www.bregroup.com

Briefing Paper

The causes of fire fatalities and serious fire injuries in Scotland and potential solutions to reduce them- Phase 1: IRS review

Raman Chagger

Acknowledgements

The author would like to thank David McGown, Deputy Chief Officer Prevention & Protection of Scottish Fire and Rescue Service for supporting this research work and providing the essential data. The contributions and efforts of Area Manager Stuart Stevens are also appreciated, as is the assistance of other members of the SFRS.

The author would also like to thank the individuals, and the organisations they represent, that supported this research work by providing funding and in-kind contributions, namely:

- Martin Duggan – Fire Industry Association
- Colin Hird – Scottish Government
- Colin Todd – Fire Industry Association

Finally, the author would like to thank colleagues at BRE who contributed to this work and the BRE Trust for the funding it provided to support the work on this project.

Cover photo courtesy of Scottish Fire and Rescue Service

Contents

Summary 2

Abbreviations and glossary 2

Introduction 3

Methodology 6

Findings 8
- Month and time of call 8
- Property type 9
- Area of fire damage 10
- Cause of fire 10
- Ignition source 11
- Room of fire origin 11
- Occupancy type 12
- Ages of victims 12
- Severity of injury 13

Analysis 14

Recommendations for reducing fire fatalities and serious injuries 15
- Additional warnings from smoke alarms 15
- Extension of detection and suppression water mist systems 16
- Video analytic technology for performing multiple functions 16
- Addressing fires from electrical items 17
- Recommendations for improving IRS database 17
- Proactive recommendations 18

Conclusions 19

References 20

Summary

The first phase of a comprehensive investigation into the underlying conditions surrounding fire deaths and serious fire injuries in domestic dwellings in Scotland, for the period from April 2013 to March 2017, has been completed.

Data for this phase of research work was gathered using the Incident Recording System (IRS) and provided by the Scottish Fire and Rescue Service (SFRS). It comprised 19,645 accidental domestic fire incidents in which there were 147 serious injuries and 126 fire fatalities. Focussing specifically on the responses to 38 questions from the IRS, the data was reviewed to identify the key factors and common conditions under which fatalities and serious injuries were occurring.

This enabled a profile of a person involved in a typical fire fatality or serious injury to be formed, and the associated demographic profile and common background conditions to be identified. Factors such as living alone, being vulnerable or elderly, falling asleep or being asleep, having medical conditions, illnesses or temporary lack of physical mobility, or not hearing the alarm all contribute.

Considering the fire safety issues highlighted for the adequate protection of vulnerable people, as current technologies and approaches may provide insufficient protection, fourteen recommendations have been made. They are targeted at further developing existing technologies with the intention of safeguarding vulnerable people, and generally reducing fire-related fatalities and serious injuries in the future. They include:

- providing additional warnings from smoke alarms;
- increasing the use of combined detection and suppression water mist systems;
- developing video analytic techniques;
- reviewing fires from electrical items and proposing ways to reduce their occurrence;
- making the greater use of the most appropriate means of fire detection (e.g. using smoke alarms in utility spaces containing white goods) in domestic dwellings.

The next phases of this research work will focus further on specific details from fire investigation reports for each of the 126 domestic fire fatalities. In order to assess the proposed recommendations, the potential effectiveness of each of them will be considered during the review of the fire investigation reports.

Abbreviations and Glossary

The abbreviations list and glossary are compiled from terms used in this publication. The descriptions in the glossary are not intended to be comprehensive, but to help the reader understand the meaning of terms as they are used in this briefing paper.

Abbreviations

ADF	Accidental Dwelling Fires
ARC	Alarm Receiving Centre
EACMD	Electrical Appliance Current Monitoring Device
FRS	Fire and Rescue Service
HMO	House in Multiple Occupation
IRS	Incident Recording System
MO	Multiple Occupation
P	Provisional
PV	Photovoltaic
RCD	Residual Current Devices
SFRS	Scottish Fire and Rescue Service

Glossary

Alarm Receiving Centre – continuously manned premises, remote from those in which the fire detection and fire alarm system is fitted, where the information concerning the state of the fire alarm system is displayed and/or recorded, so that the fire and rescue service can be summoned.

Fire Fatalities – those fire incidents attended by Fire and Rescue Services that resulted in a fatality due to the fire or products of the fire. This includes all responses to Question 9.20 of the IRS – "Circumstances of fatal casualty" and includes people that were either dead when the firefighter arrived, unable to resuscitate and later died, as well as those that were alive on leaving the scene but died later (in the majority of cases within 1 week).

Incident Recording System – a tool used by fire and rescue service personnel to record the details of all incidents attended.

Serious Fire Injuries – those fire incidents attended by Fire and Rescue Services that resulted in a serious fire injury due to the fire or products of the fire. It is classified as a serious fire injury when the response to Question 9.24 of the IRS – "What is your understanding of the severity of the injury?" is Code 1: Victim went to hospital, injuries appear to be serious.

Introduction

Plateau in the decline of fire deaths

Domestic fire deaths in the UK have been steadily decreasing over the last three decades, with factors such as the increasing use of smoke alarms, the Furniture and Furnishings (Fire Safety) Regulations 1988 (as amended) and preventive measures such as Home Fire Risk Checks (HFRC) all contributing to this decline [1].

Despite concerns that, more recently, the number of fire deaths appeared to show a small increase [2, 3], data from England and Scotland suggests that the fire deaths have plateaued. The official figures obtained from the Fire and Rescue Incident Statistics for England [4] and for Scotland [5] are shown in the Figures 1 and 2 respectively, in which the plateau can be observed from around 2012/13.

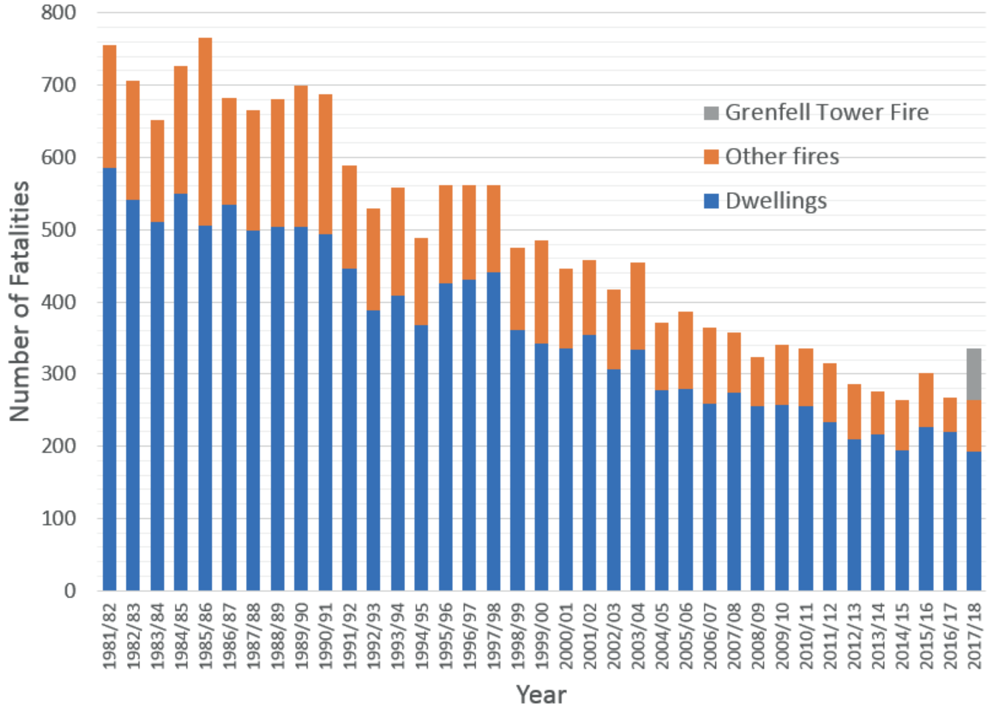

Figure 1: Total fire-related fatalities in dwelling or other fires, England; 1981/82 to 2017/18

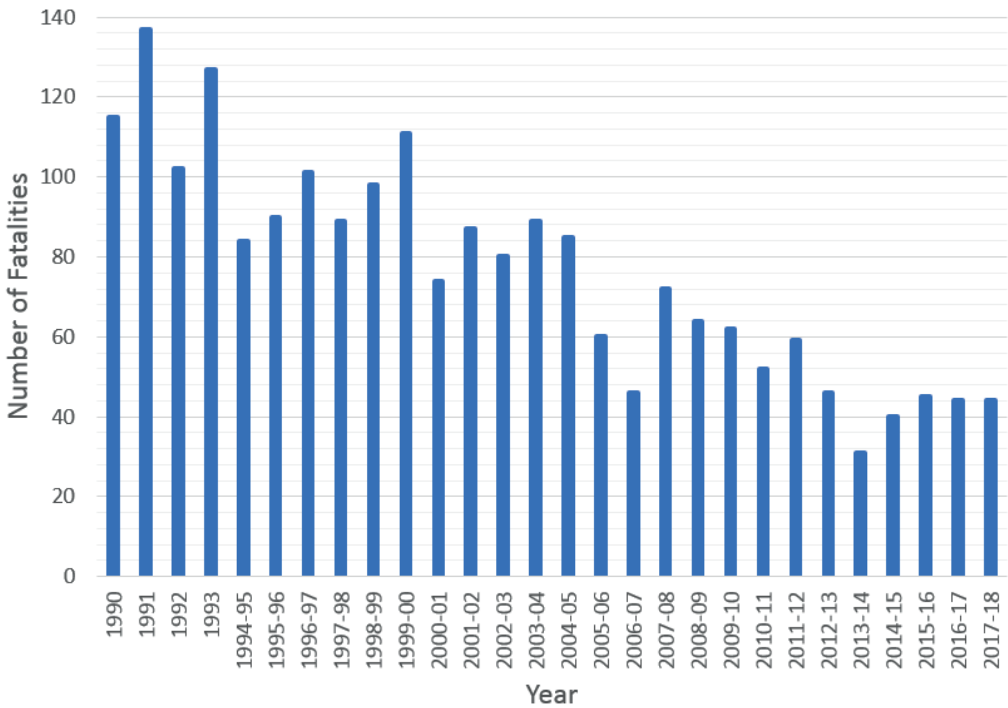

Figure 2: Long-term trend of fire fatalities in Scotland, 1990 to 2017/18

Fire fatalities in Scotland

A comparison of the fire fatalities per million population for England, Scotland and Wales is shown in Figure 3 (from Fire and Rescue Incident Statistics (Scotland) 2016-17 [5]). Note: p = provisional.

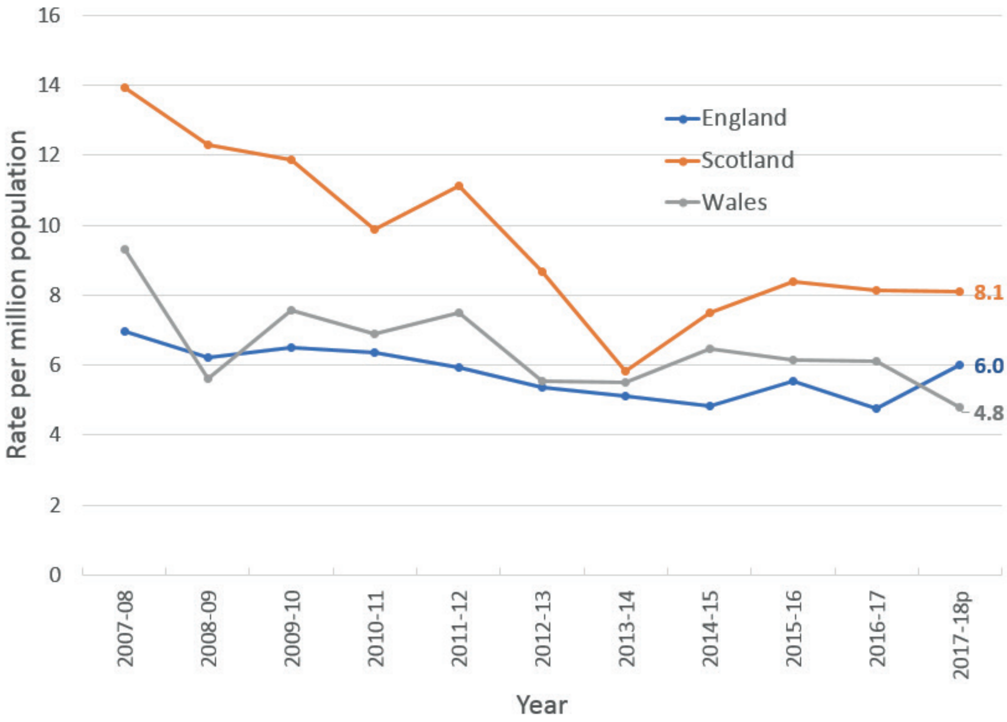

Figure 3: Fire fatalities per million population, Great Britain, 2007-08 to 2017-18

The fatalities data per million of the population for Scotland in recent years has been higher than England and Wales. An explanation for this is provided below by Stuart Stevens, Area Manager, SFRS.

"Analysis from fatal fire investigation highlights that fire deaths often occur as a result of human behaviour. A number of factors are known to contribute towards fire death incidents including: the area in which you live, lifestyle choices and health issues, all of which can lead to increasing the risk of fire occurring in the home and, consequently, the chances of dying in a fire. In order to address the reasons why Scotland witnesses more fire deaths per head of population and suffers from more fires than the rest of the UK, health and societal issues should be considered in order to highlight any significant differences.

Fire incidents cannot be looked at in isolation, and, when other contributory factors are considered, it is evident that health, demographics and deprivation are key elements to Scotland's high rate of fires. This was all considered as part of the Scotland Together report [6], in which a review of published statistics, reports and strategies was utilised to help understand any differences between Scotland and other parts of the UK.

The information from the Scotland Together report is around 10 years old, so it is recommended that fresh analysis is undertaken to establish if any differences remain between the health and societal issues raised in the report. At the time of writing that report, Scotland was experiencing higher levels of alcohol consumption than the rest of the UK and most European countries. A recent NHS Health Scotland report [7] noted that in 2017, 14% more alcohol was sold per adult in Scotland than in England and Wales. It also noted that "Alcohol-specific death rates are consistently higher in Scotland than in England & Wales. In 2016, rates were more than twice as high in men and 75% higher in women."

The Scottish population smoked more than the rest of the UK, and more people were suffering severely from smoking related illnesses. A range of other illnesses and health conditions were all also identified as having a higher prevalence in Scotland, including mental health.

Although difficult to do a direct comparison (due to different recording systems), it was also suggested in the report that Scotland has more severe deprivation, which can also be directly linked to fire fatalities.

In order to understand who is dying in fires, and why, it is therefore suggested that a wider review of health and societal factors is included in any research. This will also support SFRS to develop key working relationships with partners by outlining the wider context and articulating that the prevention of fire fatalities and serious injuries is not just the responsibility of SFRS."

Incident Reporting System

The Incident Reporting System (IRS) is an online tool [8] for fire and rescue authorities, used by fire personnel to record all details of callout events in the United Kingdom. It allows for the following details to be recorded: Initial call, FRS attendance, location, other supporting additional information, resources used, action taken, amount of damage and details of persons involved in the incident.

The terminology used for gathering injury data via the IRS changed in 2010, and therefore data using a consistent definition is only available since 2010. The annual serious injuries noted in England from September 2010 to September 2018 are shown in Figure 4. Whilst the number of severe admissions to hospitals are generally in decline over this 9-year period (as indicated by the dotted straight line of best fit), they occur more than twice as often as fire fatalities. The equivalent data for Scotland was not available.

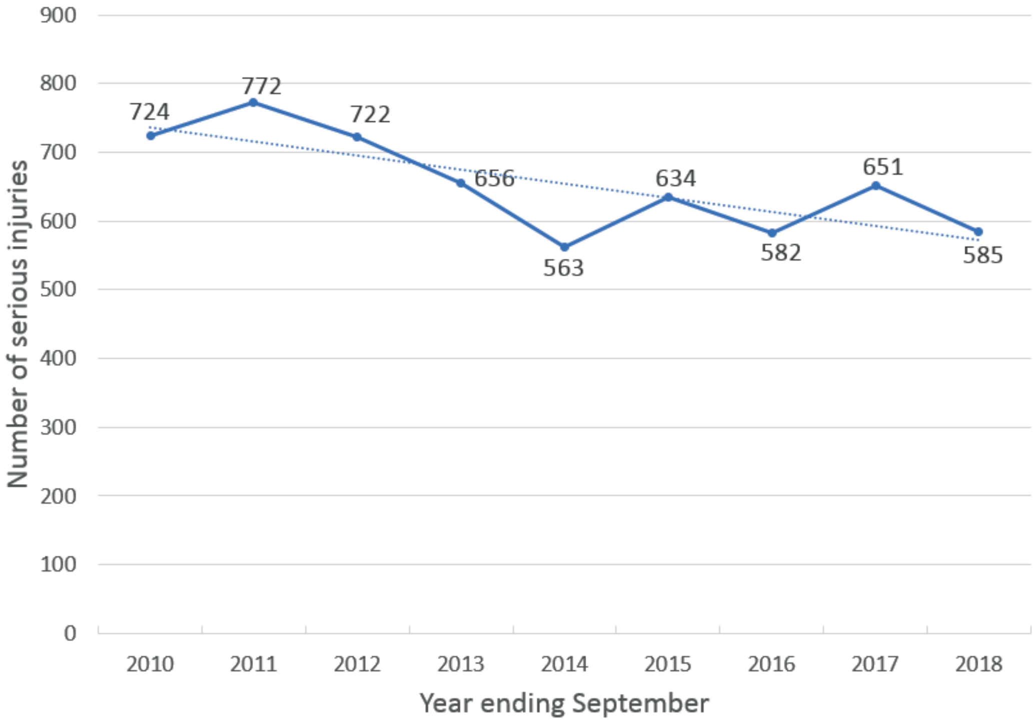

Figure 4: Severe injuries in England from fires in the period 2010 to 2017

Review of the IRS data

A review of data provided through the IRS has been conducted to identify patterns or trends of fatalities and serious injuries (which represent fatality "near misses"), when compared with total fire incidents in domestic environments. An analysis of this data has given insights into the causes, factors and circumstances in which fatalities and serious injuries occur, thereby highlighting issues requiring further attention. With this knowledge, innovative solutions can be developed, or new modern digital technologies proposed, to further protect people from the dangers of fire.

Scotland was used for this research work as its FRS ranks amongst the largest in the world, and serves a complete spectrum of demographic, social and geographic conditions. A stakeholder group comprising Scottish Fire and Rescue Service (SFRS), BRE Global, Fire Industry Association and Scottish Government (Scottish Building Standards) agreed the scope of this research work as well as the methodology for gathering and analysing the data.

The need for research

What is clear from Figures 1-4 is that, whilst fire fatalities in England and Scotland have come down considerably over the years, both fatalities and serious injuries could potentially be reduced further. The 1988 furnishing regulations, increased use of smoke alarms and Fire and Rescue Service (FRS) initiatives have been largely responsible for the reductions in fire deaths and injuries to date. But there may be issues contributing to the occurrence of fires that these initiatives do not fully address, which could be resolved with other simple interventions.

Domestic fire death statistics have not been subject to detailed scientific analysis for many years, and information on relevant social, medical and architectural issues is largely anecdotal. It is possible that with more focused attention on high risk situations (often arising from the vulnerability of people, lifestyle factors and living conditions) there is still a significant amount that can be done to reduce fire death and injury.

The research programme

This first phase, of a proposed three-phase research project, has reviewed SFRS accidental dwelling fire (ADF) fatalities data from the IRS database, together with the data for the most serious fire-related injuries, in the period from April 2013 to March 2017.

It is anticipated that the second phase will review Fatal Fire Investigation reports, and the third phase will look in detail at the case studies from fires over the same time period.

This briefing paper summarises findings from the first phase of this research study.

Methodology

It was envisaged that the first-phase examination of the IRS database would provide an overview of the circumstances under which fire deaths and serious injuries are occurring, along with any more general patterns.

During this first phase, it was anticipated that the socio-economic, lifestyle and living circumstances of the typical person involved in a fire fatality or serious injury would be revealed, as well as the circumstances surrounding the fire.

Factors that may skew the data, such as suicides, wilful fire raising/ arson, vehicle fires and fires in a non-domestic premise, were filtered out. The following 38 questions from the IRS database were examined for the period April 2013 to March 2017.

IRS	Question
Q 2.1	What was the time and date of call?
Q 3.2	What type of Property was involved?
Q 5.2	How long was it between Ignition and Discovery?
Q 5.3	How long was it between Discovery and First Call?
Q 5.4	How was the fire discovered?
Q 5.6	Means of Escape
Q 5.8	Was there any alarm system present?
Q 5.9	Alarm Systems Type
Q 5.10	Alarm System Location
Q 5.11	Alarm System Operated?
Q 5.12	Reason system did not function as intended
Q 5.16	Estimated Fire Damage (sq. m.)
Q 7.12	Type of active safety systems present
Q 7.13	Location of active safety systems in relation to Fire
Q 7.14	Did the safety system operate?
Q 7.15	How many operated?
Q 7.16	Impact upon Fire
Q 7.17	Reason safety system did not function as intended
Q 8.1	What was the cause of the fire?
Q 8.4	What was the source of ignition?
Q 8.14	What type of room/compartment was the fire origin?
Q 8.15	What was the Household Occupancy Type at the time of the incident?
Q 8.16	Human factors contributing to fire
Q 8.17	Was “impairment due to suspected drugs/alcohol” a contributory factor?
Q 8.19	Was there heat and/or smoke damage only (no flame)?
Q 8.20	What was the extent of flame and/or heat damage on arrival?
Q 8.30	Which floor/deck did the fire originate upon?
Q 9.4	Reason for any delay to evacuation
Q 9.7	Age (e.g. 1)
Q 9.8	Gender
Q 9.10	Where was the victim when the fire started?
Q 9.11	Where was the victim found?
Q 9.12	What role did this victim play in the incident?
Q 9.13	Was the victim rescued?
Q 9.20	Circumstances of fatal casualty
Q 9.22	What is your understanding of the cause of death / nature of injury?
Q 9.24	What is your understanding of the severity of the injury?
Q 9.25	What were the other circumstances of the victim?

Table 1: The 38 questions from the IRS that were examined in detail

In this briefing paper the 38 questions considered, such as that concerning the room of fire origin (Q8.14), are described as "categories". Each category has a number of sub-categories, for example the room of fire origin sub-categories include: kitchen, living room and bedroom, etc.

In order to compare the relative involvement of each sub-category in the three accidental domestic fire incident groups – i.e. all incidents, fire fatalities and serious fire injuries – the data are presented as percentages for each sub-category. For most of the sub-categories presented in this report, the total number of incidents is 19,645, the fire fatalities total is 126 and serious fire injuries 147. The number of incidents under each sub-category have been divided by that sub-category's total and expressed as a percentage to enable quick and clear comparisons to be made.

The data are presented by arranging the percentages for each sub-category within the relevant category in descending order, starting with the highest. Figure 5 presents a hypothetical example to illustrate the method of presentation. In this example, the fatalities and serious injuries in each sub-category follow the same profile as the total number of fires. This shows that the sub-categories have no significant effect on the rate of fatalities or serious injuries. In other words, the frequency of fatalities and serious injuries are simply proportional to the number of incidents; the frequencies are as would be expected from the number of incidents, all other things being equal.

For example, if the number of fatalities and serious injuries that occur as a result of a fire that starts in each room were always directly proportional to the number of fires that start in that room, it would be deduced that the room of fire origin has no influence on the likelihood of a fatality or serious injury; the more the profile of fatalities or serious injuries departs from the profile of the total number of fires, the greater the influence of the sub-category on the risk of death or serious injury.

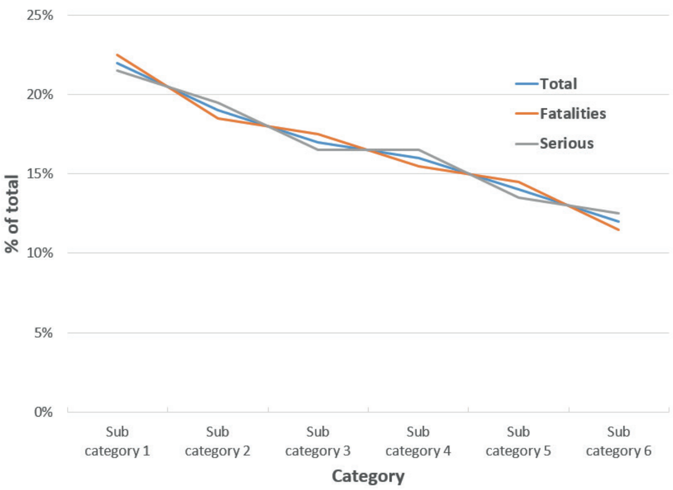

Figure 5: Example of no significant differences between total incidents, fatalities and serious injuries

The second hypothetical chart in Figure 6, on the other hand, shows that sub-categories 2 and 5 have had some effect on the fatalities and serious injuries, as these points diverge from the distribution for the total incidents. The greater the divergence, the greater is the impact of the sub-category on the incidence of fatalities and serious injuries.

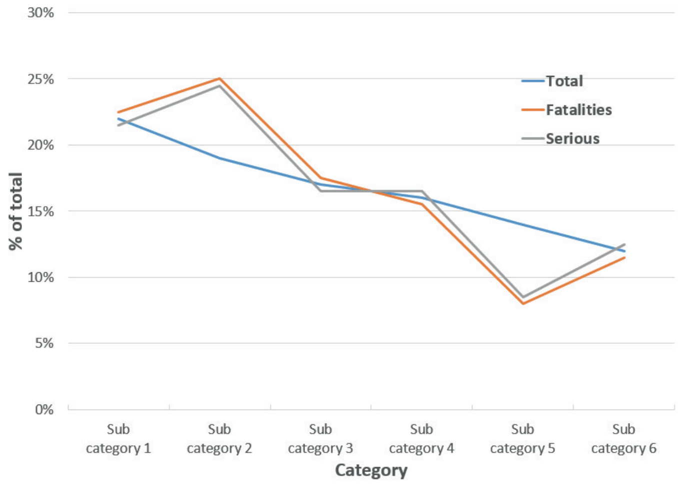

Figure 6: Example of significant differences between total incidents, fatalities and serious injuries

While each item of data is discrete, the data is presented in line graphs – more commonly used for continuous data – as this enables clear, quick and easy interpretation.

Such charts were produced and observations made for all of the 38 questions reviewed using the IRS data. In the next section ten key examples of these charts are presented along with the associated observations. The numbers appearing in brackets in these charts refer to the total sample size for each dataset.

Findings

Month and time of call

The responses to Q 2.1 – "What was the time, date and day of call?" – were examined to identify any trends related to the day of the week, month and time of call. The chart generated for the date of call arranged by the month is shown in Figure 7.

The key observations from this data are:

- The period November to March has a comparatively high percentage of fatalities.
- There are significantly more serious injuries observed in the months of November and March.

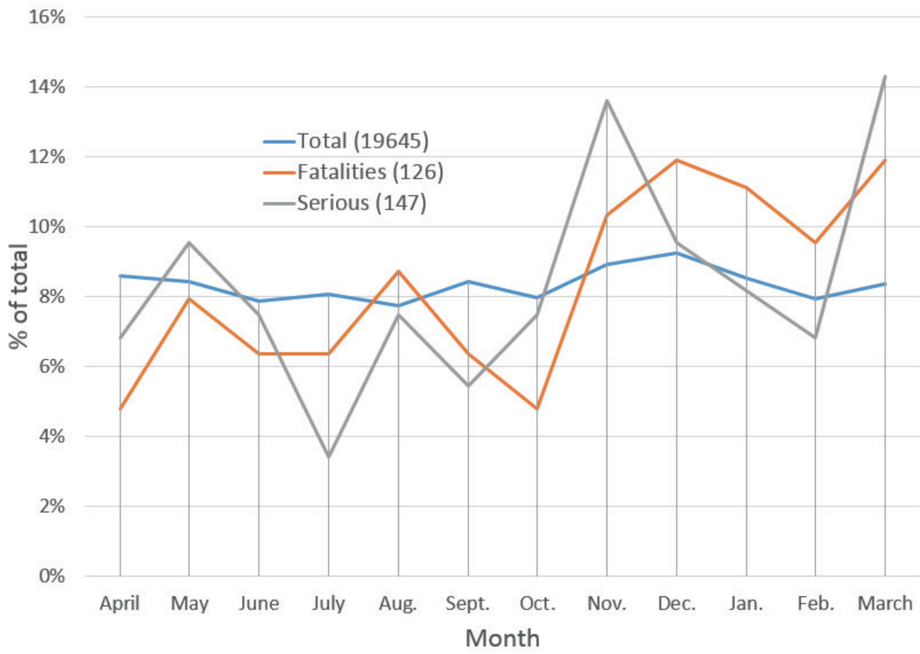

Figure 7: Incident data by month of year

The chart generated for the incident data by time of day is shown in Figure 8, with the actual number of incidents shown next to the data points for total incidents, fatalities and serious injuries at each hour.

The key observations from this data are:

- There appears to be a sinusoidal wave of total events peaking at 5pm and with a trough at 5am.
- The majority of accidental dwelling fire incidents occur between 10am and 10pm.
- The greater number of fatalities occur between 8am and 8pm (71 of a total of 126).
- Fatalities and serious injuries are relatively high between 12 midnight and 9am. Only 18% of fires occur during this period, with 35% of fatalities and 39% of serious injuries occurring then.

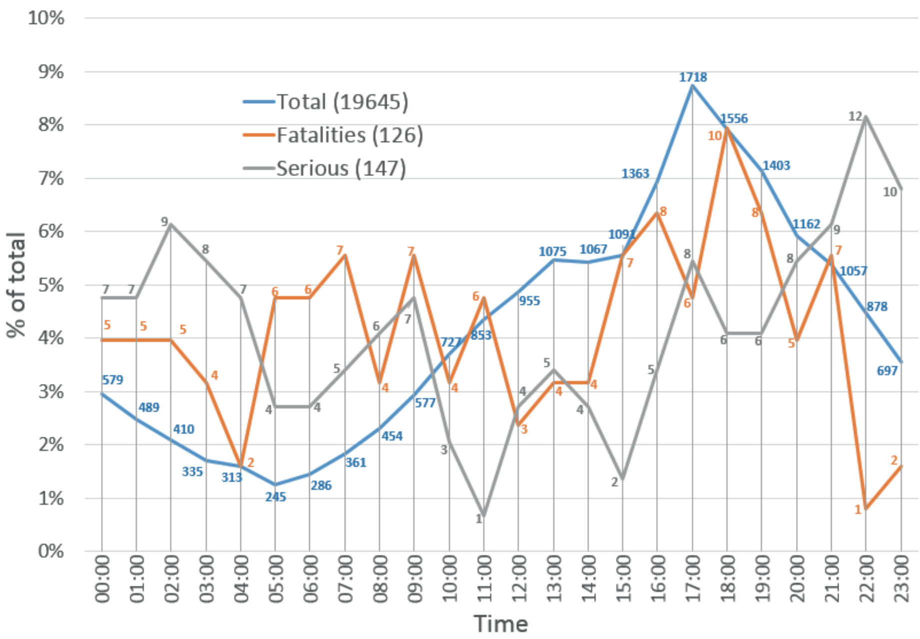

Figure 8: Incident data by time of day (hourly)

Property type

The responses to Q 3.2 – "What type of Property was involved?" – were examined to identify the trends depending on the dwelling type. The chart generated for the type of property involved is shown in Figure 9.

Note: MO = Multiple Occupation and HMO = House in Multiple Occupation.

The key observations from this data are:

- The percentage of fatalities peaks above that of total numbers where there is single occupancy (houses and bungalows). This is consistent with national guidance on fire safety in purpose-built blocks of flats in England [9] that, "a fire in a bungalow is more likely to result in a fatality than a fire in a high-rise block of flats (because of the age demographic of those living in bungalows)".
- There are disproportionately lower numbers of fatalities in tenement buildings and self-contained sheltered housing. The lower number of fatalities in tenement buildings is of interest as it is known that SFRS carry out a significant number of rescues from tenements using high reach appliances or ladders.
- The serious injuries are proportionately higher for purpose-built and tenement buildings and slightly above total for the bungalow single occupancy.
- Licensed HMOs were the only dwelling type in which no fatalities or serious injuries were observed. This may be because of the fire precautions required as a condition of licensing and because they are relevant premises within the meaning of the Fire (Scotland) Act.

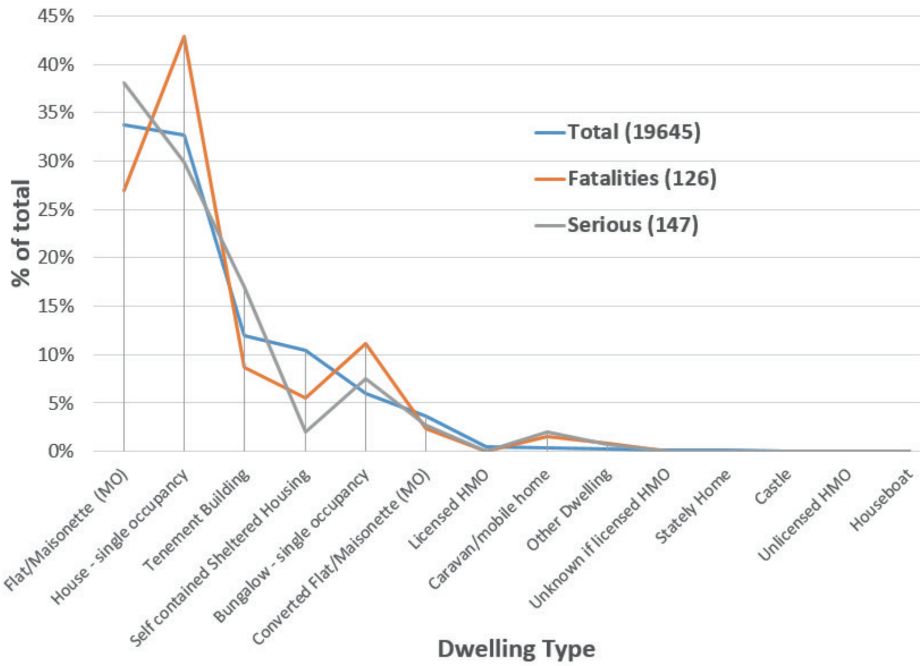

Figure 9: Incident data by dwelling type

Area of fire damage

The responses to Q 5.16 – "Estimated Fire Damage (m²)" were examined and the chart generated is shown in Figure 10.

The key observations from this data are:

- The fatality and serious injuries profiles both significantly exceed the total between 6 and 200m² of fire damage.
- It is more common for fires to be less than 5m² for which both serious injuries and fatalities are significantly lower than total.

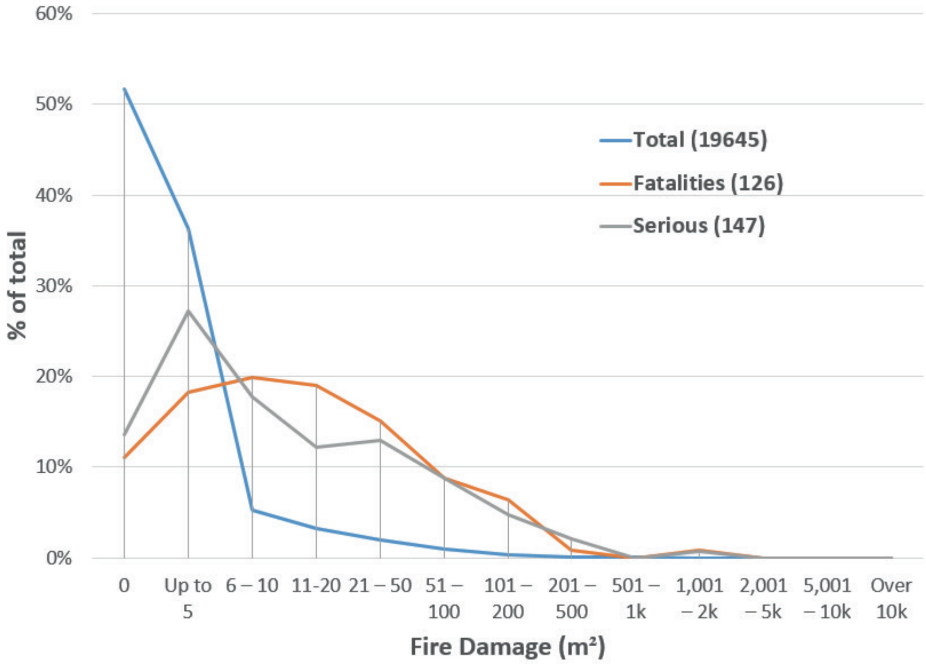

Figure 10: Incident data by area of fire damage (m²)

Cause of fire

The responses to Q 8.1 – "What was the cause of the fire?" – were examined and the chart generated is shown in Figure 11.

The key observations from this data are:

- Fatalities and serious injuries are proportionately higher for combustible articles too close to heat source, careless handling (both types) and other.
- Whilst cooking fires account for the majority of causes, the associated fatalities and serious injuries are significantly lower suggesting that not many people are dying or being seriously injured as a result of cooking.

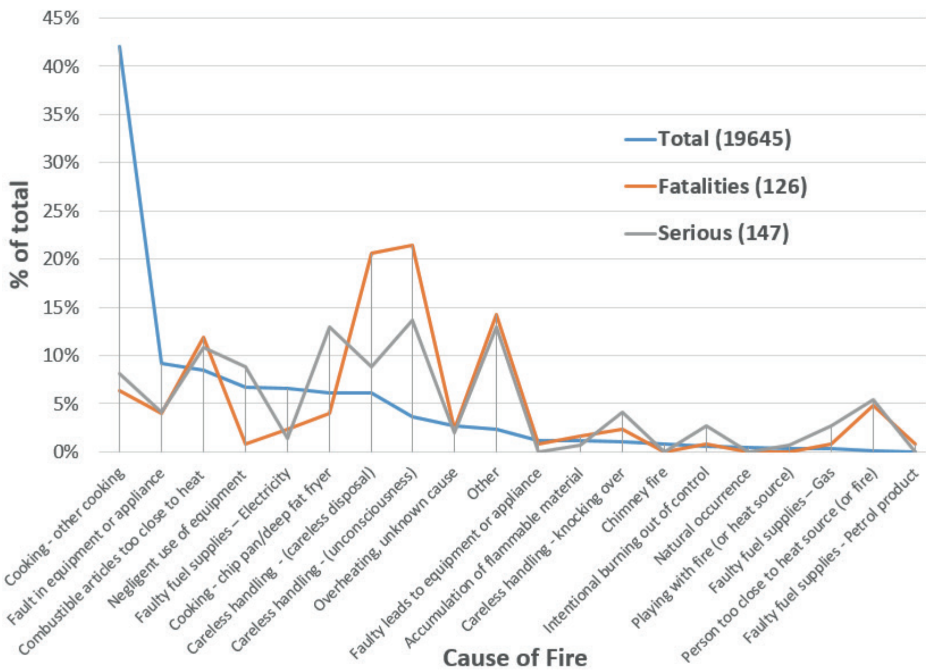

Figure 11: Incident data by cause of fire

Ignition source

The responses to Q 8.4 – "What was the source of ignition?" – were examined and the chart generated is shown in Figure 12.

The key observations from this data are:

- The fatalities and serious injuries are proportionately higher for smoking related and heating equipment sources of ignition. As with Question 8.1 the relative fatalities and serious injuries are disproportionately lower from cooking appliances.
- Whilst not directly relevant it is worth noting that data on the adult smoking habits in the UK in 2017 [10] showed that 15.1% of people aged 18 and above in the UK smoked. The figure for Scotland was 16.3% which was not the highest of the constituent countries (Northern Ireland was 16.5%).
- The introduction of cigarette safety standards in November 2011 required all cigarettes sold in Europe to meet a reduced ignition propensity requirement. Whether these appear to have made any difference to the number of fires starting from cigarettes will be reviewed during Phase 2.

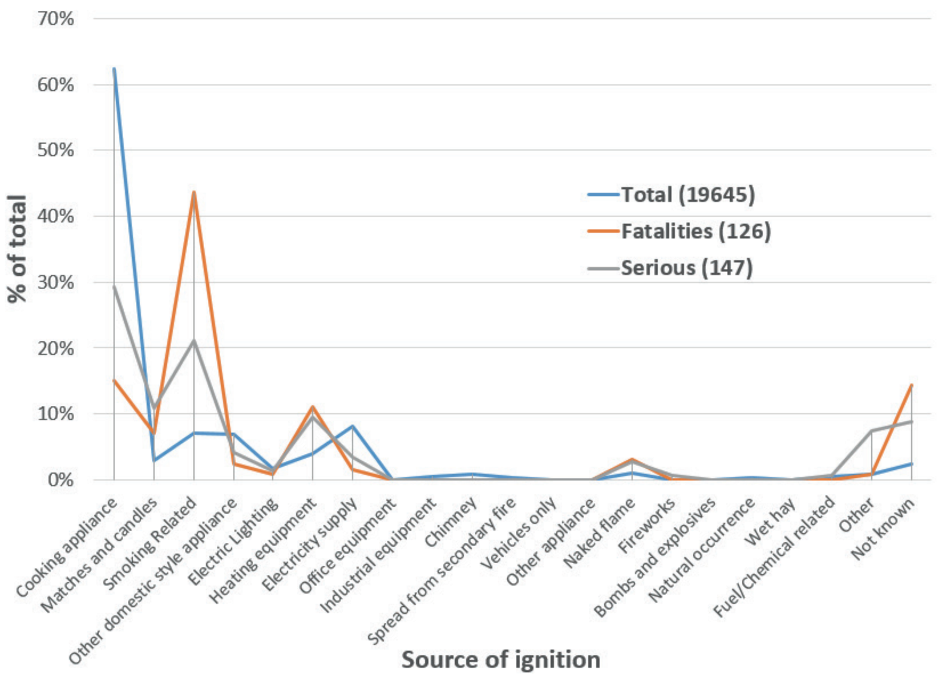

Figure 12: Incident data by source of ignition

Room of fire origin

The responses to Q 8.14 – "What type of room/compartment was the fire origin?" – were examined and the chart generated is shown in Figure 13.

The key observations from this data are:

- Both fatalities and serious injuries are proportionately higher when the location of the fire origin is the living room or the bedroom.
- Compared to the total number, the fatalities and serious injuries in the kitchen are significantly less.
- The greatest number of serious injuries occur in the kitchen.

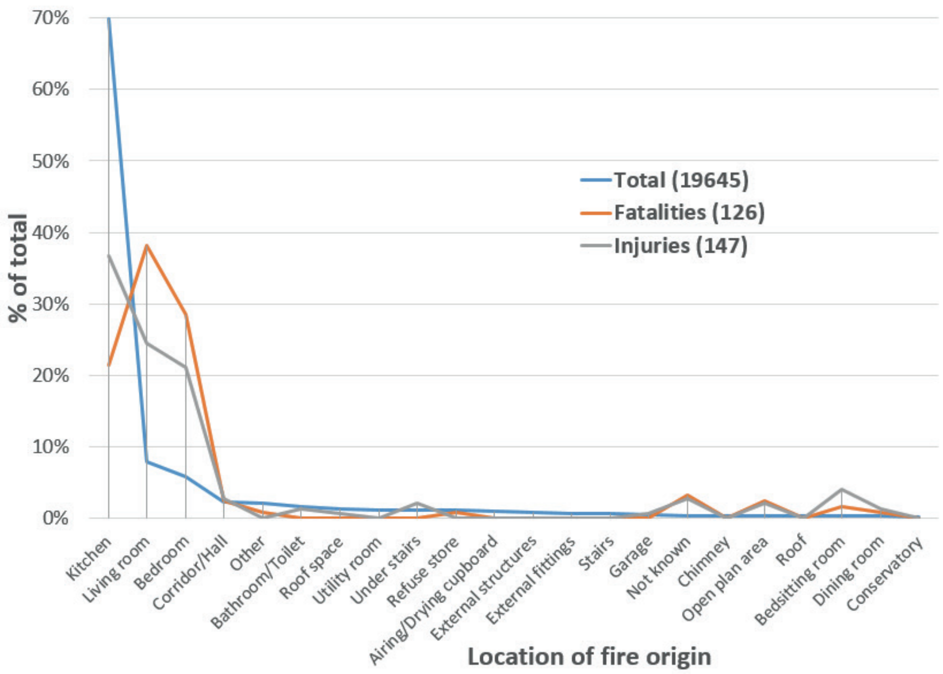

Figure 13: Incident data by location of fire origin

Occupancy type

The responses to Q 8.15 – "What was the Household Occupancy Type at the time of the incident?" – were examined and the chart is shown in Figure 14.

The key observations from this data are:

- Fire fatalities are proportionately higher for lone persons over and under pensionable age.
- Serious injuries peak for lone persons under pensionable age.
- Serious injuries and fatalities are lower when people do not live alone.

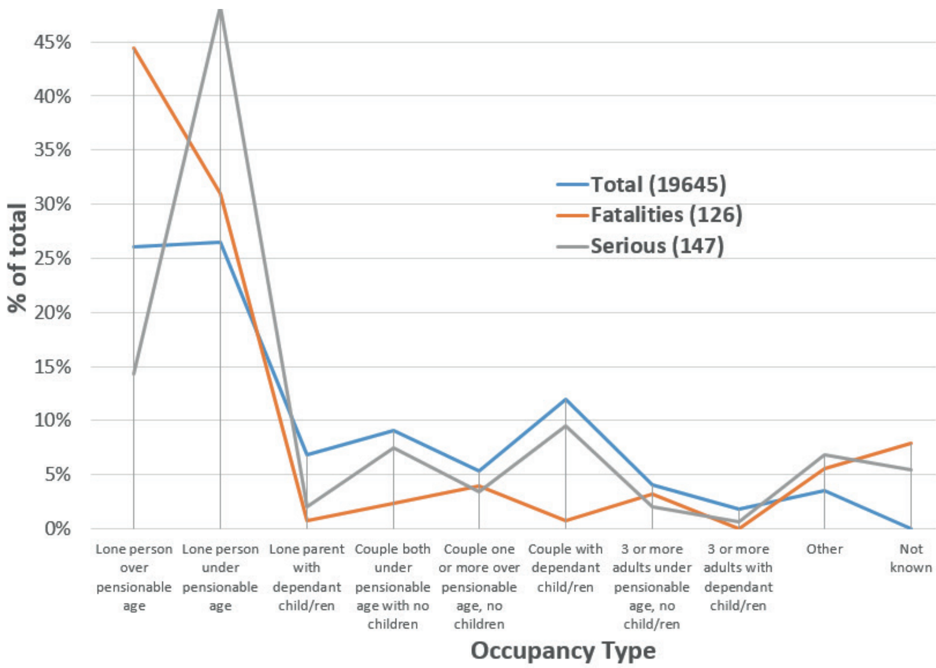

Figure 14: Incident data by occupancy type

Ages of victims

The responses to Q 9.7 – "Age" – were examined and the chart generated is shown in Figure 15, with the age groups split into ranges used by the SFRS in other databases.

The key observations from this data are:

- Fatalities are less likely for persons aged up to 60. Once this is exceeded, fatalities increase significantly (60.3%). The particularly high rate of deaths for those aged over 80 years, compared to the total number of incidents, should be noted.
- Serious injuries are less likely for the majority of ages except in the 31 to 60 age range.

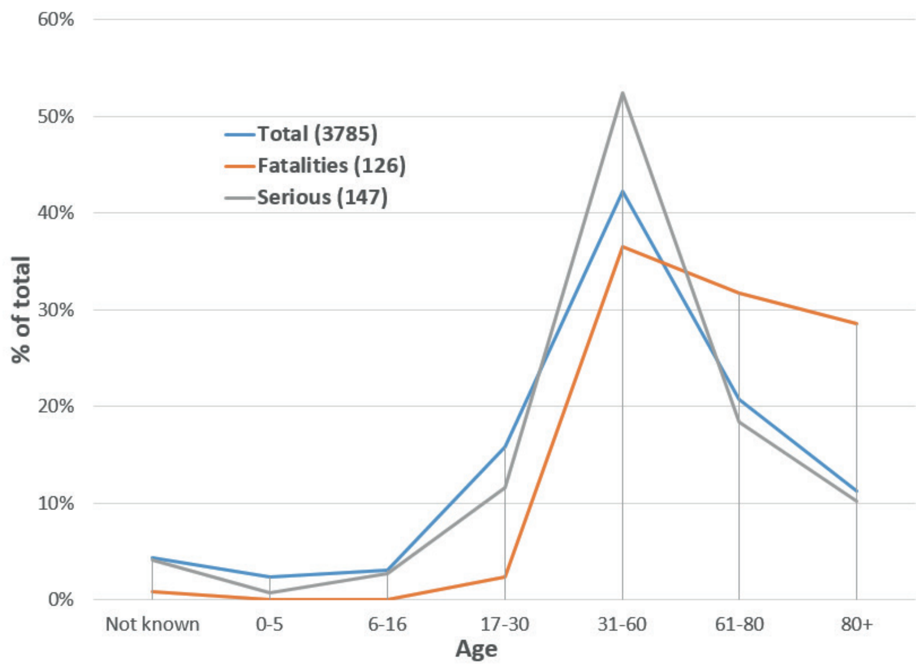

Figure 15: Incident data by age of victim

Severity of injury

The responses from Q 9.24 – "What is your understanding of the severity of the injury?" – were examined and the chart relating to the severity of the injury is shown in Figure 16.

The key observations from this data are:

- Further gradations of the severity of injury would be useful in the IRS database, for injuries that are between serious and slight – perhaps with some explanation of what is meant by these.
- Fatalities and serious injuries account for 7.2% of all incidents in which people are harmed.

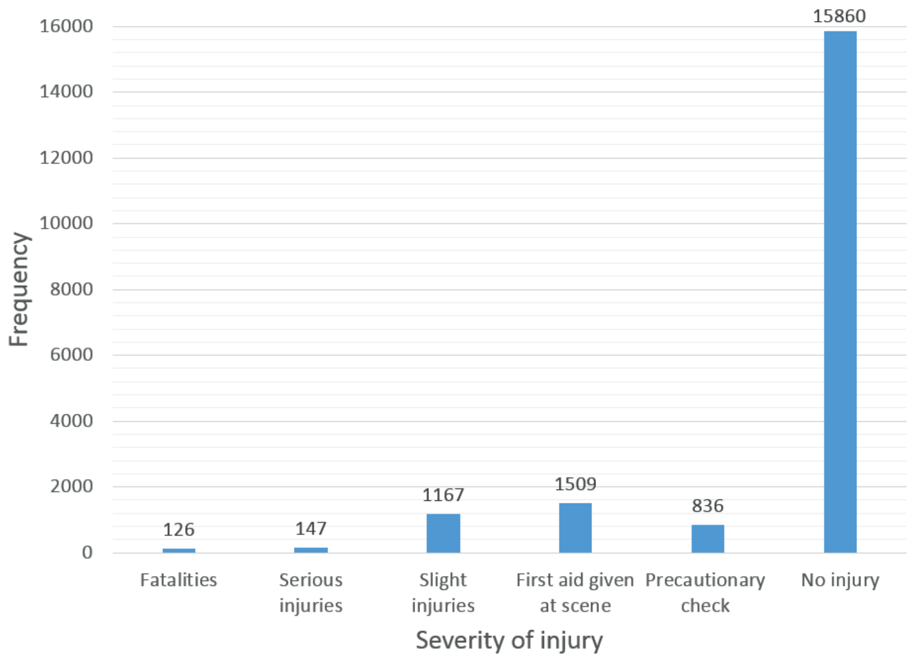

Figure 16: Incident data by the severity of the injury

Analysis

From the observations made with all 38 questions used to review the IRS data (not just the 10 presented in the charts in this briefing paper), the following factors emerge of a typical person involved in a fire fatality or serious injury in Scotland, and the surrounding circumstances.

Fatalities are significantly more likely when those aged 60 or above are involved, whereas serious injuries are most prevalent in the 31 to 60 age range. Men are involved in about 54% of all fires, with the percentage of fatalities higher than this, and serious injuries marginally higher.

Fire fatality and serious injury victims are more likely to be falling asleep or asleep, or to have an underlying medical condition or illnesses. Excessive and dangerous storage, as well as temporary lack of physical mobility, are factors contributing to an increase in both fatalities and serious injuries. The likelihood of a fatality increases if the victim is disabled.

The likelihood of fatalities and serious injuries increases when there is suspicion of impairment due to drugs or alcohol, and both are more likely when the victim has been trapped because they were unaware of the fire at the time. The likelihood of a fatality is raised when the victim is chair-ridden or bedridden, and chances of serious injury are proportionately higher or when injuries were sustained at the start of the fire. A poor outcome is more likely when occupants do not respond, or when no person is in earshot of the fire warning.

Figure 17: The majority of serious injuries and fatalities occurred when people were asleep or falling asleep

It was observed that fatalities are more likely in dwellings of single occupancy, and serious injuries are less likely in tenement buildings and self-contained housing. Fatalities are more likely in households in which there is a lone person, and serious injuries are more likely for lone persons under pensionable age.

Most of the fire fatalities occur between the hours of 12 midnight and 9am, midweek from Tuesday to Thursday, and in the months November to March. Serious injuries in contrast happen most frequently over the weekend from Friday to Sunday and in March and November but are also most frequent between 12 midnight and 9am.

The vast majority of fires occur in properties on the ground, first, second and third storeys of premises. Fatalities are more likely when the fire origin is on the ground floor, and serious injuries are more likely when the fire origin is on the first floor. When a fire occurs, there is no greater risk of a fatality or serious injury if it is in a high-rise flat, than in any other dwelling. Fatalities (67%) and serious injuries (46%) are both more likely when the location of the fire origin is the living room or the bedroom.

The likelihood of fatalities and serious injuries are significantly increased when combustible articles are too close to the heat source or careless handling has been involved. Notably, both fatalities and serious injuries are lower in cooking fires which account for the majority of fire causes. The sources of ignition more likely to lead to fatalities or serious injuries are those resulting from smoking-related and heating equipment fires. The sources of ignition leading to fatalities and serious injuries are generally smoking materials, heaters, candles and lighted paper or card.

The likelihood of a fatality increases significantly as the time between ignition and discovery exceeds 30 minutes, and for serious injuries peaks between 5 and 30 minutes. Fire fatalities and serious injuries are increasingly more likely when the fire is discovered by a person rather than an automatic fire detector.

There are increased incidents of serious injuries and fatalities when the locations of people at the start of fires is unknown. The likelihood of a fatality is significantly higher – and of serious injury higher – when the victim's location is in the room or compartment of origin.

A fire fatality is significantly more likely when the victim is found in the room or compartment of origin and is significantly lower when the victim is found outside the building. Serious injuries are marginally more likely when the victim is found in a different room or compartment on the same floor as the fire of origin, or on the floor above the fire origin.

Fire fatalities and serious injuries are both significantly less likely when there is no smoke or heat damage only i.e. when no flames were present. Fire fatalities and serious injuries are more likely when the fire damage area is between 6 and 200m^2 and less likely when the fire damage is less than 5m^2.

Fire fatalities and serious injuries are both more likely when the burns are severe, and both are elevated when there is a combination of burns and being overcome by toxic gases from the fire or smoke. Unfortunately, a significant proportion (76.2%) of fire fatalities were already dead when firefighters arrived, or they could not be resuscitated and were later confirmed dead. The majority of the fatalities and serious injuries are attributed to the victim being overcome by "gas, smoke or toxic fumes" a term used in the IRS which refers to the smoke and gaseous products of combustion.

No fire fatalities or serious injuries were observed for the 31 incidents involving sprinklers, though sprinklers were only present for a small number of those incidents attended by SFRS (0.16%).

Recommendations for reducing fire fatalities and serious injuries

The review of the IRS data for serious injuries and fatalities reveals that the victims are generally people who are older or in some way vulnerable. Underlying factors such as falling or being asleep, having medical conditions or illnesses, or a temporary lack of physical mobility (chair-ridden or bedridden) all contribute. The victim is likely to be alone at the time of the fire. Most of the fires start in the bedroom or living room. The time from fire to discovery is also critical as those discovered sooner (before 30 minutes) lead to serious fire injuries, whereas those discovered after 30 minutes are more likely to result in a fatality.

We have an aging population with increased vulnerabilities to conditions such as dementia. People will therefore need to be protected in increasingly more sophisticated ways than have been used to date for able bodied people capable of responding to alarms – and acting appropriately to save their own lives. The expectation that a fire alarm system will activate, the FRS be informed and arrive to tackle the fire in time to save lives, is unrealistic for elderly and vulnerable people.

More needs to be done in terms of reliable early detection and suitable intervention, to either delay the development of the fire or to notify people – using technology – so they can take suitable action at the early stages of the fire.

With these points in mind, the following technologies and solutions are proposed that, if implemented, could potentially help to protect people in the future. The recommendations are based on the findings in this report (or other sources as stated).

Additional warnings from smoke alarms

The likelihood of a life being saved increases with quicker fire detection and warning provision. As victims may have physical limitations, such as being asleep, bedridden or having medical conditions or illnesses that affect mobility, simply providing warning is not always sufficient. Using modern technology, it should be relatively easy to modify smoke alarms to provide warnings via local wi-fi to other people (e.g. carers or neighbours) with devices such as smartphones (Figure 18).

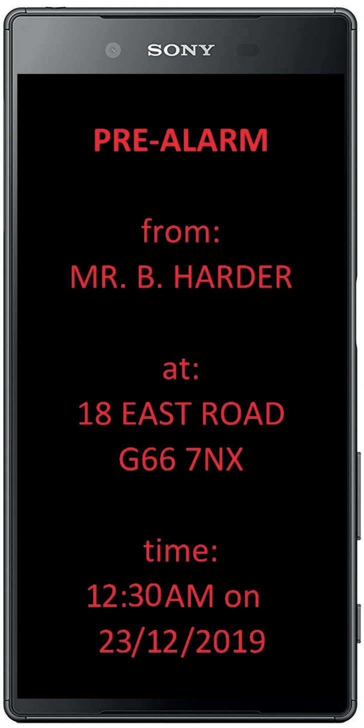

Figure 18: Example of a pre-alarm notification sent to a mobile phone

Recommendation 1

Smoke alarms can easily be configured to give a pre-alarm when smoke is detected prior to the fire alarm threshold being reached and would therefore provide earlier warning. The alarms could be set-up to provide a pre-alarm fire warning to a carer located nearby or a neighbour (hereafter referred to as a fire sentinel). If false alarms are sufficiently well controlled for the occupier and fire sentinel to trust a pre-alarm signal, it will not only provide reliable fire warning but also earlier warning. This would allow more time for the fire sentinel to reach the premises and perform a basic check. Progression into a fire alarm state would also provide the fire sentinel, and any other persons designated to receive a warning from the detector, an indication of how fast the fire was progressing.

If the pre-alarm and alarm states are immediately transmitted as text warnings to the fire sentinel (and others), there is an increased chance that –even if the fire occurred in the middle of the night – somebody could get there much sooner to intervene and potentially save a life. The logistics of the fire sentinel's access to the property would need to be reviewed and agreed beforehand. The fire sentinel could also call the premises in advance to ascertain whether a fire really was in progress, and potentially alert the occupier if they were not already aware. Incorporating both technology and people in this way offers a quite simple but effective solution that could save lives.

Recommendation 2

It is well known that most false alarms are due to human activity, and that there are not many false alarms while people are sleeping in their own homes. As proportionately higher incidents of fatalities and serious injuries occur from midnight to 9am (see Figure 8), it is proposed that consideration is given to smoke alarms that incorporate a night mode during which the sensitivity is increased, thus reducing the time for the smoke alarm to activate.

Recommendation 3

It is noteworthy that according to the Office for National Statistics [11], "… in the 2016 to 2017 winter period, there were an estimated 34,300 excess winter deaths in England and Wales." The deaths and serious injuries resulting from fires pale in comparison.

Modern alarm devices are increasingly able to perform a range of functions using remote signalling. It is proposed, therefore, that multi-sensor alarms incorporating heat sensors as well as smoke alarms be used in domestic premises. As well as potentially reducing false alarms, the thermistor used to provide temperature information can also identify when the temperature falls below a threshold for a period of time. This can then be used to alert someone else (perhaps a carer or neighbour, using the method described under Recommendation 1) or to provide an alternative warning to the occupant.

Recommendation 4

FRSs are most commonly alerted to fires in commercial premises via Alarm Receiving Centres (ARCs). Whenever an alarm occurs at a premise, a signal from the control panel is sent directly to the ARC, which then calls the FRS and informs them of the fire's location. It is proposed that this service be extended so that smoke alarms present in high-risk domestic premises can be configured to provide an automatic warning to the ARC.

Extension of detection and suppression water mist systems

As a significant number of incidents occur in the living room or bedroom, it is worthwhile considering the extension of a combined detection and suppression solution such as one complying to LPS 1655 [12]. Currently, an LPS 1655 compliant system (see example in Figure 20) will provide early fire detection in a compartment in domestic premises, and then provide local application of a watermist system in that zone. The system works by having a smoke detector connected to a control unit that triggers local water mist suppression, using water from a designated water tank.

Such watermist systems are designed to specifically cover one local zone and protect vulnerable people present. Their effectiveness has been proven in domestic environments [13], and they offer significant advantages over sprinklers. A frangible bulb sprinkler system will only operate once a fire has developed and is producing sufficient heat to trigger a sprinkler head. An LPS 1655 system is activated sooner by detecting smoke from a fire and therefore providing effective suppression earlier in the fire's development.

It would be expected that this earlier detection and intervention would prove to be quite effective in domestic environments, particularly as the rooms in which the greatest number of fatal and serious injuries occur are the living room and bedroom.

Figure 19: An installed LPS 1655 system (photo courtesy of Surefire Services)

Recommendation 5

Rather than having just one fire alarm and one local suppression solution, the extension of this to cover multiple zones is recommended. By utilising multiple fire alarms (including heat alarms in the kitchen), and implementing pipework with appropriate heads, the water mist can be provided to different areas using one control panel in such a way that zones could be addressed and configured so that the water mist suppression is delivered in the area in which the fire is present. As an extension to LPS 1655, the associated costs of zoned detection and suppression would be expected to be significantly less than purchasing a few units and having them in multiple locations. This solution would be expected to suppress the fire, if not extinguish it, increasing the likelihood of the vulnerable person being rescued.

Recommendation 6

Discussions with those that specify and have installed LPS 1655 systems have revealed that these systems suffer from false alarms and therefore unwanted water mist activations. It is highly likely that a group of detection and suppression specialists, as well as industry experts, could collectively write a code of practice to address commonly observed issues. This will inform users and installers, etc, on how best to specify and use these systems in the most effective way, thereby raising awareness and enhancing their reputation. The code could also provide guidance to promote robust management procedures in the active protection zone.

Video analytic technology for performing multiple functions

As a significant number of incidents involve elderly or vulnerable people, using technology that provides early warning and automatically informs relevant authorities is explored here.

Video analytics is emerging as a technology that, as well as providing very early warning of fire, can transmit images (or a video sequence) of the fire to confirm its presence – and provide updates on its development (Figure 20). Video analytics use the images produced from a CCTV or other video camera, and process the data using complex algorithms to identify a spatial event. By effectively working as sensors and processing information they can be configured to monitor for a number of life safely scenarios, providing appropriate detection and warning when an event occurs.

Video fire detectors are currently being used to detect fires in some commercial premises. They can be highly effective as they can recognise smoke production and movement at a very early stage – long before it reaches the ceiling and is sufficiently concentrated to trigger a smoke detector. They are increasingly used in open areas such as hangars, warehouses, large atria etc, but may easily be adapted for use in domestic premises. They would respond earlier during a fire and would have the capability to automatically notify FRSs directly to ensure that valuable seconds are saved in the detection and reporting of a fire.

Figure 20: Fire threat detected by a video fire detection system

Recommendation 7

Video analytic technology could be modified and used to provide warning when the smoke or flame from a fire is present in a domestic environment. The system can be configured so that the CCTV is essentially just a sensor that provides images for processing that are then run through a series of algorithms to identify patterns representative of smoke movement. Video data does not need to be transmitted over the internet nor does it need to be stored. However, with the permission of the occupier, a video sequence can be sent to the FRS when a fire is present. This would provide warning and a visual verification of a fire in progress by detecting the flame and/or smoke signatures of the fire.

Additional detection algorithms can be used to detect and provide warning of other safety issues, such as trip hazards, intruders attempting to enter properties through windows, someone falling, and temperatures that are too hot or cold. Also, the system could potentially give emergency services and others helpful information on occupancy numbers. As an example of an incident where this could have helped, the FRS reported that an elderly man with dementia had insisted his wife was still in a building that was on fire. The FRS re-entered the building, risking their own lives, only later to be informed that his wife had passed away some years ago.

The detection outputs can be linked to relevant authorities who can be sent warnings when certain criteria are met. For example, an intrusion attempt video sequence would be sent to the police, smoke detection to the FRS, trip hazard to a carer or neighbour, and fall detection to the ambulance service/NHS.

So, this technology offers an increasing range of possibilities for providing different types of safety solutions. As well as providing a more 21st century approach to current and future life safety issues for an aging and increasingly vulnerable population, by acting only as a sensor it safeguards against criminal activity, such as spying, and maintains the privacy of the occupiers.

Addressing fires from electrical items

As electrical items appear to contribute to the ignition of a large proportion of fires in the UK, it is clearly worth exploring how fires from electrical items may be reduced. A review of the IRS data, for example, revealed that electrical sources were potentially responsible for up to 42% of domestic fires in Scotland.

Recommendation 8

Further research to investigate the true extent of fires from electrical appliances is recommended, perhaps by first focusing on the most frequent offender to establish whether research in this area is likely to lead to practical and reliable outcomes. In the absence of any objective evidence on the specific causes of fires due to electrical appliances, an initial feasibility study may be necessary to identify whether subtle but signature changes in power usage of an appliance are a pre-cursor to a fire. If this were the case, then suitable technologies in this area could be developed to act to isolate a failing appliance before there is a fire.

Recommendation 9

If current draw issues are found to lead to a significant number of fires, this could potentially be controlled using a mains appliance tripping device similar to residual current devices (RCD). Traditional plug-in RCDs can be used to supply power and monitor the electrical current flowing through the circuit of an electrical appliance by connecting its plug to the RCD socket. The RCD measures the current difference between live and neutral conductors and, once a pre-set threshold of leakage current is exceeded, the device trips.

Figure 21: Example of a fire from an electrical item

As electrical items will have a characteristic signature current draw during each cycle of their use and throughout their lifetime, these can be "learnt" using algorithms or artificial intelligence and can be programmed into a monitoring device.

The end user would select an Electrical Appliance Current Monitoring Device (EACMD), use a recessed rotary switch to select the appliance type and then connect it to the appliance itself. The EACMD would then monitor the current consumption/signature. When the rate of rise or peak limit for the current draw characteristics go outside the expected profile, the EACMD would activate thus tripping the connected electrical item – potentially before or in the smouldering phase – long before a fire was present. The EACMD would need to be very well researched and have close to 100% reliability. Any false alarms from such devices, resulting in appliances being turned off, are likely to ruin their reputation and result in a loss of uptake by consumers.

Recommendation 10

Another way of addressing fires from white goods would be for more manufacturers to be informed of the extent of an issue, and for them to implement protective measures. These measures could include some form of current draw monitoring and electrical item tripping, or the use of different materials in known appliances with high risk ignition sources. It is therefore recommended that this is explored further with Electrical Safety First and the Office for Product Safety and Standards.

Recommendations for improving IRS database

The IRS database has proved to be a valuable tool for capturing the essential elements of every fire incident, comprehensively providing vital data that enables areas of concern to be identified. Its use in this study has enabled a clear picture to be drawn of the types of people involved in serious injuries and fire fatalities, as well as the circumstances under which these are occurring. However, there are a few potential improvements that could be made to the IRS, mainly relating to reporting consistency.

Recommendation 11

A way of improving the answering of questions in free field boxes is recommended. This could be achieved by having easily available online instructions for IRS users, which would guide them on completing questions in a more consistent and informative manner. The guidance could be in the form of online learning modules, audible instructions or short videos.

Proactive recommendations

The recommendations in this section are not necessarily the direct result of evidence presented in this report but are a result of key Stakeholder discussions and are proactively addressing potential fire issues in the future.

Recommendation 12

During this first phase of research work, the issue of fires being caused by electrical white goods has been raised. Anecdotal accounts suggest an increase in the number fires from white goods being reported and, whilst no evidence is presented here, this issue needs to be proactively addressed before it becomes more widespread. It is not clear whether the number of fires from electrical white goods is increasing, or the reporting of them has changed so that it appears that more are occurring.

The author of this report has personally experienced a small smouldering fire from a tumble dryer in the utility space of his home (next to the kitchen). Considering the electrical fire risks in the room, an optical smoke alarm had been installed (that in over two years had never produced a false alarm). It activated before smoke from the tumble dryer was visible to the naked eye. The early activation of the smoke alarm led to timely intervention resulting in the issue being managed, no damage to property or possessions, and the FRS being saved a callout.

It is therefore proposed that during the next revision of BS 5839-6 [14], consideration is given to a recommendation that any utility space separate from the kitchen, containing electrical white goods, be fitted with smoke or heat alarms – smoke alarms where false alarms are less likely and heat alarms where they are more likely.

Recommendation 13

A number of fires are occurring due to solar photovoltaic (PV) systems, where the panels are installed above a roof and supporting components are installed in the loft space. Such fires can lead to significant damage to the roof (Figure 22), and potentially if the fire spreads downwards into the property due to falling debris (although no known cases have been recorded in the UK).

Figure 22: Damage to a roof resulting from a fire in a PV system

The BRE National Solar Centre project, "Fire and Solar PV Systems- Investigations and Evidence" [15], found that the fires in 25 recent incidents examined in the UK were caused by the following components (in decreasing order starting with the highest): DC isolators, DC connectors, Inverters, DC cables and PV modules. Whilst the report does not state where these components were fitted, it would be expected that most of them were present in the loft space. The use of a smoke alarm in the roof void may have provided early warning, enabling the FRS to be summoned sooner and therefore the fire damage to be reduced.

The IET Code of Practice for Grid-connected solar PV [16] recommends that appropriate fire detection equipment be installed in lofts or other infrequently visited areas that contain inverters or PV switchgear – with the provision of external sound notification should it not be possible to hear an alarm from other areas of the building. It also states that PV installers should bring to the attention of their customers, the recommendation to have suitable fire detection in the loft (or other zones).

Other than this recommendation, there is currently no regulatory requirement or recommendation in the code for smoke alarms. With the increasing installation of solar PV systems it would be expected that, as these systems age and degrade, they may well cause more fires in the future.

In the commentary and informative sections of the current version of BS 5839-6, it is noted that smoke alarms in loft spaces would provide warning of fires in electrical equipment installed in loft spaces. It is expected that the next revision of BS 5839-6 will more strongly recommend this use of smoke alarms. It is proposed that awareness of this recommendation be raised to ensure it is more widely implemented.

Recommendation 14

Fire fatalities increase in the period November to March and most fatalities are in the 61+ age range, with over 50% of all fatalities occurring in single occupancy dwellings. A government campaign at the start of every winter season, encouraging the public to look out for neighbours and generally be more vigilant, may help to either identify a potential fire risk or lead to the earlier discovery of a fire.

Conclusions

The IRS data provided by SFRS for this phase of research work, included 19,645 incidents in total, 147 serious injuries and 126 fire fatalities. From a review of this data focussing specifically on 38 questions, general trends have been analysed and observations made. These have permitted factors of a typical fire fatality and serious injury to be identified, along with the associated demographic profile and background conditions. Factors such as living alone, being vulnerable or elderly, falling asleep or being asleep, having medical conditions, illnesses or temporary lack of physical mobility, or not hearing the alarm all contribute.

An aging population with increased vulnerabilities from conditions such as dementia, will need protecting in ways that are increasingly more sophisticated than those used to date for able bodied people capable of responding to alarms – and acting appropriately to save their own lives. The expectation that a fire alarm system will activate, and the FRS be informed and arrive to tackle the fire in time to save lives, is unrealistic for elderly and vulnerable people.

Using these findings, fourteen recommendations are made to develop existing technologies with the intention of protecting the vulnerable, as well as reducing the incidents of fire fatalities and serious injuries in the future. In summary these are to:

1) provide warnings from smoke alarms to mobile phones;
2) increase the sensitivity of smoke alarms at night;
3) monitor temperatures from multi-sensor or smoke alarms incorporating thermal sensors to provide warning of cold temperature;
4) link high-risk domestic premises to an ARC;
5) extend LPS 1655 watermist systems to provide greater personal protection;
6) write a code of practice to ensure optimum installation of LPS 1655 systems;
7) use video analytics technology for zone monitoring to enhance security, fire detection and safety;
8) research the underlying causes of electrical fires and any signatures they may give off prior to a fire being present;
9) develop an Electrical Appliance Current Monitoring Device to trip the voltage supply to electrical appliances when pre-defined signature characteristics of current draw criteria preceding a fire are met;
10) encourage manufacturers of white goods to review the types of fires that their appliances are causing and develop new ways of preventing these;
11) provide online material for users of the IRS database to ensure a more consistent approach to the recording of data – particularly in free fields;
12) include, during the next revision of BS 5839-6, a recommendation to consider fitting smoke or heat alarms to any utility space separate from the kitchen, which contain electrical white goods;
13) raise awareness of the need to fit any loft space containing parts of a solar photovoltaic system, or other live electrical items, with smoke alarms;
14) have a government campaign at the start of winter to encourage the public to look out for neighbours and themselves.

The next phases of research work will focus on specific details for each of the 126 serious fire fatalities that been reported here. Some additional areas have been identified for which further details surrounding some of the fatalities will be explored. In order to assess the proposed recommendations, the potential effectiveness of each of them will be considered during the review of all the fire investigation reports.

References

[1] Focus on trends in fires and fire-related fatalities, Home Office, Stephanie Bryant and Isabel Preston. 12 October 2017. https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/650869/focus-trends-fires-fatalities-oct17.pdf

[2] Firefighters' union 'horrified' at increase in people dying in fires, Fire Brigades Union, 8 Feb 2018
https://www.fbu.org.uk/news/2018/02/08/firefighters-union-horrified-increase-people-dying-fires
Retrieved 3 January 2019.

[3] Latest Fire Statistics Show Annual Increase, Fire and Risk Management, 10 Aug 2018
http://www.frmjournal.com/news/news_detail.latest-fire-statistics-show-annual-increase.html?utm_medium=email&utm_source=BRE&dm_i=47CQ%2CCCNN%2C181NWF%2C1DCEC%2C1&utm_campaign=576275_RedBook%20newsletter%20July_August%202018%20Staff%20version
Retrieved 3 January 2019.

[4] Fire and rescue incident statistics: England, year ending March 2018, Statistical Bulletin 16/18. 9 August 2018
https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/732555/fire-and-rescue-incident-march-2018-hosb1618.pdf
Retrieved 3 January 2019.

[5] Fire and Rescue Incident Statistics (Scotland) 2016-17. 26 October 2017.
https://www.gov.uk/government/statistical-data-sets/fire-statistics-data-tables#fatalities-and-casualties
Retrieved 3 January 2019.

[6] Scotland Together- A study examining fire deaths and injuries in Scotland. Brian P Sweeney. May 2010.

[7] Monitoring and Evaluating Scotland's Alcohol Strategy: Monitoring Report 2018. Giles L and Robinson M. Edinburgh: NHS Health Scotland; 2018.
http://www.healthscotland.scot/health-topics/alcohol/monitoring-and-evaluating-scotlands-alcohol-strategy
Retrieved 3 January 2019.

[8] Incident recording system - questions and lists. Version 1.6 In use from April 2012
https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/11806/Incident_Recording_System_-_Questions_and_Lists_-_Version_1.6_-__XML_Schemas_v1-0p__in_use_from_April_2012.pdf
Retrieved 3 January 2019.

[9] Fire safety in purpose-built block of flats, Local Government Group, L11-335 (2012) available from:
https://www.local.gov.uk/fire-safety-purpose-built-flats
Retrieved 3 January 2019.

[10] Adult smoking habits in the UK:2017, Ben Windsor-Shellard, Laura Pullin and Marie Horton, Office for National Statistics, 3 July 2018
https://www.ons.gov.uk/releases/adultsmokinghabitsintheuk2017
Retrieved 3 January 2019.

[11] Excess winter mortality in England and Wales: 2016 to 2017 (provisional) and 2015 to 2016 (final)
https://www.ons.gov.uk/peoplepopulationandcommunity/birthsdeathsandmarriages/deaths/bulletins/excesswintermortalityinenglandandwales/2016to2017provisionaland2015to2016final
Retrieved 3 January 2019.

[12] LPS 1655. Requirements and test methods for the LPCB approval and listing of personal protection watermist systems. BRE Global Limited. June 2015.
http://www.redbooklive.com/lps.jsp
Retrieved 3 January 2019.

[13] Personal Protection Systems can reduce home fire risks for vulnerable people. Nigel Firkins, BRE.
https://www.bregroup.com/news/vulnerable-people-personal-protection-systems/
Retrieved 7 March 2019

[14] BS 5839-6:2013. Fire detection and fire alarm systems for buildings. Code of practice for the design, installation, commissioning and maintenance of fire detection and fire alarm systems in domestic premises. BSI, London 2013.

[15] Fire and Solar PV Systems- Investigations and Evidence, BRE National Solar Centre, Eden project, Bodelva, St Blazey, Cornwall, PL24 2SG. 17 July 2017.

[16] Code of Practice for Grid Connected Solar Photovoltaic Systems, IET Standards. 2015.

BRE Trust
Watford, Herts
WD25 9XX

T +44 (0)333 321 8811
E enquiries@bregroup.com
W www.bregroup.com

FSC
www.fsc.org
MIX
Paper from responsible sources
FSC® C134608

BRE Trust
The BRE Trust uses profits made by BRE Group to fund new research and education programmes, that will help it meet its goal of 'building a better world together'. The BRE Trust is a registered charity in England & Wales:

No. 1092193, and Scotland: No. SC039320.