan upon behaviour during the Arundel Park fire (Bryan, 1957) that they will attempt to re-enter buildings (Bryan, 1977; Canter, 1990; Wood, 1972). A study undertaken on domestic fires in the UK has demonstrated that during such fires up to a third of occupants may be re-entering at least once before the arrival of the FRS (Thompson et al., 2013). Moreover, the most frequently stated reason for doing so is in order to check on the development of the fire (Thompson et al., 2013). This is clearly an area of importance, particularly because of potential risks occupants may be exposing themselves to after having evacuated. However, it is one for which limited contemporary literature exists and, as such, is deserving of a renewed and up-to-date focus.

2.7.10 Further developments in human behaviour in fire

A further major development arising from data obtained in studies of human behaviour in fire since the early 1980s has been the introduction and continued refinement of computer models. These models have been designed to simulate behavioural response and egress patterns during a fire in a building or structure, or during incidents involving large open events set within an area of curtilage and containing a number of controlled entrances and exits (Fraser-Mitchell, 1999; Galea, 2009; Gwynne et al., 1999). Often termed 'evacuation models' the principal application is to evaluate the safety of buildings by simulating how long it will take occupants to evacuate from a structure (Gwynne et al., 2005; Gwynne, 2008; Kuligowski, 2009). One of the earliest examples was the BFIRES model of 1979, developed by the Environmental Design Research Division of the National Bureau of Standards (Bryan, 1998; Stahl, 1982). Since this period, the growth in the number of evacuation models has been considerable; it is estimated that there are now more than 40 different evacuation models in existence (Galea, 2014; Kinatader et al., 2015; Kuligowski, 2008).

2.7.11 Summary

It is a truism to state that the field of human behaviour in fire is, much as with any other academic subject, one that comprises enormous scope and variety. The progress made in the field has greatly improved the understanding of how people behave and provided a robust evidential basis for this, as well as assisted the development of software tools that can in turn further aid understanding. In doing so, this research activity has identified several key aspects in which there tends to be a number of frequently observed behaviours. There is, however, an important caveat to this as, with the exception of movement through smoke, the great majority of what is known and accepted about human behaviour in fires concerns behaviour occurring in PCI spaces. It is because of this that consideration will now be given to what is known and accepted about behaviour occurring in dwellings.

2.8 THE STUDY OF HUMAN BEHAVIOUR IN DWELLING FIRES

2.8.1 Introduction

The majority of literature on human behaviour in fires is focussed upon understanding human behaviour in fires occurring within PCI spaces – there is not a comparable body of literature focussing exclusively upon human behaviour in single family/occupant dwellings (Babrauskas, 2013; Bryan, 1999; Kobes et al., 2010; Thompson and Wales, 2015). Although Wood (1972), Bryan (1977), and Canter (1990), included studies of behaviour during domestic fires in their research, since this period it is an environment that has been neglected in comparison with non-domestic settings. Moreover, the literature that does exist on human behaviour in domestic settings is focussed upon the identification of occupant risk factors related to fire deaths within dwellings (Brennan et al., 2001; Flynn, 2010; Graesser et al., 2009; Istre et al., 2001; Marshall et al., 1998; New Zealand Fire Service Commission, 2005; Sekizawa, 2005; Squires and Busuttil, 1996). These are of course important areas which need to be examined and understood. However, it is the case that such research has not been accompanied by a comparable level of focus upon the behaviour and motivations of those who survive fires in single occupancy domestic environments, either with or without injury (Bryan, 2002a; Canter, 1990; Wales and Thompson, 2013). As identified in Section 2.3, within the UK, ADFs are the cause of approximately 70% of both fire-related fatalities and fire-related injuries (Figure 6) (DCLG, 2015; Home Office, 2019). No other type of fire results in the same scale of human impact and personal loss. Consequently, the environment that accounts for the greatest number of fire-related deaths and injuries is, arguably, the least well-researched and understood (Babrauskas, 2013).

2.8.2 The incompatibility of applying existing knowledge to dwellings

It would be reasonable to consider whether what is known about human behaviour in fire in PCI spaces could be applied to the domestic setting. However, different sets of circumstances and associated influences acting upon occupants during a dwelling fire mean it is inaccurate and over-simplistic to attempt to transfer accepted behavioural responses and actions during fires which occur in PCI spaces to domestic spaces (Babrauskas, 2013; Babrauskas et al., 2010; Brennan, 1997; Canter, 1990; Canter, 1996, DiGuiseppi et al., 2000; Levin, 1984; Proulx, 2001; Proulx, 2002a; Proulx and Fahy, 1997; Proulx et al., 1995; Thompson and Wales, 2015).

Work on the area is limited, but it has been observed that the delayed response to fire alarms, voice communication, and the initial cues of a fire observed in PCI spaces is different in low-rise residential buildings, as occupants will rapidly respond to and investigate unusual smells, noises, or other changes to that immediate environment (Proulx, 2002a). This difference is explained as being the result of the feelings of responsibility for the clearly defined physical space represented by this type of building (Proulx, 2002a). Proulx goes on to identify the key factors that exert an influence upon response time within the pre-evacuation phase, among which building type plays an important role. In contrast to the delay so frequently observed for PCI spaces, cues such as the smell of burning or the sound of a smoke alarm, are sufficient to precipitate a swift response in dwellings (Proulx, 2001; Proulx, 2002a; Proulx, 2003).

This was also identified in a qualitative study of behaviour during dwelling fires, in which it was observed that participants acted quickly in response to a variety of cues (Thompson, 2011; Thompson and Wales, 2015). In line with Proulx, it is believed that the speed of the response to these initial cues is a consequence of the nature of the socio-physical environment, in which people are in a clearly bounded and defined physical and social space that represents their most intimate environment. As such this sense of ownership, responsibility and control over this space (shared or otherwise), and likely presence within this space of loved ones, leads people to act in a way that is less bounded by the constraints (such as a fear of embarrassment, a desire to conform, a lack of direct responsibility towards that space) that exert an influence upon behaviour and cue response within PCI spaces and buildings (Canter, 1990; Proulx, 2001; Proulx, 2002a; Proulx, 2003; Wales and Thompson, 2013).

2.8.3 Closed vs. open building systems

The key factor that underpins the differences between behaviour in fires across these environments and spaces is that buildings may be considered as either 'closed' or 'open' systems (Shields and Proulx, 2000). Closed-building systems (which describe PCI spaces) are those where activities are formalised and managed and in which processes are controlled. Closed-building systems have building codes (both prescriptive and performance-based), and identifiable, often hierarchical management structures (relating to both the building and those using it) (Shields et al., 1999; Dubner, 2011). By contrast dwellings may be considered as open-building systems; places where there is not a formalised management structure relating to the building and its use, including the absence of any roles prescribed by fire safety codes and regulations (Sekizawa, 2015; Shields and Proulx, 2000). This means that people's responses in the single occupancy domestic environment will not be subject to the social influences exerted upon them by the requirements and structures inherent within closed-building systems (Babrauskas et al., 2010; Shields and Proulx, 2000). In addition, Proulx and Fahy have stated that within domestic spaces a greater number of occupants are more likely to have a responsibility for others, principally children or the elderly (Proulx and Fahy, 1997). Consequently, from this seemingly straightforward distinction arise a number of important differences related to the two kinds of system which, when considering fires in dwellings, may be summarised as follows:

1. A greater (primarily familial) attachment to the building, people and items within it (Canter, 1990; Canter, 1996; O'Mahony, 2012; Proulx, 2001; Proulx, 2002a; Wales and Thompson, 2013).
2. Lower incidence of task attachment and a faster response to alarms and ambiguous cues (Galea, 2009; Kobes et al., 2010; Proulx 2001; Proulx, 2002a; Proulx, 2003; Stahl and Archea, 1977; Thompson, 2011; Thompson and Wales, 2015).
3. Lower incidence of normative social influence (although not informational social

influence) due to almost total absence of strangers compared to PCI spaces (Bryan, 1977; Groner, 1996; Nilsson and Johansson, 2009; Perry, 2010; Proulx, 2001).

4. Absence of staff or fire wardens to organise and direct behaviour according to formalised procedures and operating within recognised hierarchies (Canter, 1990; Canter, 1996; Galea, 2009; Sekizawa, 2015; Shields et al., 1999).
5. A greater propensity to attempt to tackle and or mitigate a fire (Babrauskas et al., 2010; Brennan, 1998; Bryan, 2002; Canter, 1996; Shields and Proulx 2000; Shields et al., 1999).
6. Greater incidence of re-entry (Thompson et al., 2013; Wales and Thompson, 2012; Wood, 1972).
7. Greater familiarity with the environment in what is generally a smaller space, resulting in wayfinding being less of an issue than in PCI spaces (Brennan, 1998; Horiuchi et al., 1986; Levin, 1984; Proulx, 2009).
8. The presence of feelings of guilt and or responsibility for causing the fire and the resultant desire to deal with this before deciding whether to call 999 or not (Clark and Smith, 2015; Clark et al., 2015; Thompson, 2011). In the UK, USA, Canada and Australia it is estimated that between 60% and 80% of dwelling fires are not reported to the FRS (DCLG, 2015; Greene and Andres, 2009; Home Office, 2019; Office of the Deputy Prime Minister, 2006; Proulx, 2009).

2.8.4 High-rise dwellings

It may be argued that high-rise occupancies present a combination of both open building systems (the private spaces represented by the individual flats or apartments) and closed systems (the communal areas, stairwells, lift, and building entrances and exits). In this regard such occupancies may be considered to present their own category, where, although less formal than a PCI space, a form of overall building organisation nonetheless exists (Canter, 1996). Canter et al. argued that the pattern of behaviour in high-rise occupancies is actually more complex than for single occupancy dwellings due to the number of potential information sources and resultant actions (Canter, 1990). This is apparent when one considers that high-rise occupancies have exit routes that are shared with other people and so exist outside of the private dwelling space. The same researchers also identified that there are often fewer attempts to fight a fire compared to single occupancy dwellings (Canter, 1996). Other differences within such environments include Bryan's observed phenomenon of 'convergence clusters' (Bryan, 2002). Identified from his studies of hotel fires, this describes behaviour where individuals gather, or cluster, together in rooms as a form of communal refuge. This was observed in both the Grenfell Tower and Lakanal House high-rise residential fires (Babrauskas, 2013; Bryan, 2002; Grenfell Tower Inquiry, 2018; Mansi, 2013).

Proulx (2002a) argued that by their very nature, PCI spaces, including high-rise occupancies, need to take into account specific building characteristics, not just occupancy classification. In addition to this, the management of a building is an important aspect (Proulx 2002a). Moreover, during a fire in a high-rise occupancy, the initial response of those alerted by an alarm, but who have not received direct confirmation of the fire, is likely to be characterised by the ambiguity and delayed response that is commonly seen in PCI spaces (Proulx, 2001; Proulx et al., 1995). Similar characteristics were also observed in a study of a fire in an 18 storey block of flats in Australia, which found frequent delay in response to alarms and recorded times from first being alerted to beginning evacuation that ranged from one minute to over twenty minutes (Brennan, 1997). This different status of high-rise residential buildings is further influenced by the fact that in the UK many high-rise residential buildings are subject to a design and overall building management philosophy advocating a ‘stay put’ strategy, encouraging occupants to remain in their flats in the event of a fire (DCLG, 2014b). This strategy is based on the idea that in a large structure with a number of self-contained compartments, fire doors will protect occupants for a specified period of time. Removing the need for a complete evacuation also reduces the risk for fire crews of encountering contraflows and congestion along with the need to manage a large-scale evacuation whilst simultaneously attempting to fight the fire (DCLG, 2014b). However, the Grenfell Tower fire, and reference to the stay put policy in the ensuing public inquiry, has led to public discussion about continuing with the promotion of stay put policies for high-rise residential buildings (Grenfell Tower Inquiry, 2018; The Independent, 2018; The Telegraph, 2018).

2.8.5 The study of fire fatalities in dwellings

The literature that looks at risk factors related to fatal dwelling fires predominantly derives from work undertaken in the UK, USA, Japan, Australia and New Zealand and a number of consistent themes emerge. Across these areas, accepting the limitations of reporting standards within fire service data, fires started by discarded or improperly extinguished cigarettes are identified as the leading cause (i.e. ignition source) of fires that result in fatal outcomes (Flynn, 2010; Hall, 2003; Home Office, 2019; Lewis and Clear, 2003; Sekizawa, 2005; U.S. Fire Administration, 2019). Those who are identified as being over-represented in dwelling fire fatalities are those who: are aged under five or 65 and over; are male; have a physical or cognitive impairment; undertake behaviour which is likely to limit their ability to recognise or respond to a fire (generally speaking the consumption of alcohol or recreational drugs); live in social isolation; smoke; and live in areas of deprivation (Brennan, 1998; Brennan and Thomas, 2001; Flynn, 2010; Marshall et al., 1998; New Zealand Fire Service Commission, 2005; Sekizawa, 2005a; Sekizawa, 2015; Squires and Bustil, 1996). However, it is important to note that these are a mixture of interrelated causal and non-causal factors. For example, being a smoker does not on its own make a person more likely to die in a fire, but among smokers there may be a higher incidence of individuals (particularly males) who have a characteristic or engage in behaviour that limits their ability to recognise and respond to a fire. Examples of which may include having a physical impairment, or alcohol consumption to a point where the ability to recognise and respond to fire cues becomes nullified (Brennan and Thomas, 2001; Lewis and Lear, 2003, New Zealand Fire Service Commission, 2005). It has been demonstrated in studies looking at causes of fire deaths and the presence of factors that may impair physical and cognitive response that there has often been an association with fires where the source of ignition is smoking materials and evidence of intoxication through alcohol (Brennan, 1998; DCLG, 2008a; Marshall et al., 1998).

Deprivation. The issue of deprivation is important and deserves consideration, but not because it is a causal factor. Rather it is the case that in deprived areas one tends to find a greater agglomeration of factors that increase the risk of fire fatality and with this an over representation of groups and individuals who display those factors, such as smoking, drug and alcohol use and social isolation (Hastie and Searle, 2016; Jennings, 2013; Lewis and Lear, 2003; New Zealand Fire Service Commission, 2005; Runyan et al., 1992; Xiong et al., 2015).

Age of housing. In the USA, with its larger number of wooden-built properties and much younger housing stock than the UK, the age of housing has been identified as being directly related to the fire safety of the property and likelihood of a fire starting (Flynn, 2010; Shai and Lupinacci, 2003). However, within the UK the age of housing alone is not identified as an issue, rather it is the quality of housing – in the UK there is no relationship between the age of a property and its quality (i.e. homes of greater and poorer quality have co-existed across the decades, while some older homes and new builds may both have questionable safety in the current day – the former due to wear and tear and the latter due to sub-standard construction; NHBC Foundation, 2015; Shelter, 2017). It has been argued that the quality of housing is closely related to deprivation and the associated risk factors surrounding the incidence of dwelling fires (Kobes et al., 2010; Thompson et al., 2018). Other factors associated with poor quality housing are overcrowding (increasing the risk of injury should a fire start), and poor maintenance of communal areas, escape routes, and smoke alarms (New Zealand Fire Service Commission, 2005).

Age of occupants. Among the elderly, age-related health conditions may restrict the ability to identify fire-related risks within the home, impair the ability to identify the fire cues, and limit the ability to move away from the fire to a place of safety (Flynn, 2010; Harpur et al., 2013). Large numbers of the elderly also live alone and experience a greater degree of social isolation (Elder et al., 1996; Sekizawa, 2015), which means they may not have received fire safety advice and there may not be others in the property to aid evacuation and offer assistance in the event of a fire (Brennan, 1998; Marshall et al., 1998; New Zealand Fire Service Commission, 2005). Furthermore, following a fire there is an age-related reduction in the ability to overcome and recover from both burn injuries and the injuries sustained from exposure to the products of combustion (DiGuiseppi, 2000; Keck et al., 2009; Lionelli et al., 2005). For young children, in addition to difficulties in being woken by smoke alarms (Bruck and Brennan, 2001; Bruck and Thomas, 2012), once a fire starts, they lack the ability to recognise the risk posed by the fire and smoke and associated cues and also the ability to respond effectively, as with the elderly, including the ability to evacuate unaided (Harpur et al., 2012; Marshall et al., 1998; Shai and Lupinacci, 2003; Squires and Busuttil, 1996).

2.8.6 Identification of different risk profiles between fire occurrence, injury and fatality

An important point is the understanding of the distinction between being at risk of a fire starting and being at risk of injury or death during a fire. Among the studies looking at fire fatality related risk factors, there has been a tendency not to differentiate between risk of a fire and risk of fire mortality, but simply amalgamate the two (DCLG, 2008a, Thompson et al., 2018). This has led to a questionable assumption that those groups who have more fires are the same as those groups who tend to die in fires (Barnett, 2008; Breslin et al., 2015; Lehna et al., 2015; Runyan et al., 1992).

However, an increasing body of work has begun to question this simplistic, and erroneous, assumption (Brennan and Thomas, 2001; Clark et al., 2015; Greene, 2012; Hastie and Searle, 2016; Hastie, et al., 2014; Nilson et al., 2015; Thompson et al., 2018). One of the earliest pieces of work to highlight this was the study carried out using data from 150 fatalities from 109 fatal residential fires between 1990 and 1995 in the State of Victoria in Australia (Brennan, 1998). The study considered the characteristics and behaviour of victims and survivors and identified the important distinction between the risk of a fire starting and the ability to respond effectively to a fire once it has started. The work by Xiong et al. used Australian coroners' fire fatality reports and non-fatal fire incident data to identify and compare the difference in risk factors associated with fatal compared to non-fatal ADFs (Xiong et al., 2015). Although this work identifies that risk factors for fatal fires differ from non-fatal fires and offers an overview of the differences between these two risk profiles, it adopts a fairly deterministic standpoint, in that risk factors related to non-fatal outcomes are the circumstances around the fire starting and the building type. Human agency as applied to non-fatal fires is not really put into focus. Instead the authors limit their scope to view the determinants of non-fatal fires as the consequence of environmental-based risk factors. Consequently, it is difficult to make inferences from this work about the role of human behaviour in non-fatal fires. A study carried out in Sweden has sought to identify and quantify what differences may exist in risk factors related to having a fire in the home and dying in such a fire (Nilson et al., 2015). Based upon a sample of over 13,000 respondents, 405 of which had experienced a fire, the study concluded that the risk of a dwelling fire occurring was higher among younger compared to older age groups (defined as 18 to 30 years compared to those 61+ years), and increased among those born outside of the Nordic countries (arguing that this is due to higher smoking rates among immigrants and cooking practices that are more likely to result in burn injuries among children). In their summary the authors make an important point that, based upon these results, the risk of dying in a house fire is not due to a higher frequency of fires (Nilson et al., 2015).

What becomes clear is that the risk of a fire occurring and the risk of becoming a casualty due to a fire are separate. Moreover, those who die and those who survive ADFs (either with or without injury) must be considered as at least two different groups (Thompson et al., 2018). Consequently it is inaccurate to regard ADF injuries simply as near miss fatalities as this viewpoint rests on an assumption that all occupants are passive and moving on a pre-determined course that would end in death if not for the intervention of others or some stroke of good fortune; this is a mistaken view that has been described as the 'conveyor belt theory' (Thompson et al., 2018). On the contrary, studies have begun to show that during an ADF occupants actively move around the property and undertake a number of tasks during the fire (Thompson and Wales, 2015; Thompson et al., 2013; Wales and Thompson, 2012).

2.8.7 Summary

It is apparent that compared to the abundant and rich body of literature on human behaviour in PCI spaces, there has been a very limited focus upon understanding how people behave during a fire in dwellings, particularly single family/occupant dwellings. The greatly different environmental, physical and social circumstances that are present in dwelling fires compared to fires in PCI spaces means that human behavioural knowledge relating to the latter cannot be assumed to be applicable to the former. This gap in the knowledge of behaviour in dwelling fires has only been partially filled to date as the work that has dealt with domestic environments has been dominated by a focus upon identifying the occupant and environmental risk factors related to fatalities. From this literature a consensus has emerged about those groups who are at increased risk of dying in a fire with these risk factors having been identified in studies undertaken across the UK, North America, Japan, Australia and New Zealand. Recently, there has begun to be a greater recognition of the distinction between the risk of being injured in a fire and the risk of dying in a fire. The realisation that there is a difference in the risk profiles for injuries and fatalities has led to attempts to tease out and identify the determinants related to these two different risks. Although this work is important, the fact remains that for the past 40 years there has not been any single large-scale attempt to understand the behaviour and motivations of those who survive fires in single occupancy dwellings. As will be demonstrated in the next section, in light of this gap in the knowledge, this thesis will develop a contemporary and up-to-date understanding of human behaviour in the domestic environment.

2.9 CONCLUDING REMARKS

2.9.1 Introduction

An overview of dwelling fire deaths for the UK since 1960 (as described in Section 2.3) shows that their downward trend was first observable at the end of the 1970s, with the number of fatalities declining by 47% in the period 1979 to 2000 and then by a further 32% in the period since the millennium (Figure 3). The one feature that stands out is the decline in the number of dwelling fires which, from a peak of nearly 72,500 in 1997, has fallen to around 37,700 in 2017 – of which 90% (33,900) are accidental (Figure 2). It is claimed that the main cause of the decline in the number of ADFs has been the focus by FRSs upon prevention, something addressed in Section 2.3 (FIRE, 2015; Knight, 2013; LGA, 2012; The Parliamentary Review, 2014; Ridley, 2013). Although a 'silver bullet' approach is compelling, rather than any single cause, it is most likely that a decline in the numbers of ADFs and the associated injuries and deaths, are the result of this plus several other factors such as lifestyle changes, new legislation, improved fire-fighting techniques and the great developments made in the clinical care and treatment of those suffering burns and smoke inhalation injuries.

2.9.2 Static fatality and injury rates

The late 1970s was also the era which saw the start of the marked decline in the dwelling fire fatality rate (Figure 5). From a high of 1.74 fatalities per 100 fires in 1963/64, this continued to fall throughout the following decades, dropping below 1 fatality per 100 fires in 1989 and then continuing to fall slightly during the 1990s. However, since 1999 the fire fatality rate in dwelling fires has reached something of a plateau, fluctuating between 0.63 and 0.82 deaths per 100 fires (although it should be noted that the figure for 2017/18, at 0.82, the highest since 1995, is due to the Grenfell Tower fire). This means that the overall risk of dying in a dwelling fire has not changed over this period. The same is also true with the dwelling fire injury rate, which since the millennium has remained fairly constant at between 17.6 and 20.6 non-fatal casualties per 100 dwelling fires, with a median of 19.2 (Figure 6). In addition to these static fatality and injury rates, the majority of fire-related deaths and injuries continue to occur within dwellings: 73% and 67% respectively (Figure 7) (DCLG, 2015; Home Office, 2019; Scottish Fire and Rescue Service, 2019; Welsh Government, 2019). Despite the welcome declines in the number of ADFs and associated deaths and injuries, should a fire start in a fire in the home, the overall risk of dying or being injured has not seen a commensurate reduction.

2.9.2 Gaps in the knowledge

As a result, the prevailing situation is of an unchanged risk of death or injury during an ADF coupled with a lack of formal understanding and empirical evidence about how people are behaving during such fires and the motivations for that behaviour. The extensive body of literature on human behaviour in fire is deficient in this key area meaning there is a need for a contemporary and comprehensive understanding of human behaviour in fires in the home. As was discussed in Section 2.3 and Section 2.7, it is in the domestic setting that the largest proportion of fire-related deaths and injuries occur (DCLG, 2015; Home Office, 2019), yet this is the least well understood area within the wider field of human behaviour in fire. Furthermore, since the initial work of Wood (1972), Bryan (1977), and Canter et al. (1990), those studies that have sought to look at human behaviour in dwelling fires have focussed on the identification of fire fatality risk factors; there has not been a comparable focus upon developing an understanding of the behaviours, movement, motivations and cognitions of those who survive dwelling fires. As a result, because it accounts for the greatest proportion of fire-related injuries and deaths, and involves potentially the whole population (rather than smaller groups), it is an area that requires renewed attention and a greater degree of scrutiny and study (Babrauskas, 2013; Dubner, 2011; Thompson, et al., 2018). In addition, the survivors of dwelling fires cannot be discounted on the basis that they did not die in the fire. As the Grenfell Tower fire has illustrated, the survivors of dwelling fires are likely to have suffered physical and/or psychological harm, plus damage to and loss of their property and possessions resulting in ongoing disruption to their lives and the lives of others they live with. Consequently, it is important this group are not ignored. Sections 2.6 and 2.7 presented findings from early and subsequent studies demonstrating what is known and accepted by researchers about how people behave during a fire, which leads to the question of how relevant are these aspects when applied to the domestic setting. The current gap within the literature means there is not an up-to-date understanding of core aspects of human behaviour related to dwelling fires. Moreover, as outlined in Section 2.8, this is compounded by the fact that there is also evidence to suggest that behaviour during a fire in a dwelling differs in several key aspects from behaviour during fires in PCI spaces due to the different motivating factors related to the unique socio-physical space that a dwelling represents (Canter, 1996; Nilsson and Johansson, 2009; Perry, 2010; Proulx, 2002a; Shields and Proulx, 2000; Thompson and Wales, 2015).

2.9.3 The value of a greater understanding

Consequently, in light of what has been presented and considered within the preceding sections, the aim of this PhD is to develop an understanding of how people behave during an ADF and compare this with what is already known and accepted about human behaviour during fires in PCI spaces. This goes beyond a purely academic interest, as dwelling fires are the single largest cause of all fire-related injuries and deaths in the UK (DCLG, 2015, Home Office, 2019; Scottish Fire and Rescue Service, 2019; Welsh Government, 2019), to name but one country. As described earlier in Section 2.3, this is a phenomenon that has remained unchanged despite the substantial decline in the overall number of both fires of all type and

ADFs. Moreover, the frameworks, evacuation models and other tools that people use to explain and predict behaviours lack reliable and up-to-date data on human behaviour in domestic settings (Babrauskas, 2013). This means that these tools are of questionable relevance and applicability when it comes to understanding behaviour, cognitions and movement in the space that accounts for the single largest source of fire-related injuries. Consequently, a greater understanding of the behaviours, motivations and cognitions of those experiencing a dwelling fire will assist fire safety researchers and software developers and primarily FRSs in the UK and overseas with incident planning for operational response to and management of dwelling fires, firefighter and incident command training courses, 999 emergency call handling procedures, and fire prevention and community safety initiatives.

2.10 MAJOR AIMS OF THE THESIS AND THE RESEARCH QUESTIONS

It should be noted this study does not encompass an examination of risk factors related to having an ADF or dying in an ADF, as these are areas where there can be said to be broad agreement about these risk factors – something addressed within Section 2.8. As a result, this work deliberately seeks to focus upon the aspects of human behaviour in dwelling fires that have not yet received a comparable degree of attention – the responses of those who survive ADFs (with or without injury) – and in doing so address an identifiable gap in the knowledge of human behaviour in fire. Based upon this literature review, nine key research questions will be addressed. The nine questions are organised into the following three groups:

Group 1

This addresses the need for a more comprehensive and up-to-date understanding of human behaviour in ADFs, particularly given the changes to households, gender equality and fire safety.

1. What are the key behaviours and movement taking place during a dwelling fire, and what are the motivations driving these?
2. How do these findings compare to the work carried out by Wood, Bryan and Canter et al.? In particular what is the contemporary relevance of male-female differences in behaviour during fires?
3. What are the relationships between these behaviours and the occupant characteristics studied previously by researchers in the field (not only gender but also fire safety knowledge/training, and prior fire experience)?

4. What role do smoke alarms play in alerting occupants to an ADF and in influencing their subsequent behaviours?

Group 2

This addresses the need for an understanding of the variables that are risk factors of injuries (including whether they are the same as the risk factors for deaths).

5. Establish the timing, nature and severity of injuries sustained and the relationship to occupant behaviours and characteristics (e.g. tackling the fire, occupant age).
6. What variables (behavioural and otherwise) predict being injured in an ADF?

Group 3

This addresses how human behaviour in ADFs compares to human behaviour in PCI spaces, with a view to informing the work of other fire safety professionals. For example, simulation models and conceptual models of human behaviour are based primarily on data from PCI spaces, and it may be possible that they are not actually generalizable to human behaviour in fires in other settings, such as domestic spaces.

7. Are there any differences in human behaviour between fires occurring in low-rise and high-rise dwellings and, if so, what are these differences and what is the nature of the relationship with the dwelling type?
8. Are the behaviours in domestic settings (both high- and low-rise) different from PCI spaces and, if so, in what ways and how can these differences be accounted for?
9. To what degree can knowledge about human behaviour in PCI spaces be applied to ADFs?

In summary, this literature review has identified the trends within fire statistics, outlined the current state of fire safety regulation, as well as the development and gaps in the knowledge within human behaviour in fire literature relating to dwellings. Consequently, through the foundation provided by the preceding sections, and having presented within this section the key areas that this thesis seeks to investigate, the methodologies employed to recruit participants and undertake data collection and analysis for this thesis will now be discussed.

3. METHODOLOGY

3.1 INTRODUCTION

As outlined in the literature review, in recent years there has been a lack of data on human behaviour in dwelling fires, particularly those that are survived without any fatalities, thus it is difficult to understand what behaviours may be expected, as well as predict the outcome of injury, during such fires. In addition, evidence supports the fact that experts' (i.e. operational firefighters) assumptions about human behaviour in fire may not match the reality (Bennett, 2002; Dowling, 1994; Lawson et al., 2009). Thus, it would appear important to collect data directly from surviving occupants.

3.2 METHODS USED IN PREVIOUS STUDIES

As part of the process of selecting the most appropriate data collection methods to use for this thesis, the methodologies employed by previous studies into human behaviour in fire were reviewed. This allowed for an appraisal of the merits of each approach and offered an understanding of any challenges and difficulties that were encountered, something that greatly informed the decision about which methods to use for this study. As research that seeks to understand the behaviour of individuals, it is not surprising that, since the earliest studies into human behaviour in fire, the approach has been to collect data through the use of a questionnaire survey and or interviews.

3.2.1 Bryan's 1957 study of the Arundel Park fire

The value of capturing direct witness accounts has been clear since the study conducted by Bryan in the late 1950s on the Arundel Park fire. This sought to understand the behaviour of those involved in the fire and undertook interviews with survivors as a way to achieve that aim (Bryan, 1957). This use of interviews as a means of data gathering in the study of human behaviour in fire arose from the increasing recognition that an accurate and complete understanding of a particular fire incident did not just rest upon an investigation of the materials first ignited and the means by which the fire spread, but also needed to take into account the actions of those present during the fire (Bryan, 2002). This was a theme which Bryan returned to in the subsequent 'Project People' study (Bryan, 1977).

3.2.2 The first study: Wood, 1972

Although Bryan's work on the Arundel Park fire looked at behaviour, it was still essentially a case study of a single incident. Consequently, the emergence of human behaviour in fire as a subject of academic study based on numerous incidents can be identified as beginning with the study undertaken by Wood (1972). From the outset, Wood's methodology was very much that of the social scientist, from the use of participant interviews in the pilot to the distribution of a wide-scale questionnaire survey.

For the pilot, Wood's initial approach was to undertake a series of semi-structured interviews in order to gather preliminary data that could then be used to inform subsequent data collection. Unfortunately, a number of difficulties were encountered which limited the ability to collect data. Wood was reliant upon participating FRSs notifying him of a qualifying fire; the idea being that after receiving notification he would travel to the scene and then interview the participants. However, the limitations of this approach quickly became clear as several problems arose, starting with a lack of post-fire notification from FRSs, and the small number of fires that occurred in the defined geographical area of the pilot study. Furthermore, problems were frequently encountered upon arrival at the fire scene. Wood found that it was very difficult to find an optimum time at which to arrive. If he turned up too soon after the event his lack of any official capacity made it hard to access the scene and the occupants at that scene. However, if he turned up too late then it became very hard to trace the occupants who had experienced the fire. With the use of semi-structured interviews as the data collection method, Wood came to the conclusion that these took longer than a more structured interview or questionnaire survey and offered no significant advantage over either.

A second pilot study was undertaken which sought to take these experiences into account and overcome the previous challenges. Semi-structured interviews were rejected as a data collection method and instead a fairly short questionnaire survey was developed. Rather than a researcher attempt to travel to each fire scene, fire officers were used to administer the questionnaire survey at the scene itself. The success of this method resulted in it being used with the full study that followed. For the full study the survey covered two pages, although this mainly used closed questions; open questions were used in the section that looked at respondents' actions. During this study a total of 2,193 completed surveys were returned for analysis, which took the form of frequency counts and chi-square analysis.

3.2.3 The second study: Bryan, 1977

The next major study was that commission by the U.S. Department of Commerce's National

Bureau of Standards, which aimed to take the principles of Wood's study and adapt these for the USA (Bryan, 1977). For this piece of work it was freely admitted that the study by Wood provided both the 'conceptual' and 'operational' models and it replicated the method of using FRS personnel to carry out a questionnaire survey with occupants at the scene of a fire. Drawing from the benefit of Wood's experiences it was decided from the outset that FRS personnel would be involved in this study, both with data collection and questionnaire design.

Their aforementioned erroneous assumptions about behaviour notwithstanding, FRS personnel are skilled practitioners in the field of fire safety and firefighting operations, and have experience of dealing with members of the public who have experienced fires. Thus, they do have some relevant knowledge and understanding that can aid the design of questionnaires that seek to gather data on human behaviour in fire. Consequently, the inclusion of the opinions and experience of members of the FRS, particularly in the questionnaire design stage, is valuable and something that other researchers have sought to utilise (Barnett, 2008; Barnett et al., 2007; Zhao et al., 2009).

As with Wood's study, Bryan's questionnaire survey was two pages long and divided into two sections. The first section focussed upon the building, while the second section asked questions about the participant, their actions and experiences with the fire/smoke. Through this questionnaire an early attempt was made to discern the sequence in which actions occurred by the inclusion of three numbered lines at the end of the survey to allow respondents to describe a series of up to three actions in response to the question "*What did you do when you realized there was a fire?"*. Decisions about which occupants to approach with the survey at the scene of a fire were entirely down to the FRS personnel administering the survey. The survey was administered between January 1975 and April 1976 and 584 completed surveys were returned for analysis.

3.2.4 The third study: Canter et al., 1980

The third major study was that undertaken by Breaux, Canter and Sime at the end of the 1970s (Canter, 1990). These researchers also experienced what have become the recurrent challenges when collecting data on behaviour in fires; namely the difficulty in locating and subsequently gaining access to fires and thereby those who directly experienced those fires. Moreover, it was also realised that the stress and trauma induced during a fire meant that considerable thought needed to be given to methods of questioning participants (Canter, 1990).

It was decided that, as with the previous two studies, a questionnaire survey was the most effective means of collecting data from real fires. As before, the issue of locating fires and then collecting data from people who had experienced those fires was addressed by working with several FRSs. The difference here from Wood and Bryan's studies was that although fire officers distributed the questionnaire surveys at the scene, they did not administer them. This meant that surveys were handed out and left with the occupants to complete and then return by means of an enclosed, postage paid return envelope. Data collection was carried out for a period of just over two years (December 1977 to March 1980) and 578 completed questionnaires were returned for analysis. In addition to the returned surveys, further data were obtained from follow-up interviews with some of the participants.

3.2.5 Response rates for studies in human behaviour in fire

Unfortunately Wood, Bryan and Canter et al. offered no specific details about the response rates in their studies or general information on the willingness to participate among those who were approached. However, data from more recent studies into human behaviour in dwelling fires have shown that response rates for those sent a survey without any prior contact were 11% and where there had been prior contact, in the form of an introductory telephone call, response rates increased markedly to around 25% (Thompson, 2011; Wales and Thompson, 2012; Wales and Thompson, 2012a). Although it should be noted that higher response rates than this have been recorded in other large scale studies of fires; Bryan's (1983) work on the 1980 fire in the MGM Grand Hotel recorded a response rate of 28% (N = 554 out of 1,960), while a study by Proulx (1999) of the Ottawa apartment fire in 1997 had a very high response rate of 80% (N = 213, out of 265 approached).

3.2.6 Methodologies used and challenges encountered

Since the pioneering work of Wood, Bryan and Canter et al., the use of a collaborative approach where FRSs distribute questionnaire surveys has found further application in studies of human behaviour in fire. It is a method that has been found to be particularly useful in fires that have occurred in high-rise buildings as the fire may have affected many dwellings or offices within a building and involved large numbers of people (Galea et al., 2006; Galea et al., 2012; Istre et al., 2001; Proulx, 1999; Sekizawa et al., 1999; Tseng et al., 2009; Zhao et al., 2009).

From examining the methodologies used by previous studies, it becomes clear that one of the main challenges is getting access to those who have experienced fires. Firstly through receiving notification that a fire has actually occurred (thereby allowing identification of prospective participants), and secondly successfully obtaining the participation of individuals in any study. In the studies undertaken by Wood, Bryan and Canter et al., this was achieved through FRS personnel distributing questionnaire surveys at fire scenes. The method is effective because it allows for timely access to those who have experienced the fire. There may also be a degree of legitimacy conferred on the survey by a member of the FRS distributing it. Additionally, prospective participants may feel a sense of gratitude towards the FRS thereby increasing the possibility of the survey being completed. It has also been speculated that for participants, undertaking such a survey or interview gives them a chance to share their account with someone who they perceive has an empathetic understanding of their experience (i.e. a member of the FRS) (Thompson, 2011).

3.3 SELECTING AN APPROPRIATE DATA COLLECTION METHOD

The major studies of human in fire that were reviewed earlier in this chapter all used questionnaire surveys as their main method of data collection. The reasons they did so were because the use of surveys allowed relevant data to be collected in a fairly efficient and timely manner. The other advantages were that surveys could be completed by participants with relatively limited input from the person administering the survey and the skills and training required for those administering the surveys were less than those needed for in-depth interviews. This meant that the distribution of surveys did not have to be undertaken solely by researchers; surveys could be administered by FRS personnel, thereby greatly increasing the reach and potential number of participants.

In addition to questionnaire surveys, three other methods of primary data collection were considered but rejected for a variety of reasons. These methods were: in-depth interviews; experiments using exposure to live fire tests; and field observations of behaviour during real dwelling fires. While in-depth interviews would have provided a good level of qualitative insight, their use was decided against for this study as it would have been far too difficult to carry out sufficient interviews to cover all of the different types of scenario that were of interest to this study. This was due to three reasons. Firstly, the large amount of time required to carry out and also transcribe in-depth interviews; secondly, the associated expense in travel costs, and finally the challenges of accessing sufficient participants who would be willing to be interviewed and give up the greater amount of time required compared to completing a questionnaire survey. Consequently, interviews, whilst entirely valid in certain other contexts, were not considered to be an appropriate method of data collection for this thesis. With experiments using exposure to live fire tests, the ethical standards, potential risks to participants' health from exposure to the productions of combustion as well as the expense, mean that it was not possible to run such experiments. Finally, field observations could not be carried out as it would not be possible to attend a sufficient number of ADFs while the incident was still underway. Moreover, even if the author was able to get to a live incident while firefighting operations were underway, for obvious reasons of safety, the attending emergency services would prevent access to any scene.

Consequently, having considered the data collection methods used by previous studies into human behaviour in fire, a questionnaire survey was felt to be the most suitable because it provided a means to most efficiently gather key information in a relatively short period of time. Consequently this was selected as the method used for this study.

3.3.1 Relevant datasets

A search was undertaken to see if there were any current studies using similar methods which might be aligned with and support the aims of this thesis. However, what this examination served to demonstrate was the lack of datasets in this area; there were only three that were identified as having a focus on a related area that were of sufficient scale and quality so as to be relevant to the aims of this thesis. These were the 'Post Incident Research Programme' that was undertaken jointly between Greater Manchester FRS and the University of Salford; the IRS (Incident Recording System) used by FRSs nationwide; and the LIFEBID (Lessons In Fire & Evacuation Behaviour In Dwellings) project that was undertaken by the University of Greenwich and twenty-five FRSs from across the UK. The advantages and disadvantages offered by each of these will be considered in turn.

3.3.2 The Post Incident Research Programme

The aim of this determinedly qualitative study, which actively seeks to avoid what the authors refer to as 'empiricist, behaviourist or positivist traditions' (Clark et al., 2015, p13), is to develop a better understanding of how those who have experienced a fire construct and perceive their own interpretation of fire risk. All data collection was undertaken via in-depth interviews with those who have experienced an ADF. Starting in 2012, this project built a database of 72 interviews (Clark and Smith, 2015). However, rather than seeking to map and quantify the range of behaviours undertaken during a dwelling fire, this project had a specific focus upon exploring how those who have experienced a dwelling fire reflected upon and understood the fire and its causes, the manner in which they articulated those reflections, and how the experience affected their perceptions of fire risk (Clark and Smith, 2015; Clark et al., 2015). Because this study has no specific aims related to understanding human behavioural processes and motivations during the course of a fire it was decided that the dataset generated was not of sufficient relevance or overlap and therefore could not be utilised in support of the specific aims of this thesis.

3.3.3 The Incident Recording System (IRS)

One data source that needs to be considered is the IRS: the electronic Incident Recording System used by all FRSs in the UK. Although FRSs routinely collect data on attended fires, the IRS provides only limited information about occupant behaviour. Instead the focus is on the building type, location of the fire, any subsequent spread, items involved, extent of the damage, and the firefighting methods and resources used. Although within the IRS some basic monitoring information about occupants is collected, along with a general description of any injuries sustained, the primary focus is on gathering detailed information about the spread of fire and smoke, the building type, and the firefighting methods and techniques that were employed and the resources committed in order to deal with that fire. Consequently, in terms of scope and level of detail, data collection through the IRS can be said to be far more focussed upon the building than the person. Any information about an individual or their actions is limited to a person's connection to the origin and cause of the fire and based upon pre-determined categories within a drop down menu, for example 'cooking left unattended', 'careless handling of smokers' materials'. In the event of fatal or non-fatal injury this also includes general details about the casualty (age, gender and severity of injury).

The organisation of the IRS means that any requests for amendments or additional questions related to this thesis would have to be agreed individually by each FRS in the UK. These requests, and the associated cost and time of incorporating them, would need to be weighed against FRSs' (understandable) priorities to gather information in support of operational duties, quality assurance issues, and statutory responsibilities. When they do take place, any amendments to the IRS made by individual FRSs are done so only on an annual basis meaning the timescales were not compatible with this thesis. As such it is highly unlikely that any FRS would have been willing to make amendments to the IRS.

The IRS is of great value as a source of statistical information on the numbers and types of fires and fire-related injuries and deaths, and offers a large volume of useful supplementary data. However, the previously discussed points, combined with the fact that the IRS does not – and indeed is not designed to – collect data on occupant behaviour and motivations meant that it was not an appropriate dataset to support the aims of this thesis.

3.3.4 Lessons In Fire & Evacuation Behaviour In Dwellings (LIFEBID)

LIFEBID is a Knowledge Transfer Partnership (KTP 009153) undertaken jointly between Kent FRS and the University of Greenwich's Fire Safety Engineering Group (FSEG). It also had the support of a further twenty-four FRSs from across the UK. Funded from 2013 to 2016 by Innovate UK (Technology Strategy Board) and the Engineering and Physical Sciences Research Council (EPSRC) the aim of LIFEBID was to develop a database of human behaviour in dwelling fires. Data were collected through a questionnaire survey which was hosted online or distributed in hard copy (Appendix 1). Participants were those who experienced an ADF, irrespective of whether it was attended by the FRS or not. However, the data collection method meant that, in practical terms, the survey was promoted solely to those who had had a fire that the FRS had attended.

3.3.5 The selection of the LIFEBID survey

Not only was the LIFEBID survey relevant to the aims of this thesis, it was also timely as the project was KTP funded until 2016. This avoided the need for an unnecessary duplication of a survey on human behaviour in dwelling fires and also meant that the survey was running during the data collection period of the thesis.

The relevance of the LIFEBID survey to this thesis was because LIFEBID was specifically designed to collect data on the behaviours and motivations of occupants who experienced a dwelling fire. In addition, the survey also collected data on certain demographic characteristics. As will be outlined in a later section of this chapter, several questions within the LIFEBID survey and therefore areas of data collection were of direct relevance to the aims of this thesis. Moreover, access to data from LIFEBID was facilitated by the fact that the author of this thesis was a Technical Advisor to, and member of, the LIFEBID project team. Because of these reasons, it was selected for use to support this thesis. Data were collected from across the UK between September 2014 and August 2016. Additional questions specific to the PhD were formulated and included within a revised version of the survey from November 2015.

The LIFEBID questionnaire survey was scripted, hosted and managed by a third party however, following a series of discussions with the project team, agreement was reached for inclusion of a number of questions in the survey that would address some of the aims of this thesis. The inclusion of additional questions in the LIFEBID survey was based on the identification of areas where this thesis sought to obtain information, but that were not addressed by the LIFEBID survey. These additional questions, along with the reasons for their inclusion, is examined in Section 3.4.3.

3.4 THE QUESTIONNAIRE SURVEY

3.4.1 Ethical approval

In line with the University of Greenwich's research ethics policy, ethical approval for the survey research was sought and granted by the University of Greenwich's Research Ethics Committee (UREC); further approval from the UREC was sought and obtained for the inclusion of the additional PhD-specific questions in the LIFEBID survey (UREC Minute: 13.2.5.13 and UREC Minute 13.4.6.1).

In studying how people behaving during a fire in the home, the issue of research ethics takes on a particular importance. Predominant among this were the ethical considerations and sensitivities related to collecting data about participants' experiences of events that were likely to have been traumatic and upsetting. There was also the issue of using an invasive research method in the form of a questionnaire survey – particularly one designed to be administered to those who have recently suffered from a fire in their home. Alongside this was a clear need to ensure that respondents did not feel pressured or compelled to participate, especially given the fire-related stresses to which they may have been exposed prior to being contacted. Consequently, it was imperative that there was an awareness of the researcher-participant power structures, particularly in the possibly dominant and almost 'victorious' position of the FRS in relation to those members of the public it has assisted (Flowerdew and Martin, 1997; Kitchin and Tate, 2000).

3.4.2 Survey structure

The type of data collected by this survey included: participants' socio-demographic characteristics; how they became aware of the fire; their perception of the hazard; the actions they undertook; and their reasons for those actions. The survey took approximately 25 minutes to complete and was designed so that it followed each participant's experience as the incident developed. The survey was organised into nine sections labelled A to I, each of which covered the following information:

Section A. Incident date, fire service incident code number, and participant's postcode.

Section B. Monitoring questions about the participant, including gender, age, ethnicity, previous experience of an uncontrolled fire, and source of any prior fire safety knowledge.

Section C. Incident details and context, including time and location of fire, dwelling type, numbers of people and pets present, type of initial cues and presence of smoke alarms.

Section D. Type and sequence of actions undertaken, fire hazards encountered, and timing and nature of any injuries sustained. This section takes the form of a timeline onto which respondents mark the actions they undertook and the sequence in which those actions occurred. With the electronic version of the survey an interactive timeline was developed using the survey software LimeSurvey, a free open source software survey tool (www.limesurvey.org). This allows participants to select chosen points along the length of the timeline which, depending on which one of three rows of the timeline are selected, activates a drop down list of activities, fire hazards or injuries (Table 4). Using the mouse cursor these selected options can then be dragged horizontally along the length of the timeline to give an indication of time interval between each relative to the overall incident.

Section E. Exposure and proximity to the source of the fire, entering and leaving the RFO, tackling the fire, and flame/smoke size.

Section F. Questions on calling 999.

Section G. Exiting and re-entry behaviour, including the types of items taken while exiting.

Section H. Degree of fire/smoke damage and type of medical treatment administered.

Section I. Participants' opinions of their behaviour, consumption of substances other than food.

Table 4. Categories of activities, fire hazards and injuries.

Activities
A1. Noted something unusual but did not act on it
A2. Investigated what was happening
A3. Tried to tackle fire
A4. Warned others
A5. Searched for/gathered item(s)
A6. Searched for/gathered person(s)
A7. Searched for/gathered pet(s)
A8. Closed internal doors
A9. Called 999
A10. Waited for emergency services
A11. Exited building
A12. Re-entered home
A13. Fire and rescue service arrived
A14. Ambulance/paramedics/police arrived
A15. Fire was put out
A16. Other (please specify)

Fire Hazards	**Injuries**
FH1. Smoke only	I1. Smoke inhalation only
FH2. Flames only	I2. Burn(s) only
FH3. Heat only	I3. Other injury only
FH4. Smoke and flames	I4. Smoke inhalation and burn(s)
FH5. Smoke and heat	I5. Smoke inhalation and other injury
FH6. Flames and heat	I6. Burn(s) and other injury
FH7. Smoke and flames and heat	I7. Smoke inhalation and burn(s) and other injury

Although work looking specifically at the effect of fire hazards on memory is very limited, one recent study conducted as part of the LIFEBID project specifically sought to examine the accuracy with which people recall fire hazards (Hulse et al., 2015). This piece of work found that flame size and smoke volume affected how well participants were able to perceive and recall those fire hazards. The findings of studies looking at other threatening stimuli have found that during a stressful and fast-moving incident, although people are able to recall specific incidents in detail, and often with great clarity, the perception of time and physical space can often become distorted and inaccurate (Harber et al., 2011). In line with this, studies of behaviour during real fire incidents have also demonstrated the unsuitability of relying on participants' estimates of timings. This is due to the difficulties people display in trying to accurately assess times and durations of activities during a fire (Brennan, 1997; Proulx and Fahy, 1997; Proulx et al., 1995).

In addition, studies of eyewitness accounts have identified that an effect termed 'attentional narrowing' may occur during stressful and emotionally arousing events, resulting in an increasing focus on those cues that cause the emotional arousal, while peripheral aspects become overlooked (Easterbrook, 1959; Hulse, 2005). Furthermore, research has indicated that this can also exert an effect upon the formation of memories, resulting in the 'elaborative processing' of certain aspects, in which new material is added to previously stored long term memories, distorting the accuracy of those memories when subsequently recalled (Safer et al., 1998).

As a result it was clear that consideration would need to be given to the way in which data were collected in order to ensure participants' accounts of the sequences of their actions, and the relationship between those actions and other events during the fire (such as the ability to identify instances when an injury was received or additional fire hazards encountered), were as accurate as possible. The reason that a timeline was incorporated into the survey was because it offered the most effective means of allowing participants to recall, order and then record the actions they undertook, the hazards they encountered, the occurrence of injuries, and the sequence in which those events occurred. The employment of timelines in other fields of research has been found to enhance recall (Hope et al., 2013; Van der Vaart and Glasner, 2007).

A timeline to collect data about participants' actions during the fire was first developed and used in a project the author of this thesis undertook for KFRS in 2011, into occupant behaviour during ADFs (Figure 15) (Thompson et al., 2013; Wales and Thompson, 2012; Wales and Thompson, 2012a; Wales et al., 2014). Building upon experiences from this earlier study, a timeline was designed and used in the LIFEBID survey (Figure 16). Similarly, the coding categories of the activities are based upon those that were developed by Kent FRS in collaboration with the University of Greenwich's FSEG during the analysis of data in a Kent study of human behaviour in ADFs (Thompson et al., 2013; Wales and Thompson, 2012; Wales and Thompson, 2012a). There was the possibility that participants' with a lower level of computer literacy might not fully understand how to use the timeline (or indeed any other part of the survey). Additionally, despite being warned at the start of the survey that some browsers would not be compatible with the timeline's underlying software, it was anticipated that some participants would nevertheless attempt to use such browsers and thus encounter problems. In order to mitigate this the following measures were put in place: the timeline was designed to be as intuitive as possible; contact details for the LIFEBID research team were made available on the survey so that participants could get in touch if they had any questions about completing the timeline or any other part of the survey; additionally participating FRSs put a system in place where participants could complete the survey with the assistance of a member of the FRS. As a result, the number of missing cases for timeline data was minimised.

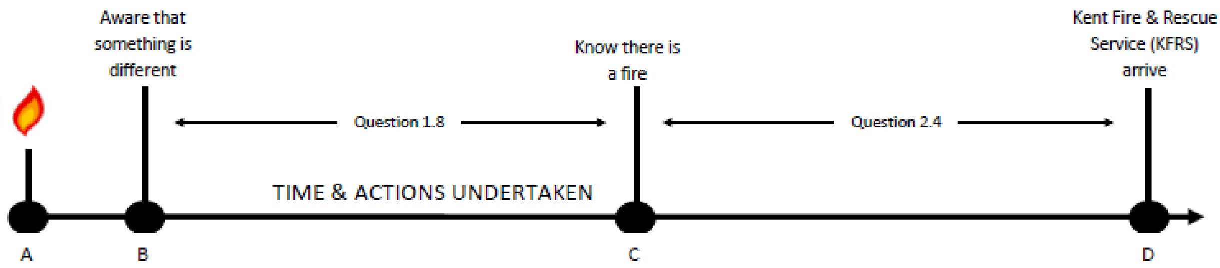

Figure 15. Timeline used in the Kent FRS study of human behaviour in ADFs.

Source: Kent FRS

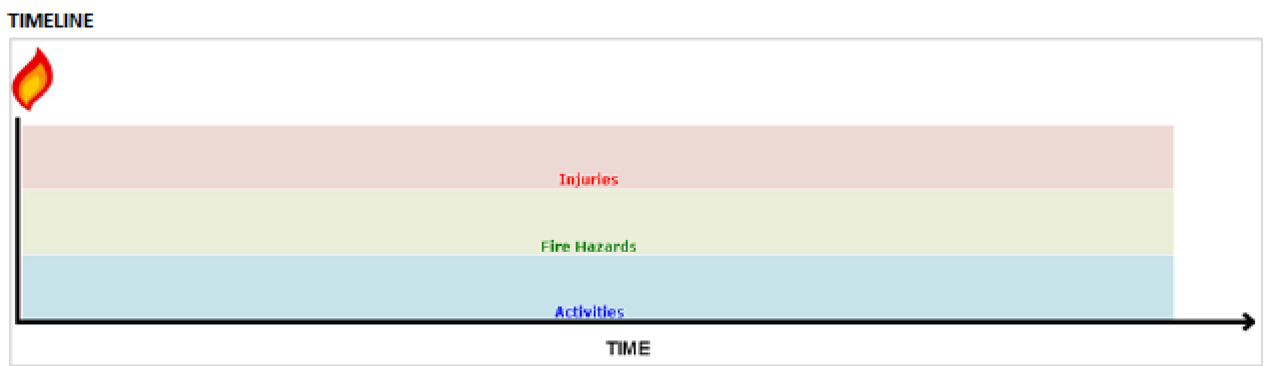

Figure 16. Timeline used in the LIFEBID survey.

Source: LIFEBID

Finally, because recalling the incident while completing the survey has the potential to be distressing for participants, the final page of the survey contained a list of organisations and websites that offer confidential support and advice.

3.4.3 Inclusion of additional questions

Although the LIFEBID survey was a dataset well-suited to the aims of this thesis, the survey did not fully address all of the areas that this thesis sought to cover. Of the nine PhD research questions set out in Section 2.10, questions 1 and 3 were not completely addressed by the LIFEBID survey. The PhD research questions that were not completely addressed by the LIFEBID survey is as follows:

PhD research question number 1 (Group 1):
What are the key behaviours and movement taking place during a dwelling fire? What are the motivations driving these behaviours?

PhD research question number 3 (Group 1):
What are the relationships between these behaviours and the occupant characteristics used by previous researchers in the field (not only gender, but also fire safety knowledge/training, and prior fire experience)?

In order to address these, the additional LIFEBID survey questions collected information on the following areas (for a list of these questions, see Appendix 2):

1. The reasons why those who stated they re-entered to check on the fire felt the need to do so (survey question G5i, contributing to PhD research question 1).
2. Participants' perceptions of immediate and or long-term risks that might arise from encountering smoke (survey question I2, contributing to PhD research question 1).
3. The perceived influence of existing fire safety knowledge on participants' behaviour (survey question I7, contributing to PhD research question 3)

The reasons for the inclusion of additional survey questions covering each of the above areas were as follows:

1. The desire to re-enter a property in order to check on the development of the fire appears to have no outwardly tangible outcome or productive benefit for those undertaking such an action. This also means that by re-entering to check on the fire, individuals are

increasing the potential risk to which they are exposing themselves, but without a seemingly commensurate benefit for doing so. Consequently, such behaviour needed to be better understood by looking at the underlying reasons.

2. There are insufficient data on individuals' perceptions of the risks when encountering smoke in domestic spaces. This is important as smoke inhalation is the leading cause of both injury and death in fires, accounting for 20% of all injuries and 40% of all deaths (Home Office, 2019). Although participants are unable to provide an objective assessment of whether certain actions increased the risk or not, they are able to account for their perception of risk. An understanding of perceived risks considered against actions (in this case encountering smoke) offers information that enhances the understanding of the motivations acting upon behaviour.

3. There has not been a recent attempt to identify whether individuals feel that a prior knowledge of fires or fire safety exerts an influence upon their behaviour during a fire. A better understanding of the perceived effect upon participants' actions will assist FRSs in fire prevention work. FRS fire prevention work seeks to alter or amend an individual's behaviour during an ADF through the provision of fire safety advice. Consequently, if such approaches are to be as effective as possible they need to be based upon an understanding of how strongly people are tied to their actions and the degree of validity that they ascribe to those actions. FRS strategies which aim to change behaviour will immediately encounter resistance (and thereby have their validity and suitability called into question) if those who have experienced a fire view their own actions in a positive light when those actions stand in contrast to established fire safety advice. The theory of occupant decision making during fires developed by Kuligowski (2008, 2009) asserts that people do not just act upon what they are experiencing at the time but are also influenced from previous experience and knowledge. In this model prior experience of a fire and knowledge or training about fires are identified as exerting an influence upon an individual's cue perception, interpretation of the situation and subsequent decision making.

3.4.4 Participation and consent

The surveys were anonymised, but not anonymous. The reason for the distinction was the need to have a capacity for individual surveys, and associated data, to be identified and deleted in the event of a participant wishing to withdraw their participation. Participants were adult occupants aged 18 years and who had directly experienced a dwelling fire within the 12 months prior to completing the survey. LIFEBID defined a dwelling fire as:

1. An incident where an item, in or around a property, ignited emitting flames and or smoke
2. The flames and or smoke posed a threat to part or all of the property and to the occupants inside the property if left unchecked
3. The threat to part and or all of the property was obvious (e.g. it would cause smoke damage, render an item inoperable, render the home uninhabitable); the threat to the occupants may not have been so obvious
4. The affected property was one used solely as a residence

Prior to commencing the survey, participants were first asked to complete a consent form, in which they were required to confirm that they were aged 18 or over, confident in their English reading and comprehension abilities, and not currently receiving treatment either as an in- or out-patient for any injuries incurred during the ADF they experienced. This latter point, while potentially limiting the numbers of those with fire-related injuries who would be able to participate, was a requirement of the UREC as the inclusion of those who were currently in- or out-patients due to any injuries incurred in the fire would require external medical ethical approval to be sought.

3.4.5 Participant recruitment

Networks were established with 25 FRSs across the UK (Table 5). The establishment of these networks was undertaken as part of the LIFEBID project of which the author of this thesis was a co-researcher. This is a large number of services, as it represented almost half of the 50 FRSs in the UK. In terms of the number of FRSs participating, it also exceeded any previous studies into human behaviour in fire. Moreover, with services from across all of the constituent countries of the UK (England, Scotland, Wales and Northern Ireland), the survey was representative of all of the regions of the UK and not just England.

To formalise the partnership and connection with each FRS, two points of contact were established: a Strategic Lead and a Practitioner Lead. The former was usually a senior FRS manager (Area Manager or Group Manager rank), while the latter was a middle or lower ranking manager (Station Manager/Commander or Watch Manager/Commander).

Table 5. List of participating FRSs

Buckinghamshire	Cambridgeshire	Devon and Somerset
Durham and Darlington	East Sussex	Essex
Greater Manchester	Hampshire	Hertfordshire
Humberside	Isle of Wight	Kent
London	Merseyside	Northern Ireland
Oxfordshire	Royal Berkshire	Scottish
Shropshire	South Wales	South Yorkshire
Surrey	West Midlands	West Sussex
West Yorkshire		

It was decided that the author would not administer the survey when at the scene of an ADF, a decision that was made for several reasons. The geographical scale of the data collection meant it was impossible for a single researcher to distribute and undertake all of the surveys. Experience from previous studies also demonstrated that when researchers had attempted to collect data from dwelling fire survivors at the scene a range of problems were encountered which made this a highly ineffective method. The operational demand placed upon fire crews when at the scene of an ADF, combined with the time needed to complete the survey, also meant it would not be feasible to have fire crews administer the survey.

Instead the main participant recruitment method used was one where fire crews attending an incident distributed postcards that were carried on the fire appliances to occupants or other people present along with a brief explanation about the work and an invitation to provide their account of the fire though the survey. This postcard (Appendix 3) contained information that briefly outlined the project, a web link to the online version of the questionnaire survey, and a telephone number for a voicemail service. On the reverse of the postcard was a space where the firefighter would write the date of the incident and the IRS incident number. In addition to distributing the postcards, several FRSs also sent letters to addresses where fires had occurred. These letters contained the same information as the postcards but also included a brief explanation of the project with an invitation for members of the public to participate. As mentioned in Section 3.3.5, data were collected between September 2014 and August 2016.

3.4.6 Methods of completing the survey

In Great Britain 90% of households have internet access and 89% of adults access the internet at least weekly (Office for National Statistics, 2018). Yet, despite these high penetration rates, internet use is still skewed towards younger age groups meaning that older sections of the population may not be accurately represented in a survey that is predominantly web based (Office for National Statistics, 2018). Previous work on human behaviour in dwelling fires has demonstrated that older age groups are willing to complete post-fire surveys (Wales and Thompson, 2012), so it was essential to ensure that the willingness of such groups to participate can be realised. Furthermore, in the aftermath of an ADF, domestic internet connections may be cut and web enabled devices rendered inoperable. Consequently, three ways to complete the survey were devised. These were selected as they offered the best opportunity for the greatest number of people to be able to participate in the survey.

1. Participants went online independently, entering the web link provided on the postcard/letter, and completed the survey via the LIFEBID website.
2. Those participants who were unable to go online independently left a message on the voicemail service and were contacted to arrange for them to undertake the survey via an offline, face-to-face method. A home visit then took place with a member of staff from the local FRS assisting the participant in completing the electronic version of the survey that was pre-loaded onto a tablet computer provided. The data was subsequently forwarded to the LIFEBID research team.
3. Those participants who were unable to go online independently left a message on the voicemail service and were sent a hard copy of the survey by their local FRS. Sent in a return envelope (to make sure there was no cost to the participant), these surveys were completed and returned to the relevant FRSs who then entered the data online via the LIFEBID website.

3.4.7 Data extraction

Both the online and offline survey data were checked by the LIFEBID research team to ensure that they met requirements, i.e. only involved (a) completed surveys about (b) accidental fires occurring at dwellings, and from occupants who were (c) present at the scene when the fire occurred. Data that met this criteria were then coded, organised, and entered into the LIFEBID database. Using the LIFEBID Query Builder tool and accompanying guidance (FSEG, 2016), the author of this thesis searched the database for data relevant to this study's aims and then extracted that data from the database into an Excel spreadsheet, from where the data were then transferred into and further checked and organised within an SPSS dataset.

3.5 ANALYSIS METHODS USED ON THE DATA

A mixture of descriptive and inferential statistical techniques was used to analyse the data. The former comprised frequency counts and percentages and they were used to describe the sample, key information such as the behaviours undertaken, and participants' injuries. The inferential statistical techniques that were used were chi-square analysis, Mann-Whitney U, one-way ANOVA, and binary logistic regression. The use of binary logistic regression allowed for several independent variables to be tested against a dependent variable at the same time to determine which (if any) were significant predictors of the dependent variable. In some of the regression models, interaction terms were included to examine whether the effect of a specific independent variable was actually determined by another (i.e. the possibility of gender interacting with being alone vs. accompanied). The software used to undertake the statistical analysis was IBM SPSS Statistics (versions 23 and 24).

In line with the standard approach to statistical significance when employing inferential techniques, the 95% confidence interval was used as a cut-off; that is, any reported *p*-value less than .05 was deemed to be a statistically significant result (Field, 2015). However, although *p*-values may be used to demonstrate the presence of relationships, they alone give no sense of the magnitude of the observed effects. This is important because one could have a statistically significant result but the effect size could be very small, meaning that the observed effect of one variable upon another, while statistically significant, was not strong. It is for this reason that this analysis also reports effect sizes. This is in line with what is increasingly regarded as best practice for reporting statistical analysis (Field, 2015). The measures of effect size used in this analysis were *r* (Pearson's correlation coefficient, used when reporting the results of the Mann-Whitney U tests and one-way ANOVA tests), Cramer's *V* (used when reporting the results of chi-square tests), and the odds ratio, *OR* (used when reporting the results of binary logistic regression tests). It should be noted that *r*- and *V*-values of .10 are commonly considered to indicate a small effect, .30 a medium effect, and .50 a large effect (Field, 2015). For the *OR*, it is more complex as values can be less than or greater than 1.00 but values less than 1.00 can only range as far as zero while values greater than 1.00 can range to infinity. Thus, it is best to conceptualise *OR*-values as follows: if OR =

1.00, then the effect is negligible; if OR < 1.00, then the effect is a decreasing effect, with values further away from 1.00 representing a greater decrease in odds (e.g., it could be the case that being female, as opposed to male, decreases the odds of engaging in behaviour such as tackling the fire); and if OR > 1.00, then the effect is an increasing effect, with values further away from 1.00 representing a greater increase in odds (e.g. it could be the case that tackling the fire, as opposed to not tackling the fire, increases the odds of being injured).

4. RESULTS AND ANALYSIS

4.1 DESCRIPTION OF THE SAMPLE

4.1.1 Sample size

Questionnaire survey data relating to several hundred participants (N = 419) were taken from the LIFEBID database. For the periods 2014/15 and 2015/16 (which correspond with the period of data collection), the number of ADFs across the country was 34,900 and 34,800 respectively (DCLG, 2015; Home Office, 2019). Consequently, the thesis dataset represents 1.2% of the average number of total ADFs for these two years (34,850). That this is a small proportion is a reflection of the numerous difficulties that exist in trying to collect data on human behaviour in dwelling fires. These include: people's priorities following a fire; a disinclination to recount a traumatic event; sensitivities around the incident limiting the ability to follow up with reminders to complete the survey; a data collection method which was reliant on fire crews remembering to distribute information about the survey when at the scene of a fire (hampered in some FRSs by periods of industrial action); and the practical difficulties of tracing participants who may no longer be resident at the property due to fire and smoke damage. However, despite the sample being small relative to the average number of total ADFs, it is sufficiently large to have only a 5% margin of error at the 95% confidence interval (Taherdoost, 2017), meaning that it is adequate for inferential statistical purposes.

For some of the headline descriptive statistics presented below, comparisons have been made with national-level statistics for ADFs where such profiles have been published. Where such statistics have not been published, comparison has been made with the UK/Great Britain/England and Wales population in general. In each case, this has been done in order to provide a degree of context.

4.1.2 Description of participants

Regarding gender, there were more female participants than male; 60% (n = 251) of the sample was female, 37% (n = 155) was male, and gender data were missing for 3% (13). Within the population of the UK in general, there were also more females in 2015, albeit only slightly (51%) (ONS, 2017).

As shown in Table 6, ages ranged across the adult lifespan and within this broad range each decade was represented. For the UK, the median age was 40, with an IQR from 21.00 to

58.00 (ONS, 2016). So the age profile of the survey sample was older than for the UK population in general.

Table 6: Age

	N = 419
Age	Range = 18-96 years Mean = 54.25 years, SD = 17.00 Median = 54.00 years, IQR = 43.00-67.00 Missing = 5% (20)
Age Category	18-19 years = 1% (2) 20-29 years = 6% (26) 30-39 years = 12% (52) 40-49 years = 19% (80) 50-59 years = 20% (85) 60-69 years = 17% (71) 70-79 years = 13% (53) 80-89 years = 6% (26) 90-99 years = 1% (4) Missing = 5% (20)

Figure 17 compares the proportion of each decade-based age group in the sample to the same age groups in the population of the UK (based on the data from the 2011 census; note, those aged 18-19 were omitted because it was not possible to extract a suitable comparison group from the census data). These were chosen to allow for a comparison of the age profile of adults. In the UK there were a total of 48,085,000 people aged 20 and over, out of a total population of 63,183,000 (representing 76% of the total). In the LIFEBID sample 399 participants stated their age of which 397 were aged 20 and over (99%). This again shows that the survey data has a slightly older age profile compared to the picture for adults in the UK as a whole (ONS, 2011a). The LIFEBID sample is concentrated around those aged between 40 and 69, compared to the UK population, where it is 20 to 49. In addition, because the minimum required age for completing the survey was 18, this also had the effect of increasing the sample's age profile relative to that of the UK population.

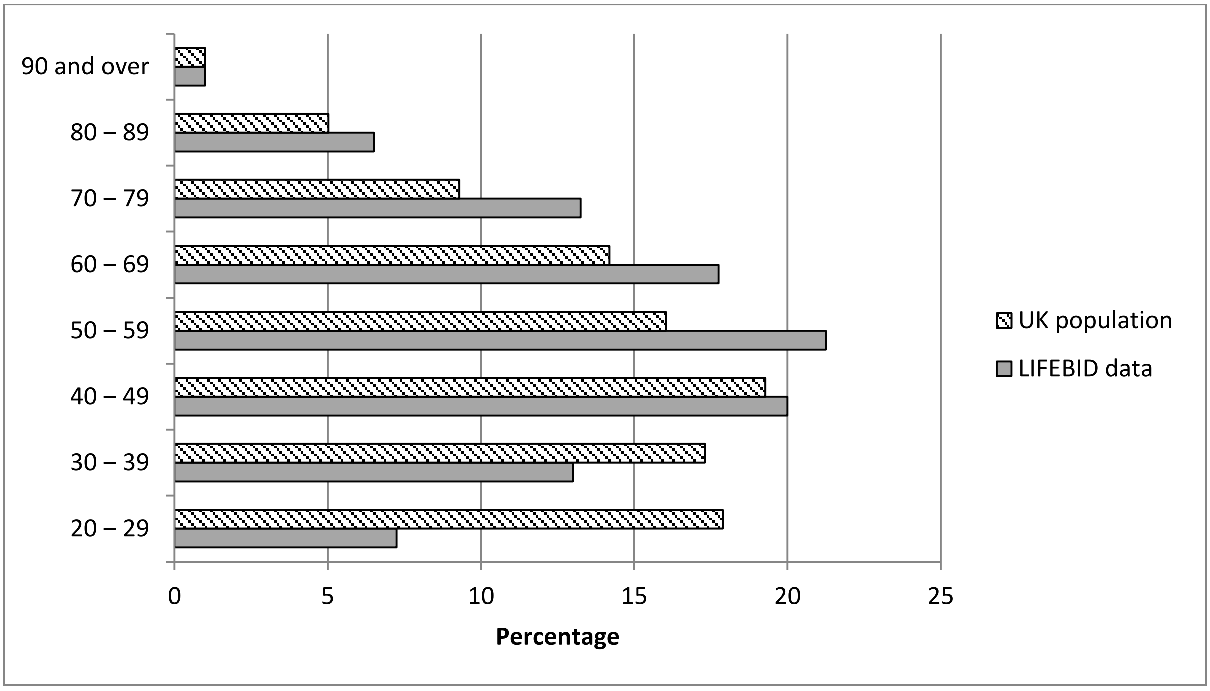

Figure 17. Comparison of participants’ age profile and the UK age profile.

Source: ONS, 2011

The sample’s ethnic profile was mainly white UK/Irish (Table 7) which, at the time of data collection, was in line with the data on ethnicity in England and Wales, where the figure was 82% (ONS, Ethnicity and National Identity in England and Wales: 2011).

Table 7: Ethnicity

	Percentage and count (N = 419)
Ethnic Group	White UK/IE = 90% (378) Asian/Asian British = 3% (11) White Other = 2% (10) Mixed/Multiple = 1% (4) Black/African/Caribbean/Black British = 1% (3) Other Ethnic Group = 1% (3) Arab = 1% (1) Missing = 2% (9)

A fifth of the sample lived alone (the national figure was 13% [ONS, 2013]). Dependents (people being cared for) were present in a substantial number of cases, and these were not always children or only children.

Table 8: Household

	Percentage and count (N = 419)
Lived Alone	Yes = 20% (83) No = 80% (336)
Dependents Present	Yes = 42% (175) No = 58% (244)
Type of Dependents	Children = 42% (74) Adults = 39% (68) Children and Adults = 19% (33)

As shown in Table 9, around a quarter of the sample reported having experienced a fire prior to the current incident and the majority stated that, prior to the incident, they had some form of knowledge about fires or fire safety. Among those with pre-existing knowledge of fires/fire safety, the most frequently cited source for this knowledge was the workplace. Finally, of those with previous knowledge about fires, almost three-quarters felt that the knowledge had influenced their behaviour (72%).

Table 9: Prior fire experience

	Percentage and count (N = 419)
Prior Fire Experience	Yes = 24% (100) No = 76% (319)
Prior Fire Knowledge	Yes = 91% (383) No = 9% (36)
Knowledge Sources	Workplace = 72% (276) Public Safety Info = 40% (153) Other Media = 37% (143) Factual TV/Film = 33% (126) School = 29% (112) Fictional TV/Film = 21% (79) Profession = 11% (44) Other Source = 8% (30)

4.1.3 Dwellings and smoke alarms

Houses comprised the majority of property types (74%), followed by flats spread over one or more storeys (16%) and bungalows (9%) (Table 10). The proportion of houses here is considerably higher than the national proportion for ADF property types at this time, for which houses comprise 57%, flats 37% and bungalows 6% (Home Office, 2019).

Table 10: Dwelling types

	Percentage and count (N = 419)
Dwelling Type	Detached House = 30% (124) Semi-Detached House = 26% (110) Terraced House = 18% (77) Flat/Apartment = 14% (59) Bungalow = 9% (36) Maisonette = 2% (7) Mobile Home = 1% (2) Park Home = 1% (1) Converted Farm Building = 1% (1) Missing = 1% (2)
Attached Dwelling	Attached = 61% (253) Detached = 31% (128) Bungalow = 9% (36) Missing = 1% (2)

Dwelling type was recoded into a new variable based upon whether the dwelling was physically connected (i.e. attached) to any another dwelling(s), either vertically or horizontally (although bungalows needed to remain a separate category as the survey did not collect data on whether they were detached or semi-detached, and no generalisations could be made). Based on this categorisation, the majority of properties were attached (61%). The reason for creating this new variable was because it was recognised that those within a property that was attached to another property (either horizontally or vertically) could experience an increased level of risk and or social influence. For example, people could be more readily affected by a fire in a neighbouring property; or people in one property could have their perception and behaviour influenced as a result of additional cues and phenomena coming from people in a neighbouring property.

As Table 11 shows, smoke alarm ownership was high and corresponded with the national picture of 90% (Home Office, 2019). Within the survey data, where present, alarms sounded in more than two-fifths of fires, which is somewhat lower than the national figure of 57% (Home Office, 2019). In the survey, the most frequent reason for alarms not sounding was the location of the alarm meaning that the fire was not detected. Flat batteries were the cause in only a small number of cases. Within the national statistics, the location of the alarm was also the leading cause for alarms not operating (63%), while ‘defective batteries’ were the cause in just 1% of cases (Home Office, 2019).

Table 11: Smoke alarms

	Percentage and count (N = 419)
Alarm Present	Yes = 94% (394) No = 6% (25)
Alarm Sounded	Yes = 42% (165) No = 46% (180) Missing = 12% (49)
Reason Alarm Did Not Sound	Location: fire undetected = 80% (144) Battery flat = 7% (13) Not known = 6% (10) Other = 3% (5) Battery missing = 2% (4) Alarm faulty = 2% (3) Alarm turned off = 1% (1)

4.1.4 Fire incident data

Most ADFs occurred in the kitchen, between 17.00 and 22.59 hrs (Table 12). Both of these aspects were concurrent with the national picture. Although, at a national level, the percentages were somewhat different: 57% of all ADFs occurred in the kitchen and 38% of ADFs occurred between 17.00 and 22.59 hrs (Home Office, 2019).

Table 12: Time of incident and RFO

	Percentage and count (N = 419)
Time of Incident	17.00-22.59 = 41% (170) 12.00-16.59 = 27% (111) 06.00-11.59 = 19% (79) 23.00-05.59 = 13% (55) Missing = 1% (4)
RFO	Kitchen = 44% (186) Living/Dining Room = 17% (73) External Structure/Areas = 9% (37) Bedroom = 9% (36) Other Interior Rooms/Areas = 6% (27) Loft/Attic/Roof = 4% (18) Laundry Room/Airing Cupboard = 4% (15) Bathroom/Toilet = 3% (13) Conservatory = 2% (10) Missing = 1% (4)

As shown in Table 13, in line with national trends, cooking appliances were the leading cause (source of ignition) of fire, however the proportion was somewhat lower than the national figure (50%) (Home Office, 2019). Despite this, in order of frequency, the following two causes, ‘other domestic-style (electrical) appliance’ and ‘electrical distribution’, also mirrored the national picture, where ‘other electrical appliances’ and ‘electrical distribution’ were second and third placed with 13% and 12% respectively (Home Office, 2019). In 69% of instances the fire did not spread beyond the room of fire origin (RFO), and in the majority of cases it remained restricted to the item first ignited. The comparable national figures were 57% of ADFs not spreading beyond the RFO and 30% remaining restricted to the item first ignited (Home Office, 2019).

Table 13: Fire spread and cause of fire

	Percentage and count (N = 419)
Fire Damage Spread	Restricted to ignited item = 42% (175) Restricted to RFO = 27% (113) Spread across RFO floor = 17% (70) Spread across building = 11% (46) Spread into other buildings = 1% (6) Missing = 2% (9)
Fire Cause	Cooking appliance = 29% (122) Other domestic style appliance = 17% (71) Electrical distribution = 12% (48) Other = 9% (36) Chimney fire = 8% (35) Space heating appliance = 6% (26) Not specified = 5% (21) Candle = 3% (12) Smoking materials = 3% (11) Lighting = 3% (11) Central/water heating appliance = 2% (10) Fuel (solid) = 1% (6) Industrial/DIY appliance = 1% (4) Fuel (gas) = 1% (3) Vehicle = 1% (3)

4.1.5 Summary

It is recognised that the total number of surveys in this sample is a small proportion of the annual number of ADFs for the period during which data were collected but, nevertheless, the sample size is large enough to permit inferential statistical techniques to be performed for analysis in this thesis. Moreover, since the three initial studies into human behaviour in fire were conducted by Wood, Bryan, and Canter et al., the LIFEBID dataset represents the largest set of primary data on human behaviour in ADFs for the past 40 years.

Some differences exist between the sample and the national picture, which are related to occupant characteristics, specifically: the slightly higher proportion of people who lived alone (20% vs. 13%); the higher proportion of females (60% vs. 51%); and the higher median age

(54 vs. 40). It should be pointed out that the national picture here is the UK population at large, not the proportion of UK occupants who have experienced an ADF (for whom a socio-demographic profile does not appear to have been published or known). On the other hand, the trends in the fire incident data matched the national fire statistics. Although there was a difference in the actual proportions, the majority of ADFs occurred in houses (although this is not altogether surprising given houses are the most common type of dwelling). The kitchen was where most fires occurred and the majority occurred between 17.00 to 22.59 hrs. Not only were cooking appliances the leading cause (source of ignition) of fire, but the following two causes also occurred in the same order. In the majority of cases, the fire was not only contained in the RFO, but restricted to the item first ignited. Additionally, the proportion of people who owned a smoke alarm was very similar to the national picture (94% vs. 90%). Therefore the characteristics of the ADFs described in the LIFEBID sample are broadly representative of those ADFs reported to FRSs and published in the national statistics.

A limitation that is important to note is the low number of ADFs in flats in this sample. This is due to several issues: firstly the complicated nature of fires in multi-storey blocks of flats makes them resource intensive for FRSs, which in turn means there are practical constraints which severely limit the time fire crews can spend distributing survey materials or collecting occupants' contact details. Secondly, the often protracted nature of high-rise fires means that residents may depart to other locations while firefighting operations are still being undertaken. Furthermore, compared to a house fire, there are a greater number of people present in a multi-storey building, making it more difficult to identify the occupants of the flat where the fire started and those flats directly affected.

Accepting the limitations of the dataset and the differences in some areas with national equivalents, it is clear that, overall, its scale and scope exceed anything that has been collected in this area within the past 40 years. As such, this dataset represents an important step forward in the field of human behaviour in fire. Taking all of these factors into consideration, this dataset permits the intended analysis.

4.2 KEY BEHAVIOURS AND MOVEMENT DURING AN ADF

Before examining the key behaviours that take place during an ADF, it is useful to review what was stated in Section 2.6 about the behaviours identified in the three early studies.

The early work undertaken by Wood, Bryan, and Canter et al. established a number of key concepts that went on to inform and direct subsequent research into human behaviour in fire; including that people will attempt to move through smoke, make attempts to tackle a fire, and also re-enter buildings after having evacuated them. In addition, all three studies placed great emphasis upon the differences in observed behaviour between males and females. Males were more likely to investigate and then tackle a fire, whereas females were more likely to warn others and evacuate the property, something described as an extension of pre-existing husband and wife roles (Canter, 1990). The great societal changes over the past forty years certainly merit a re-examination of the relevance of gender to behaviour during a fire.

Overall, these studies demonstrated that, during a fire in a building, those present were not helpless, irrational or passive. On the contrary, from these first formalised studies it appears that, before the arrival of the FRS, once people become aware of a fire they will play an active role in attempting to manage it and behave in ways that are purposeful, albeit undertaken on the basis of often very limited experience and imperfect information.

4.2.1 Descriptive statistics

Awareness. The majority of people were awake at the time of the fire (Table 14). Seeing smoke was the most frequently reported cue that alerted people to the fact that something unusual was happening; this was followed by smelling smoke and hearing an alarm.

Table 14. Awareness of the fire

	Percentage and count (N = 419)
Person Asleep	Yes = 13% (53) No = 86% (361) Missing = 1% (5)
Fire Cues	Saw Smoke = 32% (132) Smelt Smoke = 28% (117) Heard Alarm = 26% (110) Heard Fire = 18% (76) Saw Flames = 18% (75) Someone Informed = 14% (58) Saw Power Failure = 5% (22) Felt Heat = 2% (7) Perceived Occupant Commotion = 1% (6) Perceived External Commotion = 1% (4) Perceived Pet Commotion = 1% (3) Heard Sirens = 1% (3) Perceived Other Cue = 5% (19)

Substance consumption and opinions of behaviour/fire. Substances are defined as alcohol, over-the-counter prescription medication, or recreational drugs. As shown in Table 15, a number of participants reported that they had consumed a substance close to the time the fire started. A quarter of those who had consumed a substance stated that the substance had impaired them (e.g. made them drowsy, sleepy, forgetful, slowed reactions, clumsy). Approximately half of the sample reported that they were surprised by the fire. In terms of what it was that surprised participants, responses were dominated by smoke: its volume, speed and distance of spread. Yet among those who reported encountering smoke, smoke did not appear to be considered a particular risk: 32% stated they did not think about risks at all, 27% thought it would only result in temporary discomfort, and 18% considered it but thought it posed no real risk. This means that 77% did not consider exposure to smoke to be a serious risk to their health or lives.

Table 15: Substance consumption and surprise at the fire

	Percentage and count (N = 419)
Person Consumed Substance	Yes = 14% (59) No = 86% (360)
Impaired by Substance	Yes = 25% (15) No = 75% (44)
Surprised by Fire	Yes = 51% (215) No = 49% (204)
What About Fire Surprised You. NB: for this category participants were able to choose more than one answer	Volume of smoke produced = 19% (221) Speed smoke spread = 12% (143) How far smoke spread = 11% (124) Speed flame grew = 10% (117) Toxicity of smoke = 9% (105) How far flame reached = 6% (65) Noise of fire = 5% (59) Difficulty in extinguishing fire = 5% (57) Heat of flame = 5% (55) Fire occurrence: optimism bias = 5% (54) Ease in extinguishing fire = 5% (53) Darkness smoke caused = 4% (43) Heat of smoke = 3% (38) Other = 2% (22) Cognitive impairing smoke effect = 1% (13)

Number of activities. The most striking initial impression is just how active participants were during the fire (Table 16). During the incident, the number of activities undertaken overall ranged to as much as 15 activities, with a median of around half that amount. The most frequently reported initial activity was investigation of fire cues.

Table 16: Number of activities

	Percentage and count (N = 337)
Number of Activities (Timeline)	Range = 1-15 activities Mean = 6 activities, SD = 2.65 Median = 7 activities, IQR = 5-8
First Activity (Timeline)	Investigated Cue = 57% (192) Noted Cue: No Action = 17% (58) Tackled Fire = 9% (29) Called 999 = 7% (23) Warned Others = 4% (12) Other Activity = 4% (12) Closed Internal Doors = 1% (3) Fire Put Out = 1% (3) FRS Arrived = 1% (1) Ambulance/Police Arrived = 1% (1) Searched For/Got Persons = 1% (1) Searched For/Got Items = 1% (1) Exited Building = 1% (1) Searched For/Got Pets = 0% (0) Waited For Emergency Services = 0% (0) Re-entered Building = 0% (0)

<u>Tackling the fire</u>. Slightly more than half of the sample tackled the fire (Table 17). Among participants who tackled the fire, the most frequently used methods were switching off the power source, using water, and smothering the fire with something other than a fire blanket. Using a fire extinguisher and using a fire blanket were mentioned rarely.

Table 17. Tackling the fire

	Percentage and count (N = 419)
Tackled Fire	Yes = 53% (220) No = 47% (199)
Tackled Fire Method	Switching power off = 26% (82) Using water = 19% (60) Smothering with other item = 19% (59) Removing from heat source = 13% (40) Using fire extinguisher = 7% (21) Closing appliance door = 7% (21) Other method = 6% (19) Smothering with fire blanket = 4% (11)

<u>Calling 999</u>. In almost two-thirds of the sample 999 was called by the occupant personally (Table 18). However, the act of calling 999 tended not to be immediate; that is, it was the first activity undertaken in less than a tenth of cases. In over three-quarters of cases the 999 call was the second, third or fourth activity undertaken. Calling 999 most frequently came after some undefined activity, investigating the fire cues or tackling the fire.

Table 18. Calling 999

	Percentage and count
Person Called 999	Yes = 63% (265) Someone Else Did = 29% (123) No = 7% (31)
Timing of 999 Call (Timeline)	3rd activity = 31% (82) 2nd activity = 25% (65) 4th activity = 21% (55) 1st activity = 9% (23) 5th activity = 7% (19) 6th activity = 6% (15)
Activity Preceding 999 Call (Timeline)	Other Activity = 42% (112) Investigating Cue(s) = 21% (55) Tackling Fire = 20% (53) N/A Called Immediately = 9% (23) Searched For/Got persons = 5% (12) Searched For/Got pets = 3% (8) Searched For/Got items = 1% (2)

Entering RFO, exiting and re-entering the dwelling. Slightly under a third of people were in the RFO when the fire started (Table 19). This is consistent with national fire statistics, where the majority of those injured (89%) were located elsewhere at ignition (Home Office, 2019); note, the national statistics do not provide similar information about the location of non-injured occupants. Of the survey participants who were not in the RFO at the start of the fire, almost three-quarters subsequently entered. Just over half of those who were in the RFO at any point left during the fire. In terms of how close people got to the fire, almost four-fifths of the sample came at least within the same room as it, if not within touching distance.

Half of the sample evacuated the building (i.e. went outside with the intention of staying out until the incident was over), while almost a quarter left temporarily while the incident was still underway (i.e. they knew when exiting the building that they would re-enter). This means that a combined total of 72% of participants exited the building at some point while the incident was still underway (Table 19).

Excluding the participants who left temporarily, of those who evacuated the building, more than a fifth re-entered (Table 19). When combined with the participants who left temporarily, nearly half of all participants who exited the building re-entered the property while the incident was still underway. This means that quite a number of participants got out but did not stay out.

Table 19. Entering RFO, exiting and re-entry

	Percentage and count
Person in RFO at Start	Yes = 29% (122) No = 71% (297)
Entered RFO Later	Yes = 71% (211) No = 29% (86)
In RFO at Any Point	Yes = 80 % (333) No = 21% (86)
Exited RFO	Yes = 56% (186) No = 44% (147)
Closest Person Got to Fire	Touching Distance = 57% (240) Same Room = 22% (93) Same Floor Within Sight = 6% (26) Same Building Different Floor = 6% (25) Same Floor Not Within Sight = 5% (21) Building Between = 3% (14)
Evacuated Building	Yes = 50% (211) No = 28% (115) Left Temporarily = 22% (93)
Re-entered Building (out of the 211 who stated they evacuated)	Yes = 21% (44) No = 79% (166) Missing = 1% (1)
Re-entered Building (the 211 plus the 93 who left temporarily)	Yes = 45% (137) No = 55% (166) Missing = 1% (1)

Summary of results. Given when fires tended to occur, it is perhaps unsurprising that many people were awake, although not all were in a great state of consciousness with some having consumed a substance close to the time the fire started, and a proportion of those reporting that it had impaired them in some way. Most people became aware that something unusual was happening from seeing smoke, and the behaviour of smoke caught many off guard although few felt in the initial moments that it posed them any real risk. When participants became aware of something unusual happening, the most common activity was to investigate the cues. In fact, fire cues tended to act as a catalyst for increased activity, something reflected in seven activities being the median number undertaken. It was observed that most participants tended to undertake a variety of activities that, in general terms, can be put into the following sequence: investigating the cues, tackling the fire (albeit rarely using equipment designed for that task), calling 999, withdrawal, evacuation and re-entry. Indeed, rather than movement away from the fire, most participants' response to an ADF was characterised by movement towards the fire.

Finally, half of participants evacuated the building during an ADF, a figure that becomes somewhat surprising when viewed in the opposite, namely that despite being in a property where a fire was occurring/had just occurred, half of the sample chose not to leave. Among those who did leave, almost half re-entered the property, which means that although quite a few people got out, many did not stay out, returning before it was necessarily safe to do so.

4.2.2 Inferential statistics

Relationships between variables. The next stage of the analysis tested whether there were statistically significant relationships between some of the key peri-event variables examined so far (behaviours including movements) and some key pre-event variables (occupant gender, fire safety knowledge, prior fire experience). These areas were selected due to the emphasis given to them by the early research studies and current fire practitioners and authorities.

The peri-event variables of interest were the following:

1. First activity: investigate cues (no, yes)
2. Entering the RFO (no, yes)
3. Tackling the fire (no, yes)
4. Calling 999 (no, yes)
5. Evacuating the property (no, yes)
6. Re-entry to the property (no, yes)

The first step in this analysis involved testing for a relationship between each of the pre- and peri-event variables independently, using chi-square tests (e.g. one test to investigate whether gender had a significant relationship with investigating cues as a first activity, another test to investigate whether gender had a significant relationship with entering the RFO, and so on). Following that, separate rounds of binary logistic regression analysis were undertaken to examine relationships in more detail, i.e. to test whether the pre-event variables were not only related to but actually predictors of the peri-event variables, and to test whether the effect of those predictors were moderated by other relevant pre-event variables (i.e. test for interactions).

Relationships between gender and behaviours. As described in Section 2.6, behavioural differences between males and females were initially identified in the first work undertaken in the field (Bryan, 1977; Canter, 1990; Wood, 1972). Within the sample studied by Wood it was argued that females were less likely to fight the fire, but more likely to warn others, immediately leave the building, request assistance, and evacuate their family. Regarding evacuation, it was observed that males were less likely than females to leave the building, but more likely to re-enter if they did leave. In summary, Wood's study identified a number of behavioural differences between males and females, with females being more concerned with the safety of people and males being more 'situation-oriented'. Similar observations were made in the study undertaken by Bryan (1977), in which it was found that males showed a greater propensity to engage in behaviour related to fire-fighting – a relationship that was also found to be statistically significant. Among females, a relationship was found with the actions 'call the fire department', 'leave the building' and 'obtain other family members'. This means that in common with Wood, Bryan observed that females were more likely to alert others and exit the property. Canter et al. (in Canter, 1990) went further and asserted that whether a person was male or female was arguably the key determinant of behaviour during a fire, with their study reporting clear differences in behaviour between males and females. In broad terms, gender differences were identified among behaviours undertaken during the early stages of the fire, with females being identified as being more likely to warn others, close the door to the RFO and exit the property. In contrast, males were found to be more likely to fight the fire and take action to control or mitigate it.

However, given the societal changes that have taken place over the past 40 years (for a description of these please refer to Section 2.6.7), it is important to see if these gendered behaviours are still valid. Related to this, the thesis argues that there is a key area in the study of the relationship between gender and behaviour in fire that has not yet been given consideration: this is whether or not any differences exist between males and females when they are alone during an ADF. Although clear gender-based behavioural differences were identified in the early studies, neither that work nor any subsequently has established whether gendered behaviours exist when people are alone or only occur in the presence of others. Consequently, it is important to consider this for three main reasons: firstly to develop a more complete and accurate understanding of any differences in behaviour between males and females; secondly, an understanding of any gender-based differences will be of use to fire crews when assisting members of the public as it will provide additional information during incident planning stages related to the likelihood of occupants still being within a property along with the possibility of them having sustained injuries. With FRS community safety messaging, the identification of continued gender-based differences, either when alone or accompanied, will provide an evidence base to allow fire safety and prevention messages to be tailored to specific groups, thereby increasing their potential effectiveness over more generic forms of messaging.

A total of 34% of participants (n = 144) were alone during the incident. However eight of these participants did not specify their gender, so were excluded from the analysis, thereby reducing the total to 136. There were 275 participants who were accompanied during the incident, but of these, 5 did not specify their gender and so were excluded from the analysis, which reduced the total to 270.

Overall, as Table 20 shows, gender was significantly related to several behaviours, i.e. male participants tended to enter the RFO, tackle the fire and re-enter the building more often than female participants (see Table 20 for statistical results). In contrast, female participants tended to call 999 and exit the building more often than male participants. The proportion of each gender investigating cues as their initial activity was highly similar and so there was no significant relationship there. When broken down by whether participants were alone or accompanied during their ADF, the pattern of frequencies of behaviours displayed by males and females remained, although the gap between the genders tended in most cases to close when participants were alone, and so the differences in that group were less often significant. The main exception was for participants' initial activity, where the gap increased slightly among lone participants (with fewer lone males investigating cues), and closed completely among accompanied participants (with more lone males investigating cues), albeit these changes did not alter the findings significantly.

Table 20. Frequency of behaviours: overall, by gender, and whether alone (significant results highlighted

	Overall (N = 406)			Alone (N = 136)			Accompanied (N = 270)		
Behaviour	**Male (n=128)**	**Female (n=199)**	**Test output**	**Male (n = 38)**	**Female (n = 71)**	**Test output**	**Male (n = 90)**	**Female (n = 128)**	**Test output**
Initial activity investigate cues Yes = 189 No = 138	Yes 56% (n = 72) No 44% (n = 56)	Yes 59% (n = 117) No 41% (n = 82)	χ^2 = 0.21 p = .649 V = .03	Yes 50% (n = 19) No 50% (n = 19)	Yes 59% (n = 42) No 41% (n = 29)	χ^2 = 0.84 p = .359 V = .09	Yes 59% (n = 53) No 41% (n = 37)	Yes 59% (n = 75) No 41% (n = 53)	χ^2 = 0.04 p = .839 V = .01
Behaviour	**Male (N=108)**	**Female (N=180)**	**Test output**	**Male (n = 30)**	**Female (n = 66)**	**Test output**	**Male (n = 78)**	**Female (n = 114)**	**Test output**
Entered RFO Yes = 204 No = 84	Yes 79% (n = 85) No 21% (n = 23)	Yes 66% (n = 119) No 34% (n = 61)	χ^2 = 5.18 p = .023 V = .13	Yes 67% (n = 20) No 33% (n = 10)	Yes 64% (n = 42) No 36% (n = 24)	χ^2 = 0.83 p = .774 V = .03	Yes 83% (n = 65) No 17% (n = 13)	Yes 68% (n = 77) No 32% (n = 37)	χ^2 = 6.00 p = .014 V = .18
Behaviour	**Male (N=155)**	**Female (N=251)**	**Test output**	**Male (n = 46)**	**Female (n = 90)**	**Test output**	**Male (n = 109)**	**Female (n = 161)**	**Test output**
Tackled fire Yes = 211 No = 195	Yes 65% (n = 100) No 35% (n = 55)	Yes 44% (n = 111) No 56% (n = 140)	χ^2 = 15.81 p = <.001 V = .12	Yes 57% (n = 26) No 43% (n = 20)	Yes 43% (n = 39) No 57% (n = 51)	χ^2 = 2.12 p = .145 V = .12	Yes 68% (n = 74) No 32% (n = 35)	Yes 45% (n = 72) No 55% (n = 89)	χ^2 = 14.05 p = <.001 V = .18
Behaviour	**Male (N=155)**	**Female (N=251)**	**Test output**	**Male (n = 46)**	**Female (n = 90)**	**Test output**	**Male (n = 109)**	**Female (n = 161)**	**Test output**
Called 999 Yes = 260 No = 146	Yes 54% (n = 83) No 46% (n = 72)	Yes 71% (n = 177) No 29% (n = 74)	χ^2 = 11.98 p = .001 V = .17	Yes 50% (n = 23) No 50% (n = 23)	Yes 68% (n = 61) No 32% (n = 29)	χ^2 = 4.07 p = .044 V = .17	Yes 55% (n = 60) No 45% (n = 49)	Yes 72% (n = 116) No 28% (n = 45)	χ^2 = 8.28 p = .004 V = .18
Behaviour	**Male (N=155)**	**Female (N=251)**	**Test output**	**Male (n = 46)**	**Female (n = 90)**	**Test output**	**Male (n = 109)**	**Female (n = 161)**	**Test output**
Evacuated building Yes = 207 No = 199	Yes 43% (n = 66) No 57%	Yes 56% (n = 141) No 44%	χ^2 = 7.09 p = .008 V = .13	Yes 46% (n = 21) No 54%	Yes 49% (n = 44) No 51%	χ^2 = 0.13 p = .721 V = .03	Yes 41% (n = 45) No 59%	Yes 60% (n = 97) No 40%	χ^2 = 9.38 p = .002 V = .19

(Excludes left temporarily)	(n = 89)	(n = 110)		(n = 25)	(n = 46)		(n = 64)	(n = 64)	
Behaviour	**Male (N=103)**	**Female (N=193)**	**Test output**	**Male (n = 27)**	**Female (n = 62)**	**Test output**	**Male (n = 76)**	**Female (n = 131)**	**Test output**
Re-entered building Yes = 134 No = 162 (Includes those who left temporarily)	Yes 58% (n = 60) No 42% (n = 43)	Yes 38% (n = 74) No 62% (n = 119)	χ^2 = 10.75 p = .001 V = .19	Yes 52% (n = 14) No 48% (n = 13)	Yes 37% (n = 23) No 63% (n = 39)	χ^2 = 1.67 p = .194 V = .14	Yes 61% (n = 46) No 39% (n = 30)	Yes 39% (n = 51) No 61% (n = 80)	χ^2 = 9.01 p = .003 V = .21

Whether gender predicts behaviours. To test for statistically significant predictors of behaviours, a series of binary logistic regression tests were conducted. In each model, the behaviour was the dependent variable, while Gender (male, female), Alone (no, yes) and the interaction term Gender*Alone were entered as independent (predictor) variables. The findings from the regression analysis (Table 21) showed that occupant gender was a significant predictor of several behaviours. More specifically, being female, as opposed to male, decreased the odds of entering the RFO, tackling the fire and re-entering the property but increased the odds of calling 999 and evacuating. Being alone was not found to be a significant predictor of any of these behaviours. Furthermore, neither gender nor being alone was a significant predictor of investigating cues as the initial activity. Lastly, there were no significant interactions between gender and being alone in terms of predicting the behaviours. This means that the observed gendered behaviours remained the same when controlled for whether participants were alone or accompanied.

Table 21. Regression output for predicting behaviours (significant results highlighted)

	Gender		**Alone**		**Gender*Alone**	
Behaviour	**p**	**OR**	**p**	**OR**	**p**	**OR**
Initial activity: investigate cues	.965	0.99	.355	0.70	.436	1.47
Entered RFO	.016	0.42	.063	0.40	.208	2.10
Tackled fire	<.001	0.38	.178	0.62	.337	1.54
Called 999	.004	2.11	.565	0.82	.999	1.00
Evacuated building (n = 207, excludes left temporarily)	.002	2.16	.616	1.20	.149	0.53
Re-entered building (out of everyone who exited, n = 134)	.003	0.42	.433	0.70	.618	1.32

Summary of results. From the above analysis, significant predictors were identified for a majority of the behaviours that were examined (i.e. five out of the six). These results are summarised in Table 22.

Table 22. Summary of results of regression analysis on activities undertaken and gender

Activity	**Males**	**Females**	**Gender*Alone interaction**
Investigate cues	Same likelihood as females	Same likelihood as males	No interaction
Enter RFO	More likely to enter	Less likely to enter	No interaction
Tackle fire	More likely to tackle	Less likely to tackle	No interaction
Call 999	Less likely to call 999	More likely to call 999	No interaction
Evacuate property	Less likely to evacuate	More likely to evacuate	No interaction
Re-enter property	More likely to re-enter	Less likely to re-enter	No interaction

The analysis showed that being alone during the fire was not a significant predictor of any of the six behaviours. Furthermore, no significant interaction effects were observed between gender and being alone. This means that while there were some gender differences in the incidence of different behaviours, these gender differences were not dependent on whether participants were alone or not during the fire.

In summary, the overriding impression from this analysis is that gender remains as important today as it was found to be several decades ago in the original studies. Moreover, the direction of the gender-based behaviour observed here is consistent with the observations made by Wood, Bryan and Canter et al. about the propensity towards different behaviours between males and females during a dwelling fire. It is important to highlight that the analysis undertaken for this thesis introduced an additional focus that does not appear to have been considered before – specifically the need to examine the influence upon behaviours of being alone or in the company of others. However, it was found that irrespective of whether they were alone or not, males were still more likely to approach and tackle the fire as well as re-enter the property, while females were more likely to seek safety by calling 999 and leaving the building. However, behaviours can be said to be somewhat nuanced due to the fact it was observed that males and females were just as likely to investigate cues as a first activity, irrespective of whether they were alone or not. This is interesting as it again serves to underscore just how instinctive the desire to investigate the source of the fire cues is, regardless of gender. This is a finding that has some ramifications for FRS policy; these will be discussed in Section 5.

Relationships between knowledge/training, experience and behaviours. As well as gender, each of the three early studies (Bryan, 1977; Canter et al., 1990; Wood, 1972) looked at whether any relationship existed between the actions people undertook during the fire and having knowledge/training and or prior experience of a fire. Wood found that those individuals who had previously been involved in a fire were less likely to leave the building, but also more likely to re-enter if they did leave. Also, compared to individuals with some fire safety training, a greater proportion of those with no training left the building. Bryan reported that those without training were more likely to undertake the actions 'obtained other family members' and 'went to the fire area' while those with training were more likely to undertake the action 'got extinguisher'. No statistically significant differences were found in the first actions of those participants who had or had not experienced a fire previously. Finally Canter et al. admitted surprise that a clear relationship was not found between firefighting and frequency of fire safety training. Because of this they argued that it was an area where further research is needed. Interestingly, Canter et al. did find that prior experience was associated with people being less likely to leave immediately, more likely to tackle the fire and more likely to re-enter the property. Additionally those with prior experience were not any more likely to act in a way that follows established fire safety advice, for example calling 999. So, unlike for gender, where the results of these three studies were largely in accordance with each other, the results around fire safety knowledge/training were a little more mixed. However, for prior experience, it can reasonably be hypothesised that those with experience will be less likely to evacuate and more likely to re-enter.

From the LIFEBID survey data, along with prior fire experience, a total of seven fire safety knowledge sources were specified, plus one miscellaneous category (see Section 4.1). Of these seven, two may be considered to represent structured and credible sources of knowledge and or training. The first was the participant's profession, defined as a current or previous job in an area related to fire safety. The second was the workplace, i.e. not one directly in a fire safety-related area, but one where the participant had received fire safety training. As shown in Table 23, no significant relationships were found between professional or workplace knowledge and behaviours except in one case: those who had workplace knowledge investigated the cues with a significantly greater frequency than those who did not. For prior fire experience, those with experience tackled the fire significantly more frequently than those without, while they called 999 and evacuated significantly less frequently. Prior fire experience was not significantly related to re-entry.

Table 23. Frequency of behaviours: by professional knowledge, workplace knowledge and prior fire experience (significant results highlighted)

	Professional Knowledge			**Workplace Knowledge**			**Prior Fire Experience**		
Behaviour	**Have (N = 33)**	**Do not have (N = 304)**	**Test Output**	**Have (N = 224)**	**Do not have (N = 113)**	**Test Output**	**Have (N = 79)**	**Do not have (N = 258)**	**Test Output**
Initial activity: investigate cues Yes = 192 No = 145	Yes 55% (n = 18) No 45% (n = 15)	Yes 57% (n = 174) No 43% (n = 130)	χ2 = 0.88 p = .767 V = .02	Yes 62% (n = 139) No 38% (n = 85)	Yes 47% (n = 53) No 53% (n = 60)	χ2 = 7.03 p = .008 V = .14	Yes 51% (n = 40) No 49% (n = 39)	Yes 59% (n = 152) No 41% (n = 106)	χ2 = 1.69 p = .193 V = .07
Behaviour	**Have (N = 29)**	**Do not have (N = 268)**	**Test Output**	**Have (N = 205**	**Do not have N = 92)**	**Test Output**	**Have (N = 71)**	**Do not have (N = 226)**	**Test Output**
Entered RFO Yes = 211 No = 86	Yes 72% (n = 21) No 28% (n = 8)	Yes 71% (n = 190) No 29% (n = 78)	χ2 = 0.03 p = .864 V = .01	Yes 74% (n = 151) No 26% (n = 54)	Yes 65% (n = 60) No 35% (n = 32)	χ2 = 2.20 p = .286 V = .06	Yes 76% (n = 54) No 24% (n = 17)	Yes 70% (n = 157) No 30% (n = 69)	χ2 = 1.14 p = .286 V = .06
Behaviour	**Have (N = 44)**	**Do not have (N = 375)**	**Test Output**	**Have (N = 276)**	**Do not have (N = 143)**	**Test Output**	**Have (N = 100)**	**Do not have (N = 319)**	**Test Output**
Tackled fire Yes = 220 No = 199	Yes 57% (n = 25) No 43% (n = 19)	Yes 52% (n = 195) No 48% (n = 180)	χ2 = 0.37 p = .545 V = .03	Yes 54% (n = 148) No 46% (n = 128)	Yes 50% (n = 72) No 50% (n = 71)	χ2 = 0.41 p = .525 V = .03	Yes 63% (n = 63) No 37% (n = 37)	Yes 49% (n = 157) No 51% (n = 162)	χ2 = 5.80 p = .016 V = .12
Behaviour	**Have (N = 44)**	**Do not have (N = 375)**	**Test Output**	**Have (N = 276)**	**Do not have (N = 143)**	**Test Output**	**Have (N = 100)**	**Do not have (N = 319)**	**Test Output**
Called 999 Yes = 265 No = 154	Yes 55% (n = 24) No 45% (n = 20)	Yes 64% (n = 241) No 36% (n = 134)	χ2 = 1.60 p = .206 V = .06	Yes 66% (n = 181) No 34% (n = 95)	Yes 59% (n = 84) No 41% (n = 59)	χ2 = 1.90 p = .169 V = .07	Yes 47% (n = 47) No 53% (n = 53)	Yes 68% (n = 218) No 32% (n = 101)	χ2 = 14.91 p = <.001 V = .19
Behaviour	**Have (N = 44)**	**Do not have (N = 375)**	**Test Output**	**Have (N = 276)**	**Do not have (N = 143)**	**Test Output**	**Have (N = 100)**	**Do not have (N = 319)**	**Test Output**
Evacuated building Yes = 211 No = 208 (Excludes left temporarily)	Yes 48% (n = 21) No 52% (n = 23)	Yes 51% (n = 190) No = 49% (n = 185)	χ2 = 0.14 p = .712 V = .02	Yes 54% (n = 150) No 46% (n = 126)	Yes 43% (n = 61) No 57% (n = 82)	χ2 = 1.90 p = .169 V = .07	Yes 38% (n = 38) No 62% (n = 62)	Yes 54% (n = 173) No 46% (n = 146)	χ2 = 8.02 p = .005 V =.14

Behaviour*	Have (N = 28)	Do not have (N = 275)	Test Output	Have (N = 208)	Do not have (N = 95)	Test Output	Have (N = 60)	Do not have (N = 243)	Test Output
Re-entered building Yes = 137 No = 166 (Of all 304 who exited)	Yes 39% (n = 11) No 61% (n = 17)	Yes 46% (n = 126) No 54% (n = 149)	$\chi2 = 0.44$ $p = .508$ $V = .04$	Yes 44% (n = 92) No 56% (n = 116)	Yes 47% (n = 45) No 53% (n = 50)	$\chi2 = 0.26$ $p = .611$ $V = .03$	Yes 48% (n = 29) No 52% (n = 31)	Yes 44% (n = 108) No 56% (n = 135)	$\chi2 = 0.29$ $p = .588$ $V = .03$

**One participant who evacuated did not state whether they re-entered or not, hence the crosstabulations totalling 303*

Whether knowledge/training and experience predict behaviours. A series of binary logistic regression tests were again conducted, with the same behaviours as before used as the dependent variables. Professional Knowledge (no, yes), Workplace Knowledge (no, yes) and Prior Fire Experience (no, yes) were entered as predictor variables. There was no hypothesis that these predictor variables would be moderated by any other pre-event variables and so no interaction terms were included here. The findings from the regression analysis (Table 24) showed that professional knowledge was not a significant predictor of any of the behaviours. However, workplace knowledge was a significant predictor of investigating cues, entering the RFO and evacuating, i.e. having gained fire safety knowledge from one's workplace, as opposed to not having gained knowledge from this source, increased the odds of engaging in these three behaviours. So, the regression analysis differed slightly from the chi-square analysis here; that is, when controlling for all other predictor variables, workplace knowledge was now revealed to have more relationships with behaviours than had first appeared. Lastly, prior fire experience was a significant predictor of three behaviours. In other words, compared to having no prior experience, having experience increased the odds of tackling the fire but decreased the odds of calling 999 and evacuating.

Table 24. Regression output for predicting behaviours (significant results highlighted)

	Professional Knowledge		**Workplace Knowledge**		**Prior Fire Experience**	
Behaviour	**p**	**OR**	**p**	**OR**	**p**	**OR**
Initial activity: investigate cues	.717	0.87	.010	1.84	.287	0.76
Entered RFO	.938	0.97	.013	1.50	.274	1.42
Tackled fire	.820	1.08	.445	1.17	.017	1.76
Called 999	.397	0.76	.215	1.31	<.001	0.43
Evacuated building	.896	0.96	.033	1.57	.008	0.53
Re-entered building	.433	0.72	.624	0.89	.459	1.25

Summary of results. A variety of influences were found between activities undertaken and types of knowledge and experience. The results of the analysis show that whether fire safety knowledge was a predictor of behaviours or not depended upon the source or type of that knowledge (Table 25). The possession of professional knowledge (e.g. gained through being or having been a practising fire safety engineer or firefighter) did not influence the key behaviours undertaken during a fire. However in certain areas workplace knowledge did, as participants with workplace knowledge (e.g. gained through participating in fire drills or health and safety training) were found to be significantly more likely to investigate the cues, enter the RFO and evacuate. Prior experience of a fire was also found to be a predictor of certain behaviours. In fact, it was observed that those participants who had prior fire experience were actually more likely to engage in risk-taking behaviours. Specifically, they were more likely to tackle the fire, less likely to call 999 and less likely to evacuate the property during the fire, although they were no more likely to re-enter the property (as had been hypothesised).

Table 25. Summary of results of regression analysis on activities undertaken and types of knowledge and experience

Activity	Professional Knowledge	Workplace Knowledge	Prior Fire Experience
Investigate cues	No main effect	More likely to investigate	No main effect
Enter RFO	No main effect	More likely to enter	No main effect
Tackle fire	No main effect	No main effect	More likely to tackle fire
Call 999	No main effect	No main effect	Less likely to call 999
Evacuate property	No main effect	More likely to evacuate	Less likely to evacuate
Re-enter property	No main effect	No main effect	No main effect

The focus on analysing gender, knowledge/training and experience is not to suggest that these occupant variables are the only factors that will exert an influence on key behaviours during an ADF – indeed, it is conceivable that other factors (such as fire size) may exert a greater effect on whether people, say, leave or remain in the property – but that these variables were looked at because they had been identified and examined in the early studies and are still of interest today. These findings are important for the community safety work of FRSs as they will further help to inform and tailor fire safety messaging and campaigns. They are also important for fire safety training courses in the workplace as they appear to be influential source and so could provide useful information to address behaviours that may increase the risk of injury. These points will be discussed further in Section 6.

4.3 SMOKE ALARMS AND OCCUPANT BEHAVIOURS

4.3.1 Introduction

In Section 4.2 it was reported that observing smoke was most frequently cited as the cue that alerted people that something unusual was occurring; second and third were smelling smoke and hearing an alarm. These results therefore raise questions about the role smoke alarms realistically play in ADFs. Because of the importance of smoke alarms to fire prevention and home fire safety campaigns, at both the national and individual FRS level, analysis was undertaken looking mainly at smoke alarms and behaviours (on the assertion in fire safety campaigns that people will hear a smoke alarm sounding and, in response, evacuate the property). These areas were explored to see whether people do indeed avoid approaching and coming into proximity with the fire (i.e. are less likely to investigate the cues, enter the RFO, come within touching distance of the fire, tackle the fire) when an alarm sounds or, more specifically, when an alarm is the first cue to alert them to the fire. This analysis also served as a useful insight into whether the presence of a functioning alarm during a fire causes people to behave differently from when other fire cues are the first means of alert.

4.3.2 Relationship between a smoke alarm sounding and fire size

Before looking at alarms and their impact on occupant behaviour, the analysis first turned attention to alarms and their relation to the fire itself. Alarms sounding may not have been the first cue to the fire for the majority of participants but alarms should nonetheless be activated by the presence of a fire, particularly a larger fire which would be producing greater quantities of smoke as well as flames. To identify whether there was a relationship between larger fires and a smoke alarm sounding, the incidence of the alarm sounding was compared across different groups of fire size (i.e. the five Fire Damage Spread categories; see Section 4.1.4). It was observed that, for fires that had grown beyond the ignited item, alarms more often sounded than did not (Table 26). Notable scenarios were fires that remained restricted to the ignited item. There, in contrast to other scenarios, an alarm was less likely to sound. As mentioned earlier (Section 4.1.3), alarms most often did not sound due to being located somewhere where the fire could not be detected and (in Section 4.1.4) kitchens were most often the RFO. As the general advice is not to site smoke alarms in a kitchen (due to the heightened risk of false alarms caused by burnt food during cooking), this finding is logical. However, even if a fire is relatively smaller and it is just the original item that has been ignited, the fire will still be producing hazardous products such as smoke within its vicinity and anyone entering that vicinity will therefore be exposed to that. This is the intended purpose of alarms: they are supposed to detect the fire early on, when the quantity of hazardous products is more minimal, and then prompt occupants to remove themselves, out of harm's way.

Table 26. Crosstabulation of smoke alarm sounding and fire size

	Fire Size				
Alarm Behaviour (N = 339)	**Restricted to Ignited Item (n = 146)**	**Restricted to RFO (n = 96)**	**Spread Across Floor of RFO (n = 57)**	**Spread Across Building (n = 36)**	**Spread Into Other Building(s) (n = 4)**
Alarm Sounded (n = 165)	34% (n = 50)	61% (n = 59)	53% (n = 30)	67% (n = 24)	50% (n = 2)
Alarm Did Not Sound (n = 174)	66% (n = 96)	39% (n = 37)	47% (n = 27)	33% (n = 12)	50% (n = 2)

4.3.3 Smoke alarms as a cue to alert occupants

If an alarm does not sound initially, there are other cues that could possibly alert occupants to the presence of a fire, either in addition to the hazardous fire products being emitted or instead of them. To examine the relative contribution of the different types of fire cue, the cues that first made participants aware that something unusual was happening (this is distinct from the whole range of cues participants experienced during the fire, as during the course of a fire many participants would have experienced a variety of cues) were sorted into three categories: social cues (e.g. being directly informed by someone, or noticing unusual activity from people or pets); physical cues (e.g. seeing smoke and or flames, smelling smoke and or burning, feeling heat, seeing a power failure, hearing the sounds of fire, hearing the sirens of the emergency services); and a smoke alarm. As Table 27 shows, a similar proportion of the sample were alerted by social cues and by a smoke alarm, while a much larger proportion were alerted by physical cues. So, occupants may not be able to rely on other cues to provide an alert before an encounter with hazards such as smoke; that is, just as alarms were an infrequent means of alerting the participants in this sample, so too were social cues such as being informed by someone that there is a fire. Physical cues were four times more likely to alert participants than these other means.

Table 27. Cues that alerted participants

Type of Cue (N = 369)	**Percentage alerted by each cue and count**
Social	16% (n = 58)
Physical	68% (n = 250)
Smoke alarm	17% (n = 61)

4.3.4 Relationship between smoke alarm sounding and investigating as a first activity

When the proportions of participants who investigated the fire cues as a first activity was looked at against whether an alarm sounded vs. did not, they were found to be similar. That is, in both cases, over half investigated the cues (Table 28). Being so close, it was not surprising that no statistically significant difference was found between the proportions. Although this variable offers no information about exactly when the alarm had sounded (for example, it may have sounded after a participant investigated the cues), it nonetheless offers a useful indicator about how a sounding smoke alarm did not appear to significantly reduce the proportion of people who investigated the cues of a fire.

Table 28. Crosstabulation of smoke alarm sounding and investigating as a first activity

	First Activity: Investigate Cues		
Alarm Behaviour	**Yes**	**No**	**Test Output**
Alarm Sounded (n = 137)	56% (n = 77)	44% (n = 60)	$\chi^2(1) = 0.40$ $p = .528$ $V = .04$
Alarm Did Not Sound (n = 152)	60% (n = 91)	40% (n = 61)	

Because the above test gave no indication of whether the alarm sounding was the first cue that alerted people (meaning an alarm could have sounded in the background at any point during the fire and potentially after a participant was already aware of the fire), the incidence of investigating the cues as a first activity was examined alongside whether a smoke alarm was the first cue that had alerted participants.

Interestingly, among those first alerted by an alarm, the proportion who investigated the cues as a first activity was greater than for those who were first alerted by other means (Table 29). However, this association was not found to be statistically significant. Nevertheless, it would appear that being first alerted to a fire by a smoke alarm does not actually dissuade or discourage people from investigating the fire.

Table 29. Crosstabulation of smoke alarm as first cue and investigating as a first activity

	First Activity: Investigate Cues		
Cue Type	**Yes**	**No**	**Test Output**
Alarm First Cue (n = 49)	67% (n = 33)	33% (n = 16)	$\chi^2(1) = 2.52$
Alarm Not First Cue (n = 288)	55% (n = 159)	45% (n = 129)	$p = .113$ $V = .09$

4.3.5 Relationship between social cues and investigating as a first activity

A similar test was run to investigate whether social cues, specifically being directly informed of the fire by someone, had a better influence on participants' first activity, even if that occurred less frequently. When the proportions of participants whose first activity was to investigate the cues was examined alongside whether the first cue for those participants was being alerted by someone vs. being alerted by other means, the proportions were found to be similar; i.e. in both cases, over half investigated the cues (Table 30). Unsurprisingly, the proportions were not found to be statistically significantly different. So while smoke alarms might not prompt people to immediately move away from the fire to a place of safety, it would appear that, in an ADF, being directly informed of a fire by someone is also unlikely to prompt such withdrawal. This result then serves as yet another example of how common investigating the fire cues is as a first activity.

Table 30. Crosstabulation of being alerted by someone and investigating as a first activity

	First Activity: Investigate Cues		
Cue Type	**Yes**	**No**	**Test Output**
Informed First Cue (n = 47)	53% (n = 25)	47% (n = 22)	$\chi^2(1) = 0.32$
Informed Not First Cue (n = 290)	58% (n = 167)	42% (n = 123)	$p = .572$ $V = .03$

4.3.6 Relationship between being woken by an alarm and investigating as a first activity

One situation where a smoke alarm might possibly be more effective in keeping occupants away from the fire is when occupants are asleep initially. In such a situation, they are likely to be located further away from the RFO, perhaps not fully dressed, and the fire might have been burning for longer and thus the environment could be more hazardous. So, upon awaking to an alarm sounding, occupants might be more inclined to undertake activities other than investigating the cue, such as calling the FRS, warning others in the building, gathering clothes/belongings, and so forth. While this is an intuitive hypothesis, the timeline data did not support it (Figure 18). Here it was found that, irrespective of whether participants were initially asleep or awake, when first alerted by a smoke alarm, a nearly identical proportion – just over two-thirds – investigated the fire cues as their first activity. Consequently, it would appear that a smoke alarm sounding does not cause people to behave in a different way as part of their initial response to the cue, and it certainly does not appear to result in people moving away from the fire.

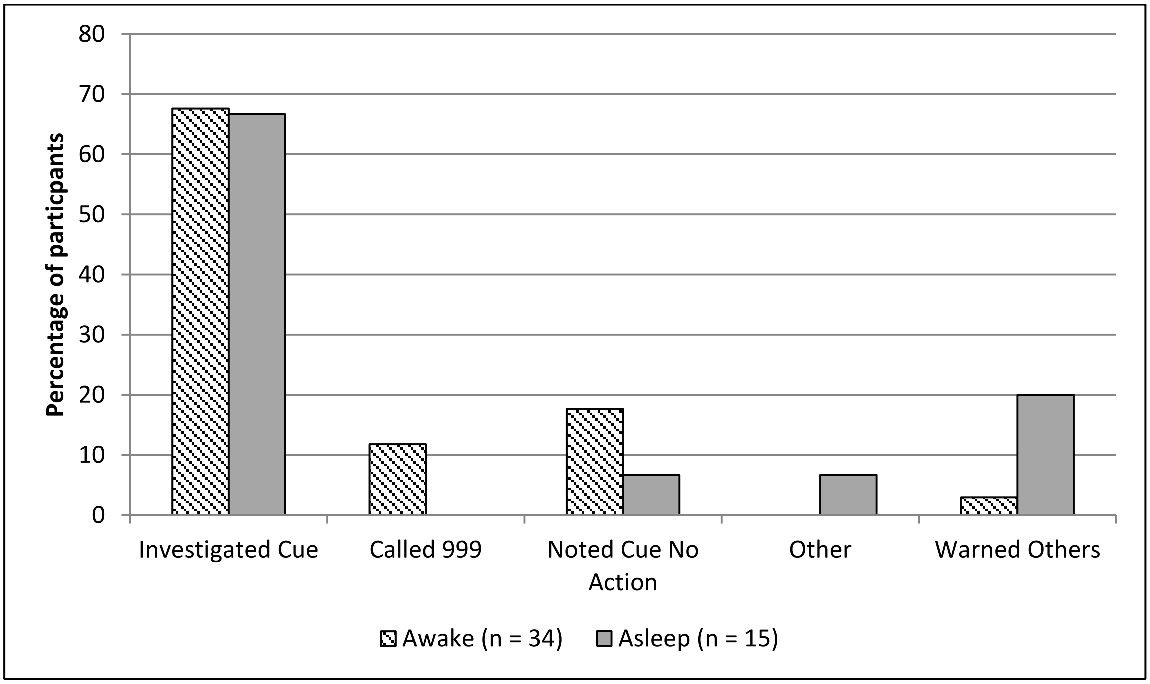

Figure 18. First activity undertaken by participants who were alerted by a smoke alarm.

4.3.7 Relationship between a smoke alarm sounding and proximity to the fire

This point about movement in relation to the fire was examined next: i.e. what was the closest that participants came to the fire (proximity to the fire) when an alarm sounded? As Table 31 shows, the proportion who came within touching distance of the fire was actually somewhat higher when an alarm had sounded than when one had not, although this was not a statistically significant difference. Again, this suggests that a smoke alarm sounding does not discourage people from approaching a fire.

Table 31. Crosstabulation of smoke alarm sounding and coming within touching distance

	Proximity to Fire: Touching Distance		
Alarm Behaviour	**Yes**	**No**	**Test Output**
Alarm Sounded (n = 165)	61% (n = 100)	39% (n = 65)	$\chi^2(1) = 2.79$ $p = .095$ $V = .09$
Alarm Did Not Sound (n = 180)	52% (n = 93)	48% (n = 87)	

However, as already mentioned, this Alarm Sounded variable simply provides confirmation of the fact that the alarm sounded at some point during the fire; participants could already have been in close proximity to the fire before the alarm sounded. To investigate this further, instances of entering the RFO (where occupants were outside of the RFO at the start but subsequently chose to enter) was examined against instances where a smoke alarm or something else was the cue that first alerted people. As Table 32 shows, when a smoke alarm was the first cue, the incidence of entering the RFO was similar to when participants had been alerted by other cues, i.e. both quite high, and was not found to be statistically significantly different. In other words, being alerted by a smoke alarm did not cause people to behave differently in this regard and did not discourage people from approaching the fire.

Table 32. Crosstabulation of smoke alarm as first cue and entering the RFO

	Proximity to Fire: Entered RFO		
Cue Type	**Yes**	**No**	**Test Output**
Alarm First Cue (n = 53)	68% (n = 36)	32% (n = 17)	$\chi^2(1) = 0.31$ $p = .581$ $V = .32$
Alarm Not First Cue (n = 244)	72% (n = 175)	28% (n = 69)	

4.3.8 Relationship between a smoke alarm sounding and tackling the fire

Lastly, the influence of a smoke alarm was investigated in relation to instances of tackling the fire. As can be seen in Table 33, the proportion of participants who tackled the fire when an alarm sounded vs. did not were similar (around half), and not found to be statistically significantly different. So once more, the presence of a functioning smoke alarm did not discourage people to keep away from the fire.

Table 33. Crosstabulation of smoke alarm sounding and tackling the fire

	Tackled Fire		
Alarm Behaviour	**Yes**	**No**	**Test Output**
Alarm Sounded (n = 165)	55% (n = 90)	46% (n = 75)	$\chi^2(1) = 0.90$ $p = .344$ $V = .05$
Alarm Did Not Sound (n = 180)	49% (n = 89)	51% (n = 91)	

In case the smoke alarm could have sounded after participants had started to tackle the fire, the instance of tackling the fire where a smoke alarm was the cue that first alerted people was also examined (Table 34). This showed that when a smoke alarm was the cue that first alerted participants to the fire, the incidence of tackling the fire was comparable to when participants were alerted by other cues (again around 50%), and not statistically significantly different. This further emphasises the point that being alerted to a fire by a smoke alarm does not actually discourage people to keep away from the fire.

Table 34. Crosstabulation of smoke alarm as first cue and tackling the fire

	Tackled Fire		
Cue Type	**Yes**	**No**	**Test Output**
Alarm First Cue (n = 61)	49% (n = 30)	51% (n = 31)	$\chi^2(1) = 0.32$ $p = .574$ $V = .03$
Alarm Not First Cue (n = 358)	53% (n = 190)	47% (n = 168)	

4.3.9 Summary

Alarms tended to sound more frequently in cases where the fire had grown beyond the item that first ignited. When the fire was restricted to the item first ignited, it was more often the case that an alarm did not sound. Further analysis showed that, in the absence of an alarm sounding initially, other types of cue such as social cues were also unlikely to be the ones to alert participants; physical cues, including the sight of smoke, were far more likely to be the means by which participants were alerted. This suggested then that a lot of participants were being exposed to fire products which could prove harmful to them. Smoke alarms are designed to avoid this kind of situation. Thus, the analysis went on to probe what happened when an alarm did sound versus when one did not: were participants more likely to avoid coming into close contact with and or engaging with the fire when an alarm sounded? It was observed that even if a smoke alarm did its job in the sense of being the first cue to alert people to a fire, it did not additionally dissuade or discourage people from investigating fire cues, entering the RFO, coming within touching distance of the fire, and tackling the fire. Thus, looked at another way, a functioning smoke alarm does not make people any more likely to behave in a manner that is consistent with current fire safety advice of first getting out of the building. Moreover, this was found to hold true whether participants were awake or asleep initially – those who were asleep and woken by a smoke alarm sounding were just as likely to first go and investigate the cause of the alarm sounding as those who were already awake. Indeed, it can been seen that the desire to first investigate the source of fire cues is a deeply ingrained response, irrespective of the type of cue that alerts people (and this includes other warnings such as being directly informed by someone that there is a fire). Thereby it could be asserted that a person's propensity to undertake certain behaviours is not moderated by the presence of a smoke alarm sounding. Consequently, there needs to be a debate about the degree to which smoke alarms can continue to be assumed to be agents of behavioural change.

4.4 INJURIES

4.4.1 Introduction

The main risk factors in the profile for ADF deaths are well-established within the literature. Those who are identified as being over-represented in dwelling fire fatalities are: the young and the old (those aged under five years and equal to or over 65 years respectively); males; those who have a physical or cognitive impairment; those who undertake or engage in behaviour which is likely to limit their ability to recognise and or respond to a fire (generally speaking the consumption of alcohol or recreational drugs); those who live in social isolation; smokers; and those living in areas of deprivation (Brennan, 1998; Brennan and Thomas, 2001; Flynn, 2010; Marshall et al., 1998; New Zealand Fire Service Commission, 2005; Sekizawa, 2005a; Sekizawa, 2015; Squires and Bustil, 1996; Thompson et al., 2018).

Given that the very young and the old are more likely to die in ADFs, age is clearly an important factor within the profile of fatal fires. For this reason it is also arguably the single most important factor in the risk profiling undertaken by FRSs as part of their fire prevention activities. Those who are aged 65+ (this cut off is used by FRSs due to its traditional association with the male retirement age in the UK) are defined as being at greater risk of being injured and dying in an ADF (CFOA, 2011; Scottish Fire and Rescue Service, 2016). Consequently, age (particularly participants aged 65+) is the focus of a range of inferential statistical analysis here. The analysis here also follows up on a variable considered in Section 4.3 in relation to behaviours: i.e. smoke alarms.

Firstly, it is important to describe how injury data were collected and the distinctions between these types of injury data, before looking at the injury profile of this sample and the circumstances of their instances of injury. Of the 419 completed surveys, 134 participants (32%) stated that they had incurred injuries. Of these 134 injured participants, 115 experienced one injury and 19 experienced more than one injury (either different types of injury or the same injury type occurring more than once). It is for this reason that, at 153, the number of injuries is greater than the number of injured participants. These data were collected through a 'yes/no' question in the LIFEBID survey about being injured with a follow-up question allowing participants to indicate the type of injury or injuries they received. The three injury type categories were smoke inhalation, burn, and other. A smoke inhalation injury is one that occurs through being exposed to and breathing in smoke, with the products of combustion (gases, vapours and or particles) within that causing harm. In a fire, a burn injury is one that occurs through exposure to extreme heat, or contact with a flame or very hot object, which results in harm. The last injury type category, other, covers a variety of fire-related injuries (excluding smoke inhalation and burns), which occur through the presence of such things as physical impact or sudden and severe stress, and result in harm (e.g. fractures, shock, trauma).

Of the 134 injured participants, 106 went on to complete the timeline which provided data on when in the sequence of events their injury was incurred and the activity being undertaken when that injury was incurred. This allowed the author of this thesis to be able to investigate the timing and sequence of injuries. All analysis referencing the type of injury that was first incurred is based on coded data from the 106 participants who completed the timeline. This timeline data forms the basis of the analysis reported in sections that follow (timing of first injury and activity undertaken when first injury was incurred).

This means that in terms of injury data, there are three key figures to bear in mind: 134, which is the number of injured participants; 153, which is the number of instances of injury; and 106, which is the number of injured participants who completed the timeline, thereby providing data on the timing of their injuries (along with the type of injury itself). Where appropriate, analysis was undertaken variously on all three of these areas and, to ensure clarity, the specific area being discussed is always identified for the reader.

4.4.2 An overview of the injury profile

Overall, just under a third of participants sustained an injury (32%, n = 134; uninjured n = 285). The proportion of each gender that was injured was found to be identical with 32% of both males and females being injured. Regarding injury type for all instances of injury (n = 153), the majority of injuries were smoke inhalation (72%, n = 110), with 'other' injuries comprising less than a fifth of all injuries (14%, n = 22). Burns made up the remaining 14% (n = 21).

Concerning the type of treatment given, over two-fifths of those injured received no treatment (43%) while slightly under a third received first aid at the scene (28%), 14% went to hospital but were discharged the same day, and 3% were kept in overnight (Figure 19). The remainder comprised no treatment at the scene but visited a doctor later (3%), specialist care unit (1%), and not specified (7%).

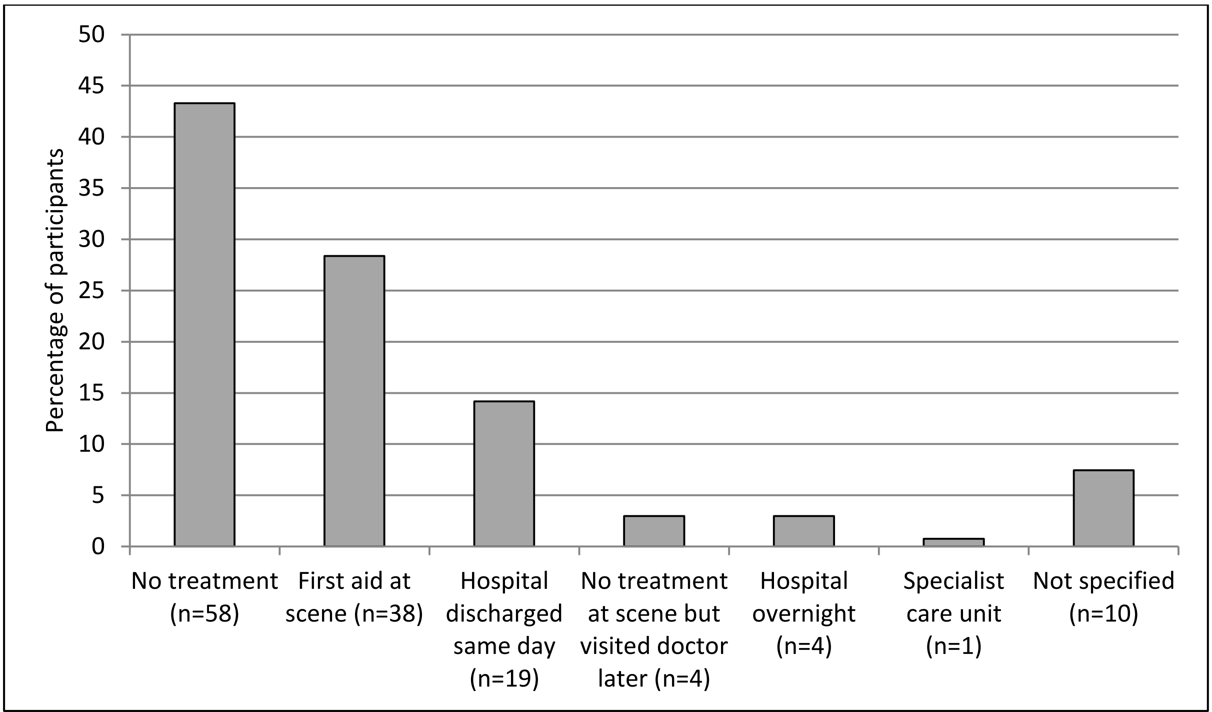

Figure 19. Type of treatment given

The types of treatment participants received were used to determine the severity of participants' injuries. To do this a three-level scale of injury severity was adopted: minor, moderate and severe. When the severity of injuries is looked at, the data show that 75% were minor injuries (n = 100, treatment received was: first aid at scene, visited doctor later, or no treatment), 14% moderate injuries (n = 19, treatment received was: hospital same day), 4% severe injuries (n = 5, treatment received was: hospital overnight, specialist care unit) and 7% not specified (n = 10).

An examination of the severity of the different injury types themselves shows that burn injuries were characterised by a more serious injury profile when compared to smoke inhalation injuries and the category 'other injuries'. It is important to re-state here that participants were able to select more than one answer, hence the total number of injuries (n = 153) is larger than the number of injured participants (n = 134). Burns (n = 21) had the greatest proportion of severe and moderate injuries and the lowest proportion of minor injuries of all three injury types; 52% (n = 11) of all burn injuries (n = 21) were either moderate or severe compared to just 16% (n = 18) of all smoke inhalation injuries (n = 110) and 9% (n = 2) of other injuries (n = 22) (Figure 20).

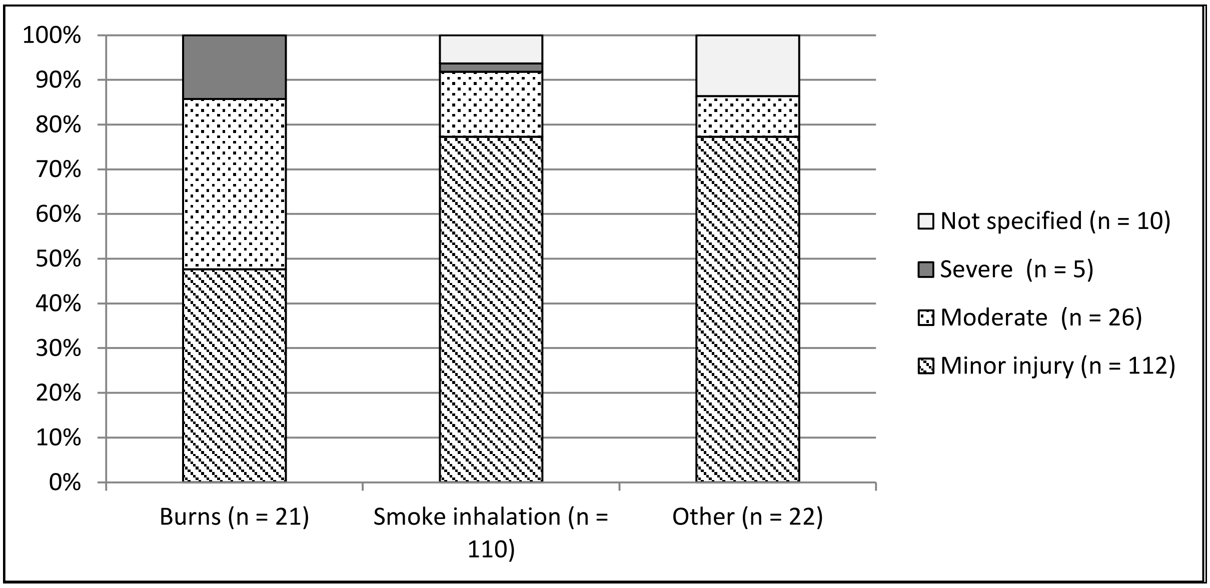

Figure 20. The proportions of severity within each type of injury

4.4.3 Timing of first injury

The timeline data from the survey allowed analysis to be undertaken on: the activity undertaken at the first instance of injury, the timing of participants' injuries, and the types of injury incurred. Looking initially at the timing of first injury, 106 participants provided data on when their first injury was incurred. Of these, three-fifths (n = 64) of all first instances of injury occurred during the first or second activity participants were undertaking (Figure 21). This means that, overall, people got injured at the start of their involvement with the fire.

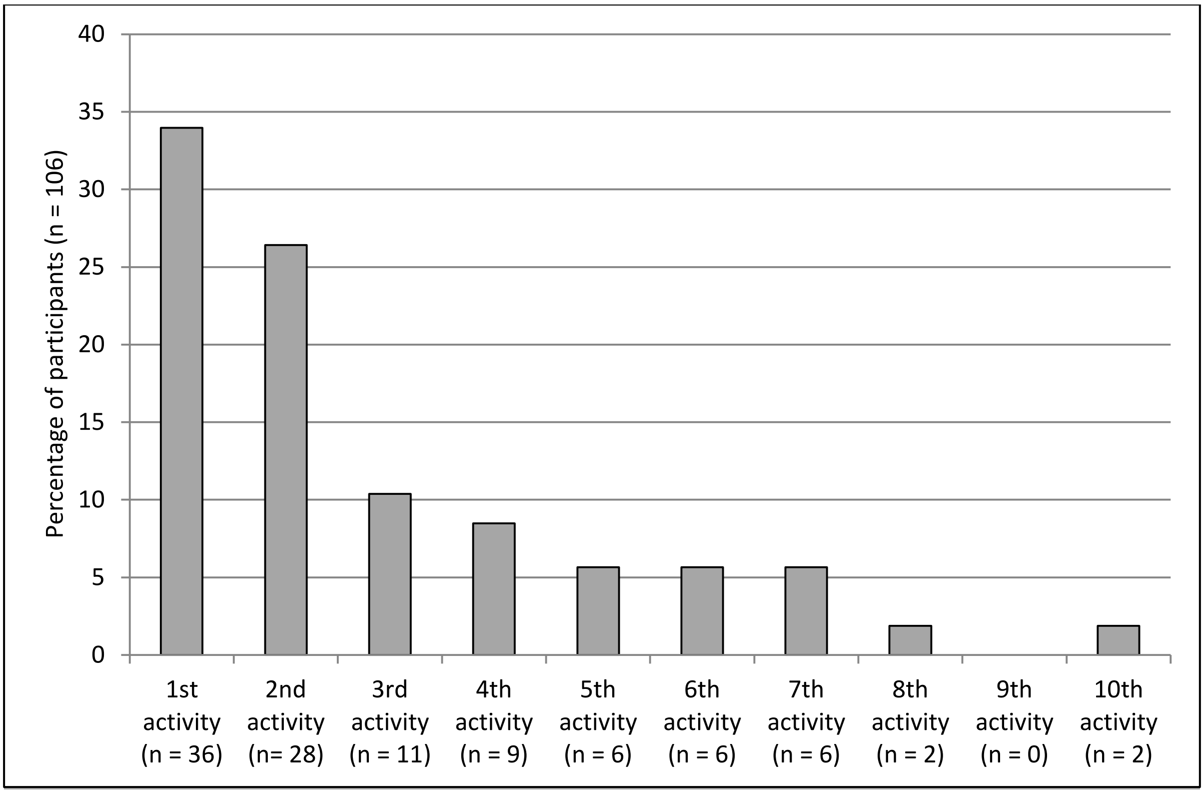

Figure 21. Timing of first instance of injury

When broken down by injury type, the data on when injuries were first incurred show some interesting differences between the injury types (Figure 22). Although there are limitations due to the small number of cases for some injury groups (n = 5 [5%] for burns, n = 16 [15%] for other injuries and n = 85 [80%] for smoke inhalation injuries), it is interesting to note that, in cases where burn injuries were the first injury incurred, these were all during either the first or second activity. By comparison, where smoke inhalation injuries were the first injury incurred, although the greatest concentration was during the first two activities, there was more of a spread across the range of activities; a similar pattern is evident for the category 'Other injuries'.

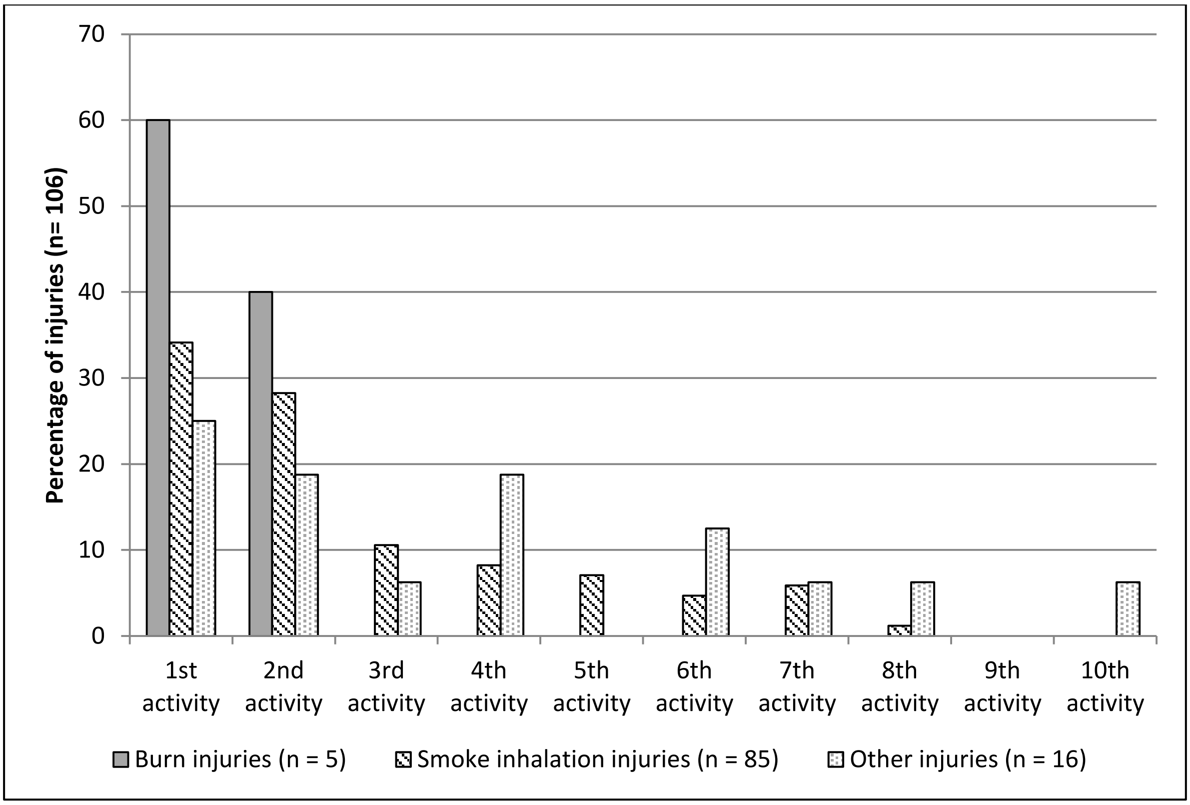

Figure 22. The proportion of each injury type incurred as a first injury by when the injury was incurred.

4.4.4 Activities undertaken at first instance of injury

Based upon the timeline data it is possible to establish the nature of the activities that were being undertaken when participants (n = 106) incurred their first injury (Figure 23). The two activities most frequently undertaken were tackling the fire (26% of the total, n = 27) and investigating the cues (22%, n = 23), while the third most frequent type of activity (exiting the building**)** was some way behind these at 9% (n = 10). That almost half of initial injuries were incurred through the behaviours of investigating and tackling (combined at 48%) further underscores the strength of desire among many to approach and subsequently engage with a fire. It also explains why all of the burn injuries (n = 5), and over 60% (n = 53) of smoke inhalation injuries, occurred within the first two activities (Figure 22), given that these behaviours are likely to bring people into direct physical contact with or close proximity to heat and toxic products.

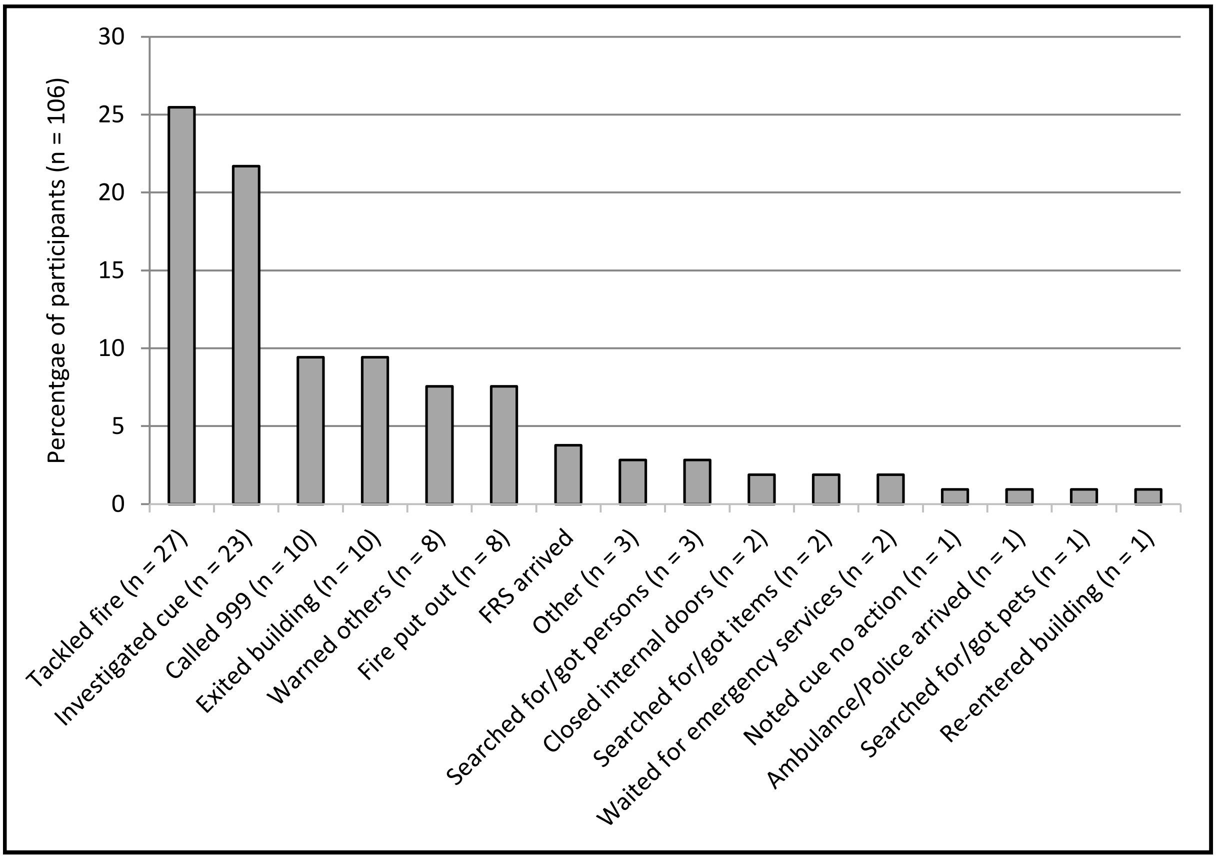

Figure 23. Activity undertaken at first instance of injury

Using the data for all participants (134 injured and 285 uninjured), a comparison of the incidence of injury by whether participants tackled the fire or not showed a clear difference between the two groups (Table 35): among those who were injured, almost two-thirds tackled the fire, while for those who were not injured the figure was under a half. This difference was found to be statistically significant.

Table 35. Crosstabulation of being injured and tackling the fire

	Tackled Fire		
Injured	**Yes**	**No**	**Test Output**
Yes (n = 134)	64% (n = 86)	36% (n = 48)	$\chi^2(1) = 10.77$ $p = .001$ $V = .16$
No (n = 285)	47% (n = 134)	53% (n = 151)	

Using the same injury data, the incidence of injury by whether participants investigated the cues or not was compared. However, this time there was no obvious difference between the two groups (Table 36): among those who investigated the cues, a third were injured, while for those who did not investigate the cues the figure was also close to a third. As expected, there was no statistically significant difference.

Table 36. Crosstabulation of being injured and investigating as a first activity

	First Activity: Investigate Cues		
Injured	**Yes**	**No**	**Test Output**
Yes (n = 134)	33% (n = 81)	31% (n = 53)	$\chi^2(1) = 0.18$ $p = .669$ $V = .02$
No (n = 285)	67% (n = 166)	69% (n = 119)	

Based on the data for all participants, proximity to the fire was compared to incidence of injury (Figure 24). A clear difference between the injured (n = 134) and uninjured (n = 285) groups was apparent in the proportion who were within touching distance of the fire: for injured participants 68% (n = 91) came within touching distance; however for those participants who were not injured the proportion who came within touching distance fell to 52% (n = 149) (Figure 24). The association between injury and coming within touching distance was found to be statistically significant ($\chi^2(1) = 9.10$, $p = .003$, $V = 0.15$).

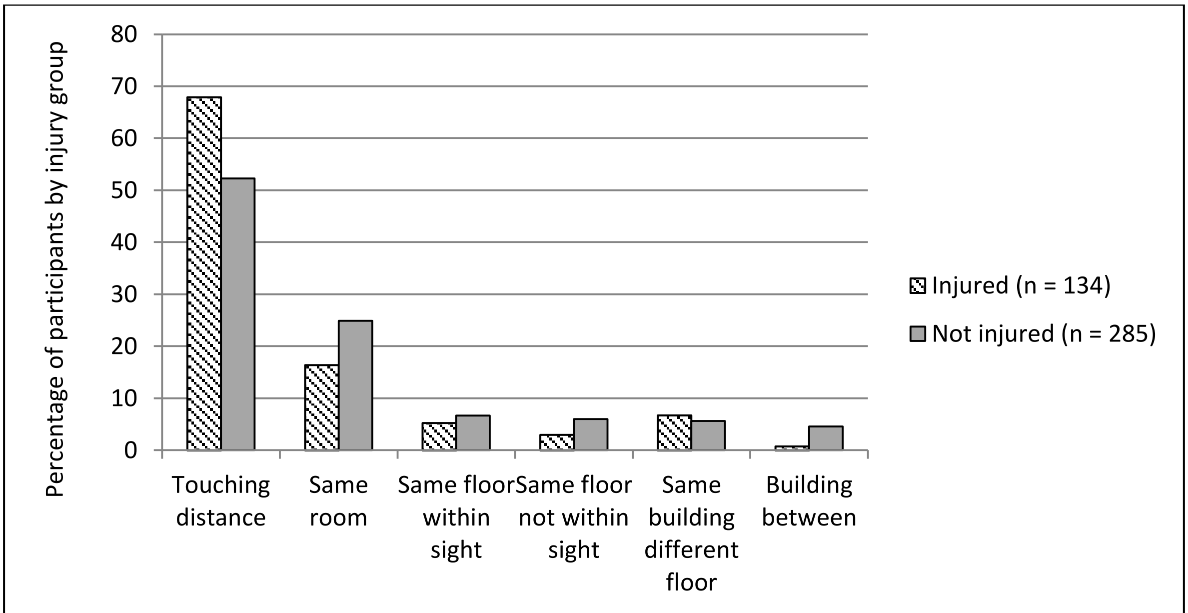

Figure 24. Participants' proximity to the fire and incidence of injury

To examine this further a comparison was undertaken between the timeline data on injuries (n = 106), showing the proportion of each type of first injury by how close participants got to the fire. As shown in Figure 25, all of those with burn injuries (100%, n = 5), three-quarters

(73%, n = 62) of those with smoke inhalation injuries and over half (56%, n = 9) of those with other injuries came into direct contact with the fire.

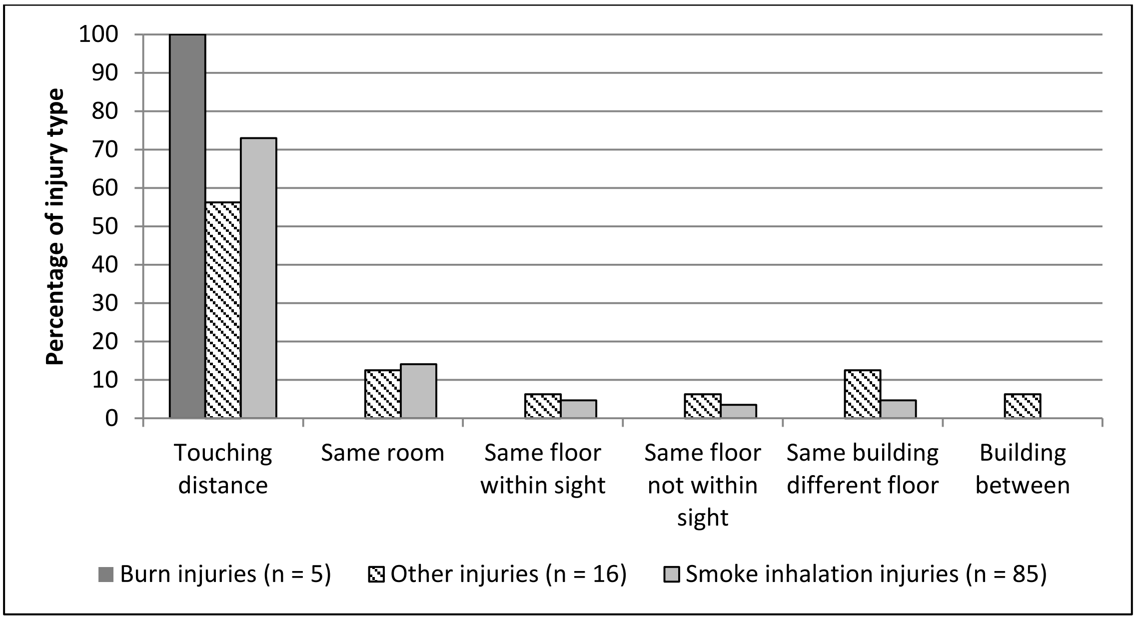

Figure 25. Percentage of first injury type by participants' proximity to the fire

However, it should be noted that this does not reflect how close participants got to the fire when they were injured, rather the closest they got to the fire during the entire duration of the incident (because this is how the question on proximity was worded in the LIFEBID survey). Nonetheless, it provides a useful overview and it offers further evidence to support the conclusion that it was participants' coming into proximity with the fire and smoke through specific activities (namely tackling the fire) that resulted in their injuries. It should be remembered that the methods employed in tackling the fire typically did not involve using specialist firefighting equipment (see Section 4.2). Tackling without such equipment generally requires one to come into close proximity or direct contact with the fire and products of combustion. This can be seen in Figure 26, which is based on data from all participants who tackled the fire (n = 220) and shows that four-fifths of those who tackled the fire came within touching distance. By comparison, among those who did not tackle the fire only a third came within touching distance.

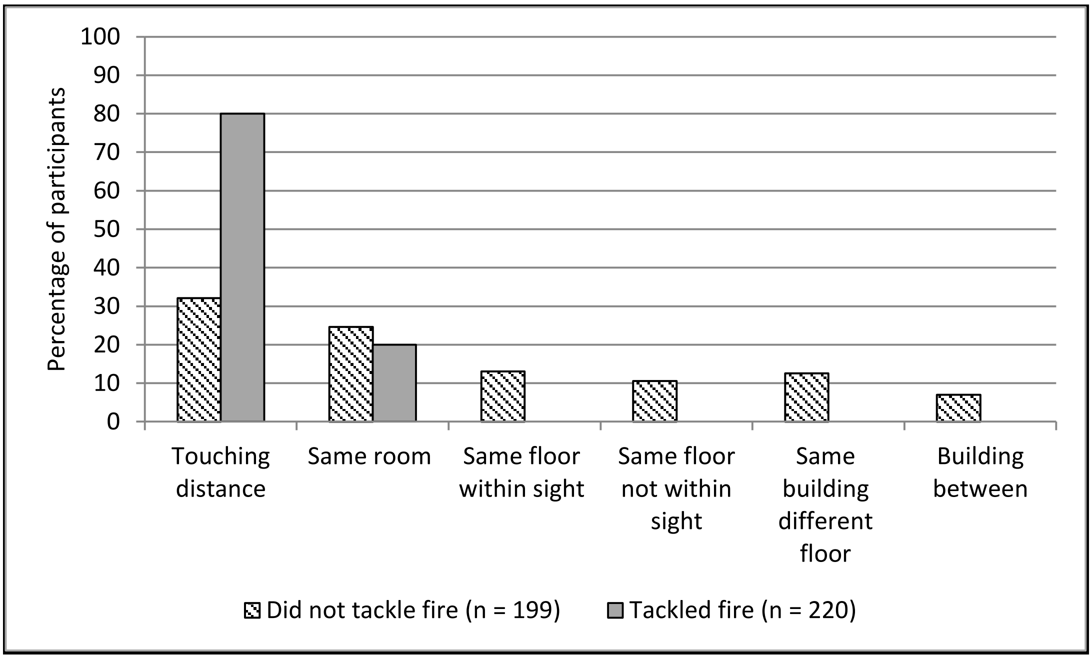

Figure 26. Proximity to the fire among those who tackled and did not tackle the fire

Although there will be a slight amount of duplication (due to a small number of participants incurring more than one injury) using the data on all injuries (n = 153) to present a comparison of the proportion of each injury type and the incidence of tackling the fire, the data nonetheless show that in 95% (n = 20) of all instances where there was a burn injury (n = 21) and 66% (n = 73) of instances where there was a smoke inhalation injury (n = 110) participants had tackled the fire (Figure 27). What is also interesting is that in instances of ‘other injuries’ (n = 22), only 23% (n = 5) of participants tackled the fire.

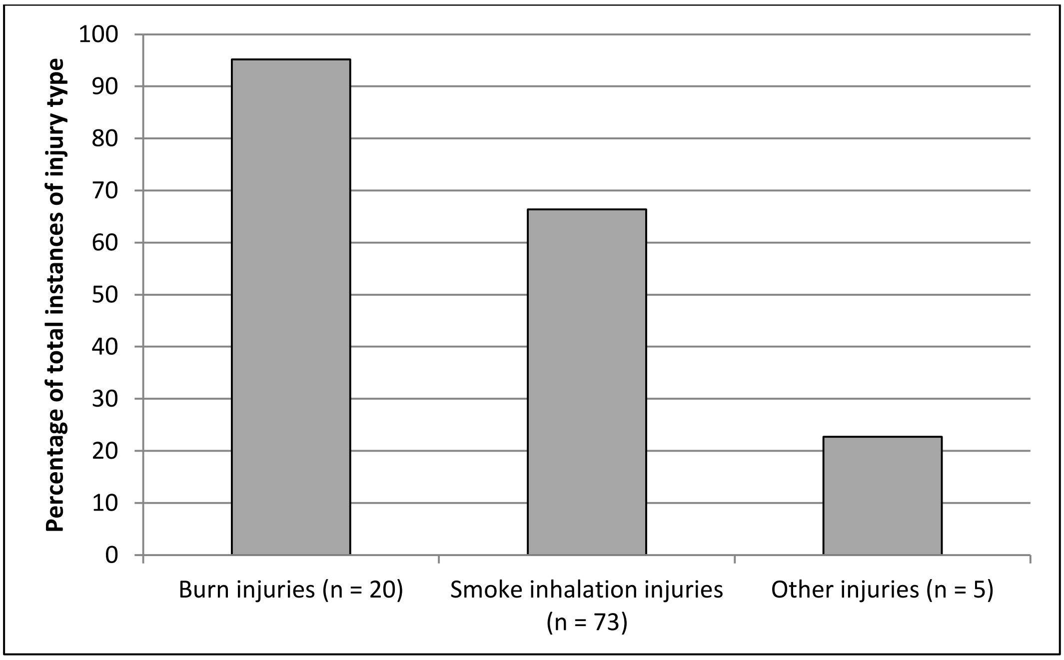

Figure 27. Proportion of instances of each injury type and tackling the fire

4.4.5 Summary of results

Having undertaken a range of analysis on the timing of injuries and the activities undertaken when injuries were incurred, it can be seen that in the majority of cases, injuries were first incurred at the earliest stages of participants' involvement with the fire (defined as the first two activities). The key activity that resulted in participants being injured was tackling the fire – while injuries also often occurred around the time of investigating the fire cues, this activity per se was not found to have a significant relationship with incidence of injury. Across two of the three injury groups (burns and smoke inhalation) a clear majority of participants tackled the fire. As for the nature of the relationship between tackling the fire and the incidence of injury, the reason participants were injured was because this was an activity that required participants to come into close proximity with the fire and smoke.

However, rather than being seen as vindicating the value of current fire safety messaging (i.e. 'get out, stay out, call 999'), these findings should instead be seen as giving further evidence to the need to reappraise the validity of such fire safety messaging (Starling, 2015). The reason for this is because the findings demonstrate the strength of attachment and desire among people to seek to understand what is going on and then to try to deal with the fire themselves in the first instance. Looking back to the first studies undertaken by Wood, Bryan and Canter et al., these all identified a propensity for people to investigate the cues and tackle the fire, which means that some forty years later various attempts to 'change' these behaviours have not had the desired effect. It may be a case that when faced with a fire in one's home, the desire to attempt to mitigate the fire is simply too deeply held to alter. Indeed, one could go further and argue that if one accepts that the home is the single most important store of people's possessions (and of course a physical shelter and refuge) then it is actually completely counter intuitive to ask people not to attempt to deal with a fire in the first instance. This issue will be explored further in Section 5.

4.4.6 Relationships between smoke alarms and injury

As covered in Section 4.3, it is claimed that smoke alarms detect a fire, consequently prompt occupants to move away from the fire, and thus keep occupants safe from harm (DCLG, 2008). The analysis on alarms in Section 4.3 found evidence to dispute their behavioural influence; this section now considers the safety aspect.

When the proportion of people who were injured within each of the three categories of cue was looked at, the lowest proportion with injuries was among those alerted by social cues (16%), followed by those alerted by physical cues (34%), while the highest proportion of injuries was actually among those alerted by a smoke alarm, where 38% of participants were injured. Because the proportion of injuries was highest among those where smoke alarms were the first cue that alerted people to the fire, this area was examined in more detail. The proportion of participants who were injured was compared between fires where smoke alarms sounded and fires where no alarms sounded. It was found that the proportion of participants who were injured was actually higher in cases where an alarm sounded than in cases where an alarm did not sound (Table 37). This difference was found to be statistically significant.

Table 37. Crosstabulation of smoke alarm sounding and being injured

	Injured		
Alarm Behaviour	**Yes**	**No**	**Test Output**
Alarm Sounded (n = 165)	39% (n = 64)	61% (n = 101)	$\chi^2(1) = 7.57$ $p = .006$ $V = .15$
Alarm Did Not Sound (n = 180)	25% (n = 45)	75% (n = 135)	

4.4.7 Being alerted by a smoke alarm and injury

The proportion of participants who were injured was then looked at against whether or not an alarm was the first cue that alerted them to the fire (Table 38). Here it was found that a slightly larger proportion of participants were injured when the first cue was a smoke alarm compared to when it was not. However, this difference was not statistically significant.

Table 38. Crosstabulation of smoke alarm as first cue and being injured

	Injured		
Cue Type	**Yes**	**No**	**Test Output**
Alarm First Cue (n = 61)	38% (n = 23)	62% (n = 38)	$\chi^2(1) = 1.08$ $p = .300$ $V = .05$
Alarm Not First Cue (n = 358)	31% (n = 111)	69% (n = 247)	

The reason that the proportion of injured participants was significantly higher when an alarm sounded but not when it was the first cue may be because the latter type of instance possibly involved more small fires but ones situated close to an alarm while the former type possibly involved more larger fires, ones which generated sufficient smoke to eventually reach and activate an alarm sited further away. This is supported by the analysis on alarms and fire size reported in Section 4.3.2 which found that alarms were more likely to sound when the fire was larger and had spread beyond the item first ignited. From this it could be surmised that it is the size of the fire, rather than the alarm sounding, which is associated with injury.

4.4.8 Summary of results

While no statistically significant relationship was found between being alerted by a smoke alarm and being injured, a significant relationship was found between a higher rate of injury and an alarm sounding. It is believed this is because injury may actually be a function of larger fires, which make it more likely that an alarm will sound, something which was supported by analysis on fire size undertaken earlier in this thesis (Section 4.3.2). Thus, it does not appear that smoke alarms per se make people less safe from harm during an ADF. However, on the other hand there is no evidence here that the presence of a smoke alarm reduces the likelihood of injury.

4.4.9 Relationships between age and incidence of injury

Why age is important. For FRSs in the UK, old age is widely assumed to be one of the key characteristics related to ‘fire risk’. As discussed in Section 2.8, while there is a clear consensus and evidence to support the fact that the elderly (i.e. those aged 65+) are over-represented in fire fatalities, the same cannot be said for injuries. Nonetheless, at UK government, devolved administration and individual FRS level, it is believed that those aged 65+ are at greater risk of not just being injured in a fire, but also of incurring more serious injuries should a fire occur. The acceptance of this is reflected in the strategy document produced by the Chief Fire Officers Association (CFOA) (CFOA; 2011) for meeting the challenge of protecting an ageing population, and in the supporting document for the framework developed by the Scottish FRS to allow people to ‘age safely’ (Scottish Fire and Rescue Service, 2016), both of which assert that older people are at greater risk of being injured in ADFs.

Analysis on age and being injured. Given the importance of this issue and its centrality to FRS risk profiling, community fire safety initiatives and indeed UK-wide FRS strategy, an extensive range of inferential statistical analysis was undertaken of the LIFEBID data in order to examine the nature of the relationship between age and risk of injury and degree of injury severity. The first stage of this was to look simply at age – as it was captured in the

LIFEBID survey; that is, as a continuous variable, measured in years – and risk of injury, i.e. were those participants who were injured significantly older than those participants who were not injured?

In the group of 132 participants who were injured and reported how old they were, the mean age was 55.33 years (SD = 17.65, Range = 20-96), while in the group of 267 participants who were not injured and reported how old they were, the mean age was only slightly lower at 53.71 years (SD = 16.68, Range = 18-93). However, a test of normality was run and this indicated that the age distribution of the Injured group was different from normal (Kolmogorov-Smirnov: Not Injured D[267] = 0.05, p = .200; Injured D[132] = 0.09, p = .009), and so a test of the difference in means (such as an independent samples t-test) would not be appropriate here. Instead, a non-parametric equivalent test was used (in this case, the Mann-Whitney U test, as there is a continuous dependent variable and a categorical independent variable with two categories). This found no statistically significant difference in age between those who were injured (Median = 53.00 years, IQR = 43.00-71.75) and those who were not injured (Median = 55.00 years, IQR = 42.00-65.00); Mann-Whitney U = 18,432.50, p = .454, r = .04. So, in other words, older participants were not more likely to be injured.

However, researchers, practitioners and policymakers have tended to divide age into a categorical variable, rather than capture or analysis it as a continuous variable. So the LIFEBID age data was then split into two categories: participants aged 65+ (elderly) and participants aged less than 65. Among those who were injured, 36% (n = 48) were aged 65+, while for those who were non-injured, 26% (n = 70) were aged 65+. A chi-square test found a statistically significant relationship between being elderly and being injured; χ^2 (1) = 4.37, p = .037, V = .11. So, now it would appear that older participants are more likely to be injured – a finding in line with the belief that those aged 65 and over are in a higher risk age group (although it should be noted that the specific nature of that risk is often not clearly identified by others, e.g. does risk in this context refer to the risk of fire, risk of injury, and or risk of death?).

<u>Exploring a range of categories in the older age group</u>. The division into categories of a variable that is inherently continuous, as age is, should be guided by theory, if done at all (e.g. it should be demonstrated that, around the age of 65, some relevant change occurs in the

physical, cognitive and or socio-economic circumstances of the average person meaning that someone beyond this age can now expect a different outcome as a result). For some time in the UK, 65 years was the age of retirement – albeit only for males – but that is no longer the case, with the current UK retirement age now rising, for both genders (GOV.UK, 2017). Thus, a change in socio-economic status (i.e. a reduction in income, potentially leading to more deprived living conditions and thus greater vulnerability) is no longer tied to the age of 65. Similarly, while some biological conditions associated with aging can result in medical impairments (e.g. ones that would affect a person's sensory abilities or mobility, thus making them more vulnerable), these conditions can occur much earlier than 65 (e.g. around 45) or may be seen at more significant levels of prevalence much later than 65 (e.g. around 75 or 85) (Manini, 2011). Thus, if one wanted to examine the effects of physical or cognitive changes on the risk of injury then it would seem that the variable Medically Impaired would be more appropriate than Age or Elderly.

Moreover, analysis may use a categorical variable simply because the data was collected that way (i.e. the question asked participants to select one out of several age categories, often organised in decades, within which they fell as opposed to asking for their age in years, based on the assumption that participants might be sensitive about providing their precise age and therefore leave the question blank). The use of age categories as a means of sorting a sample can impose limitations as it is the categories that are being tested rather than age itself. For example, there is no theoretical justification for why the age category 20-29 is any more valid than 27-36; it is simply a case that people feel comfortable sorting numbers into decades. It also runs the risk of creating a misleading impression that, because they are in different categories, a 29 year old, for example, is somehow different from a 30 year old.

As demonstrated above, whether there is a significant relationship between being injured and being older varied according to whether age was included in the analysis as a continuous or categorical variable. The results of the latter seemingly confirmed the widely accepted idea that those aged over 65 are at greater risk, with the implication being that the risk increases in line with age so that the older people become the more likely they are to sustain injury. In contrast, the results of the former contradicted this idea.

To explore the matter further, 11 new age-based categorical variables were created to represent 'older' vs. younger participants. These variables grouped ages around decades or arbitrary intervals stretching from five to 15 years or more. The lowest age selected as a cut-off was the youngest age at which people (females this time) could retire in recent UK history, i.e. 60. The highest age selected as a cut-off was the oldest for which the group would contain a minimum of 20 participants (hence no 85+ or 90+ categories). The new age-based predictor variables were as follows:

1. 60+ (n = 154 vs. n = 245 for <60)
2. 70+ (n = 83 vs. n = 316 for <70)
3. 80+ (n = 30 vs. n = 369 for <80)
4. 65-70 (n = 42 vs. n = 281 for <65)
5. 65-74 (n = 65 vs. n = 281 for <65)
6. 65-79 (n = 88 vs. n = 281 for <65)
7. 70-74 (n = 30 vs. n = 316 for <70)
8. 70-79 (n = 53 vs. n = 316 for <70)
9. 73-77 (n = 23 vs. n = 337 for <73)
10. 75-79 (n = 23 vs. n = 346 for <75)
11. 75+ (n = 53 vs. n = 346 for <75)

A series of chi-square tests were run to see if there was still a significant association between age as a categorical variable and being injured. The outputs are summarised below (Table 39).

Table 39. Chi-square outputs for categorical age variables (significant results highlighted)

	Injured		
Age group	**$\chi^2(1)$**	**p**	**V**
60+	0.82	.053	.01
70+	5.01	.025	.11
80+	0.01	.976	.01
65-70	0.20	.889	.01
65-74	1.22	.270	.06
65-79	5.35	.021	.12
70-74	1.18	.277	.06

70-79	7.15	.007	.14
73-77	4.48	.034	.11
75-79	8.57	.003	.15
75+	4.11	.043	.10

Taken together, this additional analysis reveals a more nuanced picture. Being of (female former) retirement age, i.e. 60+, did not mean participants were significantly more likely to be injured but being aged 65-79 did. Again this would appear to support the idea that an increase in age, starting from 65, leads to an increase in the likelihood of injury. However, other age categories starting from 65 and still ending in the 70s were not significantly associated with being injured. Moreover, if it is getting older per se that makes the likelihood of injury greater, then those aged 70 or more should also have been significantly more likely to be injured. However, while those aged 70+, 70-79, 73-77, 75-79 and 75+ were all significantly more likely, participants in another age category starting at 70 were not. Similarly, participants aged 80 and over should also have been at a higher risk of injury; however this was not the case. Again this underscores how using age categories (such as 65+) can result in a misleading and potentially inaccurate picture.

Summary of results. The available data do not support the assumption that risk of injury increases in line with age from 65 (or indeed any 'older' age for that matter). If this were the case then there would be a detectible and related increase in the proportion of people injured as one moves up through the years, beyond the mid-60s, through the 70s, and into the 80s and beyond; rather it is a series of sporadic peaks and troughs. However, by creating a group that happens to bring together these particular ages (e.g. 65+, 65-79, 70+, 70-79, 73-77, 75-79 or 75+) the results become skewed leading to the erroneous assumption that because a number of participants in their 70s had high rates of injury, all those aged 65 and over must therefore be at a greater risk of injury. In short, being older does not increase the likelihood of sustaining an injury.

Further investigation shows that the statistically significant results for some age groups can most likely be attributed to six specific ages where over 50% of participants of each of those ages were injured (the ages in question were 67, 72, 75, 77, 78, 79). There is no obvious reason why these particular ages should be associated more with injury, suggesting that the factor underlying injury is something else that happens to co-exist with age.

4.4.10 Relationships between age and severity of injury

Why age is important. Having established that the relationship between age and incidence of injury is not straightforward, the next step was to see whether any relationship existed between age and the severity of injury. This area was looked at because, in addition to the assumption that elderly groups are more likely to be injured, FRS fire prevention and home fire safety risk initiatives are also predicated on the assumption that the elderly are more at risk of serious injury in ADFs (CFOA, 2011; DCLG, 2015a; Scottish Fire and Rescue Service, 2016; Scottish Fire and Rescue Service, 2017). Consequently, an accurate understanding of this area, including whether the current position can be evidenced or not, is of key importance to the fire prevention and community fire safety work of FRSs.

Descriptive statistical analysis. Among the injured group within the sample, three new categories were created: Minor Injury, Moderate Injury and Severe Injury. However it should be noted that for two of the categories the numbers are low: the Moderate and Severe Injury categories only contain 19 and 5 cases respectively (the Minor Injury category contains 99 cases, a figure which drops to 97 when crosstabulated against participant age due to some missing cases). Nonetheless when injury severity is broken down by those aged <65 and 65+, the proportion of each level of injury severity is similar across these two age groups (Figure 28). This is an important observation as it shows that there are not greater proportions of more serious injuries among the 65+ age group (i.e. the Elderly variable). Were the elderly to be at greater risk of more serious injuries then one would expect to see a substantially greater proportion of moderate and severe injuries among this group compared to those aged under 65, however this was not the case as the percentage of 65+ in the Severe Injury category is the same as the percentage of <65 (i.e. 4% each), while the percentage of 65+ in the Moderate Injury category is actually slightly lower (13%) than the percentage of <65 (17%). A range of inferential statistical tests were undertaken to examine this in more detail.

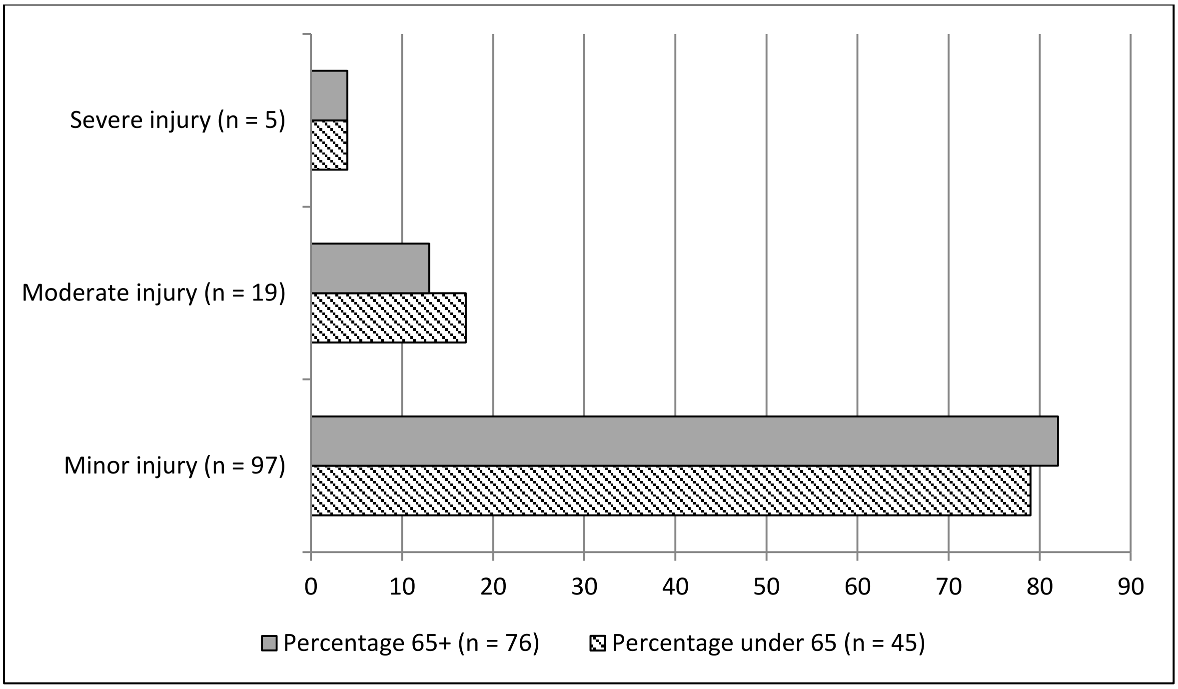

Figure 28. Proportion of each age group by injury severity

Inferential statistical analysis. A test was conducted to see if a statistically significant relationship existed between Age and the three levels of Injury Severity. Before that, a test of normality was run and this indicated that the age distribution for the Minor Injury group was different from normal (Kolmogorov-Smirnov: Minor Injury D[99] = 0.11, p = .006; Moderate Injury D[19] = 0.10, p = .200; Severe Injury D[5] = 0.17, p = .200), thereby necessitating the use of a non-parametric equivalent test (Kruskal-Wallis H test). Age was the dependent variable and Injury Severity the independent variable. Age was tested as a continuous variable. There were no statistically significant differences between the age of the three injury groups (Minor: Median = 53.00, IQR = 43-72; Moderate: Median = 51.00, IQR = 43-67; Severe: Median = 45.00, IQR = 25.50-76.50); $\chi^2(2) = 0.74$, p = .693, r = .01. As no differences existed it was not necessary to perform a post-hoc test.

Because of the low numbers in the Moderate and Severe Injury categories, these were merged resulting in two categories of Injury Severity: Slight (i.e. Minor) Injury and Serious (i.e. Moderate/Severe) Injury. A non-parametric equivalent test was again used. A Mann-Whitney test comparing Age by Injury Severity found no significant relationship between how old participants were (Slight: Median = 53.00, IQR = 43-72; Serious: Median = 51.00, IQR = 42.25-66.75) and the severity of their injuries (U = 1081.00, p = .495, r = –0.06).

One further test was undertaken to see if any significant relationship existed between Injury Severity, which remained coded as a two-category variable (slight, serious), and being older. This time the categorical variable Elderly (<65, 65+) was used instead of the continuous variable Age. A chi-square test found no significant relationship between being aged 65 or over and sustaining serious injuries; $\chi^2(1) = 0.14$, $p = .712$, $V = .03$. So, the results for injury severity were more straightforward than the results for being injured; that is, regardless of how age was coded, it was clear that older participants were not more likely to be at greater risk of incurring more severe injuries.

Summary of results. Several analytic methods were considered here to look more deeply at age and injuries. The approach adopted in previous research and practice – i.e. to treat age as a categorical variable and compare the elderly (typically deemed to be those aged 65+) against adults aged under 65 – was taken, as was the alternative approach of keeping age as a continuous variable (its natural form). There was no doubt with the results: no significant relationship was found between older age and more serious injuries, whether they were moderate or severe. Consequently, from this it may be concluded that any claims that the elderly are more likely to sustain serious non-fatal injuries – by virtue of the fact they are older – are not supported by these data. In summary, during an ADF, those classed as older (65+) cannot be said to be at greater risk of either injury or at greater risk of moderate/severe injuries. These are findings that are of direct and practical value to FRSs nationwide as they offer important new insights in relation to risk profiling and community fire safety initiatives.

4.4.11 Identifying predictors of injury

First round – Testing the variables from the literature. Within the literature there continues to be a lack of distinction between the risk of fire fatality and the risk of fire injury. Consequently, the term 'risk' is often used without being clearly defined, but tends to default to the identification of fire fatality risk factors; something that may be the result of the prevalence of the 'conveyor belt' view of fire fatality risk in which every ADF is a potential death (Brennan and Thomas, 2001; Thompson et al., 2013; Thompson et al., 2015; Thompson et al., 2018; Wales et al., 2015). Because of the fact that there is very little within the literature that deals specifically with the identification of dwelling fire injury risk factors, the list below reproduces those fire fatality risk factors for which there is a consensus within the literature and thus are used by FRSs for risk profiling and targeting home safety visits.

As a result, testing these risk factors (pre- and peri-event variables) and the main outcome of interest (being injured) allows an important question to be considered, which is whether fire fatality risk factors are also accurate predictors of fire injury? This is particularly important when one considers that the assumption among FRSs and those working in the field of human behaviour in fire tends to be that fire injury and fire fatality risk factors are one and the same – if indeed the distinction between the two is considered at all (Thompson, Galea and Hulse, 2018). The LIFEBID project team (who were behind the LIFEBID survey and included the author of this thesis) began an investigation of this matter using the LIFEBID data, with the analysis shaped by that project's main areas of interest (Thompson, Wales and Hulse, 2017). For the thesis, the author revisited this issue, conducting new analysis on the data, this time shaped by the findings borne out of the preceding analysis described in this thesis.

A first round of binary logistic regression analysis was undertaken to identify whether the dependent variable Being Injured (no, yes) was significantly predicted by the following fire fatality risk factors which were entered in the model as independent (predictor) variables:

1. Having children present (Children Present: no, yes)
2. Being elderly (Elderly: <65, 65+)
3. Being male (Gender: female, male)
4. Having a form of medical impairment (Medically Impaired: no, yes)
5. Being asleep (Asleep At Ignition: no, yes)
6. Consuming alcohol or drugs (Consumed Substance: no, yes)
7. Not having a smoke alarm (Alarm Present: yes, no)
8. Living alone (Lived Alone: no, yes)
9. Living in an attached dwelling (Attached Dwelling: [detached compared to] attached, bungalow)
10. Originating from a minority ethnic group (Ethnicity: white UK/IE, minority)

The first two predictor variables cover the risk associated with young and old age – note, the LIFEBID survey only sampled from the adult population but the first variable accounts for the absence of children in the sample by capturing their presence in participants' homes; the third variable is self-explanatory in what risk it covers; the fourth variable covers the risk associated with having a physical or cognitive impairment; the fifth, sixth and seventh variables cover the risk associated with behaviours (including not installing a smoke alarm) that are likely to limit one's ability to recognise and or respond to a fire; the eighth variable covers the risk associated with being socially isolated; and the ninth and tenth variables are proxies which cover the risk associated with living in areas of deprivation.

Note that the risk associated with smoking is not tested directly here, partly because the LIFEBID survey did not collect data on whether participants were smokers but also because, upon further review of the literature, it appeared that being a smoker per se is not necessarily the risk factor as being a smoker does not on its own make a person more likely to die in a fire. However, among smokers there may be a higher incidence of individuals who have a characteristic (e.g. impairment) or engage in behaviour (e.g. alcohol consumption) that limits their ability to recognise and respond to a fire the home (Brennan and Thomas, 2001; Lewis and Lear, 2003). There may also be a higher risk of a linked secondary factor: an increased risk that the children of smokers will have a greater likelihood of obtaining lighters and matches in the house (Miller, 2005).

Table 40. Regression output for predicting injury – 1st round (significant results highlighted)

	Injured	
Behaviour	**P**	**OR**
Children present	.896	0.96
Elderly[1]	.055	2.42
Gender	.610	0.88
Medically impaired	.335	1.44
Asleep at ignition	.008	2.42
Consumed substance	<.001	3.40
Alarm present	.586	0.75
Lived alone	.574	1.19
Attached dwelling 1 (attached)	.015	1.96
Attached dwelling 2 (bungalow)	.272	1.64
Ethnicity	.256	1.67

[1]*Note: Replacing the categorical variable Elderly with the continuous variable Age does not change the findings here. The model was able to explain 15% of the variance in the data (Nagelkerke R-squared = .15). The model was able to correctly classify people into the injured and non-injured groups 70% of the time overall..*

In this model (Table 40) Consumed Substance, Asleep At Ignition, and Attached Dwelling 1 (attached) were significant predictors of being injured, in descending order of the size of their effect on the outcome. This means that the odds of being injured were increased if participants: had consumed a substance prior to ignition as opposed to not having consumed a substance; were asleep at ignition as opposed to being awake; and lived in an attached dwelling as opposed to living in a detached dwelling. This analysis identified that just three of the 10 variables tested were found to be significant predictors of injury. As these 10 variables were all closely associated with dwelling fire fatalities, this indicates that the risk profile for fire fatalities is not representative of the risk profile for fire injury. This in turn leads to the conclusion that the risk factors for fire injury and fire fatality are not identical.

Second round – Testing new potential predictors. As analysis earlier in this Section 4.4 revealed connections between occupant behaviours and injury (specifically that the first instance of being injured tended to occur when tackling the fire or investigating cues; that there was a significant relationship between being injured and both tackling the fire and getting within touching distance of the fire), it was of interest to see if these additional variables would act as significant predictors of injury. Also, analysis in Section 4.2 revealed relationships between some of the behaviours and pre-event variables (i.e. possessing fire safety knowledge gained from the workplace was related to investigating cues, while having prior fire experience was related to tackling the fire), and so if the presence of these pre-event variables increased the likelihood of risky behaviours then they too might predict being injured. Furthermore, analysis in Section 4.3 found a significant relationship between an alarm sounding (as opposed to merely being present or not) and being injured, although further analysis on alarms revealed that they tended to sound in cases where the fire had grown beyond the item of ignition. From this it was hypothesised that an indicator of the size of the fire, i.e. the spread of fire damage, would predict being injured.

1. First Activity: Investigated Cues (no, yes)
2. Tackled Fire (no, yes)
3. Proximity To The Fire (beyond touching distance, touching distance)
4. Workplace Knowledge (no, yes)
5. Prior Fire Experience (no, yes)
6. Fire Damage Spread ([restricted to ignited item compared to] restricted to RFO, spread across same floor as RFO, spread across building, spread to other buildings)

A second round of binary logistic regression analysis was undertaken to identify whether the dependent variable Being Injured (no, yes) was significantly predicted by the above listed new factors (pre- and peri-event variables), which were entered in the model as predictor variables (Table 41).

Table 41. Regression output for predicting injury – 2nd round (significant results highlighted)

	Injured	
Behaviour	**P**	**OR**
First activity: investigated cues	.160	0.72
Tackled fire	.007	2.14
Proximity to the fire	.014	2.00
Workplace knowledge	.873	0.96
Prior fire experience	.433	1.23
Fire damage spread 1 (restricted to RFO)	.018	2.01
Fire damage spread 2 (spread across same floor as RFO)	<.001	5.02
Fire damage spread 3 (spread across building)	<.001	7.79
Fire damage spread 4 (spread to other buildings)	.003	15.54

Note: the model was able to explain 19% of the variance in the data (Nagelkerke R-squared = .19) The model was able to correctly classify people into the injured and non-injured groups 72% of the time overall.

In this model Fire Damage Spread (1, 2, 3 and 4), Tackled Fire, and Proximity To The Fire were significant predictors of being injured, in descending order of the size of their effect on the outcome. This means that the odds of being injured were increased if participants: experienced a fire that spread beyond the item of ignition as opposed to not spreading beyond the item of ignition; tackled the fire as opposed to not tackling it; and got within touching distance of the fire as opposed to staying further away from it.

<u>Third round – Testing the significant predictors from rounds 1 and 2 together</u>. Following the results of the previous two sets of regression analysis, a third round of binary logistic regression analysis was undertaken in which all of the variables that were found to be significant predictors of the dependent variable Being Injured (no, yes) from rounds 1 and 2 were put into a single model and tested (Table 42). As a reminder, these predictor variables were as follows:

1. Consumed Substance (no, yes)
2. Asleep At Ignition (no, yes)
3. Attached Dwelling ([detached compared to] attached, bungalow)
4. Fire Damage Spread ([restricted to ignited item compared to] restricted to RFO, spread across same floor as RFO, spread across building, spread to other buildings)
5. Tackled Fire (no, yes)
6. Proximity To The Fire (beyond touching distance, touching distance)

Table 42. Regression output for predicting injury – 3rd round (significant results highlighted)

	Injured	
Behaviour	**P**	**OR**
Consumed substance	.001	2.90
Asleep at ignition	.028	2.21
Attached dwelling 1 (attached)	.008	2.13
Attached dwelling 2 (bungalow)	.098	2.14
Fire damage spread 1 (restricted to RFO)	.089	1.68
Fire damage spread 2 (spread across same floor as RFO)	<.001	4.37
Fire damage spread 3 (spread across building)	<.001	6.33
Fire damage spread 4 (spread to other buildings)	.010	11.79
Tackled fire	.014	2.08
Proximity to the fire	.014	2.09

Note: the model was able to explain 26% of the variance in the data (Nagelkerke R-squared = .26) The model was able to correctly classify people into the injured and non-injured groups 75% of the time overall.

In this model, all variables were significant predictors of being injured, in the following descending order of their effect on the outcome: Fire Damage Spread (2, 3 and 4), Consumed Substance, Asleep At Ignition, Attached Dwelling (1), Proximity To The Fire, and Tackled Fire. The only result that differed from the previous rounds of regression analysis was that the category representing relatively smaller fires, Fire Damage Spread (1), was no longer a significant predictor. These findings mean that the odds of being injured were increased if participants: experienced a fire that spread beyond the room of fire origin as opposed to not spreading beyond the room of fire origin; had consumed a substance prior to ignition as opposed to not having consumed a substance; were asleep at ignition as opposed to being awake; lived in an attached dwelling as opposed to living in a detached dwelling; got within touching distance of the fire as opposed to staying further away from it; and tackled the fire as opposed to not having tackled it.

Summary of results. Three separate rounds of binary logistic regression analysis were carried out. For each round of regression analysis tests were first run to check for the absence of multi-collinearity (i.e. checking that there are not two or more predictor variables that are highly correlated with each other). There was no sign of multi-collinearity for each round of regression (i.e. all Tolerance values > 0.7, all VIF values < 2). In the first round, 10 variables were tested which were taken from the literature as risk factors related to dwelling fire fatalities. Of these, three variables – Consumed Substance, Asleep At Ignition, and Attached Dwelling – were significant predictors of being injured. As previous analysis in this Section 4 had suggested the presence of additional variables which might act as predictors of being injured, a second round of binary logistic regression analysis was undertaken. New variables were tested and, once again, three of these – Fire Damage Spread, Tackled Fire and Proximity To The Fire – were significant predictors of being injured. For the third round of regression analysis, all six of the variables that were previously found to be significant predictors of being injured were put into one model and tested. In this model all variables were significant predictors of being injured, the only difference being now that the size of the fire, as indicated by the spread of the fire damage, had to be slightly larger (i.e. beyond the room of fire origin, as opposed to beyond the item of ignition) before it had a significant impact on being injured.

Consequently, this regression analysis advances the understanding of risk factors for dwelling fires that result in harm to occupants. That is to say that it demonstrates that: risk factors for fire fatalities are not necessarily risk factors for fire injuries; the size of the fire is a very important factor and one for which efforts must be made to minimise; occupant behaviours are key, both in the lead up to the time of ignition and during the occupant's response to the fire; and people living in dwellings that have less separation from other dwellings face a greater risk of injury when a fire occurs.

4.5 GET OUT, STAY OUT, CALL 999

4.5.1 Introduction

In 1998 the UK adopted a national fire safety campaign which uses the slogan 'Get out, stay out, call 999'. As described in the literature review (Section 2), the first example of this featuring in the UK government's public fire safety literature was in a 1998 report titled '*Safe as Houses. The Report of the Community Fire Safety Task Force'*, where it is presented as a core message about what to do after a fire has been discovered (Home Office, 1998). There is nothing within this report that indicates that this message was based upon any behavioural research. Instead it appears to have been developed as an educational safety message in the vein of other public safety announcements (Bradley and Boyce, 2004). This message has been supported by FRSs from the outset. However as identified within this Section 4, the evidence indicates that while some undoubtedly follow the core principles of it, many behave in a manner that is not consistent with the message. When first alerted to the cues of a fire, a considerable proportion of people investigate those cues, approach the fire, attempt to tackle it, re-enter the property and only call 999 following initial attempts to deal with the fire. In short, they are not getting out, staying out or calling 999 in a timely manner. Consequently, the final section of this analysis chapter considers the motivations that underpin decisions to enter or not enter the RFO, to leave it after entering, the reasons for not staying out (i.e. re-entering the property) and the reasons for calling or not calling 999.

4.5.2 Descriptive statistics

Entering, exiting the RFO and tackling the fire. People most frequently entered the RFO for the following reasons: in order to investigate the fire cues; tackle the fire; and evaluate the fire (Table 43).

Table 43. Reason for entering the RFO

	Percentage and count (N = 303)
Reason for Entering RFO **N.B. For this category participants were able to choose more than one answer so these totals are different from counts for individuals.**	Investigate fire cues = 29% (88) Tackle fire = 22% (67) Evaluate fire = 19% (58) See to believe fire = 8% (24) Unaware of fire = 7% (20) Get pets from RFO = 4% (13) Get persons from RFO = 4% (11) Other/unspecified reason for entering RFO = 3% (10) Evacuate via RFO = 3% (9) Get items from RFO = 1% (3)

For the participants who were not in the RFO when the fire started and chose not to enter, the most frequently cited reason was interesting in that it was because participants were following instructions given by the 999 control operator not to enter (Table 44). This point highlights the fact that it is possible to exert a degree of influence with the occupant during a

999 call. Following on from this, the next two most frequently cited reasons were: keeping away from the RFO in order to warn and or assist in evacuating others in the property; and keeping away from the RFO in order to prevent being harmed.

Table 44. Reason for not entering the RFO

	Percentage and count (N = 139)
Reason for why RFO not entered **N.B. For this category participants were able to choose more than one answer so these totals are different from counts for individuals.**	Evacuation instruction from 999 control operator = 19% (26) Priority was to warn/evacuate others = 18% (25) Avoid endangering own health/life = 13% (18) Felt scared = 11% (15) Prevented by other circumstances = 10% (14) Prevented by hazardous conditions = 9% (12) Other reason = 7% (10) Unspecified reason = 6% (8) Evacuation instruction from others at the scene = 5% (7) Priority was to move belongings = 1% (2) Responsibility for someone else = 1% (1) Felt unwell/was injured = 1% (1)

When it came to evacuating the RFO, it was again interesting to observe that the most frequently cited reason for doing this was because participants were following instructions from the 999 control operator (Table 45). Once again, this underscores the influence that can be exerted through the 999 call. Interestingly, being forced out by hazardous conditions only represented slightly over a tenth of the reasons given.

Table 45. Reason for evacuating the RFO

	Percentage and count (N = 263)
Reason for evacuating RFO **N.B. For this category participants were able to choose more than one answer so these totals are different from counts for individuals.**	Evacuation instruction from 999 control operator = 33% (87) Other/unspecified reason = 22% (57) Undertake other response activities = 19% (50) Forced out by hazardous conditions = 14% (37) Fire seemed to be out = 6% (15) Evacuation instruction from others at the scene = 3% (9) Unspecified reason = 3% (8)

For those participants who did not evacuate the RFO, the most frequently given reason was because they had completed tackling the fire (Table 46). For 58% (n = 44) of participants in this group (i.e. those who managed to extinguish the fire themselves), the initial smoke size was rated by participants at the lowest or second lowest point on a 5-point scale. Similarly with flame size, for 69% (n = 52) of participants, the initial flame size was rated at the lowest or second lowest point on a 5-point scale (see Table 47).

Table 46. Reason for not evacuating the RFO

	Percentage and count (N = 149)
Reason why RFO not evacuated **N.B. For this category participants were able to choose more than one answer so these totals are different from counts for individuals.**	Completed tackling the fire = 52% (78) Unspecified reason = 19% (28) Watch others tackle fire = 10% (15) Fire seemingly burnt itself out = 10% (15) Other reason = 6% (9) Too unwell/injured to move = 3% (4) Trapped in RFO = 0% (0)

Table 47. Initial perceived size of fires that were extinguished by occupants

Initial smoke (1 small through to 5 large)					
No smoke	**1**	**2**	**3**	**4**	**5**
21% (n = 16)	40% (n = 30)	18% (n = 14)	5% (n = 4)	7% (n = 5)	9% (n = 7)
Initial flame (1 small through to 5 large)					
No flame	**1**	**2**	**3**	**4**	**5**
15% (n = 11)	40% (n = 30)	29% (n = 22)	12% (n = 9)	0% (n = 0)	5% (n = 4)

For those in the sample who tackled the fire, the three most frequently given reasons for doing so were: to contain it until help arrived; it looked small (and therefore manageable); and to prevent damage to the property (Table 48). This means that participants were keen to be actively involved in dealing with the fire even if help was en route.

Table 48. Reason for tackling the fire

	Percentage and count (N = 592)
Reason for tackling fire **N.B. For this category participants were able to choose more than one answer so these totals are different from counts for individuals.**	Contain fire until help arrived = 18% (107) Fire looked small = 15% (89) Prevent damage to property = 15% (88) Did not think: instinctive = 12% (70) Felt personally responsible = 11% (64) Prevent harm to self = 7% (36) Nobody else could/would = 5% (33) Prevent harm to other occupants = 5% (30) Fire looked large but manageable = 5% (28) Prevent harm to neighbours = 5% (27) Unspecified reason = 2% (11) Other reason = 2% (9)

Calling 999. The most frequently stated reasons for calling 999 were: there was a risk of property damage; the fire was beyond the participant's capabilities; and the participant believed that one is supposed to call 999 when there is a fire (Table 49).

Table 49. Reason for calling 999

	Percentage and count (N = 728)
Reason for why 999 called **N.B. For this category participants were able to choose more than one answer so these totals are different from counts for individuals.**	Risk of property damage = 23% (164) Fire beyond capabilities = 20% (146) Supposed to call 999 when there is a fire = 11% (82) Others were endangered = 10% (76) Own health/life was endangered = 9% (68) Need practical advice to tackle the fire = 7% (52) Fire was large = 7% (49) Scared and needed reassurance = 6% (43) Nobody else could/would = 4% (28) Official report for tenancy/insurance reasons = 2% (12) Other reason = 1% (7) Unspecified reason = 1% (1)

For those participants who did not call 999, the main reason was because others had made the call (Table 50).[2] The next most frequent reasons given for not calling 999 were: because participants were capable of handling the fire; and that the fire was small.

Table 50. Reason for not calling 999

	Percentage and count (N = 201)
Reason for why 999 not called **N.B. For this category participants were able to choose more than one answer so these totals are different from counts for individuals.**	N/A call made by others = 62% (125) Capable of handling fire = 11% (23) Fire was small = 10% (21) No others endangered = 5% (9) Other reason = 4% (8) Avoid diverting resources away from others = 4% (7) FRS attendance would draw unwanted attention = 1% (2) Nervous: never called 999 before = 1% (2) Too busy undertaking other activities = 1% (2) Avoid concerning property owner = 1% (1) Unspecified reason = 1% (1) Remaining reasons all = 0%: Avoid affecting insurance, Avoid concerning relatives, Thought might have to pay FRS, No working phone available

[2] From this it is unclear whether participants agreed that where there was a need for someone else to call 999 (the survey did not collect data on this point). It is likely that in some cases participants felt the FRS was required, but in other cases the call was made without their knowledge by someone outside the property, e.g. neighbour or passer-by.

Re-entry to the property. Checking on the fire was most frequently mentioned as the reason for why people re-entered the building (Table 51). This was followed by re-entering to tackle the fire.

Table 51. Reason for re-entering the building

	Percentage and count (N = 190)
Reason for why re-entered building **N.B. For this category participants were able to choose more than one answer so these totals are different from counts for individuals.**	Check on fire = 26% (49) Tackle fire = 16% (31) Other reason = 12% (22) Close internal doors = 11% (20) Just wanted to be doing something = 8% (16) Get/search for pets = 7% (14) Unspecified reason = 7% (14) Get/search for persons = 7% (13) Get items: practical importance = 3% (5) Get items: sentimental importance = 2% (3) Get items: financially valuable = 2% (3)

Those who had stated that they re-entered in order to check on the fire were asked a follow-up question as to why they felt the need to check on the fire (Table 52). The numbers within this subset are small – partly because this question was added to the survey for thesis purposes at a later date (November 2015), and partly because not everyone who evacuated re-entered or did so for this reason – meaning that the responses can only be regarded as providing a very limited insight. The one given most often for checking on the fire was in order to see if the fire was a size that participants could potentially put out by themselves. This was followed by a desire to observe if the fire was spreading, and so an update (likely unsolicited) could be provided to the FRS. These behaviours again emphasise the desire among participants to play an active role (as opposed to passive) during the incident.

Table 52. Reason for why participants felt the need to check on the fire

	Percentage and count (N = 16)
Reason for why felt the need to check on the fire **N.B. For this category participants were able to choose more than one answer so these totals are different from counts for individuals.**	To see if it was a size that I could potentially put out by myself = 31% (5) To see if it was spreading to other parts of the property = 25% (4) To update the FRS = 19% (3) To see the degree of damage to the property = 13% (2) To satisfy my own curiosity = 6% (1) To see if it was posing a risk to neighbouring/adjacent properties = 6% (1) Other = 0% (0)

4.5.3 Summary of results

It is clear from the results previously reported in this Section 4 that a large proportion of participants behave in a manner that is contrary to the ‘Get out, Stay out, Call 999’ message. The motivations that underpin these behaviours can be seen as entirely understandable in the situation. Overall, they highlight the way in which people are motivated by a fundamental desire to understand what has caused them to be aware of a difference in their environment (i.e. the cues) and then, once discovered, to take steps to extinguish the fire and, in doing so, exert a measure of control over the situation. The motivations for tackling the fire reveal a deep-seated desire among people to resolve the situation themselves or at least contain it until additional help arrives.

This desire to understand what is happening and then seeking to control or mitigate the detrimental effects of the flames/smoke is also clear in the fact that the single most frequently cited reason for re-entering the property was in order to check on the fire. The number of responses was very small, so the results are at best a general indicator, but delving even deeper to ask why people felt the specific need to check on the fire revealed that most often it was to see if the fire was a size the participant could attempt to deal with. Once again, this emphasises the strength of desire among people to take action to deal with the fire.

What was striking about calling 999 was that the main motivation was to prevent damage to property as opposed to preventing injury. The other frequently cited reason for calling 999 (the fire being beyond a participant’s ability to control it) suggests that, rather than being the initial course of action, 999 is used as an option once attempts by the participants to deal with the fire have proved unsuccessful. Additionally, the desire to maintain a level of understanding about what is happening after such a point has been reached is apparent in people’s need to check on the fire, effectively undertaking a process of sense checking of the incident and its development.

Also noteworthy was the influential role played by 999 fire control operators. Safety advice given directly by control to callers was a factor in preventing a number of participants from entering the RFO and also in causing a number of participants to exit the RFO. The influence of 999 fire control operators offers one area through which participant behaviours may be influenced and they clearly have a role to play in this regard. However the effect of this would still remain somewhat limited as there are a considerable number of people who do not call 999. Moreover, even when people do call 999 during an ADF, the fire control operators would be unable to influence the behaviours that take place before that call is made, and often those behaviours include tackling the fire, leading to injury.

Consequently, the motivations that accompany each of the key behaviours that participants undertook can be summarised as flowing from to a wish to understand the situation through to an attempt to deal with the situation. These are, in this context, entirely understandable and logical motivations. This leads to two key questions which are (a) whether such behaviour needs to be changed and (b) whether such behaviour can be changed.

5. DISCUSSION OF FINDINGS

5.1 INTRODUCTION

The most striking aspect about the numbers of reported fires, deaths, and injuries in the UK is the scale and speed of the decline that has taken place between 2000/01 and 2017/18. As described in Section 2.3, with the exception of the Grenfell Tower fire, the total number of fires in general, ADFs specifically, and associated deaths and injuries, has reduced each year. Moreover, these declines have been considerable. Yet ADFs remain the cause of between 58% and 73% of all fire-related injuries and fatalities. This proportion has remained broadly consistent in spite of the decline in the number of fires, fatalities and injuries that have occurred since the millennium. While the risk of having an ADF has reduced, the risk of dying or being injured in an ADF has not reduced. As reported in Section 2.8, research has uncovered risk factors for ADF fatalities. ADF injuries, in contrast, have not received the same attention. Thus it has been unclear to date why people may be more likely to incur injuries that whilst survivable are still undesirable. Presenting an understanding of why the risk of being harmed in an ADF remains high, and directing the focus onto injuries, would be an important contribution to developing solutions that aim to reduce these fire outcomes. This thesis contends that such investigation should also focus on the behaviour of occupants, during an ADF. Not only would this be beneficial for understanding injuries but it would also have practical implications such as helping inform FRS prevention and response operations (e.g. helping identity whether occupants should and or can be dissuaded from any behaviours, and the situations fire crews might likely encounter when called to attend an incident). Important research has been conducted previously on human behaviour in fire (Section 2.6). However, 40 years on, the findings of these seminal studies require revisiting, especially given that the body of research in between that has been building on these foundations (Section 2.7) has tended to focus on behaviour in PCI (non-domestic) spaces, and there have also been societal changes meantime (Section 2.6).

Based upon an evaluation of the results of the current study against the nine thesis research questions, explanations for why the risk of being harmed in an ADF has not reduced will be put forward and discussed. This will be accompanied by a concept which describes and explains the nature of the behavioural response of occupants to fires in domestic settings. As part of this, the first step is to reiterate each of the research questions and then consider the degree to which the findings have addressed and answered these.

5.2 DISCUSSION OF THE RESEARCH QUESTIONS

5.2.1 Group 1

This group of research questions addresses the need for a more comprehensive and up-to-date understanding of human behaviour in ADFs, particularly given the changes to households, gender equality and fire safety.

Research question 1. What are the key behaviours and movement taking place during a dwelling fire, and what are the motivations driving these? (Re: sections 4.2 and 4.5 analysis)

It is clear that during an ADF those who are present are not passive or helpless during a fire; the reality is that most people play an active role during the incident, particularly in the early stages after becoming aware. Participants' activities demonstrated the degree to which people are motivated by a core desire to understand what has caused them to be aware of a change to their environment (the awareness is not always accompanied by an immediate realisation that there is a fire) and then following this the motivation to enact a process to extinguish or otherwise mitigate the fire. In doing this it is apparent that participants are exerting, or attempting to exert, a measure of control over the situation. Furthermore, the motivations for tackling the fire reveal a deep-seated desire among people to resolve the situation themselves or to attempt to limit the spread and resultant damage until the arrival of external assistance (i.e. the FRS), which includes summoning that external assistance.

It was found that upon becoming aware of a change in the environment, the most common response was to investigate the source of the cues. Slightly more than half of the sample reported that they were surprised by the fire. While other research has noted a tendency towards optimism bias in emergencies, in which the possibility of negative events are downplayed or ignored, thereby resulting in people dismissing the cues of a fire, or at the very least not immediately considering what those cues represent, beyond a general change in the environment (Knuth et al., 2015; Shepperd et al., 2002; Sharot, 2012; Weinstein, 1980; see Section 2.7.6), participants in this study seldom attributed their surprise to an optimism bias. Instead, participants' responses about surprise were dominated by impressions of the smoke: the volume, the speed of spread and distance over which it spread. While the work on this area is limited, the surprise expressed is something that is consistent with findings from previous studies, in which participants expressed shock and surprise at how quickly the smoke developed (Thompson, 2011; Thompson and Wales, 2015). This surprise is the result of exposure to an uncontrolled fire, and moreover the contrast between an uncontrolled fire and the experience of a controlled fire, which exists in a space that is bounded and regulated and where a key consideration is maintaining the fire and not allowing it to self-extinguish (i.e. think barbecues or open fires in the home and the frequent effort required to maintain one).

The surprise expressed about the smoke and its speed of spread is reinforced when one considers that, among those who reported encountering smoke, it was not flagged by many as seeming (at the time of encountering it) to be a particular risk. The underestimation of the risks of smoke is again consistent with what has previously been found in studies of behaviour in dwelling fires, where participants did not regard smoke, or indeed smoke inhalation injuries, as having the same level of severity as burn injuries (Thompson and Wales, 2015; Thompson et al., 2013). What is interesting about this is how it stands in contrast with what has been demonstrated about the speed with which smoke results in a diminution of cognitive ability, negative physiological impact and the consequent reduction in the ability to move through smoke (Jin, 1982, 2002; Jin and Yamada, 1989; Sime et al., 1992).

An underappreciation of the risk smoke presents likely contributed to the demonstrated willingness to both engage with the event and attempt to address it and control it themselves. Participants not only investigated the cues, which involved movement towards the fire, but also slightly more than half of participants tackled the fire, the three main methods being switching the power off, using water or smothering with an item other than a fire blanket. The findings of this study in relation to tackling the fire is consistent with other work looking at behaviour in dwelling or low-rise residential fires which have found an increased incidence of attempts to tackle a fire compared to in PCI spaces (Babrauskas et al., 2010; Brennan, 1998; Bryan, 2002; Canter, 1996; Shields and Proulx 2000, Shields et al., 1999; Xiong et al., 2017).

Calling 999 was also a common activity, carried out by nearly two-thirds of participants, although this tended to come more towards the middle of the sequence of activities. The timing of 999 calls in the overall sequence of events was again found to be consistent with previous work looking at the sequence of behaviours during an ADF, in which rather than being done at the start of the incident, the 999 call was most frequently made later on after a period of sense making and an attempt to tackle the fire (Thompson et al., 2013; Wales and Thompson, 2012).

Regarding re-entry behaviour, there are two groups of participants to be considered: those who evacuated, that is those who at the point they left the property did so thinking they would stay out until the incident was over; and those who left temporarily, knowing when they left the property that they would re-enter (e.g. to tackle the fire after having first removed some occupants or items from harm's way). Half of the sample evacuated the building and almost another quarter left temporarily, meaning close to three-quarters exited the building. Irrespective of their original intentions, almost half of those who exited re-entered the property while the incident was still underway. While there is only a limited amount of work available that has looked at the proportions of re-entry to domestic properties during a fire, from what is available, previous studies have identified that between 20% and 44% of people re-enter (Bryan, 1977; Thompson et al., 2013; Wood, 1972). This means that the findings of this study are consistent with what has been observed in previous studies that have looked at this, and further confirm that during an ADF anything between a fifth and half of people will re-enter.

The proportions of people re-entering are both the result of, and indicative of, the desire among people to make sense of the incident and attempt to mitigate it. This is illustrated by the reasons given for re-entering in which the two main reasons were to check on the fire and to tackle the fire. The number of responses were small, meaning the results can only offer a general indication at best, but exploring this issue further revealed that the main reason why people felt the need to check on the fire was in order to see if it was of a size that they could attempt to tackle and put out. So again, people desired to take action to deal with the fire.

Related to this is the issue of why some participants chose not to evacuate the building. More than half who remained stated it was because they had completed tackling the fire, thereby removing the threat and with it their reason for needing to evacuate. This is a point that again underlines the desire among many to become involved with the fire and to seek to mitigate it in some way. In summary, the overall theme of participants' behaviours during an ADF was characterised by a rational manner of response, goal-oriented tasks, and movement around the property, including in and out of the RFO and the building itself.

Research question 2. How do these findings compare to the work carried out by Wood, Bryan and Canter et al.? In particular what is the contemporary relevance of male-female differences in behaviour during fires? (Re: Section 4.2 analysis)

In terms of overall behaviours there is a considerable amount of overlap between the main findings of this study and the three original studies. However, before discussing the similarities, one practical difference between this study and the original studies that is worth noting is in the statistical techniques utilised. As demonstrated in the analysis undertaken for this study, not only can a greater range of statistical techniques be employed, but the obvious increase in computing power means they can also be carried out with far greater speed than what would have been possible 40 years ago. In the studies by Wood (1972) and Bryan (1977), the analysis undertaken on the data used frequency counts and chi-square analysis to test relationships between several variables. In Canter et al.'s study (Canter, 1990), limited information was given about the statistical techniques used. However, all three studies also utilised graphical means of displaying their findings about behaviours ('question/response charts', 'weighted diagraphs', 'decomposition diagrams').

Notwithstanding some individual variations in the way data were coded and (perhaps relatedly) in the reported frequencies of certain activities, all three early studies found evidence of people tackling fires, moving through smoke, and re-entering buildings. These were behaviours that were also observed with this thesis, as half the sample tackled the fire, close to three-quarters entered the RFO if they did not start in that location while more than a half of the entire sample got within touching distance of the fire (thereby surely entering areas with smoke), and almost half of those who exited re-entered the property. In fact, with re-entry behaviour, the reasons given by the participants in the studies undertaken by Wood and Canter et al. (tackle the fire and observe the fire) are identical to those given for this thesis. This adds up to a situation in which the overall nature of people's response to an ADF remains broadly consistent today and characterised by the same behavioural themes of investigation, approach, and involvement with the fire.

As will be discussed in more detail in the next section, in the original studies, gender was very much found to be a key determinant of several behaviours. All three studies found that females were more likely to warn others and leave the building. Wood and Bryan also found that females were more likely to evacuate family members and also call the FRS. Bryan and

Canter et al. both observed that males were more likely to tackle the fire, while Wood found that they were less likely to evacuate and more likely to re-enter. And for Canter et al., when combined with building type, gender was arguably the single most important factor in determining people's actions during a fire. As has already been discussed, these were a range of behaviours that typified and were grounded in stereotypical ideas of gender in which females adopt a more caring, protective approach, whereas males tend to display a greater willingness to deal with the incident. In the study for this thesis, gender was found to be just as relevant as it was in the original studies and also to closely follow the same kinds of behaviours (for males, entering the RFO, tackling the fire and re-entering the property; for females, calling 999 and evacuating the property). In fact this aspect is all the more notable given the significant changes that have taken place over the past 40 years in gender relations and gender politics (see Section 2.6.7). Consequently, it can be stated that the contemporary relevance of gender is as important as it was at the time of the original studies.

Research question 3. What are the relationships between these behaviours and the occupant characteristics studied previously by researchers in the field (not only gender but also fire safety knowledge/training, and prior fire experience)? (Re: Section 4.2 analysis)

In the early studies gender was consistently identified as a key variable in determining behavioural differences (Bryan, 1977; Canter, 1990; Wood, 1972). Within this thesis, while a number of male-female differences were observed, the initial response was characterised by investigation of the source of the fire cues, irrespective of gender. Investigation was the first activity undertaken by both males and females; the observed gender-based differences then occurred from this point onwards.

Males were significantly more likely to enter the RFO, tackle the fire, and re-enter the property. In comparison, females were significantly more likely to call 999 and exit the property. This means that, despite a difference of approximately 40 years, along with the fundamental societal changes that have taken place in gender relations during this period, the data present a range of findings that are broadly consistent with those of Wood, Bryan and Canter et al.. Overall, males were more likely to behave in ways that may be considered a form of active engagement with the fire, whereas females were characterised by behaviours related to withdrawal and notification. Furthermore, no significant interaction effects were observed between gender and being alone. This meant that lone males were still as likely to enter the RFO, tackle the fire, and re-enter the property as accompanied males. Similarly, lone females were still as likely to call 999 and exit the property as accompanied females. Taking this a step further, it can be argued that, when unaccompanied, females did not alter or amend their behaviour by becoming more likely to enter the RFO and or tackle the fire. There do not appear to have been any previous published studies that have examined this. As a result, in the absence of any preceding work on this area, this study may arguably be the first in the field of fire safety to examine gender-based behavioural differences while controlling for whether males and females were alone or not.

The above points lead onto the obvious question of why gendered behaviour appears to be entrenched. It may be the case that the differences are grounded in both a social and biological basis. Dealing firstly with the social basis, there is possibly an overlap with Canter's Role/Rule Model (see Section 2.5.5) and its assertion that people are goal-oriented and their motivations driven accordingly (Canter, 1996). These goals may be considered as a function of a person's role in that specific setting at that particular point in time. These 'roles' in turn have a series of associated expectations and actions, which are the 'rules' in Canter's model. If this model were to be applied to the findings from this study, then males and females would take on stereotypical gender-based roles during a fire in which males adopt a more aggressive approach and posture towards the incident while females adopt a more protective or nurturing approach. Applying the model to this general observation means that the 'rules' for males would be defined by engaging and dealing with the fire, while for females these would be defined by evacuating dependants and calling 999.

However, even if this is the case, while the model offers a way to describe the observed behaviours, it still does not really provide a means of explaining why those behaviours are associated with each gender. This situation is compounded by the fact that work on this area in the field of fire science is scarce (Hahm et al., 2016). So, in order to better understand possible reasons for why these gendered behaviours occur during a fire (and have not changed for the past 40 years), it is necessary to consider some of the large body of work that has looked at how males and females differ when it comes to both risk perception and risk-taking behaviours. Within this area, while much has been made of the observed differences between males' and females' perceptions of risk, a range of theoretical explanations for those differences have been put forward in an attempt to systematically relate the differences to gender theory and gender study (Henwood et al., 2008). It has been identified that, compared to females, males have a greater tendency to underestimate large risks, something which would include entering a room in which there was a fire as well as tackling a fire (Hakes and Viscusi, 2004). In terms of an explanation for this, it has been argued that it is gender structures themselves (particularly gender ideology) that account for the gender differences that occur with the perception of risk, with gender exerting a regulatory effect upon people's perceptions, attitudes and subsequent actions (Gustafsod, 2006; Henwood et al., 2008). A meta-analysis of 150 studies comparing the risk-taking tendencies of males and females found very clearly that males are more likely than females to take risks across a wide range of activities (Byrnes et al., 1999). Explanations for the differences include a greater ability for females to perceive certain future risks in some contexts (particularly in relation to assertive or physically aggressive behaviours), greater susceptibility to the perceptions within the social environment about their role, a greater degree of optimism bias among males, and the idea that differences may result in gender-linked differences in competitiveness (Byrnes et al., 1999; Miller and Byrnes, 1997). These are factors that would have a clear overlap with the differences in gendered behaviours during an ADF that have been observed in this study.

The knowledge of this area also presents opportunities for changes to policy and improvements in practice among FRSs. There are implications for FRS policy in relation to operational response and prevention work. An accurate understanding of gender-based differences has direct relevance to fire crews as it provides additional information during the incident planning stages around the likelihood of occupants having sustained injuries along with the possibility of them still being within a property or trying to regain access to the property. This informs the tactical planning of incident commanders and the subsequent utilisation and allocation of resources and assets. To give one example, rates of re-entry are likely to be influenced by the number of adult males present during a fire. Knowledge of this fact means that, when attending an ADF, crews can be aware that males may be more likely to try to breach the inner cordon in an attempt to re-enter. This fact can then be directly addressed when crews are speaking with the occupants at the scene. Consequently, crews can incorporate lessons from such situations into their training and tactical planning.

In relation to fire safety messaging, this knowledge about gender differences allows messages to be developed for males and females with the messages targeting different aspects of gender-based behaviour. For example, FRSs' fire safety messages could be designed to specifically target males to address the risk-taking behaviours and attempt to dissuade people from entering the RFO, tackling fires and re-entering the property. Messages aimed at females could be designed to continue to support and encourage important behaviours such as calling 999 or assisting others to evacuate. For FRS practice, there is an opportunity to take the key findings of this thesis and incorporate them into the incident command training and continuous professional development of firefighters.

Having discussed gender, attention will now be given to knowledge/training and prior fire experience. Overall, the effect upon behaviour of workplace knowledge and prior fire experience was not straightforward. The regression analysis found that the presence of workplace knowledge was a significant predictor of being more likely to investigate a fire, more likely to enter the RFO, and more likely to evacuate the building. This may be connected with the approach to workplace fire safety training in the UK that, in certain circumstances, encourages people to confirm the source of the cues as being a fire before taking further action. For example, in 2013, Kent FRS changed its policy on responding to automatic fire alarms (AFAs) in PCI spaces, moving away from an automatic attendance to a requirement for the responsible person to confirm that it is in fact a fire that has caused the AFA to activate before they call 999 (KFRS, 2019).

By contrast, having previous experience of a fire was not found to have any significant effect upon whether or not participants investigated the fire or entered the RFO. However, it was a predictor of tackling the fire, being less likely to call 999 and being less likely to exit the property. This means that the presence of prior fire experience is linked with a set of behaviours in which people are more likely to engage with, and less likely to withdraw from, a fire. A possible explanation for this may be an increased level of confidence that arises from having some degree of experience of a fire. This finding is very similar to what was originally found by Wood in his 1972 study:

"Previous involvement in a fire appears to reduce some of the stressful elements of the fire, since people who had been previously involved were less likely to leave immediately and more likely to firefight in addition to moving further through smoke. They were not, however, any more likely to behave in a 'correct way' such as contacting the fire brigade, and indeed were more likely to return into the building." (Wood, in Canter, 1990, p92)

In terms of how experience influences behaviour, studies looking at the effect of experience in participation in extreme sports, marketing management and financial decision making have established that experience influences both risk perception and the inclination to perform or undertake a certain activity (Creyer et al., 2010; Mahajan, 1992; Zacharakis and Shepherd, 2001). Furthermore, with high-risk recreational activities, the likelihood of participating in them has been shown to be determined by prior experience and risk perceptions, which are in turn reduced through prior experience of that activity (Creyer et al., 2010; Heath and Tversky, 1991). This has also been found to be the case with risk taking in financial investment decisions, where experience affects perception of risk to the point where people are willing to take more risks (Forlani and Mullins, 2000). This is something that has been attributed to an increased level of confidence from prior exposure to risk, leading to a sense of control over the situation and its attendant risks (Parhankangas and Hellström, 2007). This also has a direct link to the effects of fire safety training and prior fire experience in giving people more information about an event, something that in studies of risk taking and decision making has been shown to lead people to believe they will make better decisions, something which leads to greater levels of confidence but decreases the accuracy of decisions (Zacharakis and Shepherd, 2001). The other area that is relevant in this context is the recognition that risk perception is also influenced by the outcomes of previous events and the effect that beneficial outcomes in previous events have upon reducing perceptions of risk due to an association with a positive outcome and associated belief on one's ability to control that risk (Ohman, 2017). This is something that has a relevance to fire safety training as there could be value in incorporating this point into workplace fire safety courses, so that attendees are made aware that, through exposure to such a course, they should not let this lead to them underestimating the risks of a controlled fire, nor overestimating their ability to manage the risks associated with that.

Research question 4. What role do smoke alarms play in alerting occupants to an ADF and in influencing their subsequent behaviours? (Re: sections 4.3 and 4.4 analysis)

The main cues that alerted participants to the fire were seeing smoke or smelling smoke, smoke alarms being cited only third most frequently. This is principally due to the location of smoke alarms meaning that the fire was not detected by one. The reason for this was because most fires originated in the kitchen and smoke alarms are not recommended for fitting in kitchens because of them being unnecessarily activated as a result of smoke generated during cooking. It is for this reason that, rather than a smoke alarm, building regulations require new build properties or dwellings that have undergone certain alterations to have a heat alarm installed in a kitchen where the kitchen is not separated from a circulation space (hallways and landings) by a stairway or door (Fire Angel, 2019).

However, even if a heat detector is present to alert occupants, the analysis from this thesis shows that its presence is unlikely to change behaviour and result in occupants avoiding injury. Arguably the most striking feature of the analysis looking at smoke alarms was the finding that they do not modify behavioural responses. The analysis looked at two main areas: smoke alarms and activities undertaken; and smoke alarms and injury. These areas were chosen as they allowed two of the main assumptions about smoke alarms to be tested: the first, based on the messaging in fire safety campaigns, that people will hear a smoke alarm sounding in the home and take actions to avoid the fire; and the second, that working smoke alarms prevent injury though alerting people and thereby giving them more time to move away from the fire. Participants did respond actively to sounding smoke alarms (a notable difference from PCI spaces where response to alarms is marked by delay; see Section 2.8). Yet it was observed that, whether the alarms sounded at any point during the fire or were the first cue, participants' subsequent behaviour did not differ significantly compared to when they were alerted by other cues (including being directly informed by someone that there was a fire). That is, participants still tended to respond by first investigating the cue. Furthermore, this initial response to smoke alarms did not differ depending on whether participants were awake or had been asleep. Additionally, smoke alarms were not found to deter participants from entering the RFO and getting within touching distance of the fire, nor deter them from tackling the fire.

When fire cues were organised into three groups (social, physical and smoke alarm), the largest proportion of injuries was actually among those who were alerted by smoke alarms, and a significant association was found between incidence of injury and a smoke alarm sounding. However, no such association was found when the focus was reduced from instances where an alarm sounded at all to instances where the sounding alarm was the first cue. It is possible that the former type of instances included more cases where the alarm sounded as a consequence of a larger fire, one large enough to generate sufficient smoke to eventually reach and activate an alarm sited further away, whereas the latter type of instances possibly included more cases of smaller fires but ones situated closer to an alarm. So it was probably the size of the fire rather than the alarm sounding that was actually associated with being injured. This position is supported by the fact that increased fire damage spread was found to significantly predict being injured while having an alarm present was not.

From these results, it is apparent that a functioning smoke alarm does not make people any less likely to approach and tackle a fire or, conversely, make people any more likely to promptly evacuate. In addition, the presence of a functioning smoke alarm during an ADF does not appear to result in people being any less likely to be injured. So, this raises the question of what purpose do smoke alarms serve? What is their value, if any? Since 1988 in the UK, considerable effort has been put into media campaigns from both central government and individual FRSs, which have sought to increase ownership of domestic smoke alarms (DCLG, 2008; Knight, 2013). In addition, from 2005, the Fire and Rescue Services Act 2004 (England and Wales) and its legislative equivalents in Scotland and Northern Ireland have mandated the need for FRSs to actively promote fire safety and fire prevention strategies, a key part of which is promoting smoke alarm ownership (Legislation.gov.uk, 2004; Legislation.gov.uk, 2005a; Legislation.gov.uk, 2006). This was supported with 'pump priming' grants from central government (the 'Home Fire Risk Check Initiative' and the 'Fire Prevention Grant') (DCLG, 2009; Wiredgov, 2009). Many FRSs also fund the purchase and installation of smoke alarms as part of their community safety initiatives. Moreover, a law has also been introduced to ensure that where the occupant is not the owner of their home, this action is not overlooked, by placing the responsibility (at the start of each new tenancy) with landlords (The Smoke and Carbon Monoxide Alarm [England] Regulations 2015; see Section 2) (Legislation.gov.uk, 2015). Yet the results suggest that alarms have no apparent effect on how people respond to a fire or whether they are injured in a fire.

Before concluding then that alarms are ineffective, it is important to state that (i) this sample comprised people who did not incur fatal injuries during their ADF, and (ii) smoke alarms are primarily designed (by the manufacturers) with detection in mind. Alarms can play a vital role in fire and life safety during ADFs in situations where people are asleep or otherwise unable to detect the smell or sight of smoke (e.g. due to a sensory impairment). In such situations, a failure to detect the fire promptly can result in the inhalation of fatal quantities of smoke without waking or in occupants becoming aware of the fire too late, finding themselves trapped in areas such as upstairs bedrooms where the means to escape or call for help may be limited and thus the occupants are overcome by flames and or smoke (see, for example, New Zealand Fire Service Commission, 2005). So, the findings here are not suggesting any diminution of alarms' undoubted importance, rather they highlight that there needs to be discussion around and recognition of the specific role and benefits of smoke alarms in domestic settings. Overstating what alarms can do to improve home safety could ultimately lead to complacency, and consequently injury, which even if not fatal could still be serious and disruptive to people's lives and well-being.

5.2.2 Group 2

This group of research questions addresses the need for an understanding of the variables that are risk factors of injuries (including whether they are the same as the risk factors for deaths).

Research question 5. Establish the timing, nature and severity of injuries sustained and the relationship to occupant behaviours. (Re: sections 4.4 and 4.5 analysis)

It was established that almost one-third of participants had incurred at least one injury. Using data from the timeline to determine the timing of injuries showed that three-fifths of all the initial instances of injury occurred during the first or second activity participants were undertaking. When this was compared with the type of activities being undertaken at this point in the timeline sequence, the two most frequently cited were tackling the fire and investigating the cues. Given that participants tended to be injured at the start of their involvement with the fire, following deliberate movement towards the fire, leading to increased proximity to flames and products of combustion, the question arises: why are people engaging in behaviours that would apparently lead to injury? It should be noted that a number of participants were able to put out the fires by themselves and these fires tended to be (or were at least perceived to be) smaller when first encountered, generating less smoke, with the majority scoring 1 or 2 on a five-point scale of perceived fire size. So it could be that participants perceived the fires to pose less risk initially and thus believed their activities were less risky. As previously discussed in Section 5.2, participants also tended more generally to not conceive of smoke as posing a risk. However, this thesis argues that, more importantly, it comes down to a fundamental characteristic of human behaviour in fire, which is a desire to understand the situation and, where possible, seek to control it. The core of this behaviour will be discussed later in Section 5.

Smoke inhalation injuries dominated and, in terms of severity, three-quarters of participants had minor injuries; few had severe injuries. The fact that most injuries during these ADFs were minor and not more serious in nature is welcome. However, the identification that injuries are occurring at the very beginning of participants' involvement with the fire presents a challenge for FRSs, as it means that they tend to occur before FRSs are in a position to prevent them. Furthermore, as will be discussed more in Section 5.5, because this sort of behaviour is highly typical of the human behavioural response to emergency events, it will in all likelihood be very challenging to seek to change this behaviour through fire safety messaging, particularly as numerous studies evaluating the effectiveness of public health campaigns have demonstrated that even where people listen to public safety and health advice, a limited number act on that advice and, among those who do, the effect tends to be short-lived as people revert to their previous habits and behaviours (Aschemann-Witzel et al., 2012; Hornik and Kelly, 2007; Jepson et al., 2010; Maibach et al., 2007; Walls et al., 2011).

Research question 6. What variables (behavioural and otherwise) predict being injured in an ADF? (Re: Section 4.4 analysis)

Known risk factors for dying in an ADF were not necessarily the variables that significantly increased the odds of being injured in an ADF. Identified risk factors for injury are discussed more in Section 5.3. However, it is worth noting that they include a behaviour already much discussed: tackling the fire. One interesting point with this, particularly in light of the identification of gendered behaviours, which included the greater propensity of male participants to engage in tackling the fire, was that gender was not found to significantly predict being injured.

Another occupant characteristic looked at here was age. Given the assumptions related to age and injury, it is noteworthy that specifically older age was not found to be a significant predictor of being injured in an ADF when other variables were controlled for. Even when looked at in isolation (i.e. without controlling for other variables that are likely to be present during an ADF), the results on age and injury were not always significant; when they were, this was heavily dependent on the largely arbitrary cut-off points applied to categorise participants' age into 'older' and (relatively) 'younger'. In short, the data do not support the current and widely-held assumption that the elderly (65+) are more at risk of (non-fatal) injury during a fire in the home. Nor do the data from further analysis support the assertion that the elderly are more likely to sustain non-fatal injuries of a more serious nature. However, it should be emphasised that, in the event of an older person becoming injured, their advanced age means that the physiological effects of injury are likely to be more serious and their chances of successfully recovering from that injury are reduced (Davis et al., 2012; Lungren et al., 2009). This may also present problems for older people in the ability to recover from what can be the long-term neurobehavioural side effects of carbon monoxide exposure caused by smoke inhalation (McConnell et al., 2004). These latter points have implications for both a reappraisal of the approach for injury prevention targeting but also to the consideration of prioritisation of treatment of the elderly at a fire scene. This is because, while the elderly do not appear to be significantly more likely than younger adults to be injured (including seriously injured) in an ADF, any injury they do sustain, particularly a serious one, should mean that they are prioritised because of the greater difficulty elderly people experience in recovering from an injury and its effects compared to younger adults. Moreover, fire safety messaging targeted at the elderly could emphasise the importance of seeking help and not attempting to downplay or dismiss injuries (CDC, 2017).

The above points are of direct and practical value to FRSs as they offer important new insights in relation to risk profiling. For example, they highlight that younger adults may be just as likely as older adults to be injured, and be seriously injured, in an ADF, and so should not be overlooked. However, the above points also suggest prioritising locations where there are concentrations of elderly residents, due to the increased difficulties in recovery from injury. This also allows FRSs to consider using additional measures (e.g. smoke hoods) in order to prevent elderly occupants from being (first or further) exposed to smoke while they are escorted or otherwise removed from a property.

5.2.3 Group 3

This group of research questions addresses how human behaviour in ADFs compares to human behaviour in PCI spaces, with a view to informing the work of other fire safety professionals. For example, simulation models and conceptual models of human behaviour are based primarily on data from PCI spaces, and it may be possible that they are not actually generalizable to human behaviour in fires in other settings, such as domestic spaces.

Research question 7. Are there any differences in human behaviour between fires occurring in low-rise and high-rise dwellings and, if so, what are these differences and what is the nature of the relationship with the dwelling type?

Research question 8. Are the behaviours in domestic settings (both high- and low-rise) different from PCI spaces and, if so, in what ways and how can these differences be accounted for?

Research question 9. To what degree can knowledge about human behaviour in PCI spaces be applied to ADFs?

Because of the inter-related nature of the three questions in Group 3, and because they can mainly only be answered through a consideration of the analysis as a whole, alongside a comparison with the existing literature on this particular area, they will be discussed as a group rather than be answered separately.

It was not possible to answer research question 7 due to a lack of LIFEBID data from fires in high-rise dwellings. In the UK the definition of a high-rise residential building is one that has ten or more storeys (see Section 2.2.4), however, within this sample, less than a fifth of participants lived in flats and none lived higher than the fourth floor. This meant that it was not possible to undertake analysis on occupant behaviour in high-rise vs. low-rise residential buildings.

As mentioned in Section 4.1.5, compared to low-rise dwellings, collecting data from fires in high-rises poses the following two considerable challenges. Firstly, the complicated nature of fires in multi-storey blocks of flats, and the much greater potential for life risk compared to in a low-rise dwelling, makes them resource intensive for FRSs (both in terms of firefighters and fire appliances/specialist equipment), which imposes practical constraints that will severely limit the time fire crews can spend distributing survey materials or collecting occupants' contact details. In many instances, the demands of dealing with the incident and casualty evacuation, as well as attempting to manage a large fire ground and associated cordon, will often prohibit this altogether. Secondly, the often protracted nature of high-rise fires means that residents may be likely to depart to other locations while firefighting operations are still being undertaken. Compared to a house fire, there are a far greater number of people present in a multi-storey building, especially a high-rise block of flats, which will make it far more difficult to identify both the occupants of the flat where the fire started and the occupants of those flats directly affected. These challenges mean that it is unlikely the fire crews would be able to recruit participants at the time of the incident. As a result, a method would need to be used that would allow occupants to be contacted after the incident. Following a high-rise fire, if the building was not seriously damaged, and if access was not now restricted, one method might be to undertake a leaflet drop to all of the unaffected flats in order to encourage residents to go online and share their experiences. However, if access to the building was restricted, this would not be possible, so an alternative could be to try to enlist the assistance of the local authority or managing agent in order to seek their agreement to publicise the survey to occupants when they get in contact following the fire (e.g. when requesting assistance with temporary alternative accommodation or making an insurance claim). The other method would be for an FRS to publicise the survey on its website and seek the participation of those who have visited the site. However, both of these methods come with limitations: for the first, there may be some work to overcome an initial unwillingness among local authorities and managing agents to co-operate; and secondly, promotion via a website would reach only those prospective participants who have internet access, thereby limiting the potential pool of suitable participants, particularly older adults as they are less likely to use the internet (ONS, 2018b).

Earlier in this thesis (Section 2.8) it was argued that the greatly different set of circumstances and associated influences acting upon occupants during a dwelling fire mean that they must be considered a separate and distinct group. It would be inaccurate and over-simplistic to assume that the accepted behavioural responses and actions during fires in PCI spaces can be applied to domestic spaces. This thesis argues that the key factor which underpins the differences between human behaviour in fires in domestic spaces and fires in PCI spaces is that buildings may be considered as either ‘closed’ or ‘open’ systems (Shields and Proulx, 2000). As stated, closed-building systems (which describe PCI spaces) are those where activities are formalised and managed and in which processes are controlled. These manifest themselves through the presence of building codes (both prescriptive and performance-based), and identifiable, often hierarchical management structures (relating to both the building and those using it) (Shields et al., 1999). In contrast, dwellings may be considered as open-building systems; places where there is not a formalised management structure relating to the building and the manner in which it is used, including the absence of any roles prescribed by fire safety codes and regulations (Sekizawa, 2015) – except for on the installation and maintenance of smoke alarms (see Section 2.3), and these regulations are limited in terms of to whom (landlords), to where (privately-rented dwellings), and to when (start of new tenancies) they apply. Consequently, occupants’ responses in the single occupancy domestic environment will not be subject to the social influences exerted upon them by the requirements and structures inherent within closed-building systems.

In Section 2.8 it was argued that dwellings represent a singular type of socio-physical environment, one in which people are in their most intimate physical space. As such this sense of ownership, responsibility and control over this space (shared or otherwise), and likely presence within this space of loved ones, leads people to act in a way that is less bounded by the types of constraints (such as a fear of embarrassment, a desire to conform, a lack of direct responsibility towards that space) that exert an influence upon behaviour and cue response within PCI spaces and buildings. Consequently, drawing from an assessment of the literature (incorporating studies of human behaviour in fire), eight key differences between PCI spaces and dwellings were identified and outlined in Section 2.8.3. The validity of each of these eight differences can now be considered with reference to the findings of the analysis undertaken for this thesis. These are as follows:

1. A greater (primarily familial) attachment to the building, people and items within it (Canter, 1990; Canter, 1996; O'Mahony, 2012, Proulx, 2001; Proulx, 2002a; Wales and Thompson, 2013).

Although it sits outside of the field of fire safety science, the analysis of 'home' and its importance to people's lives has been the subject of a considerable body of empirical study and theoretical analysis (O'Mahony, 2012). This provides a useful framework for understanding the degree of attachment to a dwelling and the difference with PCI spaces in that regard. This difference is based upon the fact that a dwelling represents the most intimate form of socio-physical space (Longhurst, 2012; O'Mahony, 2012). The people, the possessions, and the building itself comprise a person's 'home'. People share their dwellings with family members and others with whom they have intimate relationships (Casey, 2012; Mee and Vaughan, 2012). Dwellings are also the repository of the bulk of people's possessions, including those items and objects of greatest sentimental, memorial and/or religious value and importance (Kong and Nair, 2012; Noble, 2012). Furthermore, the building can be more than a simple physical construction, but may itself engender a strong emotional attachment greater than that felt towards a work or leisure space (Murphy and Levy, 2012; Sixsmith, 1986).

This greater degree of attachment is evident in the thesis analysis from the range and variety of activities that were undertaken by participants. The number of activities ranged from 1 to 15 individual activities with a median of 7. A lack of attachment would be reflected in a smaller number of activities, which would principally centre on evacuating at the earliest possible opportunity. However, the opposite was observed. As well as investigation, other activities that were frequently undertaken included attempts to tackle the fire plus actions to limit the damage, for example by closing internal doors, along with searching for and retrieving various items from within the property. These are all actions which suggest that participants attach importance to the building, and people and items within it. Additional evidence for this comes from the frequent occurrence of re-entry – something undertaken by almost half of participants. Further insight into this is derived from the fact that the two most frequently cited reasons for re-entry were to check on the fire or tackle it. This is again indicative of the importance of both the building and its contents, as participants would not undertake such potentially risky behaviour were this level of attachment not present.

2. Lower incidence of task attachment and a faster response to alarms and ambiguous cues (Galea, 2009; Kobes et al., 2010; Proulx 2001; Proulx, 2002a; Proulx, 2003; Stahl and Archea, 1977; Thompson, 2011; Thompson and Wales, 2015).

The phenomenon of task attachment is established within the literature as a recurrent feature of human behaviour during fires in PCI spaces (Canter, 1996; FIRE, 2014a; Proulx 2001). In short, this describes the desire to continue with or complete the task that preceded awareness of the cues and the accompanying disinclination to initiate a new behaviour in response (Canter, 1990; Proulx, 2001). Examples of which may include eating a meal, shopping, working, and watching a film or live music event. However, the results of this study (Section 4.2) show that within dwellings this is not the case as, upon becoming aware of the cues, the vast majority of participants immediately undertook a new activity in response to those cues. Of these activities, the three most common (in descending order) were to investigate the cues, tackle the fire, and call 999.

It is well-established that, as a first cue, smoke alarms do not lead to immediate or rapid response during a fire in a PCI space (Sime, 1984; Canter, 1990; Sime 2001; Proulx, 2009; Galea, 2009). However, through this study, a major difference was observed between PCI spaces and dwellings as, among those who were alerted by smoke alarms, the vast majority responded by stopping what they had been doing and undertaking a new activity (Section 4.3). The high proportion of those who immediately ceased the preceding activity indicates that, unlike in PCI spaces, task attachment is not a feature of human behaviour in dwelling fires. However, alongside this it is important to re-state the point made in Section 5.2.1 that while people respond actively to smoke alarms (and other cues) in their own homes, smoke alarms do not modify the type or nature of that response compared to other cues. In other words, hearing a smoke alarm when in a dwelling does not make a person more likely to evacuate nor does it make them any less likely to investigate the cue.

3. Lower incidence of normative social influence (although not informational social influence) due to almost total absence of strangers compared to PCI spaces (Bryan, 1977; Groner, 1996; Nilsson and Johansson, 2009; Perry, 2010; Proulx, 2001).

Normative social influence describes the disinclination to stand out when in a group by being the first person to engage in an activity or behaviour that would draw attention (Asch, 1956; Cialdini and Goldstein, 2004). During a fire, a lack of response from some of those who are present has been demonstrated to exert an inhibiting effect upon others who are also present – something that was very effectively identified in the work of Latane and Darley (1968). An example of this would be delaying evacuation from a room because no-one else in that room has started to evacuate. This means that during a fire people may not respond to ambiguous cues, their lack of response may then exert an inhibiting influence upon others which creates something of a self-reinforcing pattern until the cues reach a point at which they can no longer be ignored and a response is initiated (Schmidt and Galea, 2013).

As with the description above in point 2 of the absence of task attachment during an ADF, the absence of normative social influence during an ADF can be inferred from the large proportion of participants who reported immediately responding to the cues. The reason that the remaining proportion of participants, the ones who continued with the task that preceded awareness of the cues, is lower (fewer than a fifth) than for fires in PCI spaces may be attributable to the fact that the intimacy and familiarity with the people and setting does not lead to the same fear of humiliation and ridicule (or at least make such emotions less disconcerting) as in a public or workplace setting (Canter, 1996). The privacy of the setting also means that people are more likely to be alone at home than in PCI spaces.

4. Absence of staff or fire wardens to organise and direct behaviour according to formalised procedures and operating within recognised hierarchies (Canter, 1990; Canter, 1996; Galea, 2009; Sekizawa, 2015; Shields et al., 1999).

While the absence of staff is obvious, the lack of formalised procedures may be seen in the number and variety of activities that are undertaken by participants (Shields et al., 1999). This is because the formalised procedures that exist in PCI spaces are generally aimed at ensuring those who are present move away from the fire and smoke, and evacuate in the minimum time possible (Shields and Proulx, 2000). In contrast, the response in ADFs is characterised by movement towards and engagement with the fire, the undertaking of a variety of activities, and re-entry to the property. These points are evident when one considers that, of those who were not in the RFO at the start of the fire, almost three-quarters subsequently entered the RFO – a figure that rises to four-fifths when those who came within touching distance of the fire are also included. The fact the people were re-entering, again usually to approach and engage with the fire, also highlights how during an ADF there is not necessarily anyone in a formal position of authority on the scene to prevent such risky behaviour, in contrast to PCI spaces where a warden could prevent this even if the FRS were not yet at the scene.

5. A greater propensity to attempt to tackle a fire (Babrauskas et al., 2010; Brennan, 1998; Bryan, 2002; Canter, 1996; Shields and Proulx 2000; Shields et al., 1999).

While separate breakdowns of the frequency of firefighting in dwellings compared to PCI spaces were not provided in the early studies, all three identified that the frequency of tackling fires when they occur in dwellings was greater than for PCI spaces (Bryan, 1977; Canter, 1990; Wood, 1972). Firefighting as a first activity was reported more frequently in Bryan's study compared with Wood's: a rounded 23% tackled the fire in Bryan's versus a rounded 15% for Wood's (Bryan, 1977; Wood, 1972). By comparison, the proportion in this study who tackled the fire as the first activity was 9%. While Canter et al. did not reference a specific proportion who tackled the fire, the authors of that study stated that in domestic settings there was a greater incidence of tackling the fire compared to in non-domestic settings (Canter, 1990). When the incidence of tackling the fire was looked at in this thesis across the duration of the incident (i.e. beyond just the first activity), the analysis revealed that over half of the sample tackled the fire. Wood observed that people were more likely to tackle a fire if it was thought not to be very serious (Wood in Canter, 1990). However, this study shows that, even if a fire is not initially perceived to be serious, tackling it is not without risk of harm; this behaviour was one of the significant predictors of being injured.

The reasons for the greater incidence of tackling fires in domestic spaces include: the presence of family members and other loved ones; the nature of a dwelling as the repository of the majority of people's physical possessions; and the value attached to the building. As a result of these three factors, actions are undertaken to lessen or neutralise the threat to all three that is presented by a fire, even if that means a greater threat (of injury) to one's self.

6. Greater incidence of re-entry (Thompson et al., 2013; Wales and Thompson, 2012; Wood, 1972).

The absence for nearly 40 years of any large-scale studies looking specifically at behaviour during dwelling fires means that there are few sources of up-to-date information about the frequency of re-entry behaviour in both ADFs and fires in PCI spaces (Thompson et al., 2013). While re-entry behaviour has been observed as a feature of behaviour in dwelling fires (Bryan, 1977; Canter et al., 1990; Wood, 1972), there has been only limited focus upon this since the early studies. This may be due to the fact that much of the work on human behaviour in fire in PCI spaces has been driven by evacuation modelling, where the focus is on people's movement up to the point at which they exit the building. Nonetheless, where re-entry behaviour has been referred to in studies of fires in PCI spaces, this has identified a low incidence of re-entry (Bryan, 1983; Canter, 1996). The reasons for this include: the lack of attachment to the building; lack of or lower level of familiarity with the internal layout; and the fact that PCI spaces are closed building systems, leading to processes that deter or prevent re-entry (Shields and Proulx, 2000; Shields et al., 1999). By comparison, the admittedly limited information available about this that relates to ADFs supports the position that re-entry rates are higher for fires in dwellings, with up to a third of occupants re-entering at least once before the arrival of the FRS (Thompson et al., 2013).

In the work undertaken for this thesis, it was observed that almost three-quarters of the sample exited the building and almost a half of those re-entered the property. Looking at these figures, it becomes clear that the findings on re-entry behaviour for this thesis are similar to the early studies, in which between one quarter and one half of occupants were also reported as re-entering domestic properties (Bryan, 1977; Wood, 1972). Wood commented that re-entry behaviour occurs more frequently when people are ‘completely familiar’ with the building (Wood in Canter, 1990, p92). A greater level of familiarity is something that would be expected to be more common in domestic settings.

The other point borne out by the thesis findings is that it is not just that more people re-enter dwellings but that people may already have re-entry in mind when they first exit the property (see Section 4.2.1 on those who ‘left temporarily’ as opposed to ‘evacuated’). So not only would it be hard to prevent re-entry to dwellings due to a lack of staff, fire wardens or firefighters being present, it also appears that a not insignificant proportion of occupants could be even more determined to go back into the property because they never regarded themselves as actually evacuating when they exited.

7. Greater familiarity with the environment in what is generally a smaller space, resulting in wayfinding being less of an issue that in PCI spaces (Brennan, 1998; Horiuchi et al., 1986; Levin, 1984; Proulx, 2009).

Wayfinding is an important issue during fires in PCI spaces (Kobes et al., 2010). The fact that it is so important is due to the unfamiliarity with the layout of the building (e.g. a hotel or hospital) and the location of escape routes and exits. In contrast, lack of familiarity with the layout of the building would rarely be an issue in ADFs (Thompson, 2011). It is important to point out, however, that this is entirely different from disorientation caused by smoke logging. There, the issue is not unfamiliarity but a lack of visibility, or the debilitating physiological effects of the smoke.

This also relates to the finding above about people leaving temporarily, i.e. those who knew at the time when they exited the building that they would re-enter. This is relevant because if people exited with the intention of only ever leaving temporarily then it indicates that they viewed exiting and re-entering as activities that were simply short-term interruptions to their fire-related activities, which means they did not expect to encounter any problems with finding their way out or back into the property.

8. The presence of feelings of guilt and or responsibility for causing the fire and the resultant desire to deal with this before deciding whether to call 999 or not. In the UK,

USA, Canada and Australia it is estimated that between 60% and 80% of dwelling fires are not reported to the FRS (DCLG, 2015; Greene and Andres, 2009; Home Office, 2019; Office of the Deputy Prime Minister, 2006; Proulx, 2009).

Evidence for the desire to deal with the fire before calling 999 during an ADF can be seen from the fact that calling 999 was certainly not the most common first activity undertaken by participants; this was instead investigating the cues (Section 4.2). Unlike in certain PCI spaces (e.g. hotels), there is likely to be less ambiguity in the early stages of an ADF, or such ambiguity that does exist in the early stages lasts for a shorter period than in PCI spaces. This is because in a dwelling the smaller size means people are more likely to be closer to the fire, within sight of it, or present at the outset of the fire. Furthermore, the generally smaller physical space of a dwelling compared to PCI spaces means people do not have to travel as far, and do not have to move around inside a building that may be unfamiliar to them, in order to seek confirmation about the cues.

In order to spare potential embarrassment, the LIFEBID survey deliberately avoided asking participants a question about how the fire started. Nonetheless, the location of the RFO and fire cause (source of ignition) (Section 4.1) and the methods used by those who tackled the fire (Section 4.2) were strongly suggestive of fires related to cooking activities of the participant or other occupants. Among the reasons given by participants for tackling the fire (Section 4.5), there are several which suggested that many participants felt a sense of needing to deal with the fire themselves and not leaving it to others. These include 'felt personally responsible', 'nobody else could/would', 'prevent harm to other occupants', and 'prevent harm to neighbours'. This is reinforced from the findings of an earlier piece of work looking at responses to ADFs which found evidence of a sense of responsibility among people that meant, in addition to reducing the damage to their own home, they expressed a sentiment that they were responsible for ensuring damage to neighbouring properties was either prevented or reduced (Thompson and Wales, 2015). This is clearly different from PCI spaces, such as hotels, where concerns about fire damage to the building and, to an extent, the contents of the building are of a more secondary nature.

In summary, of these eight proposed differences between PCI spaces and dwellings, it has been demonstrated that there are in fact differences across all eight areas. It was found that there is a greater degree of attachment with a dwelling (number 1). This was evident through the number of activities undertaken and the frequent occurrence of re-entry. Unlike in PCI spaces, task attachment was not observed as a feature of human behaviour in dwelling fires (number 2). When alerted, a high proportion of participants responded by stopping what they had been doing and undertaking a new activity. With the next point (number 3), it was observed that there was an absence of normative social influence in ADFs, meaning the inhibiting factors related to PCI spaces were not present for participants in ADFs. The absence of staff and wardens was concluded to have exerted an effect on participants' behaviours (number 4) as, rather than staying away from the fire, people's responses were characterised by initial and subsequent movement towards and engagement with the fire. People did indeed display a great propensity to attempt to tackle the fire in a dwelling, something not observed so frequently in PCI spaces (number 5). Re-entry was shown to occur with a greater frequency during ADFs (number 6). In addition, this study identified that, during a dwelling fire, a number of people already have re-entry in mind when they first exit the property. Compared to in PCI spaces, wayfinding was shown to indeed be less of an issue in ADFs (number 7). This was a point reinforced by the fact that a considerable proportion of participants were prepared to go back into the property during the fire, thereby indicating that they did not expect to encounter problems in moving around the property. Finally, a sense of guilt and or responsibility for the fire and the resultant desire to deal with the fire personally before calling for FRS assistance can be said to be a feature of ADFs (number 8). Taking these eight points together, this means that it can be stated that, due to a range of social, physical and environmental characteristics, human behaviour in dwellings has a number of differences with human behaviour in PCI spaces. In turn, this means that what is known about human behaviour in PCI spaces cannot be assumed to be applicable to that in dwellings.

5.3 WHY HAS THE INJURY RATE NOT CHANGED?

Having considered the key variables and identified the ways in which human behaviour in dwellings differs from that in PCI spaces, it is now possible to consider the conundrum presented at the start of the literature review in this thesis (Section 2.3.5). That is, why is it that the number of ADFs and associated injuries have been falling year upon year yet the proportion who are injured when an ADF does occur has remained broadly consistent? Based on the evidence presented here, there are several inter-related reasons why the injury rate in ADFs has remained consistent. First, a fire of any size will produce harmful products, particularly smoke. As soon as these products are released into the environment, the potential is there for them to be directly encountered and thus for injury to occur. Naturally, the larger the fire, the greater the quantity of products present in the environment, and therefore the greater the risk of injury, as was shown with the finding that greater fire damage spread (indicating larger fires) was the biggest significant predictor of being injured. To limit the size of the fire, and therefore the chance of occupants being exposed to it, particularly in greater quantities, one solution would be for the fire to be swiftly detected and responded to.

The finding that having consumed a substance close to the time of ignition was the next biggest significant predictor of being injured suggests that people may not always be capable of swiftly detecting and or responding to a change in their environment. However, while the substance could be alcohol or recreational drugs, it could also be prescription medication. Thus, it may not be advisable to try to dissuade people from this type of behaviour. Being asleep at the time of ignition – the next biggest predictor of being injured – could in some cases be associated with the consumption of substances. Moreover, devices such as smoke alarms already exist to rouse people from their sleep. Thus, there might be little scope for addressing this behaviour.

Similarly, given the size of the UK, in terms of land and population, and the price of housing, there is also little scope for reducing the next biggest predictor of injury, attached dwellings. In other words, it is likely that increasing numbers of people will live in a flat or terraced house and so, even if no fire starts in their own home, they may be affected by fires in neighbouring properties, which will be more serious by the time they have spread beyond the original home. Hence why fire doors have been designed to confine the fire to the RFO for a certain period thereby giving occupants time to evacuate. However, even if a home has fire doors, in order to be effective and protect occupants they must be closed from the point of ignition, occupants must be outside of the RFO, and occupants must not subsequently open the door and enter the RFO. The final two significant predictors of injury found here, getting within close proximity to the fire and tackling the fire, show that people do not behave as expected and so fire doors may not provide protection. Moreover, these underlying behaviours observed in the analysis undertaken for this thesis remain consistent with those described in the early studies 40 years ago (Bryan, 1977, Canter, 1990; Wood, 1972). In general terms, these early studies all found evidence of people approaching and attempting to tackle fires. The fact that proximity to, or direct contact with, the fire was identified as a predictor of injury in the current study is given context when one considers the high proportion of participants who entered the RFO. In light of this, it is unsurprising that a third of participants reported being injured during the fire. Compared to 40 years ago, people are less likely to have a fire in the home. However, when they do experience a fire, the behaviours they undertake are still the same kinds of behaviours that were identified in those early studies and it is these behaviours that contribute to people becoming injured.

With injuries, three separate rounds of regression analysis were undertaken using a total of 16 variables (Section 4.4.11). In the first round, 10 predictors were identified from a range of variables derived from the considerable body of literature on fire fatalities. Only three out of the 10 significantly predicted being injured. This highlighted that the fire fatality risk factors recognised in the literature are not necessarily fire injury risk factors, thereby establishing the fact that two different sets of risk profiles exist between dwelling fire fatalities and dwelling fire injuries. The second round included six new predictors identified from the results of preceding analysis in this thesis. When considered altogether, three of these six significantly predicted being injured. This confirmed that fire injury risk factors are not merely a smaller subset of fire fatality risk factors and that attention needs to be directed at what is happening during a fire, not just prior to a fire. The final round tested a model comprised of the six significant factors from the first and second rounds combined and, when considered altogether, all six still significantly predicted being injured. So, another reason why there has been an unchanging likelihood of being injured when an ADF occurs could be because, to date, researchers, practitioners and policymakers have not had an adequate understanding of this phenomenon.

Consequently, the static ADF injury rate may be accounted for by the fact that some factors may be difficult to address and other factors, the same kinds of behaviours that were identified in the early studies as occurring, continue to be undertaken yet this fact fails to be properly recognised and understood. In short, large proportions of people continue to approach and tackle the fire and, in doing so, incur injury.

5.4 WHY HAVE THE KEY BEHAVIOURS NOT CHANGED?

5.4.1 The human response to emergencies

Having established that ADF injury rates have been static partly because participants' core behaviours have not yet changed, this leads on to the question about why people are still behaving in the same way; particularly in light of 40 years since the initial studies and 20 years of national fire safety messaging campaigns exhorting people to immediately leave their property, not to engage with the fire, and call 999.

As demonstrated, it is not just the underlying core behaviours of approaching and attempting to tackle the fire that have remained largely unchanged since the early studies. Other behaviours, such as re-entering the property during the incident, have also been observed here, as has the influence on behaviours of characteristics such as gender. Some of the behaviours overlap directly with the predictors of injury and the risk profile that has been identified from this. This thesis asserts that the reason these behaviours have not changed is because they are a fundamental part of the human response to unplanned emergency situations. Consequently, these behaviours are reflective of the resilience, initiative and lack of panic that is shown by individuals when faced with sudden emergency and mass casualty events.

Section 2.5.2 outlined how this was first identified in Prince's study of the response to and aftermath of the Halifax Explosion of 1917 in Canada (Prince, 1920), and the patterns of behaviour that were first identified by Prince led to a number of what are now commonly accepted themes. Notably emergent behaviour, stranger assistance, mutual aid, community resilience, and an absence of role abandonment (Cocking et al., 2007; Cocking et al., 2008; Drury et al., 2009; Gwynne, 2008; Provitolo et al., 2011; Quarantelli, 1983; Scanlon, 1988). In short, during an emergency event, people engage in a series of actions which can be characterised as rational and benevolent responses to a highly emotional and unfamiliar situation. These are rational modes of behaviour in contrast to the irrationalist theory that is still prevalent within some areas such as the media and, arguably, some emergency services.

Within Section 2.7.2, it was also outlined how, starting with the work undertaken by Quarantelli in the 1950s (Quarantelli, 1954), the belief that 'panic' (defined as maladaptive, irrational and aggressively competitive individualistic behaviour driven by self-preservation) commonly occurs as a reflexive response to fires and other disasters has been demonstrated to be inaccurate. Rather than panic, what has been observed is that people make rational decisions, but do so in situations where the circumstances are prone to unforeseen or sudden change, and where access to information is imperfect or limited (Mileti and Beck 1975; Mileti and Sorensen 1990; Wolfenstein, 1957; Zajonc and Bernstein, 1961). The use of the term 'rational' in this context describes how people have made a specific choice about how to respond, and not reacted unthinkingly or purely on the basis of emotion. Following such decisions, people display a desire to help manage the situation and bring about more positive outcomes, often in the form of co-operation and altruism. Within the UK, these qualities were evident in the response of members of the public to the terrorist attacks at Westminster Bridge in March 2017, and London Bridge and Borough Market in June 2017, where during both attacks members of the public in the immediate area formed protective groupings with strangers, undertook first aid and psychological support for those who were injured, and assisted the emergency services with patient evacuation (Cocking, 2017; Evening Standard, 2017). Additionally, during the fire at Grenfell Tower in June 2017, there are accounts of residents moving to other flats in the building in order to warn others about the fire and residents helping others to evacuate (Grenfell Tower Inquiry, 2018).

Across the whole range of emergencies, irrespective of the type of incident, whether it is a fire, earthquake, tsunami, hurricane or terrorist attack, human response has consistently been observed to be characterised overall by emergent behaviour, spontaneous co-operation, stranger assistance, mutual aid, community and collective resilience, and an absence of role abandonment (Cocking et al., 2007; Cocking et al., 2008; Drury et al., 2009; Gwynne, 2008; Provitolo et al., 2011; Quarantelli, 1983; Scanlon, 1988). Indeed these are precisely the sort of behaviours that are recognised and actively supported through the provision of services such as 'Citizen Aid' (www.citizenaid.org), which works with the public's response to emergencies to help them become even more effective.

It is also important to point out that, while the examples listed above are more associated with situations where a number of other people are present, emergent behaviour and the other aspects of non-irrational and benevolent responses also apply to the individual as well as collectively. This point is important in relation to dwellings, as in a number of ADFs the occupant will be alone. The occurrence of emergent behaviour in situations where people are alone or in small groups during an emergency have been identified as occurring in family groups in the aftermath of disasters (Killian et al., 2018), becoming lost during hiking (SmokyMountains.com, 2019), survival during earthquakes (Noji et al., 1990) and during tsunami (Bird et al., 2011).

5.4.2 'Rational' behaviour

The term 'rational' has been used several times throughout this thesis in reference to its use in previous work on human behaviour in fire and disasters more generally. It is important to state that, where the term has been used by other researchers, it has been in order to provide a clear distinction from irrational behaviour and the associated idea of panic and maladaptive behaviour. However, it is useful to qualify the term 'rational' when it is being used in relation to human behaviour in fire and (in relation to this thesis) behaviour during ADFs. Rational carries with it a presumption grounded in economic utility theory that people will simply behave in a way that minimises pain and losses (Ajzen, 2005; Von Neumann and Morgenstern, 1953). Against this backdrop, one could well ask: what is it that is rational about choosing to move towards a fire, to tackle a fire, or leave a place of relative safety in order to re-enter a property that is on fire? These are behaviours that will potentially increase a person's likelihood of becoming injured and the likelihood of experiencing a highly stressful and unpleasant emotional situation. Surely a more rational approach would be to simply move as far away from the danger and the risk area (i.e. the fire/smoke and RFO) and then ensure that there is no further engagement with the fire?

It should be stated that this thesis is not seeking to challenge or undermine the use of the term 'rational' by other researchers in this context; instead, this is simply an attempt to identify and make clear the distinction between the use of a term as generally understood and its specific use within the literature on human behaviour in fire and other emergency events. This is why it is important to state clearly that the use of the term rational in this context is not in fact describing a utility maximisation based approach of rationality (i.e. rational decision making) (Von Neumann and Morgenstern, 1953). Instead, it is describing the fact that people have employed a rational manner of response, in that they have made a specific choice about how to respond, based upon what actions they think they can undertake, in order to achieve the positive outcome that they are seeking. This is fundamentally different from a utility maximisation based assessment of what would be rational (Kelly and Barker, 2016; Oliveira, 2007). Examples of this are apparent with participants' reasons for choosing to enter the RFO. These centre on investigating the cues, tackling the fire, or evaluating the fire (Section 4.5.2) and are reasons that are the result of a choice made following a decision making process. The same is true with tackling the fire (also Section 4.5.2), where the three most frequently cited reasons for doing this were: to contain the fire until help arrived; the fact that the fire looked small (indicating a process of appraisal had taken place leading to a conclusion that the smaller size meant the fire was therefore more likely to be tackled successfully); and prevent damage to property (suggesting an awareness of the consequences if left unchecked). What these behaviours demonstrate is that the approach people take during an ADF is informed by something different, more complicated and far more personal to the individual, than what fire safety professionals see as the single global aim in an emergency (i.e. evacuate to a place of safety).

The recognition of this has led to the development within this thesis of an explanation for occupant responses in ADFs. This is called the Domestic Appraisal Response (DAR), and it emphatically challenges the view, particularly within FRSs, that during an ADF occupants will panic and therefore be incapable of saving themselves and potentially hinder others.

5.5 THE DOMESTIC APPRAISAL RESPONSE (DAR)

The analysis undertaken for this thesis has demonstrated that, through the types of activities undertaken by people during an ADF, the response to fires occurring in a dwelling is a manifestation of, and consistent with, the typical behavioural response to any other sort of emergency event (including fires in PCI spaces), albeit with the specific actions comprising the response modified as a result of the domestic setting. Consequently, this thesis now seeks to propose an explanation for this, which is the DAR. The short-hand term 'DAR' is intended for others (such as FRSs) to make it easier to bear in mind the underpinning explanation, and apply this understanding to give a context to the behaviours that take place.

Rather than focus on concepts of the rational nature of occupant behaviour and response (and the associated discussion around definitions of what is meant by rational behaviour in this context), the DAR instead recognises that the motivations driving people's behaviour during an ADF are inextricably linked to, and influenced by, the highly important socio-physical status of the home and those people within it and connected to it. As mentioned in Section 5.4, this means that the response to and during an ADF cannot be presupposed to be based on the idea of rational behaviour as expressed in utility theory (Marteau et al., 2008). The fact that people are undertaking activities that will increase their risk of injury does not mean that they are behaving irrationally in any sense; instead, this is a result of the 'appraisal' that is undertaken which feeds into the decision making and subsequent actions (i.e. the 'response') (while the socio-physical environment differs, the same principle is true for human behaviour in PCI spaces). People are not panicking or acting without any purpose or aims. In fact, they are appraising options that will provide the best outcome for their particular circumstances, based on priorities as seen from their own perspective. This is the key point that must be remembered before dismissing behaviour on the basis of something as simplistic as how they might have avoided injury, and thereby falling into a trap of viewing the 'rationality' of any behaviour based on a utility maximisation principle (Kelly and Barker, 2016).

The DAR may be described as a short-hand way of conceptualising the type of response and underpinning motivations during an ADF and, in doing so, it offers a guide for understanding how and why people behave the way they do during an ADF (and that this represents continuity with the response to fires in PCI spaces and other emergencies). However, the next question that arises is: what are the decision making processes that come into play during an ADF? For an understanding of how these processes operate, it is necessary to revisit the discussion of the literature on decision making during fires (Section 2.5). There are a number of theories and models of decision making during fire that have some overlap. Of these, the decision-making processes that underpin the DAR can be explained with reference to Kuligowski's conceptual model of the behavioural process for building fires (Kuligowski, 2008). Although this model was developed for application to PCI spaces, it provides an effective way to present the decision-making process that takes place, including the interpretation of cues, situation and risk, and then the resulting decision. Kuligowski's model also identifies that each phase in the decision-making process is subject to influence from occupant-based factors and cue-based factors. This is an important distinction as it means that the model has the flexibility to incorporate the important influence that the 'dwelling' (as a socio-physical space) exerts upon the decisions and subsequent actions undertaken by occupants during an ADF (Kuligowski, 2008).

In addition to offering an overall description about how people behave during an ADF, along with the reasons for that behaviour, the DAR also presents the answers to the question about why the injury rate has remained fundamentally unchanged. The DAR brings together the series of observations from the analysis undertaken for this thesis, sorts them into three conceptual pillars, and presents these in a coherent and unified way. Consequently, the DAR provides a means of contextualising and understanding the response during ADFs. The three conceptual pillars of the DAR are as follows (and illustrated in Figure 29):

The Domestic Appraisal Response (DAR)

1. The response to a fire in the home remains consistent with what was originally observed in the early studies of human behaviour in fires 40 years ago. Behaviour is not irrational, but is based on an appraisal of the situation which incorporates the priorities that are relevant to the occupant in that moment and setting (the appraised responses).

2. Within the domestic environment, these appraised responses are characterised by an initial response of approach not withdrawal – this is irrespective of gender, or whether people are already awake or have suddenly woken up in response to an alarm to find themselves experiencing an ADF. The approach is undertaken in order to gather further information about the source of the cues. While gender-based behavioural differences then occur from that point onwards, for both males and females, the responses are driven by modes of behaviour in which the primary goal is to prevent further damage to the property or secure the safety of people in the property through reducing or mitigating, either directly or indirectly, the effects of the fire. What makes the occupant personally assume the responsibility of active 'saviour', rather than simply evacuating the property and calling 999 and thereby having the FRS achieve the outcome for them, is the fact that a dwelling represents the most intimate form of socio-physical space. The people, the possessions and the building itself comprise a person's 'home'. The importance of this cannot be overstated. There is a clear importance attached to the building as a physical structure, but the bonds go further than this. The home is a space often shared between those who have deep and often long-standing relationships and networks with each other. It is a source of and a repository for emotions. Dwellings are also the location of the bulk of people's possessions, including those items and objects that hold the greatest sentimental, memorial or religious value and importance. This adds up to a situation where the importance of home encompasses the financial, the physical, the spiritual, the emotional and the familial. Consequently, it is no surprise that it engenders a strong attachment and one which is far greater than that felt towards other spaces, such as those used for work or recreation.

3. The reason that the response to a fire in the home has remained consistent is because the behaviours described above are a manifestation, specific to the domestic environment, of the underlying types of behaviours that characterise the overall human behavioural response to emergencies and other disasters.

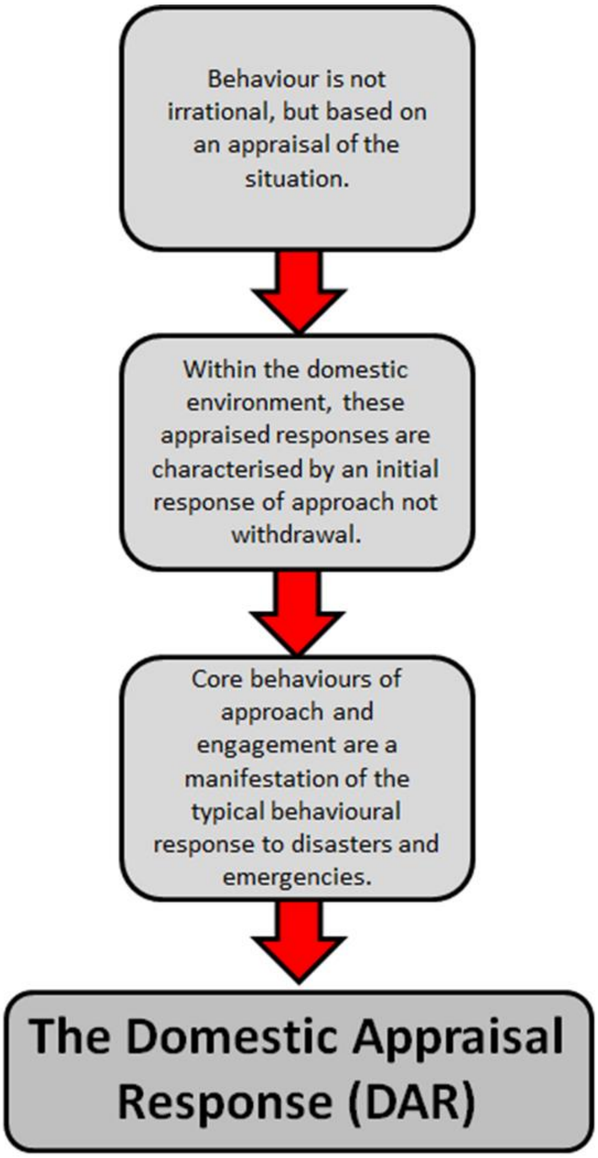

Figure 29. The Domestic Appraisal Response (DAR)

The point about people being woken from sleep by a smoke alarm and still going on to investigate the source of the cues further illustrates just how deeply ingrained such responses are. Within the context of a fire in one's home, it must be considered an entirely understandable response to attempt to make sense of an unfamiliar situation by seeking to gather further information about that situation, or get within touching distance of a fire if people think they can minimise the damage and disruption by extinguishing it themselves. Occupants are making an appraised choice with each of these behaviours that is modified for and subject to the specific influences of a domestic environment. Consequently, the DAR now assists one in answering the question about why the injury rate in ADFs has remained consistent, despite the decline in the number of both ADFs and injuries. The reason for this is partly because the response to a fire in the home is essentially unchanged from what was originally observed 40 years ago. As has been demonstrated, the predictors of injury during a fire include coming into close proximity and engagement with the fire; two behaviours that are a key part of the DAR. This is because, when first alerted to the cues of a fire, the majority of people continue to undertake a process of information gathering and sense-making about the incident. This leads people to move towards the fire, from which point injury is likely to be incurred. In short, such actions represent the manifestation within the domestic setting of the same kinds of behaviour that are observed during any other form of emergency incident.

5.6 CONCLUSION

The large amount of analysis that has been undertaken for this thesis has provided an empirical understanding about the influence of and relationship between a number of key variables. These can be distilled into the following five highlights:

1. Dwellings must be considered separately as there are key differences between human behaviour during fires in PCI spaces and human behaviour during fires in (low-rise) dwellings. Of the eight areas about which it was hypothesised that there would be differences between PCI spaces and dwellings, all eight were found to be valid.

2. The risk factors related to injuries in an ADF have been shown to be different from the risk factors related to fatalities (i.e. only a small number of fire fatality risk factors are also fire injury risk factors, and additional factors have been identified that predict injury). Consequently, predictors of fire fatality cannot be relied or solely focused upon as injuries are not ‘near miss fatalities’ and should not be described as such. The conflation of risk factors for injuries and fatalities, while frequently occurring, is erroneous (Thompson et al., 2018). The apocryphal idea that injuries are near miss fatalities has been described as the ‘conveyor belt theory’, a term used to describe the inaccurate idea that occupants are passive and will move on a pre-determined course which will end in death if there is no form of outside intervention (Berman, 2012; Runyan et al., 1992; Thompson and Wales, 2015; Thompson et al., 2013; Thompson et al., 2018).

3. The gender-based behavioural differences identified in the studies undertaken by Wood (1972), Bryan (1977) and Canter et al. (1990) remain valid. In summary, this means that

males undertake more risk-taking behaviours while females carry out a greater number of protective actions. Furthermore, these gendered behaviours remain consistent regardless of whether participants are alone or accompanied. Importantly, this thesis was, arguably, the first study to examine and control for the effects of being accompanied or alone upon the behaviour of males and females in a fire context. This finding that gendered behaviours are not influenced by the presence of others is a surprising one given the considerable (but by far from complete) societal changes that have taken place to improve female equality and access.

4. Smoke alarms do not modify responses during an ADF – irrespective of whether occupants are awake or initially asleep. Smoke alarms do not make people any less likely to approach and tackle a fire, or make people any more likely to evacuate. In addition, when alerted by a smoke alarm, people still investigate with the same level of frequency as when alerted by other cues. Consequently, based on the data, smoke alarms cannot be said to prevent injury during an ADF by dissuading people from approaching the fire or investigating the cues.

5. Being older does not necessarily mean a higher incidence or severity of injury is likely. Analysis on the LIFEBID data using continuous and categorical age variables to examine incidence of injury found that the available data do not support the assumption that risk of (non-fatal) injury increases in line with age from 65 (or indeed any age). In summary, during an ADF, those classed as older cannot be said to be at greater risk of either injury or sustaining injuries of a more severe nature. However, the caveat to this is that when the elderly do incur injuries, it is more difficult to recover from such injuries.

From these five highlights, the knowledge generated during this thesis has led directly to the development of the DAR, a short-hand way of conceptualising the type of response and underpinning motivations during an ADF. The DAR argues that the core behaviours of approach and engagement undertaken during an ADF are in fact the manifestation of the typical human response to disasters and emergency situations, but applied to, and modified for, the domestic setting. The DAR can assist in answering the conundrum about why the injury rate in ADFs has not declined along with the fall in the number of ADFs. Through the DAR it now becomes possible to contextualise and understand how deeply ingrained such behaviours are. From the analysis that has been undertaken, there now exists a robust evidence base that contributes towards researchers' knowledge and understanding of human behaviour in dwelling fires. Having summarised the key findings along with the DAR, consideration will be given in the next section as to how the findings of this work are being implemented.

6. IMPLEMENTATION OF THE FINDINGS

6.1 INTRODUCTION

The potential benefits to the public of FRSs developing a more informed understanding of human behaviour in fire have been identified in earlier work (Wales et al., 2015). Some of the changes described below began with the attitudinal changes that were engendered by the LIFEBID project. These attitudinal changes involved recognising the importance of listening to and learning from those who have experienced an ADF. Moreover, recognising that, at that time, FRS beliefs and practices related to people's behaviour and overall ADF experience were not grounded in an evidence-based understanding, and that this needed to change to ensure that the best service possible was being delivered to the public.

The thesis has now progressed these changes through consolidating and advancing this knowledge and associated practices, which will now be examined and discussed. The findings from this thesis have a number of applications which can be grouped into two areas: the applications for FRSs; and the applications for evacuation modelling.

Dealing firstly with the applications for FRSs, the findings are relevant to all three of the core functions of an FRS: prevention, protection and response. In several areas within Kent FRS (KFRS), the findings have already contributed to changes in policy and practice and there are a number of other areas where the applications of the findings are under consideration. Furthermore, following the publication of this thesis, the key insights will be disseminated to different departments across KFRS through a programme of presentations and engagement.

For each of the main areas within an FRS, the relevance of the work is outlined along with a description of the way in which the findings are being used within KFRS. The following four areas are where the findings are relevant to the work of an FRS:

- Fire safety messaging
- Fire prevention and community safety activity
- Incident command training and operational response
- Emergency call handling

6.2 FIRE SAFETY MESSAGING

The deeply ingrained nature of the responses that were described by the DAR in Section 5.5 are further highlighted when one considers that at least 20 years of fire safety messaging do not appear to have altered the core behavioural response to a fire in the home. From the evidence presented in this thesis, rather than behaviours such as investigating the cues and approaching the fire being viewed as foolish or maladaptive (which in the past has certainly been the case within some FRSs), it must be regarded as an entirely understandable response to attempt to make sense of an unfamiliar situation by gathering additional information about that situation – particularly when it is occurring in one's home (Maitlis et al., 2010; Weick et al., 2005).

This does not mean though that fire safety messaging is not important or necessary. It is very important. Fire safety messaging performs an essential role in making people aware of and encouraging them to stop practices which are unsafe because they increase the risk of a fire starting (e.g. smoking in bed) or behaviours likely to exacerbate a fire that is already underway (e.g. throwing water on a chip pan fire). However, in light of the evidence presented here, and articulated through the DAR, consideration needs to be given to the areas where fire safety messaging can be applied most effectively to exert the greatest influence (Abroms et al., 2008; Wakefield et al., 2010). To date, limited research has been carried out on assessing the effectiveness of fire safety campaigns and the need for work in this area has been identified in order to ensure the efficacy of campaigns and messaging (Bradley and Boyce, 2004). The limited work that has been undertaken has suggested that fire safety messaging has been shown to be effective when addressing the behaviours and decision making that precede an event (Arch and Thurston, 2013; DCLG, 2014). Key areas include: increasing smoke alarm ownership and reducing unsafe practices that lead to fires. This thesis contends that what needs to be considered is whether fire safety messaging is able to influence or exert any effect upon people's behaviour during, in response to, a fire. The evidence of the past several decades suggests that it has been unable to achieve this.

There is also a larger philosophical question about whether society would actually want such behaviour to change. It is recognised that during emergency events, both before and at the point of the arrival of the emergency services, the types of behaviours undertaken by members of the public involved in that event (e.g. provision of first aid, assisting evacuation, information gathering and dissemination) are beneficial and have been recognised as saving lives and being of direct assistance to the emergency services. Something that has been termed ‘zero-responders’ (Cocking, 2013). Examples of this include the response of the public during the following incidents: the Aberfan disaster (1966), the King’s Cross fire (1987), the Hillsborough disaster (1989), London 7/7 (2005), the Manchester Arena bombing (2017), the Westminster Bridge attack (2017), the London Bridge attack (2017), and the Grenfell Tower fire (2017).

Within the sphere of public health, behaviour change is recognised as being difficult (Kelly and Barker, 2016). The work for this thesis has led to the recognition of the difficulty of changing behaviour during an ADF and the limited effectiveness of the previous approach that relied upon issuing commands and directives to the public not to engage in certain behaviours. Consequently, the advice on the section of the KFRS website that covers what to do if there is a fire in one’s home has been amended both in tone and content so that the language used is less paternalistic and less directive.

“There is no such thing as a safe fire. It is better for you to prevent fire than to fight it. Tackling fire is a job best left to the professional firefighters. You should only tackle a fire if it is in its early stages and you are completely sure you can put it out and stay safe.” (KFRS, 2019b)

The content has been altered so that, while obviously not advocating or encouraging people to engage with the fire, it recognises that such behaviour can and does take place and contains advice rather than a series of commands such as ‘get out, stay out, call 999’. It is an example of where long-standing approaches are now being amended in response to an informed understanding of human behaviour. It demonstrates how, as a direct result of this study, style and content for fire safety messaging is being reconsidered and adapted.

6.3 FIRE PREVENTION AND COMMUNITY SAFETY ACTIVITY

As discussed in Section 2.3.4, the Fire and Rescue Services Act 2004 (England and Wales), and its legislative equivalents in Scotland and Northern Ireland, mandated the need for FRSs to actively promote fire safety and fire prevention strategies (Legislation.gov.uk, 2004; Legislation.gov.uk, 2005a; Legislation.gov.uk, 2006). It specified that a fire and rescue authority must make provision for the promotion of fire safety within its area, including publicity and information about how to prevent fires and fire-related death and injury through active strategies targeted at all sections of the population.

Within KFRS, this is realised through the Community Safety (CS) Team. The CS team undertake home visits (following agreement from the occupant after a request or referral) where they provide advice about fire prevention, fire safety in the home, and what to do should a fire occur. Examples of this advice include not overloading plug sockets and not leaving cooking unattended. Where appropriate, the CS Team also supply and fit domestic smoke alarms. Additionally, the team actively seek to visit sections of the population identified as 'vulnerable'. In this context the term vulnerable describes those identified as being at greater risk of having a fire, dying or being injured in a fire, generally as a result of age, physical or cognitive impairments and or lifestyle-related characteristics.

Because of their regular face-to-face contact with members of the public and consequent need to be able to give advice that is informed by an accurate and up-to-date understanding of human behaviour in dwelling fires, training on human behaviour, informed by the work of this thesis, has been provided to members of the CS Team. As a result of this training, among other areas related to human behaviour, there is now an awareness of the inaccuracy of the 'conveyor belt theory' (Berman, 2012; Runyan et al., 1992; Thompson and Wales, 2015; Thompson et al., 2013; Thompson, et al., 2018) which is the assumption that, once a fire starts, those present move along a pre-determined path of increasing injury severity that, without the intervention of others, ends in death, thereby confining injuries to the status of near-miss fatalities (Thompson et al., 2018). This has led to the updating of risk profiling at KFRS so that injuries are no longer considered as near-miss fatalities.

This training also covers the updated understanding of risk in the context of ADFs. This describes the recognition that dwelling fire risk cannot be considered as one single generic type of risk, instead it must be considered as three separate forms of risk: the risk of a fire occurring, the risk of fire injury, and the risk of fire fatality (Thompson et al., 2018). This understanding of risk as being one of three different types of risk is a new insight for the FRS, as formerly, when applied to ADFs, the term risk was used generically with no appreciation of the fact that there are three different types of risk in this context. The insights from this have now allowed KFRS to amend its risk profiling for CS and increase the quality of information that the CS Team are able to use. Related to this is the greater level of understanding through this work about age-related risks; specifically the awareness that people classed as 'older' cannot be assumed to be at greater risk of either injury or sustaining injuries of a more severe nature – with the important caveat that when older people sustain fire-related injuries, physiologically it is more difficult to recover from such injuries compared to younger age groups.

Because of the role of CS team members in fitting smoke alarms, these are also discussed in the training that is given. This describes how smoke alarms do not modify behavioural responses and so cannot be assumed to be agents of behavioural change. Being first alerted to a fire by a smoke alarm does not dissuade or discourage people from investigating, approaching and or tackling the fire. Nor does fitting a smoke alarm equate to a fire prevented (a claim anecdotally made by some FRSs). To make sure that smoke alarms are as effective as possible, it is important that the staff that fit them and provide advice about them to the public have a clear understanding of both the advantages and limitations of smoke alarms. This allows for an improved awareness of their role and the specific areas where smoke alarms have value in promoting life safety and reducing risk. Smoke alarms are extremely important, but they are not a panacea and should not be presented as such. However, their efficacy is maximised through an accurate understanding of their role and benefits. Furthermore, the areas listed above are all important because, with only limited resources available, the effectiveness and efficiency of KFRS's fire prevention activity is enhanced by access to accurate and up-to-date information about human behaviour in fire within this area.

6.4 INCIDENT COMMAND TRAINING AND OPERATIONAL RESPONSE

With incident command training, in relation to ADFs the traditional focus in FRSs has been on understanding two core areas: fire dynamics and spread; and building design and construction methods. These are, clearly, critical areas for which a level of knowledge is a necessary pre-condition of being able to apply firefighting tactics in order to deal more effectively with a fire. However, in addition to these two areas, a knowledge and understanding of human behaviour has also been shown to be necessary. As this thesis has demonstrated, fire spread can have a big impact on injury but, during a fire, those present are not passive or helplessly waiting while the fire approaches them. Instead, people actively approach and engage with the fire, move around the property and undertake a variety of activities before the arrival of the FRS. And precisely because people interact with the fire, they exert an influence on its development and outcomes for the property and others, even if a further outcome can include injury to themselves. This in turn means that the role of people (i.e. human behaviour) during a fire is, arguably, as important as fire dynamics and spread, and building design and construction methods. Yet, until recently, it was not a consideration within firefighter and incident command training. This point is important because studies have shown that operational firefighters' predictions of human behaviour in fire do not match actual behaviours undertaken by survivors of dwelling fires (Bennett, 2002; Dowling, 1994; Lawson et al., 2009). Consequently, in order to be as effective as possible when at an incident, it is important that operational firefighters have an accurate understanding of human behaviour.

It is for this reason that findings from this work have been used for inputs on incident command system (ICS) training courses run by KFRS. The ICS deals with the three different managerial levels of fire service activity when at an incident: strategy, tactics and operations. It is recognised that an accurate understanding of human behaviour is relevant to each of the three levels. In addition to ICS courses, inputs have also been given to the all of the KFRS instructors in the Training Team, so that they can apply this knowledge to the scenarios they develop for presenting to trainees and course attendees. Consequently, the relevance of human behaviour to operational learning is recognised and becoming increasingly established within KFRS.

6.5 THE COMPLEX BUILDINGS PROGRAMME

In 2019 KFRS launched the Complex Buildings Programme to ensure that, when responding to incidents in complex buildings, crews are trained to the latest standards and can consistently select and apply the relevant processes and have all the information and equipment needed to keep the public and themselves safe whilst dealing with the incident efficiently. For this programme a complex building is defined as:

"Any structure with a fire engineering solution and/or design that requires planning by Fire & Rescue staff to increase the safety of occupants or fire service personnel in the event of an incident." (KFRS, 2019a)

The importance of understanding research on human behaviour is one of the key points within the scope of the programme. The author of this thesis was appointed as the human behaviour expert in the programme team's technical group. This expertise is directly informed by this thesis and the author's work on this area over the past several years.

Consequently, the knowledge generated in this thesis has directly contributed to the Complex Buildings Programme. The most recent output and contribution is the publication of a report on human behaviour in fire. Co-written with the lead on fire engineering expertise, this report draws directly from findings and other relevant parts (e.g. the literature review) of this thesis to provide KFRS with an evidence-based understanding of human behaviour in fire in PCI spaces and dwellings and offers a comparison of the differences between the two.

This was submitted to the programme board in June 2019, after which this author was then invited to present the report's findings (on the human behaviour aspects) to KFRS's Corporate Management Board (CMB). Following on from this, at the request of the CMB, a podcast on human behaviour in fire will be written by this author and delivered for KFRS colleagues. Again, this will be directly informed by the findings on human behaviour identified in this thesis.

6.6 EMERGENCY CALL HANDLING

An early overview of the work contributed to the CFOA (now renamed NFCC) National Resilience Fire Control Projects Support Team. This was a working group established by CFOA to explore ways in which call handling incident management could be improved. In addition, within KFRS, there have been a series of inputs and workshops on human behaviour delivered to control room staff. Drawing directly on the work of this thesis, these have been undertaken to give control room staff an understanding of: the activities people will have undertaken and will be undertaking during an ADF; the point at which 999 calls most frequently occur; the implications of this for their role in control; the decision making processes callers will be working through; and the importance of recognising that callers, while in a heightened emotional state, are not panicking, but attempting to rationalise and adapt to a highly unfamiliar situation. This contribution was made as part of a wider review of how emergency calls are managed and the approaches used by control room staff.

Work on the guidance scripts used by control room staff has led to the development of a proposal for new guidance relating to how calls from those involved in an ADF are managed. This guidance uses a mnemonic (PISA: People, Incident, Scene, Action) that has been directly developed from the understanding of human behaviour resulting from this thesis (Figure 30). It has been designed to give control room staff an easy to view guide for structuring the conversation along with key information that can be sought from the caller.

The use of the structured approach based on guidance such as this is under consideration by the management of KFRS's Control function as part of a wider review of the effectiveness of emergency call handling.

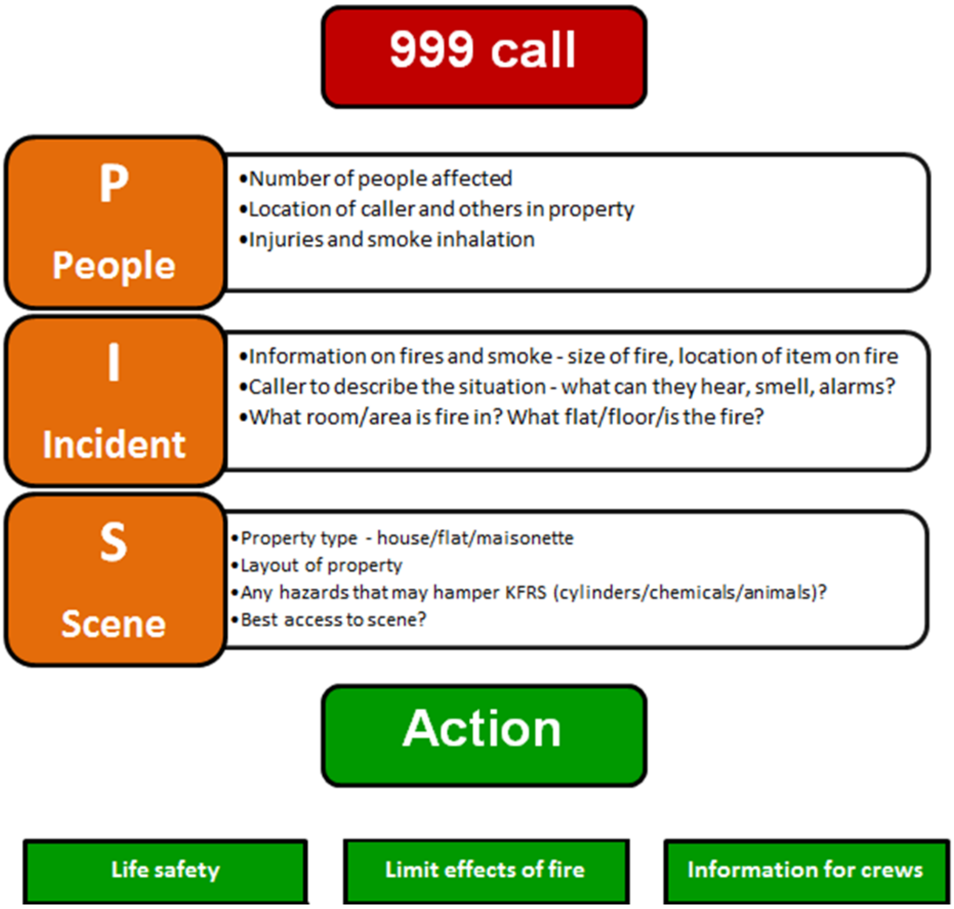

Figure 30. 'PISA' guidance for control room staff.

6.7 EVACUATION MODELLING, DECISION TREES

Having presented an overview of the practical applications of the findings from this thesis for FRSs, the second part concerns the practical applications for evacuation modelling and academic contributions. Firstly, this thesis has provided a comprehensive and up-to-date insight into human behaviour in dwelling fires, something which has been absent from the field for approximately 40 years. Moreover, the DAR has been proposed to explain both how people behave during an ADF and the underlying reasons for that behaviour. The first academic output has been the publication of a comprehensive and up-to-date review of the literature on human behaviour in dwelling fires; this review is available to an international audience in the form of a peer-reviewed journal paper (Thompson et al., 2018). In addition, parts of the analysis and findings arising from this thesis have been written up and will be submitted for publication as a peer-reviewed journal paper (Thompson et al., *in preparation*).

This contribution to the field of human behaviour in fire has also led to the development of decision trees. Decision trees are models; they present, in graphical form, the branching of a process from its root through to its various leaves, i.e. possible outcomes (Quinlan, 1986). In this case, the process was the sequence of activities undertaken by participants during their ADF timeline, starting from the root point of becoming aware of the fire, moving onto a key activity coded as binary (first-level activity), and then continuing to branch until the point where subsequent activities were undertaken by only a few participants. Each branch in a decision tree is quantified; that is, a numerical value is displayed, showing how many participants followed one particular activity with the next one, thereby providing end-users with a guide as to the relative likelihood of each outcome. By creating decision trees, the findings from this study, which employed methods common to the social sciences, can be 'translated' into a form that should be more easily interpreted by researchers from a mathematical background (specifically, evacuation modellers). However, as these decision trees are deliberately very simple models, they can be easily interpreted by other end-users as well, such as practitioners who also may not be versed in social science methods, or in complex mathematical modelling.

Examples of decisions trees created using data from this thesis are included here (see Appendix 4). They can be, and have been, organised for both people in general (all participants) and for specific groups (e.g. males vs. females). For each of these, separate decision trees have been presented for specific first-level activities that followed becoming aware of the fire. These activities include: 'investigate cues', 'warn others', 'tackle the fire', 'call 999', and 'note cue, no action'. From each of these first-level activities, the decision trees then present the second-level and third-level activities that participants undertook, along with the number of participants who undertook those activities. This numerical information is presented as both frequency counts and percentages.

The decision trees have been designed so that researchers can use them to understand the key activities that are likely to occur in an ADF and their sequence. These can be used as a resource to assist in the development of behavioural itineraries for evacuation modelling. Behavioural itineraries are sets of activities undertaken by agents (representing building occupants) from the point of notification (e.g. the sounding of an alarm) through to the point the agents commence evacuation movement. The incorporation of behavioural itineraries in evacuation models can help users better visualise the behaviour and movements of occupants prior to evacuation, and therefore better estimate how long evacuation may be delayed for and the impact of that on people's safety (Ronchi and Nilsson, 2016). Currently, evacuation models tend not to depict domestic settings, focusing instead on PCI spaces with large numbers of occupants. However, with the event of incidents such as the Grenfell Tower fire in 2017, evacuations in domestic settings have been thrust back into the spotlight. So the decision trees that have been developed as part of this thesis offer a means of assisting the development of evacuation modelling software, i.e. helping modellers understand how human behaviour data can be classified into 'rules', which could then be used to develop behavioural itineraries, which in turn could increase the functionality of the software and allow it to be applied to a new setting. Because the data are presented as both frequency counts and percentages, they allow for odds ratios to be calculated based upon preceding activities and upon occupant characteristics such as gender, which is one of the agent attributes represented in evacuation models. Of course, these decision trees are merely a first step in such development. The LIFEBID dataset used here did not contain estimations of times taken to undertake the various activities, nor did it contain much data from high-rise dwellings similar to Grenfell Tower and, as mentioned in Section 2.8.4, behaviours in these larger buildings could differ from those in single dwellings. So it could not be used directly as inputs for a model designed to simulate an ADF of that kind. Nonetheless, these limitations notwithstanding, the decision trees can at least help facilitate discussions between researchers from social science and mathematical backgrounds, by illustrating the potential for human behaviour data from ADFs to be applied to evacuation models and the way in which such data could be incorporated.

6.8 CONCLUSION

As well as the academic contribution advancing knowledge and understanding, it has been demonstrated that the findings from this thesis have a number of practical applications for both the FRS and evacuation modellers. With evacuation modelling, the use of the findings to create a catalogue of decision trees enables cross-discipline discussions, meaning that increases to the functionality of modelling software can be considered with respect to domestic settings and the development of behavioural itineraries. From this, it may be possible to enhance the modelling of human behaviour in dwelling evacuations and, through that, better communicate to various parties that immediate evacuation is unlikely in ADFs, with an illustration of how other kinds of behavioural response contribute to evacuation delay and impact safety.

With the FRS, the practical applications are relevant to four key areas of FRS activity: fire safety messaging; fire prevention and community safety activity; incident command training and operational response; and emergency call handling. Importantly, the value of an accurate understanding of human behaviour in fire based upon empirical evidence is recognised within KFRS and, as a consequence, specific findings have already begun to be implemented across each of these areas. The changes in policy and practice arising from and informed by this work have also signified the acceptance of the important role of human behaviour, alongside the traditional focus on fire dynamics and building design. It has resulted in something of a cultural shift within KFRS due to the recognition that people do not in fact behave as they do because they are foolish or in a state of panic. Instead, human behaviour during an ADF has been outlined and presented in the context of the incident to demonstrate that responses are largely rational. There is however still more to be done, as the changes that have been taking place within KFRS could also begin to be adopted by the NFCC and other FRSs across the country. This is something that will be addressed in the next section, which considers future work arising from this thesis.

7. FUTURE WORK

7.1 INTRODUCTION

While this thesis has covered a broad scope in looking at human behaviour in dwelling fires, there are some areas where the work faced limitations and so would benefit from being extended in the future. These are: high-rise dwellings; the behaviour of children; and data from fires that are not attended by FRSs because they are not reported. This section will outline the constraints that meant it was not possible to investigate these areas along with a discussion of why they are important to the understanding of human behaviour in fire and so should be considered for future studies. This chapter will then outline how, in light of the changing regulatory environment for fire safety in the UK (primarily, if not exclusively, driven by the Grenfell Tower fire) the work and findings contained within this thesis will be of relevance in the near future to legislators who have an interest in fire safety regulation.

7.2 HIGH-RISE DWELLINGS

As mentioned, one of the key limitations of this thesis is the lack of data from fires in high-rise dwellings. This was one of the reasons why dwelling type was recoded into a new variable called Attached Dwelling, which was based upon whether the dwelling was physically connected to any other dwellings, either vertically or horizontally. While this recoding into physical connection between dwellings was partly attempted to mitigate the problem of not having data from fires in high-rise dwellings, it could never be a truly satisfactory substitute. Consequently, no specific comment can be made in this thesis about behaviour in high-rise dwellings.

There were several reasons why high-rise data were lacking and these have been described in Section 5.2.3. However, as part of developing knowledge of human behaviour in dwelling fires, it is important to understand more about behaviour during high-rise dwelling fires. The most obvious example of why this is so necessary is evidenced by the Grenfell Tower fire. This fire, which broke out in a 24-storey tower block on 14th June 2017, was of such a scale and severity (there were 72 deaths, including 18 children), and the resulting level of public anger so great, that the following day the government announced that a public inquiry would be held (the Grenfell Tower Inquiry). On 28th July 2017, the government announced an independent review of building regulations and fire safety: the Hackitt Review (GOV.UK, 2018). Published on 17 May 2018, the report made several recommendations for improvements to fire safety regulations, which are outlined in Section 7.5 (GOV.UK, 2018a). At the time of writing, these recommendations are being considered by the UK government.

The report is divided into ten chapters and the general areas it focuses on are: the current state of regulations and guidance; the lack of clarity and fragmented nature of competence arrangements for higher risk residential buildings (HRRBs); failures and difficulties in ensuring compliance with building safety requirements; the absence of the 'golden thread' of fire safety information throughout the procurement, development, design, construction, maintenance and ongoing management of a HRRB; and the role and responsibilities of residents of HRRBs. This last point is interesting as it represents an attempt to recognise the role of occupants and give them a voice – indeed, recommendations 4.3 and 4.5 in the report are clearly a response to the fact that, in the period before the fire, many Grenfell Tower residents expressed concerns about several aspects of the building's fire safety. The report is also very clear from the outset that the most important people in this are the residents of HRRBs and the ultimate aim of the recommendations is to ensure their safety through having safe buildings.

The importance of understanding human behaviour is further evidenced by the fact that some occupant accounts given to the Grenfell Tower Inquiry stated that many people did not evacuate during the fire because of the advice being given to them by the FRS to remain in their flats, in line with the prevailing stay put policy, but for possibly up to two hours after the fire had started (Grenfell Tower Inquiry website, 2018; The Independent, 2018; The Telegraph, 2018). While not the place to undertake a critique or review of the stay put policy itself (for a description of this policy, see Section 2.8.4), it is also important to state that, at the time of writing, the Grenfell Tower Inquiry is still hearing evidence and there have been no findings or conclusions yet reached. This means that there should be no pre-judging outcomes at this stage. However, what this issue does highlight is the importance of understanding human behaviour during fire in high-rise dwellings, particularly the issue of responses to external sources of advice and direction. Added to this is the need to understand whether any behavioural differences exists compared with occupants of houses as a result of high-rise dwellings representing a combination of both closed and open building systems (i.e. a mixture of spaces where activities are regulated and formalised, and spaces that are private where no such regulation exists). Clearly consideration would need to be given to the constraints upon data collection described earlier, but were the survey to be extended to high-rise dwelling fires, a large amount of valuable information could be gathered on human behaviour in these types of buildings.

7.3 THE BEHAVIOUR OF CHILDREN

The second area where the work could be extended is to understand the behaviour of children during an ADF. The ethical requirements that would have needed to be met in order to survey those aged under 18, along with the need to use specialist interviewers, meant that it was beyond the scope of the LIFEBID project – which is what provided the data for this thesis. It is for these reasons that this thesis was not able to explore the behaviour of children and adolescents during an ADF.

There is a consensus within the literature that young children are at a greater risk of dying during an ADF (Squires and Busuttil, 1996; Shai and Lupinacci, 2003; Marshall et al., 1998; Harpur et al., 2012). This is a risk which may be increased by the fact it has been demonstrated that, due to the age related ability to hear different frequencies, it is more difficult to wake children with the sound of a smoke alarm (Bruck and Thomas, 2012). However, this is principally based upon injury reports and coroners' reports thereby allowing for calculations of fatality rates of children in ADFs compared to adults. What is lacking from the literature are studies utilising descriptions from children themselves. As a result, there is a real need to obtain narrative accounts from children who have experienced an ADF in order to understand their experience and the associated behaviours and motivations. The findings from this study reveal that adults are not passive in their response to a fire – would children also be active responders? If so, would they show a similar tendency to approach and engage with the fire or would they display different behaviours? If they did approach and engage with the fire, would this be due to a desire to tackle the fire or rather due to simple curiosity or disorientation?

Moreover, this is an area where only a very limited amount of work has been undertaken. A systematic review, which was published in 2017, did not find any examples within the literature of studies designed specifically to understand children's behaviour in ADFs (Mytton et al., 2017). Furthermore, only four studies were found where children's accounts had been recorded, but in each case these were incidental to the main study and the evidence was found to be incomplete and out of date (Mytton, Goodenough and Novak, 2017). Consequently, there is a need for a greater understanding of children's behaviour, and their motivations. This will also have important implications for FRS training and fire safety education programmes.

7.4 UNREPORTED FIRES

Although the LIFEBID survey was open to all (via the LIFEBID website), the main data collection method relied upon was for attending fire crews to make occupants aware of the LIFEBID survey. Thus, the data collected was largely from reported ADFs; this was confirmed by the finding that in only 7% of cases did no-one (either the participant or someone else) call 999 (Section 4.2.1). However, dwelling fires that go unreported would be an important area to investigate for any future study. The importance of unreported fires is clear when one considers that in the UK, USA, Canada and Australia it is estimated they comprise between 60% and 80% of all dwelling fires (Crossman et al., 1975; National Fire Prevention and Control Administration 1976; Green and Andres 2009; Marriott 1993; Office of the Deputy Prime Minister 2003; Office of the Deputy Prime Minister 2006, Barnett, Bruck and Jago 2007; Proulx, 2009; DCLG, 2015).

Within the UK, information on fires that are not reported to the FRS comes from the English Housing Survey (EHS, which was created through a merger in 2008 of the Survey of English Housing and the English House Condition survey) and prior to that the British Crime Survey (BCS). Carried out annually, the EHS is a survey of housing circumstances and related issues, which includes several questions on fires and fire safety – although the fire safety-related questions are rotated and so tend to be included only every two to three years, the most recent being the 'English Housing Survey. Fire and fire safety, 2016-17' (MHCLG, 2018). This states that in 2016/17, 332,000 households in England (1.4%) had experienced a fire inside their home or on their property during the previous two years. With regards to who extinguished fires, 70% of respondents said they or someone else in the household did so, while only 25% were put out by the FRS. Unlike the previous report (published in 2015), this did not make any comment on what proportion of people called the FRS. The 'English Housing Survey: 2013 to 2014: Fire and fire safety report' (DCLG, 2015b) was based on a survey of 13,276 households, and reported an extrapolated figure of 385,000 households (1.7%) having had a fire inside their home or on their property during the previous two years. Of these, 40% called the FRS – meaning 60% of dwelling fires were unreported (DCLG, 2015b). With regards to who extinguished fires (both reported and unreported), 62% of respondents said they or someone else in the household did so, while only 29% were put out by the FRS.

7.4.1 Discrepancy between EHS and Home Office fire statistics

One important point to note is the large discrepancy that exists between the numbers of dwelling fires reported in the EHS and the Home Office fire statistics for Great Britain. Because the 2015 EHS report is the most recent to report on the proportion of people who called the FRS to assist them, it is this version of the report that will be discussed here. The 2015 EHS report states that during the period 2013/14, an extrapolated figure of 262,000 households (1%) experienced at least one fire inside their home or on their property in the last year (while the 2018 EHS Fire and Fire Safety report does not report the proportion of respondents who called the FRS, the comparable figure for 2016/17 is 221,000) (MHCLG, 2019a). Taking the 40% quoted in the 2015 EHS report for the proportion of these fires to which the FRS is called (and also accepting that this 40% is based upon them having experienced a fire in the previous two years rather than in the previous year), this would give a figure of at least 104,000 dwelling fires being reported to the FRS. Even if one took a lower figure based upon the 29% of fires that respondents to the EHS state were extinguished by the FRS, this would give a figure of 75,980 dwelling fires, which is almost double the figure of 39,600 dwelling fires attended in the same period (2013/14) as quoted in the GB fire statistics (DCLG, 2015). Moreover, the EHS only covers England whereas the GB fire statistics report on data from England, Scotland and Wales. It is also worth noting that the figure quoted in the EHS for the number of dwelling fires experienced over 12 months (262,000) is higher than the total number of fires of all types attended by FRSs in Great Britain for the whole of 2013/14, which was recorded as 212,500 (DCLG, 2015; MHCLG, 2019).

If one were to take the figure of 262,000 dwelling fires reported in the 2015 EHS report and divide it by the number of fires attended by the FRS as reported in the GB fire statistics for this period (39,600), this would mean that the FRS attended 15% of all dwelling fires. Either way, there is clearly a considerable proportion of dwelling fires which go unreported to the FRS. The fact that several studies support the idea that well over half of all dwelling fires are not reported to the FRS is not due to a lack of advertising or publicity, as within the UK national fire safety campaigns have been in place since 1988 (DCLG, 2008). Yet despite this there remains a large group of people who have fires for which there is little or no information about occupant behaviour during the fire, nor the severity of damage or injury.

7.4.2 Unreported fires in Australia and the USA

Outside of the UK, work carried out in Australia by Barnett et al. (2007) sought to understand the frequency of unattended residential fires in Melbourne. A questionnaire survey was developed to collect information from respondents on fires (attended and unattended) they had experienced in dwellings, workplaces or recreational settings since the age of 18. Interviews were conducted face-to-face with findings based upon a sample of 473 adults. The results of this work showed that the majority of fires experienced were in dwellings (94%) and, of these, 75% were not reported to the FRS (Barnett et al., 2007).

In the USA, the proportion of unreported fires would appear to be even higher than in both the UK and Australia, as studies have shown that somewhere between 80% and 97% of dwelling fires are not reported to the FRS (Crossman et al., 1975; National Fire Prevention and Control Administration 1976; Greene and Andres, 2009). Work to understand the scale of this area began in 1970 with the study undertaken by Crossman et al. (1975), where surveys were posted to approximately 3,500 households in California. Just over 1,400 returned surveys were analysed and, from these, a total of 99 dwelling fires had been reported within the 12 months prior to the survey. It was found that in most cases households sought to deal with fires themselves (Crossman et al., 1975). At a similar time the work undertaken by the National Fire Prevention and Control Administration resulted in 33,000 households being interviewed, with data based on around 2,000 dwelling fires. Findings from this study showed that the FRS was called to fewer than 10% of dwelling fires ('residence-related fires' as termed in the study) (National Fire Prevention and Control Administration, 1976).

The last national study dealing specifically with the scale and nature of fires not attended by the FRS in the USA is the '2004-2005 National Sample Survey of Unreported Residential Fires'. This was the third national survey of unreported fires undertaken by the U.S. Consumer Product Safety Commission (CPSC), the first two being undertaken in 1974 and 1984. As with the first such two surveys carried out by the CPSC, data were collected from across the USA via a telephone questionnaire survey. This found that based upon 916 households who had reported a fire in the previous 90 days, only 3.4% of residential fires were attended by the FRS – a figure very similar to the 3.7% reported in the 1984 study (Greene and Andres, 2009).

7.4.3 Assumptions about the nature and severity of unreported fires

It is assumed that as these fires are unreported they are either extinguished by the occupants or they self-extinguish (DCLG, 2015). Although this is a reasonable assumption it carries the risk of creating an impression that such fires must therefore be more limited in their severity (in terms of damage and injury) than those that are reported to the FRS. This is, however, an over-simplistic and possibly inaccurate idea as it relies upon the assumption that unattended fires are those which have simply failed to reach the appropriate level of severity to trigger the occupants to call 999. It also ignores the fact that there may be specific factors – such as shame or embarrassment, the mistaken belief that a charge will be levied for FRS attendance, or a mistrust or dislike of authority – that inhibit or dissuade people from alerting the FRS. Although there have been some attempts to understand people's perception and awareness of risk related to fire and smoke (as distinct from studies of personal or occupancy related risk characteristics) (Miller, 2006; DCLG, 2008; Hulse et al., 2015), the lack of work focussing specifically upon decision making and other cognitions in relation to 999 calls in the area means that there is limited understanding of the specific factors that cause people to call 999 (or, conversely, choose not to call 999) and the points during a fire at which they make such a call.

However, this is something that this thesis has begun to address and started to provide an understanding of (sections 4.2.1 and 4.5.2). Although more work clearly needs to be done in this area, the thesis found that the main reason for calling 999 was the recognition of and desire to limit potential damage to the building and its contents. This was closely followed by the fact that participants believed the fire was beyond their capabilities – implying that they would have attempted to tackle it if they had felt it was within their capabilities then. When it came to reasons for not calling 999, leaving aside the call being made by others, the main reason was because participants felt capable of dealing with the fire themselves – again, underlying the strength of motivation to attempt to mitigate the fire.

If people were essentially neutral in their approach to the fire from the outset, automatically alerting the FRS once a fire had reached a certain size and or severity, it would be reasonable to assume that fires which may be considered 'moderate' or 'severe' would form the majority of the type of fires that are attended (as minor fires would presumably be more likely to be dealt with by the occupants). However, the flaw within this assumption is evident from the fact that FRSs attend a large proportion of fires which may in fact be considered 'minor'.

Indeed, within Great Britain, 33% of all accidental dwelling fires attended were fires that were confined to the original item ignited (Home Office, 2019). Although no standard scale or measure of dwelling fire severity exists within the IRS, work undertaken in 2012 by Fife FRS (now part of the Scottish FRS) to quantify the severity of attended ADFs demonstrated that 94% of all incidents were within the 'slight' or 'moderate' categories (the lowest two levels of a five-point scale) and that 45% of all calls did not require any firefighter action upon arrival (Fife Fire and Rescue Service, 2012). This was also something that was reinforced by the findings in this thesis where, for 69% of the fires, fire damage spread was restricted to the ignited item (42%) or the RFO (27%) (Section 4.1.4).

Currently, as an area that has received limited attention, little is known about the behaviours of those who experience an unattended dwelling fire, as well as the prevalence of injury in these cases and specific reasons for why people choose not to notify the FRS. Additionally, there is not an understanding of the risk factors for unattended dwelling fires, or the causes and reasons for those fires. An understanding of the characteristics related to, and behaviours during, unattended fires would also allow for a valuable comparison with attended fires to identify and determine any differences or similarities. This would, in turn, allow FRSs to target community safety and fire prevention services towards a hitherto neglected section of the community.

7.5 THE CHANGING REGULATORY ENVIRONMENT

In addition to FRSs and evacuation modellers, the findings from this thesis are relevant to legislators in debates about fire safety regulation in domestic settings. As described in Section 2.4.5, in October 2013 the Welsh assembly introduced the 'Domestic Fire Safety (Wales) Measure 2011', a piece of legislation making automatic fire sprinkler systems compulsory for all new and converted residential properties within Wales (Legislation.gov.uk, 2013). The second phase of this, which covers new and converted houses and flats, took effect from 1 January 2016. Furthermore, the Scottish parliament undertook a piece of work to update the cost-benefit analysis for sprinklers in residential buildings (defined as houses, flats, HMOs and student halls of residence) (Scottish Government, 2015). Although nothing comparable in relation to sprinklers is being undertaken in England, in 2015 it did become a legal requirement for landlords in England to install working smoke and carbon monoxide alarms in all of their properties (The Smoke and Carbon Monoxide Alarm [England] Regulations 2015; see Section 2.3.4).

Viewed collectively, these measures demonstrate an increasing willingness among legislators to give consideration to new forms of fire safety legislation and, with this, a move back towards a generally more prescriptive approach to fire safety regulation. This is something which, arguably, signals a reversal of the thinking that has dominated since the late 1990s, of having a ‘sector-led’ or ‘outcomes-based’ approach to regulation. Within fire safety regulation, this outcomes-based approach was typified with the introduction of the Regulatory Reform (Fire Safety) Order 2005 (DCLG, 2007; GOV.UK, 2015a). This replaced the method of fire certification that was in place with the previous Fire Precautions Act 1971 with an approach that places a duty upon the ‘responsible person’ for the building to undertake a risk assessment and reduce any fire risks. In doing so, this signalled a shift in the focus from demonstrating compliance with a series of prescriptive regulations to a more flexible approach that is predicated upon being able to demonstrate that a building is safe.

However, following the Grenfell Tower fire, the Hackitt Review (see Section 7.2) stated that a ‘radical reform’ of the building regulatory system is needed (GOV.UK, 2018; GOV.UK, 2018a). The report was clear in its view of the inadequacy of current building regulations, stating:

“…the current system of building regulations and fire safety is not fit for purpose and that a culture change is required to support the delivery of buildings that are safe, both now and in the future.” (GOV.UK, 2018, p3)

The report proposes changes which include the following: a new regulator, along with a new regulatory framework for higher-risk residential buildings; the removal of the ability for building owners to select the company that will perform the building control inspection; greater clarity around lines of responsibility for a building’s safety; and greater transparency around fire safety testing of certain building products (GOV.UK, 2018a; BBC News, 2018). In response, the government stated that, following a consultation period, it would seek to make legislative amendments to building fire safety regulations (GOV.UK, 2018b). This is indicative of a move back to a more proactive focus on fire safety regulation and enforcement. This is a move that will undoubtedly also be given an added impetus with the findings of the Grenfell Tower Inquiry and the continued public anger around the circumstances which led up to the fire.

Within FRSs, the move back towards a more proactive approach to fire safety can also be seen in the introduction on June 2018 of the revised Fire and Rescue National Framework. The government has a duty under the Fire and Rescue Services Act 2004 to publish the framework. This sets out the government's priorities and objectives for FRSs, and is a replacement for the previous 2012 framework (Home Office, 2018a). One of the key changes in the 2018 framework is a greater emphasis on fire prevention through fire safety inspections, specifically a 'risk-based inspection programme'. Section 2.3 of the new framework states:

"Fire and rescue authorities must make provision for promoting fire safety, including fire prevention, and have a locally determined risk-based inspection programme in place for enforcing compliance with the provisions of the Regulatory Reform (Fire Safety) Order 2005 in premises to which it applies." (Home Office, 2018a, p6)

In short, this means that, post-Grenfell, there is a clear emphasis on FRSs to ensure they are aware of high-risk buildings within their area and that rigorous inspections are undertaken of those buildings.

At this time of debate around potential changes to fire safety regulation relating to dwelling fire safety, the data presented within this thesis on human behavioural responses can make a timely and valid contribution to these debates. For example, the work in this thesis has demonstrated that the primary responses which lead to injury are moving into close proximity and interacting with the fire. Furthermore, such behaviour is not moderated by the presence of smoke alarms. In dwellings, smoke alarms are vitally important – particularly in alerting sleeping adults to the presence of a fire – however, because they do not alter the behaviours that follow the moment of being alerted, the evidence presented in this thesis does not support the claim that the presence of a sounding smoke alarm reduces the number of injuries (non-fatal at least). In light of this, this thesis provides evidence that can be used to support the debate for greater use of domestic sprinklers as the most effective injury (and fatality) reduction measure related to fires in the home. This is evidence which could be used to advance discussion and debate around these important life safety issues at a period of increasing change to the way in which fire safety is regulated.

7.6 CONCLUSION

A number of areas have been identified where, for specific reasons, it was not possible to collect and or analyse data for this study and where future work could be directed towards. The first of these areas was data on high-rise fires, as in this study there were no data from any fires in any flats higher than three storeys. As a result, it has not been possible to provide any information or comment on human behaviour in high-rise dwellings. However, this fact has also served to highlight one of the challenges of undertaking a large-scale study of human behaviour in dwelling fires – namely the difficulty in obtaining a large enough sample to provide adequate data from fires across a range of dwelling types. The other area was the absence of any data on the behaviour of children. As outlined earlier, within this study this was due to the ethical requirements that had been applied to the data collection. However, the behaviour of children in fires is an area for which very little information exists within the wider literature and, as such, it would be a valuable area for future study. With unreported fires, there remains a large group of people for whom there is little or no information about their behaviour and the severity of fire damage or injury experienced. Given that unreported fires could comprise up to 85% of all dwelling fires, this is an area for which further study would be of great value, particularly to determine why fires are unreported and what the injury rate is with such fires.

Finally, the findings are also relevant to the changes taking place within the regulatory environment in the UK in relation to fire safety. Although some of these changes occurred before the Grenfell Tower fire, and were the result of a wider philosophical move away from the era of 'sector-led' and 'light touch' approach to regulation and enforcement across a range of areas, Grenfell has clearly been a catalyst for the changes that are taking place and will continue to take place with fire safety regulation. The findings on human behavioural responses presented within this thesis can make a timely and valid contribution to these debates by providing an evidence base to helping to inform policy making in this area.

8. CONCLUSION

This thesis is the first large-scale study of human behaviour in dwelling fires to be undertaken in 40 years and, as a result, it has made a number of important and original contributions to this area.

The studies that were undertaken by Wood in 1972, Bryan in 1977 and Canter et al. in 1980 were the first dedicated projects to understand human behaviour in fire and also the first to do so by using data routinely collected from building fires over an extended period. But since these studies, further work of a comparable scale and scope has not been undertaken. Moreover, only a limited amount of work has been carried out in order to improve and refine the understanding of human behaviour in dwelling fires in general. As a result, this area was largely neglected in comparison with the study of human behaviour in non-domestic settings, where there is a large body of literature and a well-established research focus.

This study has discussed how the limited amount of work that has been undertaken on human behaviour in dwelling fires has tended to be characterised by a focus on the identification of occupant risk factors related to an increased likelihood of dwelling fire fatalities. There has not been a comparable amount of work undertaken to examine the behaviours of those who survive dwelling fires, with or without injury. As a result, an up-to-date and comprehensive understanding of human behaviour in dwelling fires was absent from the literature. This thesis has now addressed that by presenting the most comprehensive study of human behaviour in dwelling fires in 40 years, and moreover doing so by using data collected directly from occupants themselves.

By analysing the data which were generated through the LIFEBID survey, this thesis has offered an up-to-date overview of behaviours undertaken during an ADF and the typical sequence in which key behaviours occur, along with an understanding of the motivations for those behaviours. Additionally, this work has analysed and presented the relationships between behaviours and three key occupant characteristics: gender, prior fire experience, and prior fire safety knowledge. In so doing, this work has extended and updated the earlier findings of Wood, Bryan and Canter et al., demonstrating the extent of these variables' relevance in current times. Further potential relationships between behaviours and a key dwelling characteristic, installed smoke alarms, were also explored, putting into perspective the role of such devices in keeping occupants safe. Attention then turned to injuries, with the work here providing new insights. These include the identification of at what point in an incident occupants are most likely to be injured, clarification of whether older age increases vulnerability in terms of increased incidence and increased severity of injury, and establishing a risk profile for non-fatal fire injury. The results of these analyses should provoke a rethink among FRSs and other agencies, as they highlight weaknesses (e.g. what can happen to occupants before FRSs have been called, let alone attended an incident) and misconceptions (e.g. regarding what variables heighten the risk of physical harm) which appear to have risen due to either failing to consider such matters or establishing beliefs about them based upon assumptions rather than empirical evidence. Finally, the analysis compared the current findings on behaviour in ADFs with previous findings on behaviour in other types of building fire, demonstrating why the domestic setting is greatly deserving of far more focused attention from researchers than it has received to date.

The results that have been generated and findings presented in this thesis can be organised and distilled into five ‘highlights’, each representing new understanding in the field of human behaviour in fire. Firstly, it has been demonstrated that a number of clear differences exist between human behaviour in (low-rise) dwellings and human behaviour in PCI spaces. It is clear that the greatly different environmental, physical and social circumstances that are present in dwelling fires compared to fires in PCI spaces mean that knowledge relating to human behaviour in the PCI spaces cannot be assumed to be applicable to dwellings. These differences are predicated upon the fact that dwellings represent an intimate socio-physical space and one which has a great deal of importance attached to it by those who live within it. With dwellings, there is also a familiarity with the building and its layout, which is often not the case with PCI spaces. Additionally, dwellings tend to be smaller than PCI spaces, making it easier to locate the source of the cues. They are also open building systems (i.e. those that are not regulated and formalised), which leads to a less inhibited response and the potential for a greater freedom of decision making. While the underlying theme of occupant response is common to both PCI spaces and dwellings (the common theme being that, irrespective of the environment, people make an appraisal of the situation and act based on priorities as seen from their own perspective), the specific forms of that behavioural response are amended for the domestic environment. Consequently dwellings must be regarded as a separate and distinct type of space; one in which different behavioural responses occur compared to PCI spaces.

Secondly this thesis identified the need to distinguish between different forms of risk: here, the risk of being injured was differentiated from the risk of dying. Those who die and those who survive ADFs with injury must be considered as two different groups. Statistical analysis undertaken in this thesis has demonstrated this through the identification that the risk factors which predict ADF injuries are not necessarily the same as those which predict ADF fatalities. Of the 10 variables that were identified as being associated with dwelling fire fatalities, just three were found to be significant predictors of dwelling fire injury. A second round of analysis tested six new variables elicited from other analysis in this thesis and, of these variables, three were revealed as significant predictors of dwelling fire injury. At the culmination of regression analysis, i.e. at the end of a third round, it was found that participants were significantly more likely to be injured if: the fire was larger (one that had spread beyond the RFO); they had consumed an intoxicating substance prior to the fire; they were asleep at the time of ignition; they lived in an attached dwelling (as opposed to living in a detached dwelling); they got within touching distance of the fire; and they had tackled the fire. However, there remains a commonly held belief in the conveyor belt theory (Thompson et al., 2018), in which dwelling fire injuries are believed to be near-miss fatalities. This is a viewpoint which rests on an assumption that all occupants are passive and moving on a pre-determined course that would end in death if not for the intervention of others or some stroke of good fortune. On the contrary, this thesis has demonstrated that it is actually inaccurate to regard ADF injuries simply as near-miss fatalities, given fire fatality risk factors were present with this sample of survivors yet few resulted in them being physically harmed. The findings here have also demonstrated that occupants are not passive, but rather they actively move around the property and undertake a number of tasks during the fire.

The third ‘highlight’ is that the overall gender-based behavioural differences identified in the original studies remain valid: males undertook more risk-taking behaviours while females carried out a greater number of protective actions. While gender differences in risk-taking in other fields have been evident for some time, this finding was nonetheless surprising given the enormous improvements that have been made over the past 40 years in addressing the gender imbalance that is present in many areas of society in the UK. This work identified that while males and females were just as likely to investigate fire cues, males were still significantly more likely to undertake behaviours characterised by active engagement with the fire (extinguishing the fire and other attempts to mitigate it) whereas the response among females was still characterised by behaviours related to withdrawal and notification. The finding of gender-based differences was also surprising given societal changes leading to different household makeups in the present day – single sex and single occupant households have become more common, and are gradually challenging the (stereo)typical ‘male head of household and female housewife’ configuration. By introducing an interaction term and testing for whether gender-based behaviour differed according to whether participants were alone or accompanied, this study explored whether behaviours among males and females during an ADF were influenced by the presence or absence of others such as a member of the opposite sex. This had not been undertaken previously within the field and so was another piece of original work. It was found that the underlying gender-based behavioural differences did not in fact differ significantly according to whether participants were accompanied or alone.

The fourth ‘highlight’ relates to smoke alarms. It was found that they do not modify behavioural responses during a fire in a low-rise dwelling. This could well differ with flats and HMOs, where smoke alarms prevent injury through alerting people who, due to their distance from the fire, may not become aware of the cues until later on in the incident (this is something that would be worthwhile looking at in future work). Furthermore, the initial response to smoke alarms does not alter according to whether people are awake or asleep at the time the alarm actuates. When awoken by a smoke alarm, people still investigate with the same level of frequency as when alerted by other cues. Consequently, alarms do not make people any less likely to approach and tackle the fire, or make people any more likely to evacuate. In fires reported to the FRS in which there was no fatality, there was no evidence to suggest a relationship between being injured and the presence or absence of a sounding smoke alarm.. While they play a critical role in the detection of a fire, their role should not be inflated to contribute to other stages of a fire as it could risk complacency, i.e. ‘a working alarm is present therefore occupants will be safe from harm in the event of a fire’.

The final ‘highlight’ is that new knowledge has been generated about age and the relationship with injury. It was established that, unlike for fire fatalities, occupant age (particularly old age) was not a significant predictor of the incidence of injury, nor was it significantly associated with the severity of injury. This challenges a long-standing assumption within FRSs that, exclusively due to their age, older people are at greater risk of becoming injured and also incurring more severe injuries. The reason for this erroneous assumption is because the elderly are indeed over-represented in dwelling fire fatalities. However, this thesis has shown that what increases the likelihood of injury are other factors such as actively coming into close contact with the fire and products of combustion – something which age has no obvious relationship with. It should be noted that being medically impaired was also not a significant predictor of being injured, indicating that there is not even a clear indirect relationship between aging and injury. Consequently, this thesis has questioned a view which is not based on a robust body of evidence and, in doing so, has offered a more informed understanding about this complicated issue.

The knowledge generated during this thesis has led directly to the development of the DAR. The DAR is a short-hand way of describing the type of response and underpinning motivations during an ADF and, in doing so, it offers a guide for understanding how and why people behave the way that they do during an ADF. The DAR posits that the nature of people's response during an ADF is consistent with emergency events in PCI spaces, but with actions modified due to the domestic setting of an ADF. The issue of continuity with human behavioural response during emergency events occurring in PCI spaces is based upon the fact that the majority of people do not panic, but act with a sense of coherency and purpose in order to achieve one or more aims. In short, people make an appraisal of the situation, and act based upon a combination of the information obtained from that appraisal and their goals and motivations. The DAR recognises that the motivations that drive people's behaviour are directly linked to the enormous importance, influence and status of the home within people's lives. The centrally important socio-physical status of the home means that people may not behave in way that would fit a definition of 'rational behaviour' as expressed in utility theory; instead, what people do is act in a way that is informed by their appraisal of the situation and which is appropriate for their particular priorities in order to achieve the positive outcome that they are seeking.

Based upon the findings from the analysis that was undertaken for this thesis, the DAR is underpinned by the following three conceptual pillars: firstly, that occupant response and associated core behaviours are consistent with what was observed in the original studies of human behaviour in fire undertaken 40 years ago; secondly, that initial occupant behaviours are characterised by approach and not withdrawal from the fire (irrespective of gender); and thirdly, the reason that people's response has remained consistent with that identified in the original studies is because the actions undertaken represent the manifestation within the domestic setting of the characteristic response to emergencies and other disasters.

Against this backdrop, the fact that the same types of behaviour have been observed in separate studies conducted some 40 years apart becomes less surprising. Consequently, these underlying types of behaviour can be said to comprise a core part of the human response to emergency incidents, and not the product of a specific era or time period. Through the DAR it is now possible to answer the fundamental question about why the ADF injury rate has remained static despite a sustained decline in the number of ADFs. The answer is because, when encountering an uncontrolled fire, people's core behaviours of approach and engagement with the fire have not changed during the intervening 40 years since the original studies; and it is these behaviours that are causes of injury during an ADF. Consequently, the DAR makes an important contribution to the knowledge of human behaviour in fire by providing a means to recognise and understand the types of behaviour observed during an ADF and, in doing so, answer the question about injuries in ADFs.

During emergency events in PCI spaces, the modes of behaviour observed among the public are recognised as saving lives, as those who need help may benefit from the provision of rapid assistance from 'zero responders' before the arrival of the emergency services (Cocking, 2013). Examples where this was the case include the '7/7' attack in London, the Westminster Bridge attack, the London Bridge attack, the Lakanal House fire and the Grenfell Tower fire. From this arise important questions about the feasibility, and indeed desirability, of seeking to change these initial, and instinctive, behaviours. Consequently, this thesis has identified the need for debate and discussion among those working in fire safety (central government, FRSs and academia) about the implications of this knowledge for fire safety messaging.

Within any such debate, a key question that needs to be asked is the relevance of continuing to rely on an approach to home fire safety messaging that, arguably, is prescriptive, somewhat paternalistic and contradictory to the key aspects of how people actually behave during ADFs (or indeed any other emergency incident). Assuming that the sort of assistance offered by members of the public to each other before the arrival of the emergency services is accepted as a beneficial behavioural trait – and indeed one that forms a fundamental part of the natural human response to emergency incidents – consideration needs to be given to whether it would be desirable or even possible to seek to alter such responses within the domestic setting through a continued insistence on the 'Get out, stay out, call 999' approach.

As well as the academic and theoretical contributions outlined above, this work has found practical application within the FRS. The results of this work are being used to improve the knowledge and understanding across four core areas: fire safety messaging, fire prevention and community safety activity, incident command training and operational response, and emergency call handling. Examples of this include findings from this work being incorporated into key training courses including: incident command training for 'Level 1' (1 to 3 pumps) and 'Level 2' (4 to 6 pumps) incident commanders; training courses for firefighting instructors and the fire training team; contributions to emergency call handling procedures and call management with control firefighters; and the development of risk profiling and fire risk assessment for home fire safety checks. In a period of constrained FRS budgets, it becomes especially important to apply an accurate understanding to issues of injury risk profiling so that the limited resources allocated by FRSs to fire prevention can be directed more accurately and therefore have greater benefit by being aligned with those in greatest need. The findings from this work will also be taken forward to the NFCC so that they can be shared at a national level.

In addition to the contributions made by this work to the FRS, there has been a contribution made to facilitate development within the field of evacuation modelling. From this study it has been possible to create decision trees mapping out the sequence and frequency of key activities during an ADF. The decision trees are organised for people in general (all participants) but can be, and have been, also organised for groups based upon key occupant characteristics (such as gender). The decision trees have been designed to present the activities that are most likely to follow the key first-level activities and quantify their likelihood. These more mathematical, graphical representations of human behaviour offer those working in the field of modelling a resource to assist in the development of behavioural itineraries for evacuation modelling. That is, by highlighting how data collected via social-science methods can be 'translated' into numerical rule-based form, modellers can be persuaded that the integration of such data into models can (a) be done and (b) inform end-users as to how outcomes occurred in past events and test what could happen in future events when certain activities are undertaken.

This thesis also highlighted the challenges of working in the area of human behaviour in fire, foremost among which was the fact that data were collected on behavioural responses to dwelling fires – an event that is, for many people, highly stressful and traumatic. This became evident in the absence of data regarding fires in high-rise dwellings and the strict ethical constraints that precluded data collection from those aged under 18. Consequently, as the first study of this scale in 40 years, appropriate methods of data handling and analysis needed to be determined without the opportunity of being able to refer to and draw from the lessons of any contemporary studies in a similar area. The absence within the literature of any up-to-date work on a comparable scale added an additional level of challenge, as this thesis was not undertaken in a subject area where there is a large community of like-minded researchers offering the opportunity to learn from, build upon and refine current approaches and techniques. While the three original studies provided an enormously useful backdrop and offered a large amount of both data and information on the methods of data analysis used, the fact they were undertaken so long ago meant that the approaches used to data handling and data analysis needed to be reviewed, updated and extended. This meant that without the opportunity to reference any contemporary work conducted on the same scale, the methodology and data analysis needed to be developed from the ground up for this study. As a result, in addition to the insights obtained from the data, this study also offers other researchers a tested and proven methodological framework and a range of analytical techniques that can be adapted and applied to other studies of human behaviour in fire.

In conclusion, dwelling fires remain the single greatest source of fire-related injuries, yet the knowledge of and available literature on human behavioural responses during such fires is limited. Moreover, the work which does exist and which has offered a basis for knowledge was undertaken 40 years ago. This thesis has provided confirmation that several behavioural aspects identified within the original studies from that time remain valid. In addition, this thesis has generated a large volume of new and original knowledge about human behavioural responses and identified the behaviours that are significantly associated with injury during dwelling fires. From this original knowledge, an injury risk profile for dwelling fires has been developed. This has also led to the formulation of the DAR: a way of describing the types of occupant response and underpinning motivations in dwelling fires, offering a guide for understanding how and why people behave the way they do during an ADF. Importantly, the findings from this work are also making a practical contribution to the FRS's core areas of prevention, protection and response. Prior to this thesis, the gap in the knowledge of human behaviour in dwelling fires had only been partially filled. However, as has been demonstrated, this thesis has made several important and original contributions to the field and in doing so provides a comprehensive and up-to-date understanding of human behaviour in dwelling fires. In undertaking this work, it is hoped that the knowledge contained within it will contribute towards reducing further the number of people who are physically harmed during fires in the home.

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APPENDICES

Appendix 1. Hard copy of the LIFEBID questionnaire survey

Appendix 2. Additional questions added to LIFEBID survey to support the PhD

Appendix 3. Postcard distributed by fire crews to those who experienced an ADF

Appendix 4. Decision tree report

Appendix 1. Hard copy of the LIFEBID questionnaire survey

LIFEBID

LESSONS IN FIRE & EVACUATION BEHAVIOUR IN DWELLINGS

DWELLING FIRE SURVEY

By taking part in this research, and sharing your experience, you can help us and members of the public build a better understanding of what happens during a fire. Consequently, we can work together towards improving safety in homes.

Before beginning, please ensure you have read the participant information sheet available on the LIFEBID website survey page. Any questions can be directed to us via the website (www.lifebid.co.uk).

Many thanks,

The LIFEBID research team, in partnership with UK Fire & Rescue Services

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Are you:

- ○ the person who experienced the fire (i.e. "participant")?
- ○ someone assisting the participant with this survey (e.g. fire service personnel)?

Participants are requested to provide their informed consent.

(a) I am 18 years of age or older
(b) I am not currently receiving treatment (either as an in- or an out-patient) for any injuries incurred during the fire
(c) I have read the participant information sheet and have sufficient information about this study
(d) I am willing to revisit my fire experience and share that experience
(e) I understand that I am free to withdraw from this study at any time and do not need to give a reason for withdrawing
(f) I understand that my research data may be used for further studies in anonymous form

***Do you accept the above and agree to take part in this study?**

- ○ Yes
- ○ No

SECTION A

A1. If the fire and rescue service attended your incident, enter the incident number (if known) below.

____

A2. Enter the first half of your postcode.

This must be the postcode in which you experienced your incident.

____

A3. Enter the date of your incident.

____

SECTION B

Before we get onto the current incident, please tell us a little bit about yourself...

B1. What is your gender?

- ○ Male
- ○ Female

B2. Enter your age (in number of years).

____

B3. What is your ethnic group?

Part 1	Part 2		
○ White	- British	- African	- White & Black Caribbean
○ Black	- English	- Caribbean	- White & Black African
○ South Asian	- Scottish	- Indian	- White & Asian
○ East Asian	- Welsh	- Pakistani	- Arab
○ Mixed/Multiple	- Northern Irish	- Bangladeshi	- Other
○ Other	- Gypsy/Irish Traveller	- Chinese	

***B4. Had you ever experienced a fire prior to the current incident?**

"fire" = any incident where something ignited, emitting smoke and/or flames which, if left untackled, could have posed a threat to property or lives.

○ Yes
○ No

***B5. Had you gained knowledge about fires or fire safety from any other sources prior to the current incident?**

Tick any that apply.

- ☐ Workplace (i.e. fire drills, health & safety training)
- ☐ Profession (i.e. I have worked, or am currently employed, in an area related to fires/fire safety)
- ☐ School (i.e. fire drills, classes on health & safety)
- ☐ Factual TV/Film (i.e. documentaries)
- ☐ Fictional TV/Film (i.e. soap operas, dramas, etc.)
- ☐ Read things in other media (e.g. newspapers, magazines, internet, social media)
- ☐ Public safety information issued by the government/local authorities/fire and rescue service
- ☐ Other: ________________________________

SECTION C

Okay. Let's begin with the context surrounding the current incident...

C1. During what time of day did the incident occur?

- ○ 06:00 - 11:59
- ○ 12:00 - 16:59
- ○ 17:00 - 22:59
- ○ 23:00 - 05:59

***C2. In what type of dwelling did the incident occur?**

- ○ Flat/Apartment (i.e. property spread over 1 floor only) *- go to C2i*
- ○ Maisonette (i.e. flat/apartment spread over 2 floors) *- go to C2i*
- ○ Terraced house *- skip to C3*
- ○ Semi-detached house *- skip to C3*
- ○ Detached house *- skip to C3*
- ○ Bungalow *- skip to C3*
- ○ Other: ________________________________ *- skip to C3*

***C2i. On what floor of the building was your home?**

Enter the number of floors, from street level, you would have to ascend by stairs or lift to reach the private space you lived in.

So, if you lived in a basement flat, enter -1; a ground-floor flat, enter 0; if you had to go up one floor, enter 1; and so on.

________________ *- if a number greater than 0, go to C2ii; otherwise skip to C3*

C2ii. Was your home above a commercial property (e.g. a restaurant, shop, etc.)?

- ○ Yes
- ○ No

***C3. Were there any smoke alarms installed in your home?**

- ○ Yes *- go to C3i*
- ○ No *- skip to C4*

C3i. Had the alarm(s) been installed by the fire and rescue service?

- ◯ Yes
- ◯ No

C4. Enter below any pets you believed were in or on your property at the time of the incident.

____

C5. Enter the number of other people that normally lived with you in your home.

____

***C6. Enter the number of other people that were in your home when the incident occurred.**

_____________________ *- if a number greater than 0, go to C6i; otherwise skip to C7*

C6i. Enter the number of people present that day who were 'dependents' (i.e. young child, adult being cared for).

- ☐ Child: __________
- ☐ Adult: __________

C7. Enter the source of the fire (i.e. what first caught fire/started burning).

____

C8. Where did the fire start?

- ◯ Kitchen
- ◯ Living Room/Lounge/Dining Room
- ◯ Bedroom
- ◯ Loft/Attic
- ◯ Store Room
- ◯ Laundry Room/Airing Cupboard
- ◯ Hallway/Corridor/Stairs
- ◯ Bathroom/Toilet
- ◯ Conservatory
- ◯ Garage
- ◯ Neighbouring property
- ◯ External structure (e.g. shed, refuse store, car)
- ◯ Other: ________________________________

***C9. Where were you located when the fire started?**

- ○ Same room/area as the fire
- ○ Different room/area but same floor as the fire
- ○ Different room/area, on a floor above the fire
- ○ Different room/area, on a floor below the fire
- ○ I was inside my home, the fire was outside it (e.g. in shed, neighbouring property, etc.)
- ○ I was outside my home (e.g. in shed, neighbouring property, etc.), the fire was inside it

C10. Were you awake when the fire started?

- ○ Yes
- ○ No

***C11. What first caught your attention, making you aware that something unusual was happening?**

- ☐ Saw smoke
- ☐ Saw flames
- ☐ Smelt smoke/burning
- ☐ Felt increase in temperature
- ☐ Heard crackling sound
- ☐ Heard smoke alarm sounding
- ☐ Heard emergency services' sirens
- ☐ Someone informed me directly that something was happening
- ☐ Noticed commotion or unusual activity from people inside my home
- ☐ Noticed commotion or unusual activity from pet(s) inside my home
- ☐ Noticed commotion or unusual activity from neighbouring property/people outside
- ☐ Other: ____

If 'Someone informed me directly that something was happening' was selected then go to C11i; otherwise skip to C12

C11i. You stated that someone directly informed you - who was this?

- ☐ Male partner/husband
- ☐ Female partner/wife
- ☐ Son
- ☐ Daughter
- ☐ Father
- ☐ Mother
- ☐ Brother
- ☐ Sister
- ☐ Male neighbour
- ☐ Female neighbour
- ☐ Other: ___________________

C12. When you first noticed something unusual was happening, what was your understanding of the situation <u>at that moment</u>?

	Yes	No
I thought something threatening was happening	○	○
I thought it was a fire	○	○
I thought the situation was affecting me and/or my home	○	○
I thought I had to act quickly	○	○

SECTION D

We would now like you to summarise what happened from this point (the moment you realised something unusual was happening) onwards, and the order in which it all happened. This will involve using a timeline to list:

- **Activities undertaken (1st thing done in response to situation, 2nd thing, 3rd thing, etc.)**
- **When, during this sequence, you encountered fire hazards**
- **When, during this sequence, you experienced physical effects or injuries**

Let's focus on that last aspect for a moment. Below are types of physical effects or injuries that can be experienced during a fire:

- **SMOKE INHALATION** includes: coughing, shortness of breath, hoarse voice, noisy breathing, irritated eyes, headache, nausea, mental confusion, dizziness, fainting, unconsciousness.
- **BURN** includes: skin turned pink/red/brown/black, blisters, pain.
- **OTHER** includes: cuts, bruising, fracture, concussion, allergic reaction, heart attack, etc.

***D1. Did you experience any physical effects or injuries during your incident?**

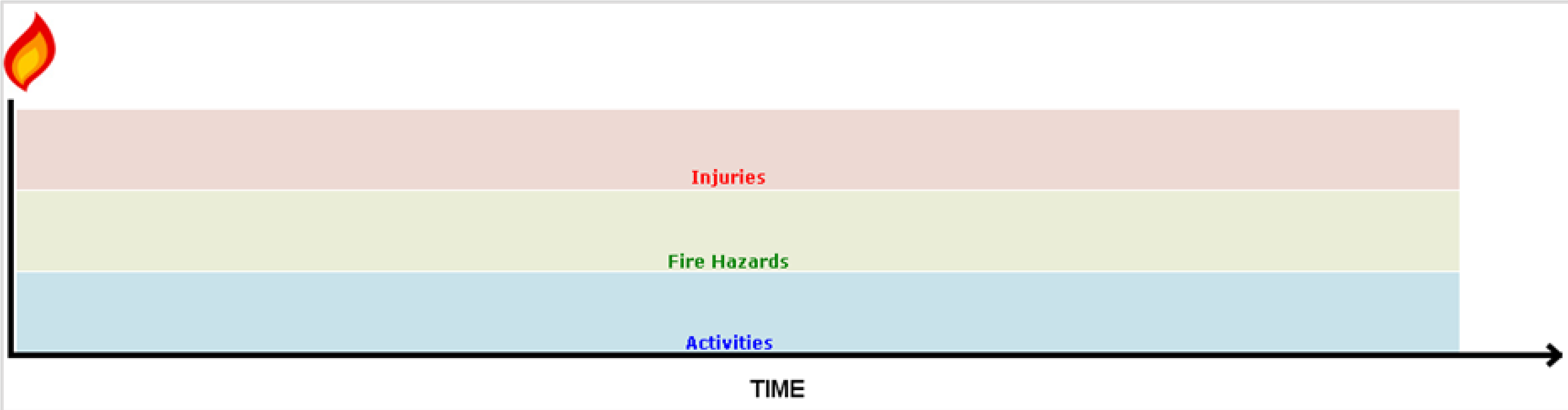
○ Yes – *go to D1i*
○ No – *skip to D2*

***D1i. What sort of physical effects/injuries did you experience? Please briefly describe symptoms and/or body part(s) affected.**

- ☐ Smoke inhalation: ____
- ☐ Burn: ____
- ☐ Other: ____

D2. Please now fill in the timeline from the moment you became aware something unusual was happening to the point the fire was out, using the categories overleaf.

TIMELINE



Activities	Fire Hazards	Injuries
A1. Noted something unusual but did not act on it	FH1. Smoke only	I1. Smoke inhalation only
A2. Investigated what was happening	FH2. Flames only	I2. Burn(s) only
A3. Tried to tackle fire	FH3. Heat only	I3. Other injury only
A4. Warned others	FH4. Smoke AND flames	I4. Smoke inhalation AND burn(s)
A5. Searched for/Gathered item(s)	FH5. Smoke AND heat	I5. Smoke inhalation AND other injury
A6. Searched for/Gathered person(s)	FH6. Flames AND heat	I6. Burn(s) AND other injury
A7. Searched for/Gathered pet(s)	FH7. Smoke AND flames AND heat	I7. Smoke inhalation AND burn(s) AND other injury
A8. Closed internal door(s)		
A9. Called 999		
A10. Waited for emergency services		
A11. Exited building		
A12. Re-entered home		
A13. Fire & Rescue Service arrived		
A14. Ambulance/Paramedics/Police arrived		
A15. Fire was put out		
A16. Other (please specify)		

SECTION E

Thank you. This information is really helping us build up a clearer picture of your experience.

We'd like to look now at a few moments in your experience in a bit more detail, starting with how close you got to the source of the fire...

Please refer back to C9: if the answer was 'Same room/area as the fire' then go to E1; otherwise, skip to E2

E1. You stated earlier that you were in the same room/area as the fire when it started.

What was the closest you got to the <u>source</u> of the fire, either at that initial moment or at any subsequent stage of the incident?

- ◯ As close as being within touching distance *- skip to E4*
- ◯ Only as close as being within the same room/area *- skip to E4*

***E2. You stated earlier that you were not in the same room/area as the fire when it started.**

What was the closest you got to the source of the fire at any point subsequently during the incident?

- ◯ Within touching distance *- skip to E3*
- ◯ Within the same room/area *- skip to E3*
- ◯ On the same floor, in a different room/area, but had sight of the fire *- skip to E4*
- ◯ On the same floor, in a different room/area, with no sight of the fire *- skip to E14*
- ◯ In the same building but on a different floor to it *- skip to E14*
- ◯ There was always a building between myself and the fire (i.e. fire was outside/in neighbouring property, I was inside or vice versa) *- skip to E14*
- ◯ There was always a building between myself and the source of the fire but the flames/smoke penetrated my property – *from this point onwards, the "fire" will be the flames/smoke that penetrated your property. Also, the "room/area where the fire started" will be the room/area of your property that was most affected by flames/smoke; now, go to E2i*

***E2i. During the incident, what was the closest you got to the flames/smoke in the room/area where the fire started?**

- ○ Within touching distance *- go to E3*
- ○ Within the same room/area *- go to E3*
- ○ On the same floor, in a different room/area, but had sight of it *- skip to E4*
- ○ On the same floor, in a different room/area, with no sight of it *- skip to E14*
- ○ In the same building but on a different floor *- skip to E14*

E3. What was your main reason for entering the room/area where the fire started?

- ○ I did not yet know there was a fire; I entered to do something else
- ○ I noticed something unusual was happening but did not know what it meant and therefore went to investigate
- ○ I sort of knew there was a fire but needed to see it for myself to believe it
- ○ I knew there was a fire and went to evaluate the situation
- ○ I was going to try and tackle the fire
- ○ I wanted to get someone who was in that room/area
- ○ I wanted to get a pet that was in that room/area
- ○ I wanted to get an item that was in that room/area
- ○ I had to pass through that room/area to exit the building
- ○ Other: ____

E4. What did the flames look like when you first saw them there?

- ○ I do not recall seeing any flames at that stage.
- ○ [selected Flame Picture A from Appendix]
- ○ [selected Flame Picture B from Appendix]
- ○ [selected Flame Picture C from Appendix]
- ○ [selected Flame Picture D from Appendix]
- ○ [selected Flame Picture E from Appendix]

E5. What did the smoke look like when you first saw it there?

- ○ I do not recall seeing any smoke at that stage.
- ○ [selected Smoke Picture A from Appendix]
- ○ [selected Smoke Picture B from Appendix]
- ○ [selected Smoke Picture C from Appendix]
- ○ [selected Smoke Picture D from Appendix]
- ○ [selected Smoke Picture E from Appendix]

If the answer to E2 was 'On the same floor, in a different room/area, but had sight of the fire' then skip to E14; otherwise go to E6

***E6. What did you do to tackle the fire?**

Tick all that apply.

- ☐ I did not attempt to tackle the fire personally
- ☐ I tried smothering it with a fire blanket
- ☐ I tried smothering it with something else (e.g. lid, wetted towel)
- ☐ I tried closing the door on the appliance, keeping the burning item inside
- ☐ I tried putting it out with water
- ☐ I tried putting it out with a fire extinguisher
- ☐ I tried switching the power off
- ☐ I tried removing the burning item from its heat source
- ☐ Other: ____

If the answer to E6 was 'I did not attempt to tackle the fire personally' then skip to E7; otherwise go to E6i

E6i. Please give your reason(s) for attempting to the tackle the fire:

- ☐ It only looked small
- ☐ It looked quite big but I thought I could put it out nonetheless
- ☐ I thought I might at least be able to contain/reduce it until other help arrived
- ☐ If I did not try, no-one else could or would
- ☐ I felt responsible for it
- ☐ If left alone it would cause a lot of damage to the property
- ☐ If left alone it would pose a threat to my health/life
- ☐ If left alone it would pose a threat to other occupants in the property
- ☐ If left alone it would pose a threat to the neighbours
- ☐ I did not really think about it, instinct just took over
- ☐ Other: ______________________________________

***E6ii. Did the flames and/or smoke increase in size at any point while you were tackling the fire?**

- ○ Yes *- go to E6iii*
- ○ No *- skip to E7*

E6iii. What was the tallest height the flames reached while you were tackling the fire?

- ○ I still do not recall any flames at this stage.
- ○ [selected Flame Picture A from Appendix]
- ○ [selected Flame Picture B from Appendix]
- ○ [selected Flame Picture C from Appendix]
- ○ [selected Flame Picture D from Appendix]
- ○ [selected Flame Picture E from Appendix]

E6iv. What was the greatest volume of smoke present while you were tackling the fire?

- ○ I still do not recall any smoke at this stage.
- ○ [selected Smoke Picture A from Appendix]
- ○ [selected Smoke Picture B from Appendix]
- ○ [selected Smoke Picture C from Appendix]
- ○ [selected Smoke Picture D from Appendix]
- ○ [selected Smoke Picture E from Appendix]

***E7. Did you leave the room/area before the fire was out?**

- ○ No, I remained in the room/area until the fire was out *- go to E8*
- ○ I left and returned at least once while the fire was still going, eventually remaining in the room/area until the fire was out *- skip to E9*
- ○ I left and returned at least once while the fire was still going, eventually leaving the room/area before the fire was out *- skip to E11*
- ○ Yes, I left the room/area and did not return to it until after the fire was out *- skip to E12*

E8. What was your main reason for remaining in the room/area?

- ○ I was managing to successfully extinguish the fire and wanted to see the job through
- ○ Someone else was tackling the fire; I wanted to see what happened
- ○ It looked like the fire might burn itself out; I wanted to see what happened
- ○ I felt unwell/was injured and could not move
- ○ I was trapped
- ○ Other: ____

If the answer to E6 was 'I did not attempt to tackle the fire personally' then please skip to E10; otherwise skip to F1

E9. What was your main reason for eventually remaining in the room/area?

- ○ I was managing to successfully extinguish the fire and wanted to see the job through
- ○ Someone else was tackling the fire; I wanted to see what happened
- ○ It looked like the fire might burn itself out; I wanted to see what happened
- ○ I felt unwell/was injured and could not move
- ○ I was trapped
- ○ Other: ____

If the answer to E6 was 'I did not attempt to tackle the fire personally' then please go to E10; otherwise skip to F1

***E10. Did the flames and/or smoke increase in size at any point while you remained there?**

- ○ Yes *- go to E10i*
- ○ No *- skip to F1*

E10i. What was the tallest height the flames reached while you remained there?

- ○ I still do not recall seeing any flames.
- ○ [selected Flame Picture A from Appendix]
- ○ [selected Flame Picture B from Appendix]
- ○ [selected Flame Picture C from Appendix]
- ○ [selected Flame Picture D from Appendix]
- ○ [selected Flame Picture E from Appendix]

E10ii. What was the greatest volume of smoke present while you remained there?

- ○ I still do not recall seeing any smoke. – *skip to F1*
- ○ [selected Smoke Picture A from Appendix] – *skip to F1*
- ○ [selected Smoke Picture B from Appendix] – *skip to F1*
- ○ [selected Smoke Picture C from Appendix] – *skip to F1*
- ○ [selected Smoke Picture D from Appendix] – *skip to F1*
- ○ [selected Smoke Picture E from Appendix] – *skip to F1*

E11. What was your main reason for leaving the room/area the final time?

- ○ 999 call handler instructed me to leave
- ○ Someone in or near the property instructed me to leave
- ○ I was forced out of the room/area by the hazardous conditions
- ○ I left to do something/get someone in response to the fire
- ○ I left because it looked like the fire was out/going out
- ○ Other: ____

If the answer to E6 was 'I did not attempt to tackle the fire personally' then please skip to E13; otherwise skip to F1

E12. What was your main reason for leaving the room/area?

- ○ 999 call handler instructed me to leave
- ○ Someone in or near the property instructed me to leave
- ○ I was forced out of the room/area by the hazardous conditions
- ○ I left to do something/get someone in response to the fire
- ○ I left because it looked like the fire was out/going out
- ○ Other: ____

If the answer to E6 was 'I did not attempt to tackle the fire personally' then please go to E13; otherwise skip to F1

***E13. Did the flames and/or smoke increase in size prior to you leaving the room/area?**

- ○ Yes *- go to E13i*
- ○ No *- skip to F1*

E13i. What was the tallest height the flames reached before you left the room/area?

- I still do not recall seeing any flames at that stage.
- [selected Flame Picture A from Appendix]
- [selected Flame Picture B from Appendix]
- [selected Flame Picture C from Appendix]
- [selected Flame Picture D from Appendix]
- [selected Flame Picture E from Appendix]

E13ii. What was the greatest volume of smoke present before you left the room/area?

- I still do not recall seeing any smoke at that stage.
- [selected Smoke Picture A from Appendix]
- [selected Smoke Picture B from Appendix]
- [selected Smoke Picture C from Appendix]
- [selected Smoke Picture D from Appendix]
- [selected Smoke Picture E from Appendix]

Please now skip to F1

E14. What was your main reason for not entering the room/area where the fire started?

- I went to get something/someone to help tackle the fire and circumstances prevented me from returning
- My priority was to alert or remove others from the property
- My priority was to move some belongings
- 999 call handler instructed me to leave the property
- Someone in or near the property instructed me to leave
- The conditions in there would have made it difficult (e.g. flames too large, smoke too thick, temperature too hot)
- I thought it would put my life/health at risk if I got any closer to the fire
- I felt unwell/was injured
- I felt scared
- Someone else in the property normally takes care of this type of thing so I thought I'd leave them to it
- Other: ____

SECTION F

Now, let's just clarify whether the fire and rescue service were involved in your incident...

***F1. Who called 999 during this incident?**

- ○ I did (either alone or in addition to someone else) *- go to F2*
- ○ Only someone else did *- skip to F3*
- ○ Nobody called 999 *- skip to F4*

F2. Please give your reason(s) for calling 999:

- ☐ I needed practical advice to help me/us tackle the fire
- ☐ The fire was large
- ☐ My health/life was at risk
- ☐ Other people's health/lives were at risk
- ☐ The property was at risk of serious damage
- ☐ I did not think I was/we were capable of handling the fire
- ☐ I thought you are supposed to call the fire and rescue service whenever there is a fire
- ☐ It could cause trouble with the owner of the property/insurance/etc. if I did not make an official report to the emergency services
- ☐ I was scared and looking for reassurance
- ☐ If I did not make the call, no-one else could or would
- ☐ Other: ______________________________________

F2i. Did the call handler offer you the opportunity to ask questions during this call?

- ○ Yes
- ○ No

F2ii. Did the call handler offer you the opportunity to pass on information (other than the address) during this call?

- ○ Yes
- ○ No

Please now skip to G1

F3. Please give the reason(s) for 999 being called:

- ☐ I do not know the other person's reason(s) for calling 999
- ☐ Practical advice was needed to help tackle the fire
- ☐ The fire was large
- ☐ Someone's health/life was at risk
- ☐ The property was at risk of serious damage
- ☐ They did not think I was/we were capable of handling the fire
- ☐ They thought you are supposed to call the fire and rescue service whenever there is a fire
- ☐ It could have caused trouble with the owner of the property/insurance/etc. if an official report was not made to the emergency services
- ☐ Someone was scared and looking for reassurance
- ☐ The person making the call normally takes charge in these kinds of situation
- ☐ Other: ____

Please now skip to G1

F4. Please give your reason(s) for not calling 999:

- ☐ The fire was small
- ☐ No-one else was at risk (only perhaps myself)
- ☐ I/we were capable of handling the fire
- ☐ I felt responsible for the fire
- ☐ The emergency services arriving would generate unwanted attention from neighbours, passers-by or even the media
- ☐ It would make things "official"; could lead to hassle from the owner of the property
- ☐ It would make things "official"; could affect my insurance
- ☐ It would make things "official"; could lead to hassle from my relatives (e.g. they would no longer trust me to be on my own)
- ☐ I thought I might have to pay if I called the emergency services out
- ☐ I could be diverting resources away from someone who might really need it
- ☐ I was nervous - I had never called 999 before and did not know what to expect
- ☐ I was too busy doing other things
- ☐ I could not find a (working) phone
- ☐ Other: ____

SECTION G

We'd like just a few more details now about your movements until the fire was out...

***G1. Did you leave your home at any point during this incident (i.e. go outside before the fire was out)?**

- ○ No, I remained inside the property at all times - *skip to H1*
- ○ I only went outside temporarily during the incident - *go to G2*
- ○ I left when the fire service arrived and helped me out - *go to G3*
- ○ I left when someone else helped me out - *go to G3*
- ○ Yes, I evacuated from my home during the incident - *go to G2*

***G2. What persons, pets or items did you take with you when you left? Please specify.**

- ☐ Person(s) – 'dependent' (i.e. young child, adult being cared for): ____________________
  ____
- ☐ Person(s) – 'non-dependent': ____
- ☐ Pet(s): ____
- ☐ Item(s): ____ ___________
- ☐ None of the above

G2i. Did you have to go out of your way to get any of the above persons/pets/items? (That is, did you have to: take an indirect route; travel an extra distance; and/or make some other kind of additional effort?)

- ☐ No
- ☐ Yes, had to go out of way to get person(s) – dependent
- ☐ Yes, had to go out of way to get person(s) – non-dependent
- ☐ Yes, had to go out of way to get pet(s)
- ☐ Yes, had to go out of way to get item(s)

If the answer to G1 was 'I only went outside temporarily during the incident' then please skip to G5; otherwise go to G3

***G3. Did you leave your home via the usual exit?**

○ Yes *- if the answer to G1 was either 'I left when the fire service arrived and helped me out' or 'I left when someone else helped me out', or the answer to F1 was 'Nobody called 999', then skip to H1; otherwise skip to G4*
○ No *- go to G3i*

G3i. Please give your reasons for not using the usual exit and describe what alternative exit was used instead.

____
____

***G4. After exiting, did you re-enter the property before the emergency services arrived?**

○ Yes *- go to G5*
○ No *- skip to H1*

***G5. Why did you re-enter the property after exiting it?**

Tick all that apply.

☐ To check on the fire *- go to G5i*
☐ To tackle the fire *- skip to H1*
☐ To close internal doors *- skip to H1*
☐ To retrieve/search for person(s) *- skip to H1*
☐ To retrieve/search for pet(s) *- skip to H1*
☐ To retrieve item(s) of practical importance (e.g. clothing, wallet, insurance/work documents) *- skip to H1*
☐ To retrieve item(s) of sentimental importance (e.g. photographs, engagement ring) *- skip to H1*
☐ To retrieve item(s) of high financial value (e.g. expensive TV) *- skip to H1*
☐ I just wanted to be doing something *- skip to H1*
☐ Other: ____ *- skip to H1*

G5i. Why did you feel the need to check on the fire?

Tick all that apply.

☐ To see if it was a size that I could potentially put out myself
☐ To see the degree of damage to the property
☐ To see if it was spreading to other parts of the property
☐ To see if it was posing a risk to neighbouring/adjacent properties
☐ To satisfy my own curiosity
☐ To update the fire and rescue service
☐ Other: ____

SECTION H

Can you please tell us a little about the immediate consequences of the fire...

H1. By the time the fire was out, what was the extent of the fire damage to property?

- ○ Damage restricted to item that first started burning
- ○ Damage restricted to room/area where the fire started
- ○ Damage spread beyond the room/area where the fire started to other parts of that floor (but not to whole property)
- ○ Damage spread across the whole property (but not to other properties)
- ○ Damage spread across the whole property and into other nearby properties

If answer to D1 was 'No' (i.e. no physical effects or injuries) skip to I1; otherwise go to H2

H2. What medical treatment did you receive for the physical effects/injuries you described earlier?

- ○ I did not receive any treatment
- ○ I did not receive any treatment at the time of the incident but I did visit a doctor at a later date
- ○ I received first aid at the scene from the emergency services
- ○ I received first aid at the scene from someone other than the emergency services
- ○ I went to hospital, received medical treatment and was then discharged
- ○ I went to hospital and was kept in at least one night to continue receiving medical treatment
- ○ My injuries were so severe I was transferred to a specialist care unit

----

SECTION I

Looking back on the incident, please answer these few final questions...

I1. Did anything surprise you about the fire?

Tick all that apply.

- ☐ That it occurred: I never thought a fire would happen to me, at my home
- ☐ How quickly the flames grew
- ☐ How far the flames reached
- ☐ How hot the flames were
- ☐ How much smoke was produced
- ☐ How quickly the smoke spread
- ☐ How far the smoke spread
- ☐ How hot the smoke was
- ☐ How toxic/irritating the smoke was
- ☐ How the smoke or gases affected my ability to think clearly
- ☐ How dark it got due to the smoke
- ☐ The noise the fire made
- ☐ How difficult it was to put the fire out
- ☐ How easily/quickly the fire went out
- ☐ Other: ____

I2. During the incident, when you encountered smoke, did you think about the risk it might pose to you?

- ○ Not applicable – I did not encounter smoke
- ○ Did not cross my mind at all
- ○ Thought it posed no real risk to me
- ○ Thought it would only result in temporary discomfort (e.g. risk to breathing, vision, etc. during incident)
- ○ Thought it could result in long-term health effects (e.g. risk to lung/heart function, etc. following incident)
- ○ Thought it could result in death

If the answer to C3 ('Were there any smoke alarms installed in your home?') was 'Yes' then go to I3; otherwise skip to I4

I3. If a smoke alarm did not sound during the incident, do you know the reason(s) why?

☐ Not applicable - all alarms in the property sounded
☐ Smoke alarm was not in a location where it could detect that fire
☐ No battery in the smoke alarm
☐ Battery was dead
☐ It had been switched off at the mains/fuse box
☐ Alarm was faulty
☐ Other: ________________________________

***I4. Had you consumed any substance other than food around the time of the incident (e.g. glass of wine, bottle of beer, over-the-counter medicine, prescription medication, other substance)?**

○ Yes *- go to I4i*
○ No *- skip to I5*

I4i. Do you think that substance impaired you in any way?

☐ No, I actually felt more alert than I had before I took it
☐ No, I felt no negative effects
☐ Yes, it had made me feel a bit drowsy/sleepy
☐ Yes, it had made me feel a bit forgetful
☐ Yes, it had slowed my reactions
☐ Yes, it had made me a bit clumsy
☐ Other: _____________________________________

I5. Were there any other factors that might have made it more challenging to notice something unusual was happening or to move around?

☐ No, there were no factors that posed a challenge to me
☐ I already had a visual condition
☐ I already had a hearing condition
☐ I already had a mobility condition
☐ Other: _______________________________________

If the answer to B4 was 'Yes' (i.e. had experienced a fire prior to the current incident) then go to I6; otherwise skip to I7

I6. Did your previous experience of a fire influence your behaviour during this incident?

○ Yes (please specify) ____

○ No (please specify) ____

If any of the boxes were ticked for B5 (i.e. had gained knowledge about fires/fire safety prior to the current incident) then go to I7; otherwise skip to I8

I7. Did your previously-gained knowledge about fires/fire safety influence your behaviour during this incident?

- ○ Yes (please specify) ____

- ○ No (please specify) ____

I8. What do you think you did well during this incident?

____

I9. If you could go back, is there anything you would do differently?

____

I10. If you were to experience a fire again, at what point do you think the fire and rescue service should be called?

- ○ As soon as detect something unusual is happening
- ○ As soon as know for sure there is a fire
- ○ When it looks like the fire is beyond my/other occupants' control
- ○ Only when someone's health/life is clearly at risk and requires assistance, e.g. when someone is trapped/in need of medical treatment
- ○ Other: ____________________________________

That is the end of the survey. Thank you for taking the time to contribute to this research.

To learn about how to prevent fires or what to do when one occurs, visit the Chief Fire Officers Association website (www.cfoa.org.uk) to find your local fire and rescue service and access free advice.

UK Counselling Resources and Support Groups

If this subject matter has raised any thoughts or feelings that you would like to talk through with someone then please find below a list of organisations and websites to help you access confidential support and/or advice. We also recommend that you speak with your GP or therapist.

Samaritans (www.samaritans.org)
Voluntary organisation available 24 hours a day to help people who are experiencing feelings of distress explore these feelings and work out the way forward. Can be contacted by telephone, email, letter (write to: Freepost RSRB-KKBY-CYJK, Chris, PO Box 90 90, Stirling, FK8 2SA) or face-to-face at one of their local branches (in various locations across the UK).

☎ 08457 90 90 90 (24 hours a day, 7 days a week) **⌧ jo@samaritans.org**

Cruse Bereavement Care (www.crusebereavementcare.org.uk)
Voluntary organisation offering support and advice to bereaved people, one-to-one or in groups.

☎ 0844 477 9400 (during working hours) **⌧ helpline@cruse.org.uk**

Anxiety UK (www.anxietyuk.org.uk)
Voluntary organisation offering information, support and understanding regarding anxiety disorders via a range of services including one-to-one therapy.

☎08444 775 774 (Mon-Fri, 9.30am - 5.30pm) **⌧support@anxietyuk.org.uk**

Appendix 2. Additional questions added to LIFEBID survey to support the PhD

G5i. Why did you feel the need to check on the fire?

Tick all that apply.

- ☐ To see if it was a size that I could potentially put out myself
- ☐ To see the degree of damage to the property
- ☐ To see if it was spreading to other parts of the property
- ☐ To see if it was posing a risk to neighbouring/adjacent properties
- ☐ To satisfy my own curiosity
- ☐ To update the fire and rescue service
- ☐ Other: ____

I2. During the incident, when you encountered smoke, did you think about the risk it might pose to you?

- ○ Not applicable – I did not encounter smoke
- ○ Did not cross my mind at all
- ○ Thought it posed no real risk to me
- ○ Thought it would only result in temporary discomfort (e.g. risk to breathing, vision, etc. during incident)
- ○ Thought it could result in long-term health effects (e.g. risk to lung/heart function, etc. following incident)
- ○ Thought it could result in death

I7. Did your previously-gained knowledge about fires/fire safety influence your behaviour during this incident?

- ○ Yes (please specify) ____

- ○ No (please specify) ____

Appendix 3. Postcard distributed by fire crews to those who experienced an ADF

Source: www.lifebid.co.uk

Appendix 4. Decision tree report

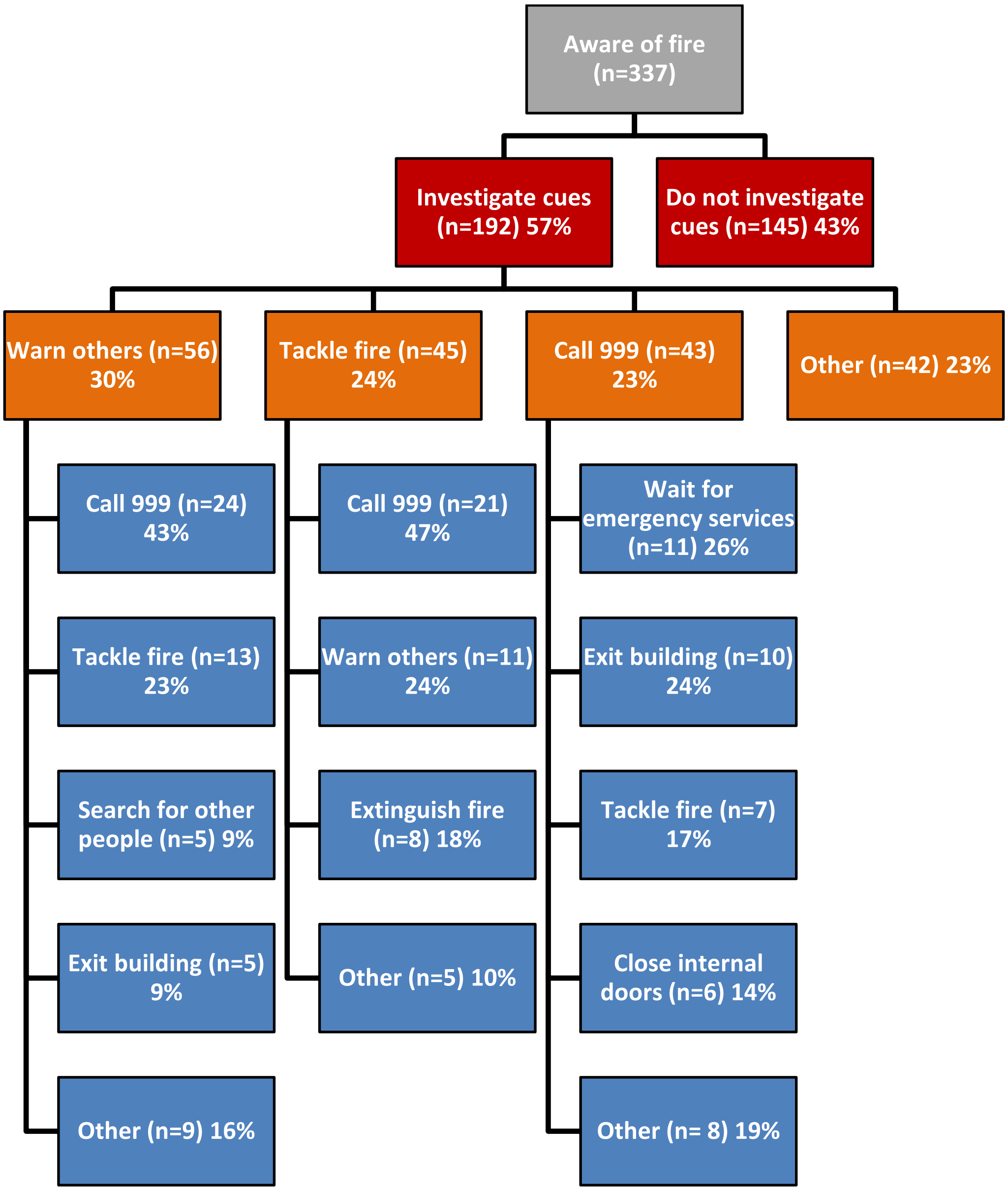
Contents

Part 1. Decision trees for all participants based on first activity undertaken

First activity undertaken (all 337 participants who completed the timeline):

Investigate cues (n=192) 57%
Tackle fire (n=29) 9%
Call 999 (n=23) 7%
Note cue, no action (n=58) 17%
Other (n=35) 10%

1.1 All participants, first activity 'investigate cues'



1.2 Smoke and flame size: all participants, first activity ‘investigate cues’

1.2.1 Warn others

Warn Others: Smoke Size

Smoke size	Count	Percentage
0	9	18
1	17	35
2	13	27
3	3	6
4	2	4
5	5	10
Total	**49**	**100**

Warn Others: Flame Size

Flame size	Count	Percentage
0	15	31
1	9	18
2	12	24
3	8	16
4	2	4
5	3	6
Total	**49**	**100**

1.2.2 Tackle fire

Tackle Fire: Smoke Size

Smoke size	Count	Percentage
0	11	26
1	11	26
2	11	26
3	3	7
4	4	9
5	3	7
Total	**43**	**100**

Tackle fire: Flame Size

Flame size	Count	Percentage
0	11	26
1	13	30
2	15	35

3	3	7
4	1	2
5	0	0
Total	**43**	**100**

1.2.3 Call 999

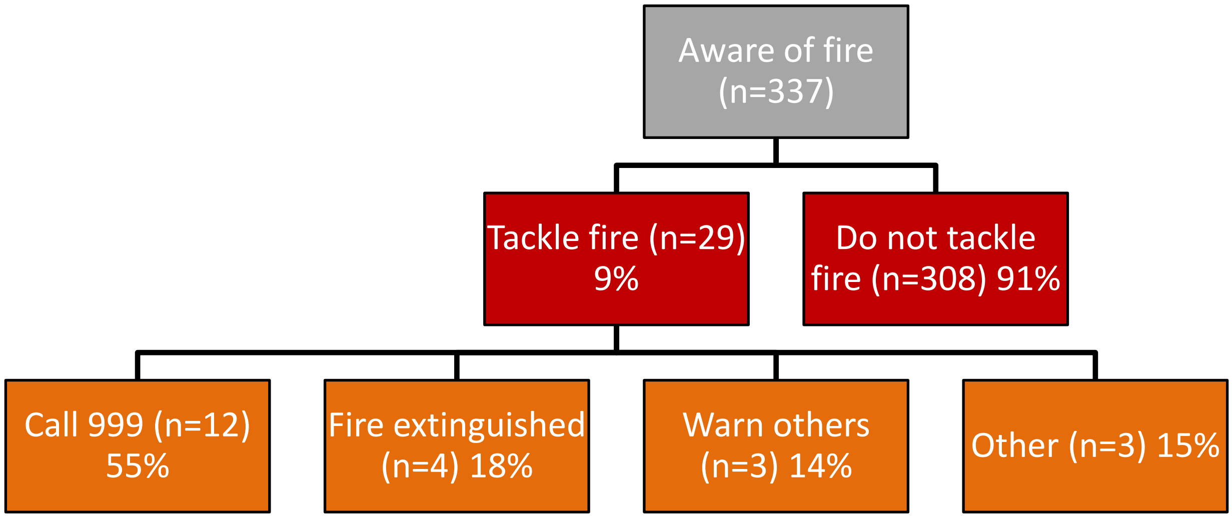
Call 999: Smoke Size

Smoke size	Count	Percentage
0	7	19
1	15	42
2	6	17
3	2	6
4	0	0
5	6	17
Total	**36**	**100**

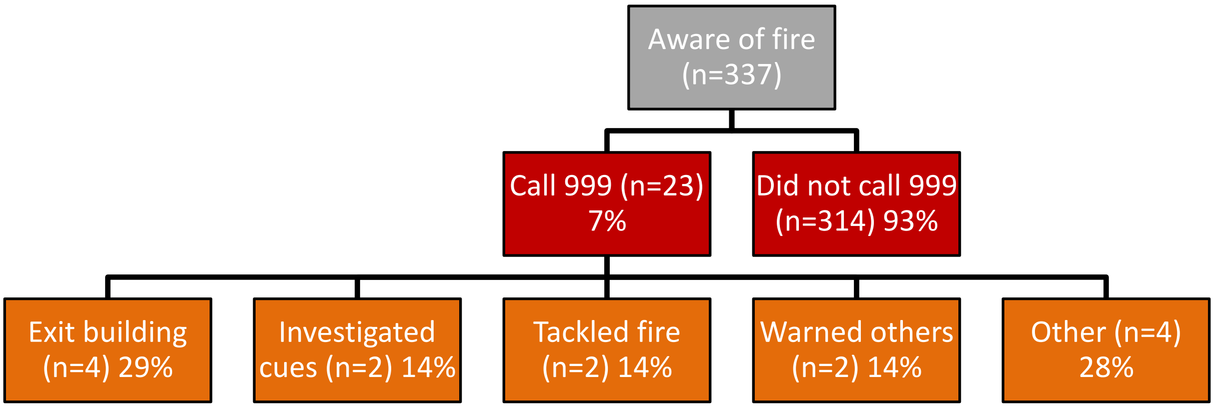
Call 999: Flame Size

Flame size	Count	Percentage
0	14	39
1	10	28
2	8	22
3	2	6
4	0	0
5	2	6
Total	**36**	**100**

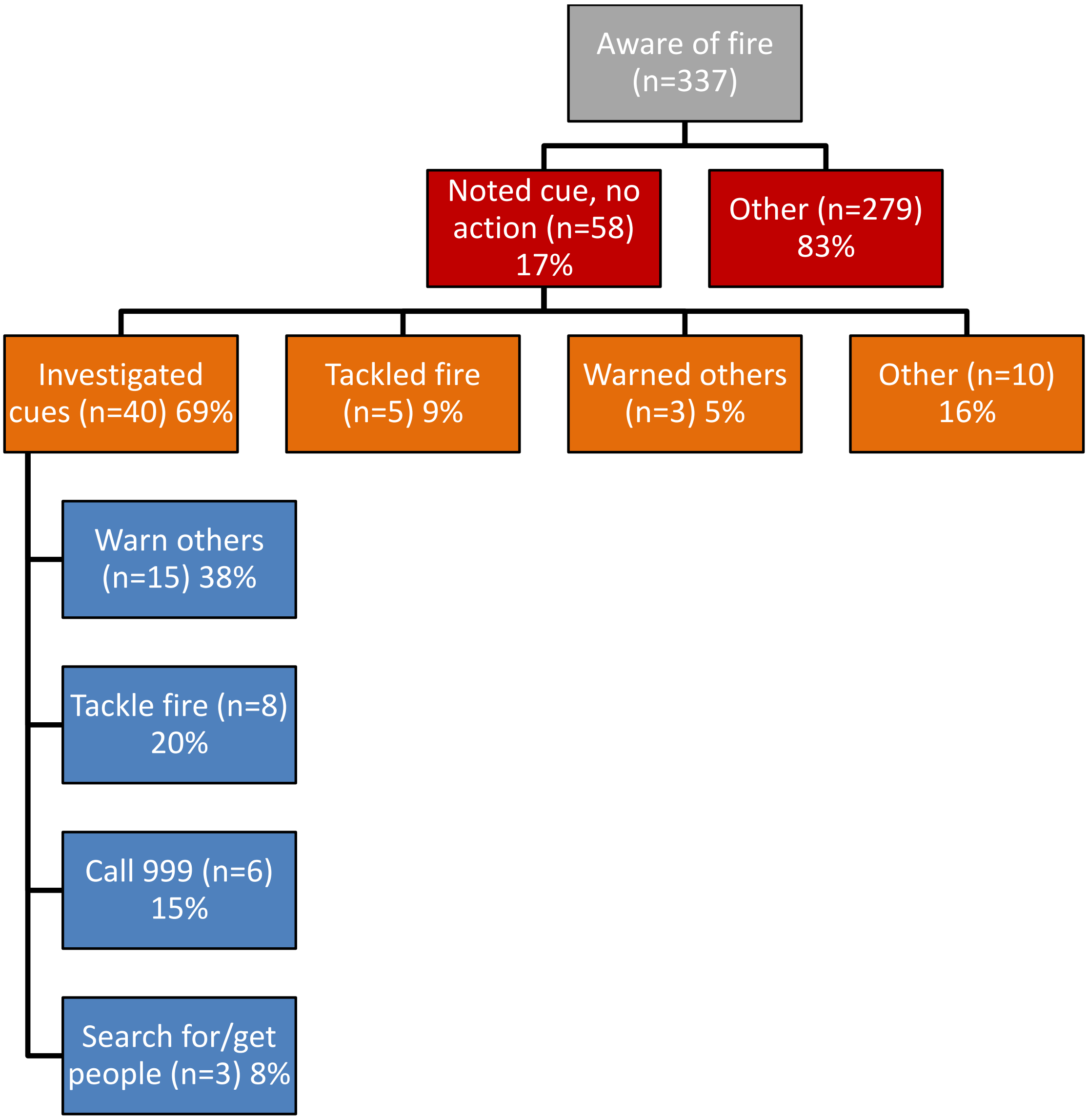
1.3 All participants, first activity 'tackle fire'



1.4 All participants, first activity ‘call 999’



1.5 All participants, first activity 'note cue, no action'



Part 2. Decision trees for gender based on first activity undertaken

NB: The total here is 327 (199 females and 128 males), as 10 of the 337 participants who completed the timeline did not specify their gender.

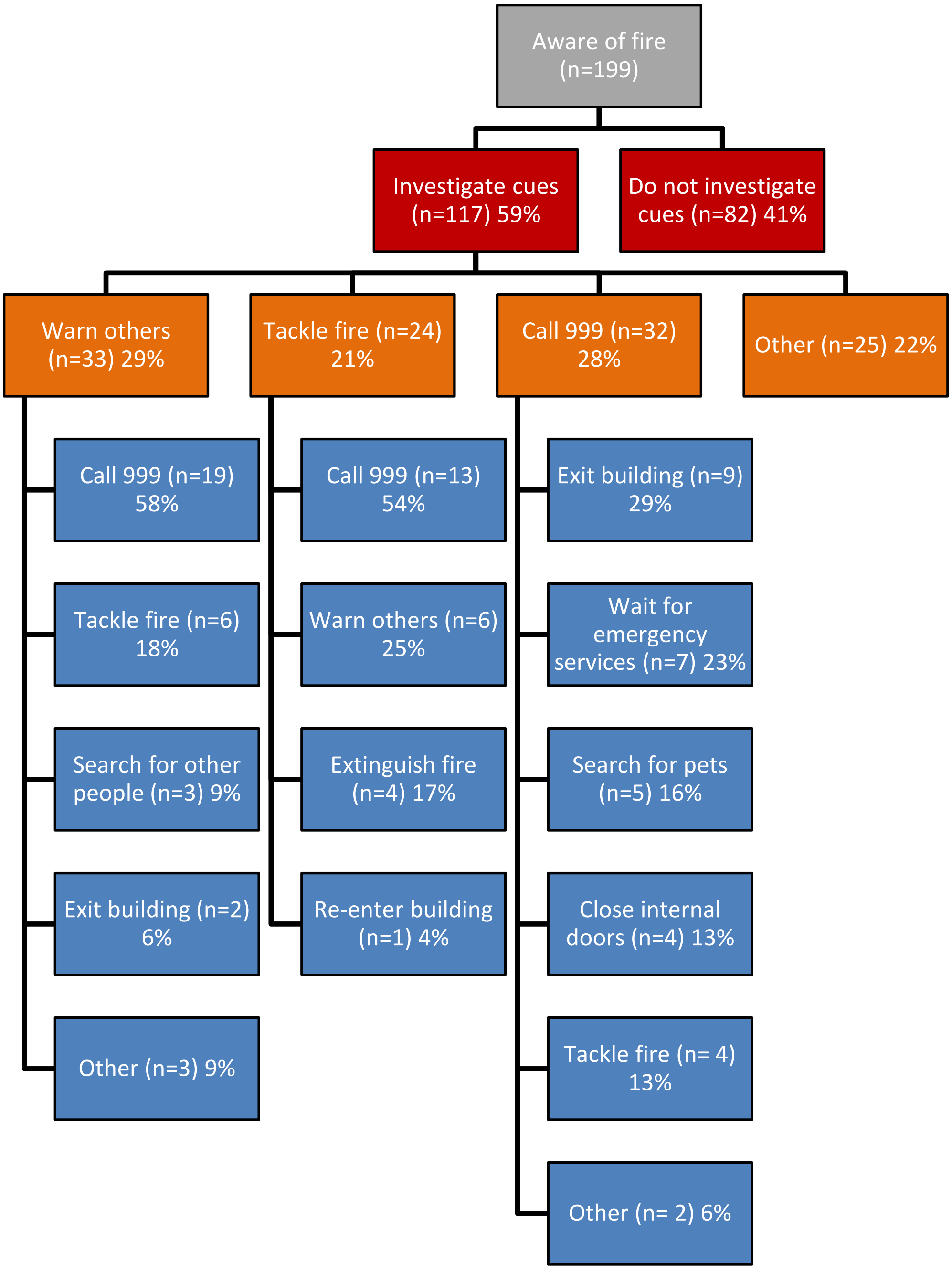
Females. First activity undertaken (all female participants who completed the timeline N=199):

Investigate cues (n=117) 59 %
Tackle fire (n=16) 8%
Call 999 (n=11) 6%
Note cue, no action (n=39) 20%
Other (n=16) 7%

Males. First activity undertaken (all male participants who completed the timeline N=128):

Investigate cues (n=72)56 %
Tackle fire (n=11) 9%
Call 999 (n=11) 9%
Note cue, no action (n=17) 13%
Other (n=17)13 %

2.1 Females, first activity investigate cues



2.2 Smoke and flame size: females, first activity 'investigate cues'

2.2.1 Warn others (females)

Warn others: Smoke Size

Smoke size	Count	Percentage
0	4	14
1	14	48
2	6	21
3	2	7
4	1	3
5	2	7
Total	**29**	**100**

Warn others: Flame Size

Flame size	Count	Percentage
0	10	34
1	7	24
2	6	21
3	4	14
4	1	3
5	1	3
Total	**29**	**100**

2.2.3 Investigate (females)

Investigate: Smoke Size

Smoke Size	Count	Percentage
0	5	22
1	5	22
2	7	30
3	1	4
4	2	9
5	3	13
Total	**23**	**100**

Investigate: Flame Size

Flame size	Count	Percentage
0	6	26
1	8	35
2	7	30
3	2	9
4	0	0
5	0	0
Total	**23**	**100**

2.2.3 Call 999 (females)

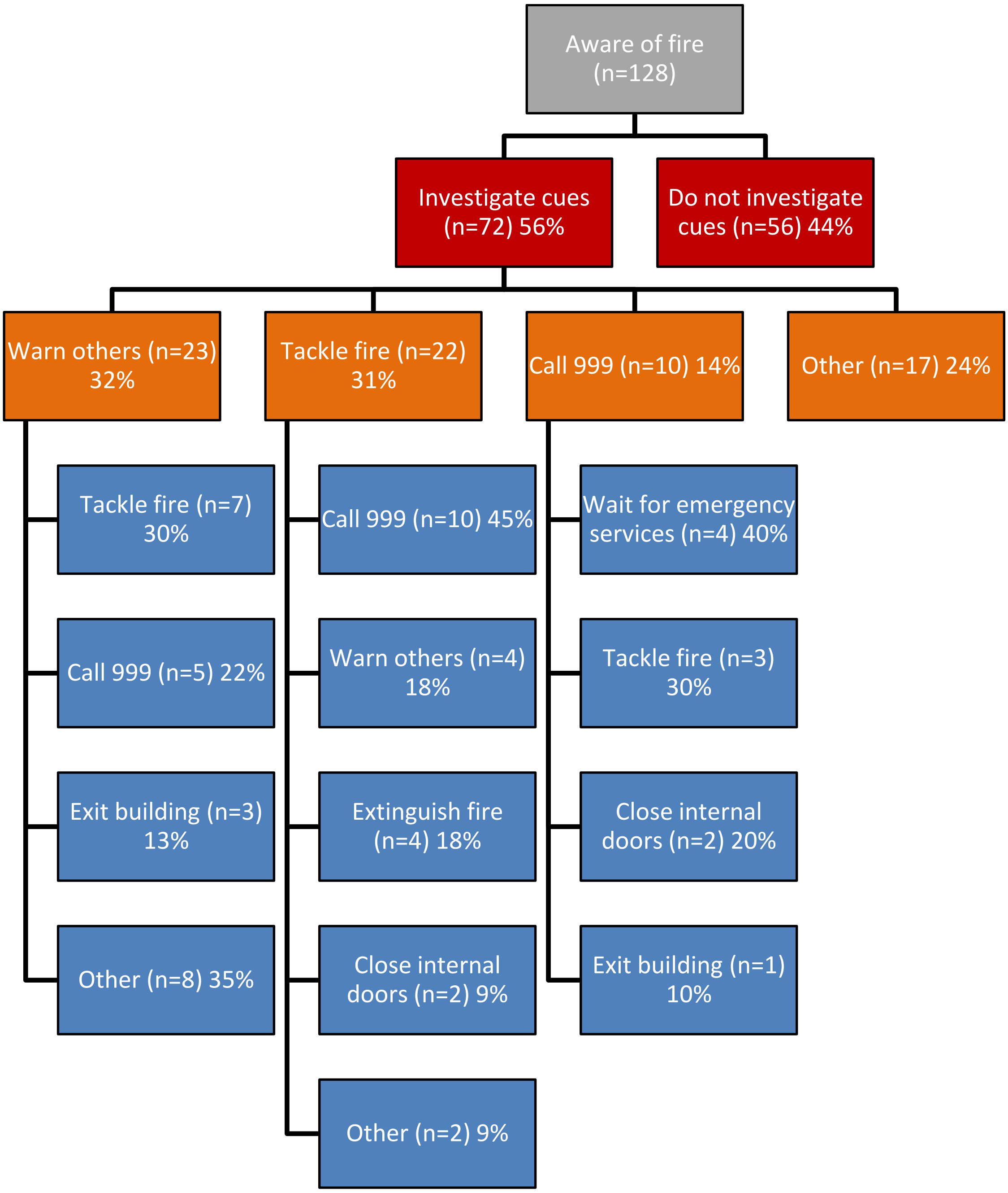
Call 999: Smoke Size

Smoke size	Count	Percentage
0	5	19
1	12	44
2	5	19
3	2	7
4	0	0
5	3	11
Total	**27**	**100**

Call 999:Flame Size

Flame size	Count	Percentage
0	11	41
1	7	26
2	6	22
3	2	7
4	0	0
5	1	4
Total	**27**	**100**

2.3 Males, first activity investigate cues



2.4 Smoke and flame size. Males, first activity ‘investigate cues’

2.4.1 Warn others (males)

Warn others: Smoke Size

Smoke Size	Count	Percentage
0	5	25
1	3	15
2	7	35
3	1	5
4	1	5
5	3	15
Total	**20**	**100**

Warn others: Flame Size

Flame size	Count	Percentage
0	5	25
1	2	10
2	6	30
3	4	20
4	1	5
5	2	10
Total	**20**	**100**

2.4.2 Tackle Fire (males)

Tackle Fire: Smoke Size

Smoke size	Count	Percentage
0	6	29
1	8	38
2	3	14
3	2	10
4	2	10
5	0	0
Total	**21**	**100**

Tackle fire: Flame Size

Flame Size	Count	Percentage
0	5	24
1	7	33
2	8	38
3	1	5
4	0	0
5	0	0
Total	**21**	**100**

2.4.3 Call 999 (males)

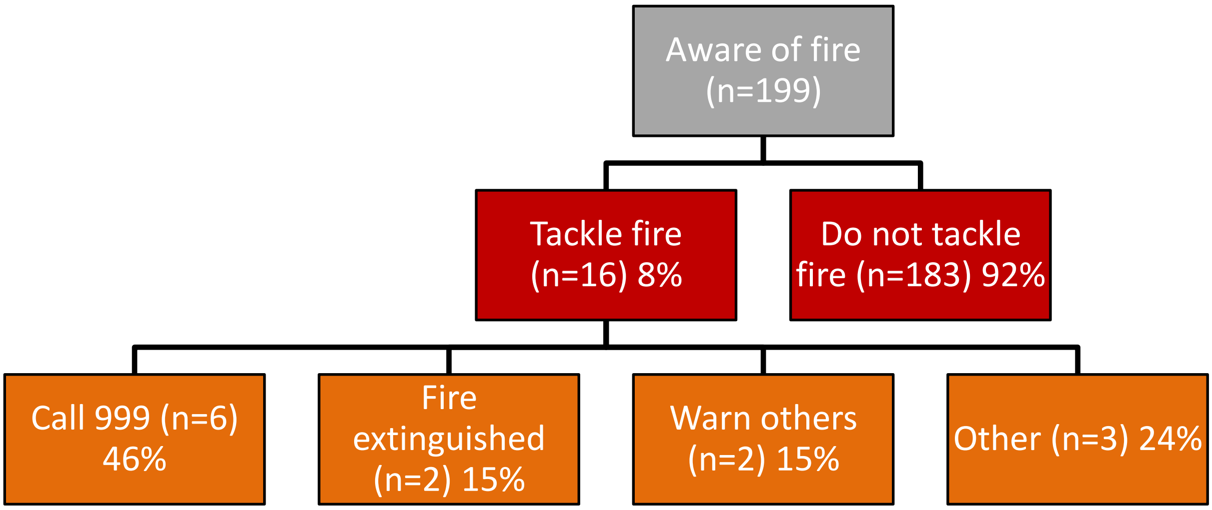
Call 999: Smoke Size

Smoke Size	Count	Percentage
0	3	33
1	3	33
2	1	11
3	0	0
4	0	0
5	2	22
Total	9	100

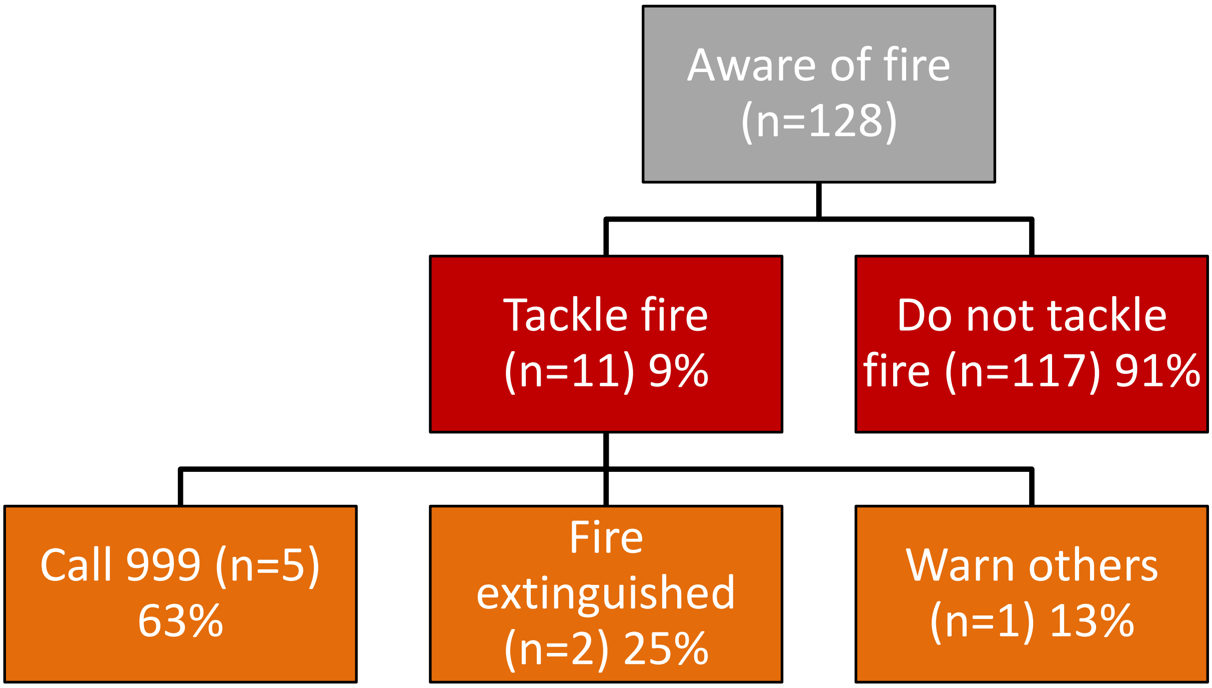
Call 999: Flame Size

Flame Size	Count	Percentage
0	4	44
1	3	33
2	1	11
3	0	0
4	0	0
5	1	11
Total	**9**	**100**

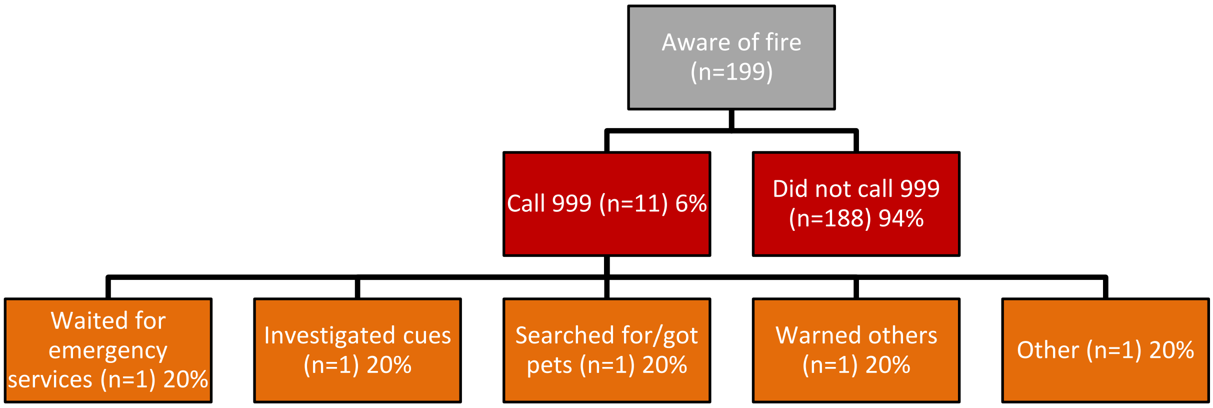
2.5 Females, first activity tackle fire



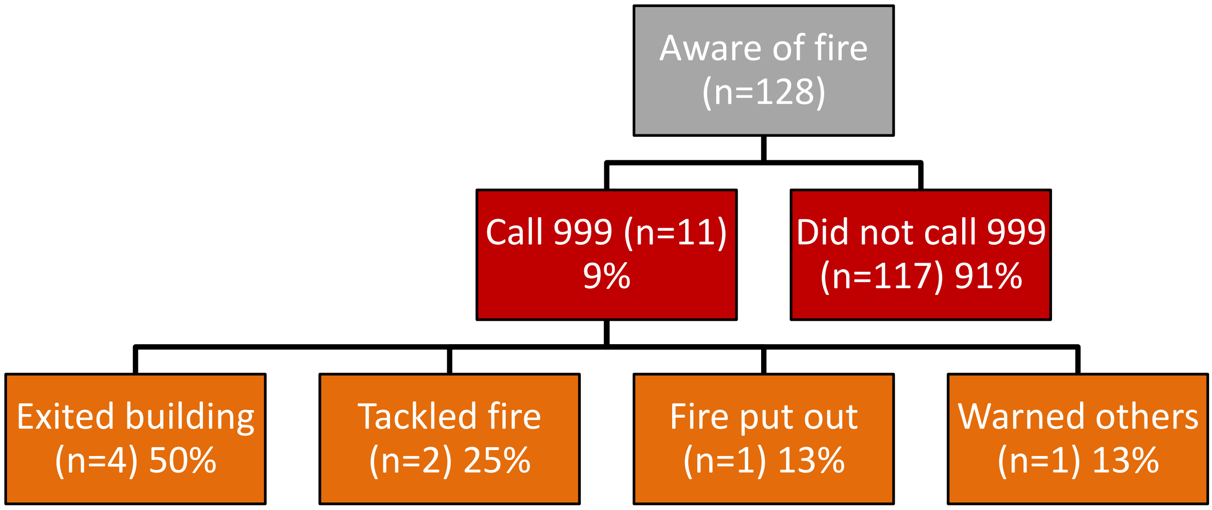
2.6 Males, first activity tackle fire



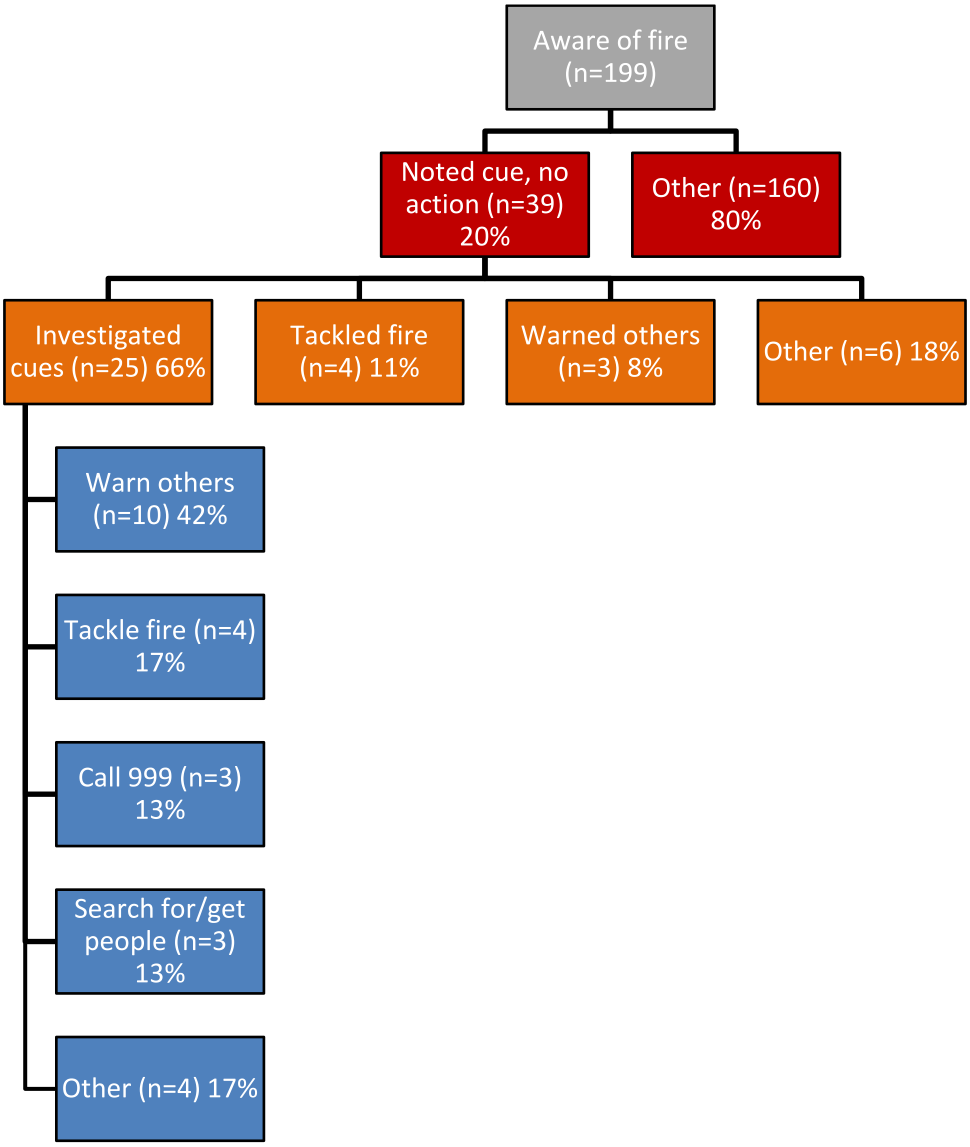
2.7 Females, first activity call 999



2.8 Males, first activity call 999



2.9 Females, first activity 'note cue, no action'



2.10 Males, first activity ‘note cue, no action’